



# Effect of Play-Based Fundamental Motor Skill Intervention on Sedentary Behavior, MVPA and Motor Development

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## Abstract

**Introduction:** Fundamental motor skills (FMS) are essential for children's motor development and physical activity (PA) engagement. Play-based interventions may enhance FMS proficiency while influencing activity behaviors, yet the mechanisms linking skill development to PA and sedentary behavior remain underexplored.

**Objective:** This study examined the effects of a 12-week play-based FMS intervention on motor development, PA, and sedentary behavior in primary-school children.

**Methods:** A total of 305 children (152 intervention, 153 control; mean age=7.95 ± 1.2 years) participated. Motor development was assessed using the TGMD-3. MVPA and sedentary behavior were measured via accelerometry. Duration of the intervention was eight weeks. AMOS v28 was utilized for data analysis.

**Results:** Post-intervention, the intervention group demonstrated significantly higher TGMD-3 scores ( $\beta=0.46$ ), increased MVPA ( $\beta=0.39$ ), and reduced sedentary behavior ( $\beta=-0.34$ ) compared to controls. SEM indicated that MVPA and sedentary behavior partially mediated the effect of the intervention on motor development ( $\beta_{\text{indirect}}=0.14$  and 0.10, respectively). Model fit indices were excellent (CFI=0.971, RMSEA=0.048).

**Conclusion:** A play-based FMS intervention effectively enhances motor development by improving MVPA and reducing sedentary behavior. Integrating enjoyable, skill-focused, and activity-promoting programs in schools may foster both immediate and long-term motor competence in children. The current research offers valuable insights for educators, coaches, and policymakers.

**Keywords:** Motor Skills, Child, Physical Activity, Sedentary Behavior, Motor Development

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## 1. Introduction

Motor development in early and middle childhood plays a crucial role in laying the groundwork for lifelong physical health, cognitive growth, and psychosocial well-being (1). Fundamental motor skills (FMS) include essential locomotor actions such as running and jumping, alongside object-control abilities like throwing and catching. These skills serve as the foundation for more complex movements and contribute significantly to overall functional competence (2,3). Achieving proficiency in these skills not only enhances participation in organized sports and recreational activities but also encourages engagement in physical activity (PA) while decreasing sedentary habits (4). This relationship between motor competence (MC) and PA is central to various theoretical models that connect motor development with health-related outcomes in children (5-7).

Sedentary behavior, characterized by low-energy activities such as sitting or engaging with screens, has become a pressing public health issue for children globally (8). Extended periods of inactivity are linked to negative health outcomes, including diminished cardiovascular fitness, increased body fat, and hindered motor skill development. In contrast,

moderate to vigorous PA (MVPA) is associated with improved cardiovascular health, greater muscular strength, better coordination, and overall fitness (9). Despite the recognized advantages of MVPA, evidence indicates that many children fail to meet the recommended levels of daily PA (10). A contributing factor to this deficiency may be insufficient motor skills, which can undermine children's confidence and willingness to participate in active play, potentially leading to a detrimental cycle of development (11).

Play-based interventions have proven to be an effective approach for improving FMS while also encouraging PA and decreasing sedentary behavior. This form of play, which is self-directed, enjoyable, and intrinsically motivating, allows children to develop locomotor and object-control skills in a supportive and engaging setting (12). Research indicates that structured play-based programs lead to enhanced FMS proficiency, alongside increased levels of PA and reduced sedentary time (13). Unlike conventional skill drills, these interventions capitalize on the engaging nature of games, imaginative play, and social interaction, which significantly boosts children's motivation and commitment to PA.

The influence of play-based interventions on motor development operates through both direct and



indirect mechanisms. Directly, these interventions facilitate the acquisition of FMS through practice and repetition, enhancing MC. Indirectly, factors such as the intensity of PA, enjoyment, and perceived competence serve as behavioral and psychosocial mediators. For example, children who find joy and success in play are more inclined to engage voluntarily, participate in more intense activities, and practice their skills more often, thereby boosting their motor development (14). This aligns with Self-Determination Theory (15), which posits that intrinsic motivation and a sense of competence are crucial for maintaining engagement in physical activities.

Structural equation modeling (SEM) provides a powerful framework for analyzing intricate relationships within research. It enables the simultaneous assessment of various direct and indirect effects, allowing researchers to measure how FMS interventions impact motor development through both behavioral factors, such as MVPA, and psychosocial elements, including enjoyment and perceived competence (16). The application of SEM in studies related to PA and motor development has grown, facilitating the testing of theoretical models, the evaluation of mediating variables, and the generation of insights for effective intervention strategies (Barnett et al., 2019; Robinson et al., 2015). However, there remains a scarcity of studies utilizing SEM to explore the concurrent effects of play-based FMS interventions on sedentary behavior, MVPA, and motor development.

Early childhood and primary school environments serve as optimal settings for intervention strategies. During this critical developmental phase, children's motor skills are particularly adaptable, and foundational habits regarding PA and sedentary behavior begin to form (17,18). Implementing play-based interventions within schools or community spaces can effectively engage a wide audience, offering avenues for skill development, social engagement, and enjoyable PA. Notably, initiatives aimed at reducing sedentary behavior can enhance efforts to promote MVPA, as increased active play naturally replaces time spent on sedentary pursuits like screen time.

