



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study

Efectos de un programa de movimiento multilateral sobre las habilidades motrices fundamentales y la autorregulación en niños de 3 a 8 años: un estudio cuasiexperimental

Endang Rini Sukamti; Wenti Nopriani; Ratna Budiarti; Risti Nurfadhila; Muhammad Wahyu Arga

Universitas Negeri Yogyakarta, Indonesia

* Correspondence Author: Endang Rini Sukamti, endang_fik@uny.ac.id

Editorial schedule: Article received 22/04/2026 Accepted: 27/06/2026 Published: 01/08/2026

<https://doi.org/10.55040/p188f042>

To cite this article use the following reference:

Sukamti, E.R.; Nopriani, W.; Budiarti, R.; Nurfadhila, R.; Arga, M.W. (2026). Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. *Sportis Sci J*, 12 (4), 1-28
<https://doi.org/10.55040/p188f042>

Author contribution: study design is E.R.S., R.B., & R.S., data collection is E.R.S., W.N., R.B., R.N., & M.W.A., statistical analysis is W.N. & M.W.A., manuscript preparation is W.N. & M.W.A., Funds Collection is E.R.S. & R.B

Funding: There is no funding in this research

Conflict of interest: All authors have no conflict of interest

Ethical aspects: The researcher explained the research objectives, training program and test procedures to the respondents and the respondents filled out the informed consent form voluntarily



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

Abstract

This study aimed to analyze the effect of the Multilateral Field Activity training model on locomotor skills, object control skills, and self-regulation in children aged 3–8 years. The study employed a quasi-experimental design with a nonequivalent control group pretest-posttest involving two groups, namely the intervention group and the control group. The sample consisted of 60 children (30 boys and 30 girls) from kindergarten to lower elementary school levels. Locomotor and object control skills were measured using the Test of Gross Motor Development-Second Edition (TGMD-2), while self-regulation was measured using the Head-Toes-Knees-Shoulders Revised (HTKS-R). The intervention program was modified based on previous scientific articles and was implemented for 8 weeks at 07:30 a.m., with a gradually increasing duration of 30–60 minutes. Each activity was performed for 3–6 repetitions with intervals of 45–60 seconds. Measurements were conducted at the pretest and posttest phases using standard assessment procedures, involving two trained raters. The MANCOVA results indicated a significant multivariate effect of group (sig. 0.000; $\eta^2 = 0.483$) and a significant effect of age (sig. 0.021; $\eta^2 = 0.156$), whereas the group $\times$ age interaction was not significant (sig. 0.501). The univariate tests showed that the group had a significant effect on the three dependent variables (locomotor $\eta^2 = 0.439$; object control $\eta^2 = 0.436$; self-regulation $\eta^2 = 0.463$). These findings indicate that multilateral field-based training can be an effective approach to support children's holistic development in psychomotor and psychological aspects.

Keywords: multilateral games, motor skills in children, executive function, fundamental movement skills.

Resumen

Este estudio tuvo como objetivo analizar el efecto del modelo de entrenamiento de Actividad en Campo Multilateral sobre las habilidades locomotoras, las habilidades de control de objetos y la autorregulación en niños de 3 a 8 años. El estudio empleó un diseño cuasiexperimental con un pretest-posttest de grupo de control no equivalente que involucró dos grupos, a saber, el grupo de intervención y el grupo de control. La muestra consistió en 60 niños (30 niños y 30 niñas) de preescolar a los primeros niveles de primaria. Las habilidades locomotoras y de control de objetos se midieron utilizando la Prueba de Desarrollo Motor Grueso-Segunda Edición (TGMD-2), mientras que la autorregulación se midió utilizando la Prueba de Cabeza-Pies-Rodillas-Hombros Revisada (HTKS-R). El programa de intervención fue modificado con base en artículos científicos previos y se implementó durante 8 semanas a las 7:30 a. m., con una duración que aumentó gradualmente de 30 a 60 minutos. Cada actividad se realizó de 3 a 6 repeticiones con intervalos de 45 a 60 segundos. Las mediciones se realizaron en las fases pretest y posttest utilizando procedimientos de evaluación estándar, con la participación de dos evaluadores capacitados. Los resultados del MANCOVA indicaron un efecto multivariado significativo del grupo (sig. 0,000; $\eta^2 = 0,483$) y un efecto significativo de la edad (sig. 0,021; $\eta^2 = 0,156$), mientras que la interacción grupo $\times$ edad no fue significativa (sig. 0,501). Las pruebas univariadas mostraron que el grupo tuvo un efecto significativo en las tres variables dependientes (locomotora $\eta^2 = 0,439$; control de objetos $\eta^2 = 0,436$; autorregulación $\eta^2 = 0,463$). Estos hallazgos indican que el

Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

entrenamiento multilateral basado en el campo puede ser un enfoque eficaz para apoyar el desarrollo holístico de los niños en los aspectos psicomotores y psicológicos.

Palabras clave: juegos multilaterales, habilidades motrices en niños, función ejecutiva, habilidades motrices fundamentales.

Introduction

The age range of 3-8 years is often regarded as a highly critical developmental period. During this phase, there is an acceleration in motor, cognitive, language, and socio-emotional development, which forms the foundation for school readiness and long-term health quality (Aniško et al., 2025). At this age, children are developing the ability to control movement, focus attention, follow instructions, and manage behaviour when interacting with game rules and learning environments (Martin et al., 2022). Evidence from physical activity interventions indicates that physical activity integrated into daily routines can influence certain aspects of executive function and language development in preschool children (Olive et al., 2024). Therefore, early childhood training programs should ideally not only target fitness or the enjoyment of movement but also support more comprehensive learning readiness.

Fundamental motor skills (FMS) are prerequisites for children to actively participate in various forms of play and physical activity throughout childhood. Within measurement frameworks such as TGMD-2, these skills are mapped into two main domains, namely locomotor skills and object control skills, which represent the ability to move from one place to another and to manipulate objects (Simpson et al., 2025; Palmer et al., 2025). Previous literature also positions fundamental motor skills as an important component of physical literacy that bridges participation in physical activity (Piotrowski et al., 2025). Furthermore, meta-analysis studies and intervention study indicate that structured programs in physical education can significantly improve fundamental motor skills (Yin et al., 2025; Safitri et al., 2025). Thus, interventions targeting locomotor and object control skills have a strong rationale for implementation in childhood.

In addition to fundamental motor aspects, behavioral self-regulation, which overlaps with executive function, is often referred to as an important predictor of learning readiness, social adaptation, and academic behavior in childhood (Wu et al., 2021). Self-regulation is trainable, making it conceptually suitable as a psychological variable in



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

physical activity interventions (da Silva et al., 2025). Empirical studies in preschool children also emphasize that the relationship between motor and cognitive domains is bidirectional and still requires broader evidence in early childhood groups (Chichinina et al., 2025). Therefore, including self-regulation alongside fundamental motor skills represents a theoretically relevant strategy.

In general, current research concludes that physical activity is associated with brain development and executive function, although the magnitude of the effect may vary depending on program design, intensity, duration, and the quality of children's cognitive engagement during movement. Recent reviews highlight that interventions incorporating cognitive engagement elements may be more relevant for targeting self-regulation compared to purely repetitive activities, although findings across studies remain mixed and show heterogeneity (Guzmán-Muñoz et al., 2025). On the other hand, experimental evidence indicates that integrated physical activity can improve certain components of executive function (Olive et al., 2024). Meanwhile, other studies report increased physical activity during sessions without consistent improvements in executive function, indicating the importance of targeted training design (Mavilidi et al., 2023). Therefore, positioning physical exercise as a means to improve both skills and self-regulation requires a training design that deliberately integrates motor demands and self-control demands.

The Multilateral Field Activity-based training model can conceptually be positioned as a multicomponent approach that combines variations of locomotor movements, manipulative skills, coordination, agility, and rule-based game elements in an open-field setting. The multilateral characteristic provides opportunities for richer movement exposure, which may simultaneously stimulate improvements in locomotor and object control skills (Šalaj et al., 2019). Literature findings suggest that structured interventions in schools can improve fundamental motor skills and emphasize the importance of adequate duration, frequency, and training period (Yin et al., 2025). In addition, approaches aligned with physical literacy or active start have been reported to produce broader impacts, not only on physical activity but also on other developmental aspects (Wilhite et al., 2025). Therefore, it is logical to design a multilateral model that simultaneously targets motor skills and self-regulation.



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.
<https://doi.org/10.55040/p188f042>

However, although evidence on improving motor skills through interventions is relatively strong, several gaps remain and form the basis for problem identification in this study. Specifically, studies examining locomotor and object-control skills, along with psychological outcomes (self-regulation), within a single experimental design remain limited. Furthermore, program components, implementation quality, and training dosage require clarification, as recent meta-analyses emphasize the need to specify intervention components and timing to optimize outcomes (Yin et al., 2025). In addition, the use of established performance-based instruments such as TGMD and HTKS-R can help reduce self-report bias and strengthen inference in two-group pretest-posttest studies (Wilhite et al., 2025).

Based on the above description, this study aims to examine the effect of the Multilateral Field Activity Training Model on locomotor skills, object control skills, and self-regulation in children aged 3-8 years. The novelty of this study lies in the simultaneous integration of psychological (self-regulation) and psychomotor outcomes. Thus, the findings are expected to provide theoretical contributions to the study of motor skills-self-regulation relationships and practical contributions to the design of more holistic training programs or physical education activities for early childhood.

Method

Research Design

This study employed a quasi-experimental design with a nonequivalent control group pretest-posttest model, comprising two groups: the intervention group and the control group. This design was selected because the research was conducted in an educational context (kindergarten to lower elementary school levels), where subject allocation often does not allow for pure randomization at the individual level as in true-experimental designs. Nevertheless, measurements were conducted at two time points (pretest and posttest) to strengthen the inference of intervention effects on the dependent variables.

Because the study was conducted in a school-based setting, participants were not randomly assigned at the individual level. Instead, group allocation was performed using a structured quasi-experimental procedure. After eligible children were identified based



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

on the inclusion and exclusion criteria, participants were distributed into the intervention and control groups by considering age category and sex composition to maintain balance between groups. This procedure was applied to reduce potential selection bias and to ensure that both groups had comparable demographic characteristics before the intervention.

Operationally, both groups underwent a baseline measurement (pretest) of three main outcomes: locomotor skills and object control skills (TGMD-2) and self-regulation (HTKS-R). Afterward, the intervention group received the training program, while the control group followed regular learning activities or routine school activities without specific intervention components from the researchers. Subsequently, both groups underwent final measurement (posttest) using the same procedures as the pretest.

To further address the nonrandomized nature of the design, baseline scores of locomotor skills, object control skills, and self-regulation were included as covariates in the MANCOVA model. Age was also included in the model because the participants covered a broad developmental range from 3 to 8 years. Therefore, the statistical analysis was designed to compare posttest outcomes between groups after controlling for baseline differences and age-related variation.

Ethical approval for this study was obtained from Universitas Negeri Yogyakarta, with reference number B/1187/UN34.16/PT.01.03/2025. The study was conducted in accordance with institutional ethical guidelines for research involving human participants. Written informed consent was obtained from all participants and from their parents or legal guardians before participation in the study.

Population and Sample

The study population consisted of children aged 3-8 years residing and attending school in Sleman Regency, Special Region of Yogyakarta, particularly at the kindergarten (TK) to lower elementary school levels. The selection of the 3-8-year age range was based on developmental considerations, as this age group represents an important phase in the development of fundamental movement skills (locomotor and object control) and self-regulation, which are essential prerequisites for learning readiness and structured physical activity.



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

Participants were recruited using a purposive sampling approach based on the eligibility criteria and the feasibility of school participation. The recruitment process involved coordination with school administrators and teachers to identify children who met the age criteria and were physically able to participate in the testing and intervention procedures. Parents or legal guardians received information about the study objectives, procedures, potential risks, and benefits before providing written informed consent.

The inclusion criteria were as follows: (1) children aged 3-8 years, (2) able to follow instructions and participate in light-to-moderate physical activity according to the research procedures, (3) healthy and not experiencing injuries or medical complaints that could hinder test implementation, and (4) having written informed consent from parents or guardians. The exclusion criteria included: (1) age below 3 years or above 8 years, (2) children who were athletes or involved in structured sports clubs or communities (to avoid extreme differences in training experience), and (3) failure to return informed consent. Thus, the total sample consisted of 60 students with a balanced composition of 30 boys and 30 girls. The sample was also balanced by age group: 12 children aged 3-4 years, 12 aged 4-5 years, 12 aged 5-6 years, 12 aged 6-7 years, and 12 aged 7-8 years.

After the eligible participants were identified, they were allocated into two groups: an intervention group ($n = 30$) and a control group ($n = 30$). Because individual randomization was not feasible in the school setting, allocation was conducted using a structured balancing procedure based on age category and sex. Each group was arranged to have a comparable distribution of boys and girls as well as a comparable distribution across the five age categories. This procedure was used to reduce selection bias and to improve baseline comparability between the intervention and control groups.

Intervention program

The intervention program in this study was modified based on previously published scientific articles. The intervention was conducted for 8 weeks (3 sessions per week) with an intervention duration of 30-60 minutes (Trost & Brookes, 2021), which increased gradually. Each activity involved 3-6 repetitions with intervals of 45-60 seconds (Khudolii et al., 2025). The sessions were conducted on Monday, Wednesday, and Friday at 07:30 a.m. The equipment required for the implementation of this intervention included: (1) a 20-meter $\times$ 40-meter field, (2) hurdles, (3) stopwatch, (4)



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

flags/cones, (5) measuring tape, (6) whistle, (7) tennis balls, (8) turbo javelin, (9) soccer balls, (10) target boards, (11) mini goals, (12) chalk, and (13) stationery.

Table 1. Multilateral Field Activity Program

No.	Name of Game	Procedure	Achievement Indicators	Implementation
1	Sprint and Hurdles Relay	The equipment is arranged along the track. Two lanes are used, one with obstacles and one without. The first track is the hurdles lane, and children perform a sprint on the second lane after completing the initial track.	Running 1. Arms move opposite to the legs, elbows flexed 2. Both feet briefly leave the ground 3. Foot placement when landing on the toes 4. Legs flex close to the buttocks at approximately 90 degrees. Leap 1. Take-off with one foot and land with the opposite foot 2. The time when both feet leave the ground is longer than running 3. Forward reach with the arm opposite the leading leg.	Estimated time: 12 minutes. Ratio: 1 child : 1 coach
2	Horizontal Jump	The child stands behind the start line. From a semi-squat position (knees slightly bent), the child jumps forward as far as possible, landing on both feet. The examiner marks the landing point. If the participant falls backward and lands with the hands, the hand position is measured. After participant 1 finishes, the next participant continues in sequence	1. Preparation by bending both knees with arms swinging behind the body 2. Arms extend forcefully forward and upward to full extension above the head 3. Take-off and landing with both feet simultaneously 4. Arms pushed downward during landing	Estimated time: 10 minutes. Ratio: 1 child : 1 coach
3			Throwing	



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

	Small Ball Throw and Catch	The child faces the coach; one student throws while another catches alternately. Distances are set at 5 meters, 7 meters, and 9 meters. Throwing and catching are performed alternately with the right and left hands to observe bilateral balance.	1. Throw begins with the hand/arm moving downward 2. Rotate hips and shoulders so that the non-throwing side faces the wall 3. Weight transfer by stepping with the foot opposite the throwing hand 4. Follow-through by releasing the ball diagonally across the body Catching 1. Preparation with hands in front of the body and elbows bent 2. Arms extend to reach the ball upon arrival 3. Ball caught using hands only	Estimated time: 10 minutes. Ratio: 1 child : 1 coach
4	Cross Jump	The child stands in the center box (number 0). After the start signal, the participant jumps with both feet touching boxes in sequence 1-4 (front, back, right, left) and returns to the center.	1. Preparation by bending both knees with arms swinging opposite the jump direction 2. Arms extend toward the jump direction and upward to full extension above the head 3. Take-off and landing with both feet simultaneously 4. Arms pushed downward during landing	
5	Turbo Throw	The child holds a tail ball or turbo javelin and prepares at the throwing start area (5 meters). The thrower runs for the approach and then throws the ball or turbo as far as possible within the	1. Throw begins with the hand/arm moving downward 2. Rotate hips and shoulders so the non-throwing side faces the wall	Estimated time: 8 minutes. Ratio: 1 child : 1 coach



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

		throwing sector. The coach observes and evaluates locomotor movement.	3. Weight transfer by stepping with the foot opposite the throwing hand 4. Follow-through by releasing the object diagonally across the body	
6	Underhand Ball Throw	The child holds the ball in front of the body. The ball is thrown using an underhand motion (straight arm swing). Feet are positioned front-back, and the body leans forward targeting the ball into a circle.	1. Dominant hand swings downward and backward, body facing the cone 2. Step forward with the foot opposite the dominant hand toward the cone 3. Knees bent toward the lower body 4. Release the ball close to the floor so it does not bounce more than 4 inches	Estimated time: 7 minutes. Ratio: 1 child : 1 coach
7	FMS Circuit (Source: CAMSA)	The child performs a circuit arranged according to The Canadian Agility and Movement Skill Assessment (CAMSA), performed individually. The total movement covers 20 meters while completing 8 movement skills: 1. Start 2. Perform 3 jumps on hoops 3. Side step from Cone A to Cone B and return to Cone A 4. Move to Cone B to catch a ball 5. Throw the ball at the target 6. Skipping from Cone B to Cone C (5 meters) 7. Return to start for hopping on 6 hoops	Assessment based on total success in completing the 8 movement skills according to TGMD-2 indicators	Estimated time: 13 minutes. Ratio: 1 child : 1 coach



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

		8. Run to Cone B to kick the ball toward the target 9. Gallop back to the line.		
8	Enemy Shooting Game	This game is a modified version of dodgeball. It is played between children and the coach. The field size is 5 meters × 10 meters. The game continues until one team wins three times (when throws hit the opponent's body). Simplified rules: (1) no throws to the head, (2) players remain in their respective zones.	The team that wins twice is declared the winner.	Estimated time: 13 minutes. Ratio: 1 child : 1 coach
9	Ninja Kids	The child performs an obstacle circuit consisting of running, climbing, jumping, and sliding movements.	Assessment based on total success in completing 8 movement skills according to TGMD-2 indicators.	Estimated time: 13 minutes. Ratio: 1 child : 1 coach
10	Soccer Penalty	The child and coach play against each other using a penalty-style mechanism without a goalkeeper. The child is given 5 kicks with the right foot and 5 kicks with the left foot.	1. Kick the ball continuously and quickly 2. Perform an approach before kicking 3. Non-kicking foot placed behind the ball 4. Kick using the instep of the dominant foot	Estimated time: 13 minutes. Ratio: 1 child : 1 coach

To ensure that the Multilateral Field Activity program could be implemented as an intervention, the program underwent validation by five lecturers: an expert in games, an expert in child development, an expert in early childhood education, an expert in sports coaching education specializing in athletics, and an expert in physical education. This validation test used Aiken's V (>0.7) with a scale of 1-4 (Wedi et al., 2024; Putro et al., 2025). The validation items used to assess the Multilateral Field Activity program consisted of: (1) the game model aligned with multilateral activities, (2) enjoyable and varied game models, (3) safe game models, (4) easily understood game procedures, and (5) systematic and measurable game program (training dosage). The Aiken's V validity



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

result was 0.88, indicating that the Multilateral Field Activity program is valid and feasible to be implemented as an intervention (Prasetyo et al., 2022; Hidayat et al., 2025).

Instruments and research procedures

This study used two main instruments. First, the Test of Gross Motor Development - Second Edition (TGMD-2) was used to measure fundamental movement skills consisting of two subtests: the Locomotor Subtest (Run, Gallop, Hop, Leap, Horizontal Jump, Slide) and the Object Control Subtest (Striking a Stationary Ball, Stationary Dribble, Catch, Kick, Overhand Throw, Underhand Roll). TGMD-2 is a valid and reliable instrument and has been widely used across populations within the age range included in this study (Bardid et al., 2016; Zhao et al., 2023; Halaši & Štajer, 2025; Simpson et al., 2025). In the Indonesian research population, TGMD-2 has also been widely adopted to analyze movement skills in preschool children and elementary school students (Arifiyanti, 2020; Conra et al., 2021; Supriady et al., 2023; Supriady, 2024).

The second instrument was the Head-Toes-Knees-Shoulders Revised (HTKS-R) to measure self-regulation based on children's performance in following rules and controlling responses (Lenes et al., 2020; McClelland et al., 2021; Fernandes et al., 2023; Ibrahim et al., 2025; da Silva et al., 2025). Although HTKS-R has not yet been widely adopted for measurement in the Indonesian population, it has been adapted into various versions across countries, particularly for preschool children and young children under 12 years old (Ahmed et al., 2022; da Silva, Mota, et al., 2025; Korucu et al., 2025).

The measurement procedure was conducted at two time points, namely pretest before the program began and posttest after the program was completed, with a consistent implementation order. To reduce variation due to fatigue or distraction, measurements were conducted in conducive environmental conditions (safe, quiet, and with sufficient space). TGMD-2 was administered in an area that allowed children to move freely according to the requirements of each item, whereas HTKS-R was conducted one-on-one in a quiet location to ensure children focused on the instructions. In addition, each participant was assigned an identification code to maintain confidentiality and allow systematic data management.

The study involved two raters to increase objectivity and allow reporting of inter-rater reliability. The raters in this study were not required to be researchers; the key



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

requirement was competence, training, and independence. The recommended composition was one rater from the research team and one independent rater (e.g., another lecturer or teacher not involved in program implementation) to reduce expectation bias. Before data collection, both raters participated in a scoring training session to ensure a shared understanding of the TGMD-2 performance criteria and HTKS-R scoring rules. The training included discussion of scoring indicators, practice scoring using example performances, and calibration of scoring decisions. During data collection, both raters followed standardized testing procedures, including consistent instructions, the same number of trials, the same scoring criteria, and the same testing environment for all participants. If differences in scoring occurred, the final score was determined through a consensus-based adjudication procedure between raters.

However, because the separate raw scoring sheets from each rater were no longer available at the revision stage, inter-rater reliability coefficients such as ICC or Kappa could not be calculated retrospectively. Therefore, measurement consistency in this study was addressed procedurally through rater training, standardized scoring guidelines, pilot calibration, and consensus-based adjudication. This issue is also acknowledged as a limitation of the study, and future studies are encouraged to retain independent rater scoring sheets or video-based double coding to allow formal inter-rater reliability analysis.

Statistical analysis

The analysis used Multivariate Analysis of Covariance (MANCOVA). In this model, posttest scores of locomotor skills, object control, and HTKS-R were treated as multivariate dependent variables, while group (intervention vs. control) served as the independent variable. Pretest scores from each outcome were used as covariates to control baseline differences. Considering the age range of 3-8 years, age was included as a covariate or additional factor depending on model requirements and data distribution (Mertler et al., 2025). The statistical analysis was conducted using SPSS 27 (George & Mallery, 2021).



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

Results

Before conducting the Multivariate Analysis of Covariance (MANCOVA), tests of normality and homogeneity were performed. The normality test in this study used residual values because the original data were not normally distributed. Normality was assessed using the Kolmogorov-Smirnov test ($p > 0.05$), as presented in Table 2.

Table 2. Normality test results

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Residual for Locomotor Skills	0.088	60	0.200*	0.988	60	0.815
Residual for Object Control Skills	0.087	60	0.200*	0.984	60	0.643
Residual for Self-Regulation	0.063	60	0.200*	0.982	60	0.520

Paragraf 2: Based on Table 2, the significance values for locomotor skills, object control skills, and self-regulation were all greater than 0.05. Therefore, the data for each variable were normally distributed. After confirming normality, a homogeneity test was conducted to determine variance equality within the population. The results of the homogeneity test ($p > 0.05$) using Levene's Test of Equality of Error Variances are presented in Table 3.

Table 3. Homogeneity test

	F	df1	df2	Sig.
Locomotor Skills	1.113	9	50	0.371
Object Control Skills	0.930	9	50	0.508
Residual for Self-Regulation	1.732	9	50	0.106

Based on Table 3, the significance values for locomotor skills, object control skills, and self-regulation were all greater than 0.05. Additionally, Box's Test of Equality of Covariance Matrices showed Box's $M = 77.329$, $F = 1.067$, $\text{sig.} = 0.345$, indicating that the data were derived from the same population.

Since the overall pretest-posttest data were normally distributed and homogeneous, the assumptions for conducting MANCOVA were met. The first step of MANCOVA involved analyzing the Multivariate Tests, as presented in Table 4.



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

Table 4. First results of Multivariate Analysis of Covariance

Effect		F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	14.751 ^b	3.000	45.000	0.000	0.496
	Wilks' Lambda	14.751 ^b	3.000	45.000	0.000	0.496
Pre-Locomotor Skills	Pillai's Trace	8.095 ^b	3.000	45.000	0.000	0.351
	Wilks' Lambda	8.095 ^b	3.000	45.000	0.000	0.351
Pre-Object Control Skills	Pillai's Trace	0.781 ^b	3.000	45.000	0.511	0.049
	Wilks' Lambda	0.781 ^b	3.000	45.000	0.511	0.049
Pre-Self-Regulation	Pillai's Trace	2.168 ^b	3.000	45.000	0.105	0.126
	Wilks' Lambda	2.168 ^b	3.000	45.000	0.105	0.126
Group	Pillai's Trace	19.494 ^b	3.000	45.000	0.000	0.483
	Wilks' Lambda	19.494 ^b	3.000	45.000	0.000	0.483
Age	Pillai's Trace	2.111	12.000	119.350	0.021	0.156
	Wilks' Lambda	2.111	12.000	119.350	0.021	0.156
Group*Age	Pillai's Trace	0.949	12.000	141.000	0.501	0.075
	Wilks' Lambda	0.949	12.000	141.000	0.501	0.075

Based on Table 4, Pillai's Trace values indicate that, after controlling for pretest scores of locomotor skills, object control skills, self-regulation, and age, there was a significant multivariate effect of group on the combined dependent variables (posttest locomotor skills, posttest object control skills, and posttest self-regulation), $F = 19.494$, $p < 0.001$, $\eta^2 = 0.483$. Age also showed a significant multivariate effect, $F = 2.111$, $p = 0.021$, $\eta^2 = 0.156$. The interaction between group and age was not significant, $F = 0.949$, $p = 0.501$, $\eta^2 = 0.075$, indicating that the group effect was relatively consistent across the age range studied. Among the covariates, pretest locomotor scores significantly influenced the combined outcomes, $F = 8.095$, $p < 0.001$, $\eta^2 = 0.351$, whereas pretest object control and self-regulation scores did not show significant multivariate effects ($p > 0.05$).

The second stage of MANCOVA involved Tests of Between-Subjects Effects to examine mean differences between groups. The results are presented in Table 5.



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

Table 5. Second Results on Tests of Between-Subjects Effects

Source		Type III Sum of Squares	df	F	Sig.	Partial Eta Squared
Pre-Locomotor Skills	Post_Locomotor_Skills	5.584	1	12.823	0.001	0,214
	Post_Object_Control_Skills	1.835	1	3.596	0.064	0,071
	Post_Self_Regulation	156.654	1	5.925	0.019	0.112
Pre-Object Control Skills	Post_Locomotor_Skills	0.301	1	0.692	0.410	0.015
	Post_Object_Control_Skills	0.950	1	1.861	0.179	0.038
	Post_Self_Regulation	0.641	1	0.024	0.877	0.001
Pre-Self-Regulation	Post_Locomotor_Skills	0.009	1	0.021	0.884	0.000
	Post_Object_Control_Skills	2.535	1	4.966	0.031	0.096
	Post_Self_Regulation	14.565	1	0.551	0.462	0.012
Group	Post_Locomotor_Skills	312.515	1	17.650	0.000	0.439
	Post_Object_Control_Skills	348.378	1	82.636	0.000	0.436
	Post_Self_Regulation	32166.716	1	16.593	0.000	0.463
Age	Post_Locomotor_Skills	5.980	4	3.433	0.015	0.226
	Post_Object_Control_Skills	7.019	4	3.438	0.015	0.226
	Post_Self_Regulation	66.371	4	0.628	0.645	0.051
Group*Age	Post_Locomotor_Skills	0.410	4	0.235	0.917	0.020
	Post_Object_Control_Skills	0.882	4	0.432	0.785	0.035
	Post_Self_Regulation	246.708	4	2.333	0.069	0.166

Based on Table 5, follow-up univariate ANCOVA analyses indicated that, after controlling for pretest scores and age, the group had a significant effect on all dependent variables. The intervention group differed significantly from the control group in posttest locomotor skills, $F = 17.650$, $p < 0.001$, $\eta^2 = 0.439$; posttest object control skills, $F = 82.636$, $p < 0.001$, $\eta^2 = 0.436$; and posttest self-regulation, $F = 16.593$, $p < 0.001$, $\eta^2 = 0.463$. Age significantly affected motor outcomes (locomotor and object control) ($p = 0.015$), but not self-regulation ($p = 0.645$). The interaction between group and age was not significant across all outcomes ($p > 0.05$), indicating that the intervention effects were relatively consistent across age groups.

Further analysis reported estimated marginal means (adjusted means) to evaluate differences in posttest scores between intervention and control groups after controlling for pretest scores and age. These values represent posttest outcome means adjusted for covariates in the model.



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.
<https://doi.org/10.55040/p188f042>

Table 6. Estimated marginal means results for the groups in the study

Dependent Variable		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Post_Locomotor_Skills	Intervention Group	8.863 ^a	0.129	8.604	9.121
	Control Group	5.704 ^a	0.129	5.445	5.963
Post_Object_Control_Skills	Intervention Group	8.890 ^a	0.139	8.610	9.170
	Control Group	5.443 ^a	0.139	5.163	5.723
Post_Self_Regulation	Intervention Group	96.086 ^a	1.002	96.071	103.101
	Control Group	56.747 ^a	1.002	54.732	58.763

Based on the results in Table 6, for locomotor skills, the intervention group showed a higher adjusted mean ($M = 8.863$, $SE = 0.129$, 95% CI [8.604, 9.121]) compared to the control group ($M = 5.704$, $SE = 0.129$, 95% CI [5.445, 5.963]). A similar pattern was observed for object control skills, where the intervention group ($M = 8.890$, $SE = 0.139$, 95% CI [8.610, 9.170]) scored higher than the control group ($M = 5.443$, $SE = 0.139$, 95% CI [5.163, 5.723]). For self-regulation, the adjusted mean of the intervention group ($M = 96.086$, $SE = 1.002$, 95% CI [96.071, 103.101]) was also higher than that of the control group ($M = 56.747$, $SE = 1.002$, 95% CI [54.732, 58.763]). These findings strengthen the results showing significant differences between groups across all posttest outcomes. The large mean differences indicate that the program had a strong practical impact on improving fundamental movement skills and self-regulation.

Discussion

The findings indicate that the Multilateral Field Activity training model significantly influenced locomotor skills, object control skills, and self-regulation after controlling for pretest scores and age, with higher standardized posttest means in the intervention group compared to the control group. Conceptually, these findings support the view that structured school-based interventions can meaningfully improve fundamental movement skills (FMS) and, under certain conditions, also contribute to self-regulation related to executive function (Yin et al., 2025). This pattern aligns with

Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.
<https://doi.org/10.55040/p188f042>

evidence suggesting that school-based FMS interventions are effective, particularly when training dosage is sufficient and implementation is consistent (Jiang et al., 2026).

The improvement in locomotor skills in the intervention group can be explained by repeated exposure to varied movements (running, jumping, hopping, direction changes) and session structures that provide sufficient practice opportunities to strengthen coordination, balance, and postural control. Meta-analyses of school-based FMS interventions indicate that improvements are most consistent in programs with higher frequency, longer duration, and extended intervention periods (Yin et al., 2025). However, heterogeneity of effects has been reported due to differences in program characteristics, instructional quality, and assessment instruments. Some studies have found smaller locomotor effects, often associated with shorter duration, lower implementation quality, or insufficiently specific locomotor content (Abe et al., 2022; Salters et al., 2025).

Object control skills require perception-action integration, including visual tracking, timing, and hand-eye or foot-eye coordination. Multilateral field-based training typically provides rich stimuli (varied targets, changing tempo, dynamic conditions), facilitating manipulative skill adaptation (Santoso et al., 2024). These findings align with previous studies showing that structured FMS or physical activity programs effectively improve total FMS, with certain approaches producing stronger gains in manipulative domains (Chen et al., 2024; Khudolii et al., 2025). However, not all programs produce equivalent improvements in object control compared to locomotor skills, especially when training lacks sufficient variation, feedback, or practice opportunities (Salters et al., 2025).

Improvements in self-regulation in the intervention group may be explained by multilateral sessions involving rules, task transitions, inhibitory control, attention focus, error monitoring, and self-correction. These components represent core aspects of behavioral self-regulation measured through the HTKS-R instrument. This finding is consistent with systematic reviews indicating that cognitively engaging physical activity can improve executive function components in children (Mao et al., 2024; Du et al., 2025), although effect sizes vary across studies. Some research reports small or non-significant effects, often due to differences in intervention dosage, heterogeneity,



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.
<https://doi.org/10.55040/p188f042>

measurement tools, and participant characteristics (Bao et al., 2024; González-Andrade et al., 2024).

The use of HTKS-R strengthens interpretation because it is performance-based, sensitive to self-regulation variation in young children, and supported by validity and reliability evidence in preschool populations (da Silva et al., 2025). Additionally, HTKS performance has been consistently associated with academic readiness and learning outcomes (McClelland et al., 2021; Kenny et al., 2023). Thus, increased HTKS-R scores can be viewed as indicators of improved self-regulation relevant to school readiness and structured activity participation.

Motor competence and executive function develop interdependently, as both involve action planning, response selection, and error control. Recent meta-analytic evidence shows positive associations between motor competence and executive function in children (Moon et al., 2024; Zhang et al., 2025). Therefore, improvements in FMS through structured training may occur alongside strengthening of cognitive control. Studies in preschool children also indicate that executive function can predict motor competence and may mediate relationships between motor skills and psychosocial outcomes (Chichinina et al., 2025; Li et al., 2025).

Age influenced motor outcomes, but the non-significant interaction between group and age suggests that program benefits were consistent across the 3-8-year age range. This aligns with literature indicating that school-based FMS programs can be effective across age groups, although effect magnitude depends on design, duration, and frequency (Jiang et al., 2026). Some studies identify moderators such as baseline skill level, where children with lower initial ability show larger improvements. The absence of age interaction in this study may indicate that the program was adaptable across ages or that age grouping was insufficiently sensitive to detect subtle variations (Bao et al., 2024).

Practically, these findings suggest that schools and early childhood education programs can adopt multilateral field-based training to improve both FMS and self-regulation, provided the program is structured, repetitive, and age-appropriate. This recommendation aligns with evidence that planned school-based interventions improve FMS and cognitively engaging physical activity supports executive function components

Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

(Du et al., 2025; Guzmán-Muñoz et al., 2025). Using performance-based measures such as TGMD and HTKS-R can help educators monitor progress objectively. The findings also support the recommendation that physical education in early childhood should be well planned, play-based, and directed toward physical, social, emotional, and psychological development rather than only toward physical performance (Giráldez, 2020). Thus, the program may serve as a practical framework for teachers to integrate movement variation, games, rules, and self-control demands in early childhood physical education.

The main limitation of this study is the quasi-experimental design, which, although controlling for pretest and age through MANCOVA/ANCOVA, still carries potential selection bias compared to randomized controlled trials. Future studies should employ cluster randomization, evaluate intervention fidelity, and include follow-up measurements to assess sustainability of effects. In addition, the sample size was relatively limited and drawn from one geographical area, namely Sleman Regency, which may restrict the generalizability of the findings to other educational, cultural, or socioeconomic contexts. Another limitation concerns measurement reliability: although two trained raters were involved and scoring was standardized through training, pilot calibration, and consensus-based adjudication, separate raw scoring sheets from each rater were not available for calculating inter-rater reliability coefficients such as ICC or Kappa. Future studies should retain independent rater scoring records or use video-based double coding to enable formal inter-rater reliability analysis. Longitudinal follow-up is also recommended to determine whether improvements in FMS and self-regulation are maintained after the intervention period.

Conclusion

This study concludes that the Multilateral Field Activity training model is able to improve the abilities of children aged 3-8 years in three important aspects: self-regulation, locomotor skills, and object control skills. Compared with the control group, children who participated in the training program showed greater development in fundamental movement skills, including locomotor abilities and object manipulation skills. In addition, the training program contributed to strengthening self-regulation, as reflected in



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

improvements in children's ability to focus attention, follow instructions, control impulses, and perform self-correction when making mistakes during activities. These findings indicate that a multilateral training approach, combining movement variation, games, clear rules, and task transitions, is not only effective in improving psychomotor aspects but also provides added value in supporting psychological development relevant to school readiness and children's participation in structured physical activities. Therefore, Multilateral Field Activity can be recommended as an alternative training or physical education program for early childhood education through lower elementary school levels to support children's development more holistically. Future implementation of this program should consider consistency of delivery, age-appropriate progression of difficulty, and continuous evaluation to ensure that the benefits obtained can be maintained and extended across different school contexts.

References

- Abe, T., Kitayuguchi, J., Fukushima, N., Kamada, M., Okada, S., Ueta, K., ... Mutoh, Y. (2022). Fundamental movement skills in preschoolers before and during the COVID-19 pandemic in Japan: a serial cross-sectional study. *Environmental Health and Preventive Medicine*, 27. <https://doi.org/10.1265/ehpm.22-00049>
- Ahmed, S. F., Skibbe, L. E., McRoy, K., & Tatar, B. H. (2022). Strategies, recommendations, and validation of remote executive function tasks for use with young children. *Early Childhood Research Quarterly*, 60, 336–347. <https://doi.org/10.1016/j.ecresq.2022.03.002>
- Aniśko, B., Bernatowicz, K., & Wójcik, M. (2025). Effects of body mass index and extracurricular sports activities on physical fitness in school-aged children. *Frontiers in Public Health*, 13. <https://doi.org/10.3389/fpubh.2025.1578304>
- Arifiyanti, N. (2020). The Gross Motor Skill Differences Between Preschool Boys and Girl. *Aulad: Journal on Early Childhood*, 3(3), 115–120. <https://doi.org/10.31004/aulad.v3i3.78>
- Bao, R., Wade, L., Leahy, A. A., Owen, K. B., Hillman, C. H., Jaakkola, T., & Lubans, D. R. (2024, August 1). Associations Between Motor Competence and Executive Functions in Children and Adolescents: A Systematic Review and Meta-analysis.



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.
<https://doi.org/10.55040/p188f042>

Sports Medicine. Springer Science and Business Media Deutschland GmbH.
<https://doi.org/10.1007/s40279-024-02040-1>

- Bardid, F., Huyben, F., Lenoir, M., Seghers, J., De Martelaer, K., Goodway, J. D., & Deconinck, F. J. A. (2016). Assessing fundamental motor skills in Belgian children aged 3-8 years highlights differences to US reference sample. *Acta Paediatrica, International Journal of Paediatrics*, 105(6), e281–e290.
<https://doi.org/10.1111/apa.13380>
- Chen, G., Tongdecharoen, W., & Wattanapayungkul, Y. (2024). Designing a Fundamental Movement Training Program to Improve Basketball Skills in Elementary Schools' Student. *International Journal of Sociologies and Anthropologies Science Reviews*, 4(3), 71–82.
<https://doi.org/10.60027/ijasar.2024.4106>
- Chichinina, E., Gavrilova, M., & Drid, P. (2025). Executive function skills predict motor competence in preschool children. *BMC Pediatrics*, 25(1).
<https://doi.org/10.1186/s12887-025-05582-z>
- Conra, M. A., Marlina Siregar, N., & Setiakarnawijaya, Y. (2021). GAME-BASED SOCCER TRAINING MODELS FOR CHILDREN AGED 6-8 YEARS. *Gladi : Jurnal Ilmu Keolahragaan*, 12(04), 281–290.
<https://doi.org/10.21009/gjik.124.07>
- da Silva, M. A. C., de Lucena Martins, C. M., Alencar, M. A., Firmino, P. R. A., & Bandeira, P. F. R. (2025). Association Between Motor Competence, Executive Functions, and Self-Regulation: A Complex Systems Approach. *American Journal of Human Biology*, 37(8). <https://doi.org/10.1002/ajhb.70110>
- da Silva, M. A. C., Mota, J. G., Lemos, N. B. A. G., Martins, C. M. de L., & Bandeira, P. F. R. (2025). Evidence of validity of the Head-Toes-Knees-Shoulders Revised (HTKS-R) for Brazilian children. *Child Neuropsychology*, 31(5), 680–691.
<https://doi.org/10.1080/09297049.2024.2424330>
- Du, A., Ning, K., Shangguan, C., Wang, C., Wan, B., & Chi, A. (2025). The Effects of Acute Cognitively Engaging Physical Activity on Executive Function in Preschool Children: Evidence from Behavioral and fNIRS Measures. *Behavioral Sciences*, 15(12). <https://doi.org/10.3390/bs15121712>

Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.
<https://doi.org/10.55040/p188f042>

- Fernandes, V. R., Becker, D. R., McClelland, M. M., & Deslandes, A. C. (2023). Head-Toes-Knees-Shoulders task and EF in two samples of adolescents in Brazil and United States. *Frontiers in Psychology*, 14.
<https://doi.org/10.3389/fpsyg.2023.1149053>
- George, D., & Mallery, P. (2021). *IBM SPSS Statistics 27 Step by Step. IBM SPSS Statistics 27 Step by Step*. Routledge. <https://doi.org/10.4324/9781003205333>
- Giráldez, V. A. (2020). ¿How should physical education work in early childhood education be? *Retos*, 40(9), 588–596.
<https://doi.org/10.47197/RETOS.V37I37.74177>
- González-Andrade, A., Tubío, J., Álvarez-Bardón, A., & Santiago-Ramajo, S. (2024). Relationship between executive functions, mathematical skills and fitness/physical activity in elementary school children: a systematic review. *Electronic Journal of Research in Educational Psychology*, 22(62), 469–504.
<https://doi.org/10.25115/ejrep.v22i63.9216>
- Guzmán-Muñoz, E., Concha-Cisternas, Y., Jofré-Saldía, E., Castillo-Paredes, A., Molina-Márquez, I., & Yáñez-Sepúlveda, R. (2025, November 1). Physical Activity and Its Effects on Executive Functions and Brain Outcomes in Children: A Narrative Review. *Brain Sciences*. Multidisciplinary Digital Publishing Institute (MDPI). <https://doi.org/10.3390/brainsci15111238>
- Halaši, S., & Štajer, A. (2025). Reliability and validity of TGMD-2 in Serbia for children aged 7-8 t. *Zbornik Radova Pedagogskog Fakulteta Uzice*, (27), 361–382.
<https://doi.org/10.5937/zrpfu2527361h>
- Hidayat, A. K., Susilowati, S., Suartini, D. A., Hastina, S., Santoso, R., Aziz, Z., & Yambedoan, T. (2025). The Development of Physical Activities Based on Racket Striking for Early Childhood Education Students in Yogyakarta City. *Jurnal Moderasi Olahraga*, 5(1), 61–74. <https://doi.org/10.53863/mor.v5i1.1548>
- Ibrahim, A., Jasim, A. G., Hawar, A. B., Ghaeb, Y. F., & Alsamaræ, M. S. K. (2025). Effect of HTKS-R–inspired visual reversal motor play on self-regulation and motor skills in preschoolers. *Retos*, 73, 1145–1155.
<https://doi.org/10.47197/retos.v73.117771>



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.
<https://doi.org/10.55040/p188f042>

- Jiang, S., Zeng, N., Ng, J. Y. Y., Chong, K. H., Zeng, T., Leung, S. K. Y., & Ha, A. S. (2026, December 1). Effects of physical activity interventions on fundamental movement skills and cognitive function in early childhood: A systematic review and network meta-analysis. *Journal of Sport and Health Science*. Elsevier B.V.
<https://doi.org/10.1016/j.jshs.2025.101085>
- Kenny, S. A., Cameron, C. E., Karing, J. T., Ahmadi, A., Braithwaite, P. N., & McClelland, M. M. (2023). A meta-analysis of the validity of the Head-Toes-Knees-Shoulders task in predicting young children's academic performance. *Frontiers in Psychology*. Frontiers Media SA.
<https://doi.org/10.3389/fpsyg.2023.1124235>
- Khudolii, M., Ivashchenko, O., & Khudolii, O. (2025, November 30). Fundamental Movement Skills Development in Children Aged 5–12: Theory, Evidence, and Pedagogical Models. *Physical Education Theory and Methodology*. OVS LLC.
<https://doi.org/10.17309/tmfv.2025.6.16>
- Korucu, I., Duncan, R. J., Kenny, S. A., Gonzales, C. R., Ahmadi, A., Karing, J. T., & McClelland, M. M. (2025). The Head–Toes–Knees–Shoulders Task as a Screening Tool for Kindergarten-Level Achievement. *Behavioral Sciences*, 15(11). <https://doi.org/10.3390/bs15111464>
- Lenes, R., Gonzales, C. R., Størksen, I., & McClelland, M. M. (2020). Children's Self-Regulation in Norway and the United States: The Role of Mother's Education and Child Gender Across Cultural Contexts. *Frontiers in Psychology*, 11.
<https://doi.org/10.3389/fpsyg.2020.566208>
- Li, S., Song, Y., Zhang, Q., & Wang, Z. (2025). Mediation of executive functions in the relationship between motor skills and psychosocial health in preschool children. *Journal of Exercise Science and Fitness*, 23(3), 167–174.
<https://doi.org/10.1016/j.jesf.2025.04.002>
- Mao, F., Huang, F., Zhao, S., & Fang, Q. (2024). Effects of cognitively engaging physical activity interventions on executive function in children and adolescents: a systematic review and meta-analysis. *Frontiers in Psychology*. Frontiers Media SA. <https://doi.org/10.3389/fpsyg.2024.1454447>



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

- Martin, R., Murphy, J., Molina-Soberanes, D., & Murtagh, E. M. (2022). The clustering of physical activity and screen time behaviours in early childhood and impact on future health-related behaviours: a longitudinal analysis of children aged 3 to 8 years. *BMC Public Health*, 22(1). <https://doi.org/10.1186/s12889-022-12944-0>
- Mavilidi, M. F., Pesce, C., Mazzoli, E., Bennett, S., Paas, F., Okely, A. D., & Howard, S. J. (2023). Effects of Cognitively Engaging Physical Activity on Preschool Children's Cognitive Outcomes. *Research Quarterly for Exercise and Sport*, 94(3), 839–852. <https://doi.org/10.1080/02701367.2022.2059435>
- McClelland, M. M., Gonzales, C. R., Cameron, C. E., Geldhof, G. J., Bowles, R. P., Nancarrow, A. F., ... Tracy, A. (2021). The Head-Toes-Knees-Shoulders Revised: Links to Academic Outcomes and Measures of EF in Young Children. *Frontiers in Psychology*, 12. <https://doi.org/10.3389/fpsyg.2021.721846>
- Mertler, C. A., Vannatta, R. A., & LaVenía, K. N. (2025). Multivariate Analysis of Variance and Covariance. In *Advanced and Multivariate Statistical Methods* (pp. 132–176). Routledge. <https://doi.org/10.4324/9781003562436-6>
- Moon, J., Webster, C. A., Stodden, D. F., Brian, A., Mulvey, K. L., Beets, M., ... Russ, L. (2024). Systematic review and meta-analysis of physical activity interventions to increase elementary children's motor competence: a comprehensive school physical activity program perspective. *BMC Public Health*, 24(1). <https://doi.org/10.1186/s12889-024-18145-1>
- Olive, L. S., Telford, R. M., Westrupp, E., & Telford, R. D. (2024). Physical activity intervention improves executive function and language development during early childhood: The active early learning cluster randomized controlled trial. *Child Development*, 95(2), 544–558. <https://doi.org/10.1111/cdev.14014>
- Palmer, K. K., McKheen, A., Palmer, S. A., Wood, A. P., Stodden, D. F., & Robinson, L. E. (2025). Using 2 Versions of the Test of Gross Motor Development to Classify and Screen Young Children's Motor Skills: A Comparison Study. *Pediatric Exercise Science*, 37(4), 330–336. <https://doi.org/10.1123/pes.2023-0189>
- Piotrowski, T., Makaruk, H., Tekień, E., Feleszko, W., Kołodziej, M., Albrecht, K., ... Gąsior, J. S. (2025, October 1). Fundamental Movement/Motor Skills as an Important Component of Physical Literacy and Bridge to Physical Activity: A



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.
<https://doi.org/10.55040/p188f042>

Scoping Review. *Children*. Multidisciplinary Digital Publishing Institute (MDPI).
<https://doi.org/10.3390/children12101406>

Prasetyo, H. J., Purnama, S. K., Doewes, R. I., Syaifullah, R., & Sugiyanto. (2022). Throwing Technique Training Model for Blind Goalball Athletes. *International Journal of Human Movement and Sports Sciences*, 10(5), 982–987.

<https://doi.org/10.13189/saj.2022.100515>

Putro, K. H., Suharjana, S., Marhaendro, A. S. D., Hariono, A., Siswantoyo, S., Fauzi, F., ... Prabowo, T. A. (2025). Evaluating Validity and Test-retest Reliability on Indonesian Basketball Talent Scouting Model for Athletes Aged 10 to 14. *Physical Education Theory and Methodology*, 25(3), 540–547.

<https://doi.org/10.17309/tmfv.2025.3.09>

Safitri, A. P., Kriswanto, E. S., Pambudi, A. F., & Prabowo, T. A. (2025). Implementing Big Ball Games to Enhance Coordination in 11–12-Year-Old Students: A Gender-Based Analysis. *Physical Education Theory and Methodology*, 25(6), 1406–1415.

<https://doi.org/10.17309/tmfv.2025.6.11>

Šalaj, S., Milčić, L., & Šimunović, I. (2019). Differences in motor skills of selected and non-selected group of children in artistic gymnastics in the context of their motor development. *Kinesiology*, 51(1), 133–140. <https://doi.org/10.26582/k.51.1.16>

Salters, D., Chauvin, E., Woodruff, S. J., & Scharoun Benson, S. M. (2025). Promoting Fundamental Movement Skills and Physical Literacy Among 8–12-Year-Old Children: Feasibility Insights from an 8-Week Pilot Program in Southwestern Ontario. *Children*, 12(7). <https://doi.org/10.3390/children12070838>

Santoso, N. P., Subagyo, S., Santoso, N., Prabowo, T. A., & Yulianto, W. D. (2024). Assessing the Effect of Traditional Games on Manipulative Movements in Elementary School Students Based on Gender. *Physical Education Theory and Methodology*, 24(3), 441–448. <https://doi.org/10.17309/tmfv.2024.3.13>

Simpson, A., Ward, B., Rosenberg, M., Jackson, B., Gou, J., Derbyshire, A., & Thornton, A. L. (2025). Preliminary validity evidence for a rapid fundamental movement skill assessment tool for primary education settings. *Frontiers in Sports and Active Living*, 7. <https://doi.org/10.3389/fspor.2025.1441402>



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n.º 4; p. 1-28, August 2026.
<https://doi.org/10.55040/p188f042>

- Supriady, A. (2024). GROSS MOTOR SKILL LEVELS IN PRESCHOOLERS. *JUARA : Jurnal Olahraga*, 9(2), 738–744. <https://doi.org/10.33222/juara.v9i2.3756>
- Supriady, A., Mahendra, A., Budiana, D., & Ma'mun, A. (2023). Improving Fundamental Movement Skills in Early Childhood through Outdoor Play Based on Gender. *Jurnal Pendidikan Jasmani Dan Olahraga*, 8(2), 260–269. <https://doi.org/10.17509/jpjo.v8i2.61277>
- Trost, S. G., & Brookes, D. S. K. (2021). Effectiveness of a novel digital application to promote fundamental movement skills in 3- to 6-year-old children: A randomized controlled trial. *Journal of Sports Sciences*, 39(4), 453–459. <https://doi.org/10.1080/02640414.2020.1826657>
- Wedi, S., Tomoliyus, T., Fauzi, F., Gemaini, A., & Prabowo, T. A. (2024). Innovation, Validity, and Reliability of Modified Dynamic Balance Test for Karate Kata Category. *Sport Mont*, 22(3), 3–8. <https://doi.org/10.26773/smj.241004>
- Wilhite, B. C., Chui, K., Sacheck, J. M., Hatfield, D. P., Morris, M., Ziembowicz, M., ... Hennessy, E. (2025). Getting an Active Start: Assessing the Impact of a Physical Literacy-Based Intervention on Preschool-Aged Children's Fundamental Movement Skills, Motor Competency and Behavioral Self-Regulation. *International Journal of Environmental Research and Public Health*, 22(12). <https://doi.org/10.3390/ijerph22121861>
- Wu, H., Eungpinichpong, W., Ruan, H., Zhang, X., Wang, S., & Ding, C. (2021). Protocol for a quasi-experimental study examining the effect of a ball skills intervention on four domains of preschooler development. *Primary Health Care Research and Development*, 22. <https://doi.org/10.1017/S1463423621000645>
- Yin, X., Zhang, D., Shen, Y., Wang, Y., Wang, Z., & Liu, Y. (2025, December 1). Effectiveness of school-based interventions on fundamental movement skills in children: a systematic review and meta-analysis. *BMC Public Health*. BioMed Central Ltd. <https://doi.org/10.1186/s12889-025-22696-2>
- Zhang, X., Tang, C., Geng, M., Li, K., Liu, C., & Cai, Y. (2025). The effects of active play interventions on children's fundamental movement skills: a systematic review. *BMC Pediatrics*, 25(1). <https://doi.org/10.1186/s12887-024-05385-8>



Original article. Effects of a multilateral movement program on fundamental movement skills and self-regulation in children aged 3–8 years: a quasi-experimental study. Vol. 12, n. ° 4; p. 1-28, August 2026.

<https://doi.org/10.55040/p188f042>

Zhao, M., Han, X., Che, L., Qi, C., Ma, X., & Wang, S. (2023). The relative age effect and gender difference on fundamental motor skills in preschool children aged 4–5 years. *Early Child Development and Care*, 193(2), 174–184.
<https://doi.org/10.1080/03004430.2022.2071870>