While current research highlights the beneficial impacts of FMS interventions on skill proficiency, there is a notable gap in studies exploring their effects on overall movement patterns, such as MVPA and sedentary behavior. Additionally, the mediating roles of behavioral and psychosocial factors have not been thoroughly investigated. Gaining insight into these pathways is crucial for developing interventions that not only enhance FMS but also foster comprehensive motor development and sustained participation in PA. Furthermore, utilizing SEM to identify both direct and indirect mechanisms can clarify which elements of an intervention - such as skill practice, structured play, and motivational techniques - are most effective in decreasing sedentary time and increasing MVPA.

This study aims to fill existing research gaps by exploring the impact of a play-based FMS intervention on children's sedentary behavior, MVPA, and motor development. Employing a path-analytic SEM approach, the research investigates both the direct effects of the intervention on motor outcomes and the indirect effects that arise from changes in activity intensity and engagement levels. We propose that the play-based FMS intervention will lead to significant enhancements in motor development when compared

to a control group, and that these improvements will be partially mediated by increases in MVPA and decreases in sedentary behavior. Furthermore, we anticipate that the final SEM model will exhibit a good fit, thereby validating the conceptual relationships between play-based FMS practice, behavioral activity patterns, and MC.

The study aims to thoroughly explore the relationships between structured play and its impact on children's movement behaviors and skill acquisition. The results are expected to inform the development of effective interventions within schools and communities that focus on enhancing motor skills, encouraging active lifestyles, and minimizing sedentary behavior. These objectives are essential for promoting both physical and psychosocial well-being during childhood.

## 2. Methods

### 2.1. Study Design and Participants

This study employed a quasi-experimental design with intervention and control groups to evaluate the effects of a play-based FMS program on children's sedentary behavior, MVPA, and motor development. A total of 305 children, aged 6 to 10 years (154 boys and 151 girls), were selected from six urban primary schools using stratified cluster sampling. The schools were randomly assigned to either the intervention group ( $n = 152$ ) or the control group ( $n = 153$ ). An a priori power analysis conducted with G\*Power 3.1 confirmed that this sample size was adequate to identify a medium effect size (Cohen's  $d = 0.5$ ) with 80% power at an alpha level of 0.05. Inclusion criteria required participants to be free from physical or cognitive disabilities that could impede their participation in physical activities, to have parental consent, and to attend at least 80% of the intervention sessions. The research adhered to all ethical guidelines outlined in the Declaration of Helsinki.

### 2.2. Intervention

The play-based FMS intervention was implemented over a 12-week period, consisting of three 45-minute sessions each week, culminating in a total of 36 sessions (21). Conducted by trained physical education specialists, the program featured structured play activities designed to enhance locomotor and object-control skills. Each session began with a 5 to 10-minute warm-up and dynamic play, followed by 20 to 25 minutes at skill-focused play stations that prioritized repetition, progression, and feedback. The sessions concluded with 10 minutes of game-based activities aimed at fostering enjoyment and peer interaction. The intervention was centered on promoting intrinsic motivation, cooperative play, and mastery experiences to boost engagement and perceived competence, while the control group maintained their standard physical education curriculum without the additional FMS activities.

### 2.3. Measurements

#### 2.3.1. Fundamental Motor Skills

FMS proficiency was evaluated using the Test of Gross Motor Development-Third Edition (TGMD-3), which comprises 13 skills categorized into locomotor

and object-control subscales (19). Each skill is scored based on specific performance criteria, with scores ranging from 0 (absent) to 1 (present), where higher scores reflect greater proficiency. In this study, the Cronbach's alpha was from 0.88 to 0.95.

### 2.3.2 MVPA and Sedentary Behavior

Activity patterns were assessed using ActiGraph GT3X+ accelerometers. The collected data were analyzed in 15-second intervals, applying Evenson cut-points to categorize activity intensity into sedentary (<100 counts/min) and MVPA ( $\geq 2296$  counts/min).

### 2.3.3 Motor Development

Motor development was defined as a composite latent variable that encompassed FMS proficiency, MVPA, and sedentary behavior. Higher scores on this composite measure indicated a more advanced level of motor development.

### 2.3.4 Demographic Data

Parents reported children's age, sex, and height/weight, with BMI calculated as  $\text{kg/m}^2$ .

### 2.4. Procedures

Baseline assessments were carried out one week prior to the intervention, which included the TGMD-3 evaluation and the deployment of accelerometers. Following the 12-week program, post-intervention assessments were conducted within one week. All assessors received training in standardized protocols and were blinded to the group assignments. Inter-rater reliability was established, with 10% of the assessments being independently scored by two raters, yielding an ICC greater than 0.90.

### 2.5. Statistical Analysis

Data analysis was performed using IBM SPSS v28 and AMOS v28, where descriptive statistics (mean  $\pm$  SD)

and group comparisons (t-tests, chi-square) were utilized to assess demographic and baseline characteristics. To investigate the direct and indirect effects of the play-based intervention on motor development, SEM was employed, incorporating MVPA and sedentary behavior as mediators. The intervention variable was dichotomously coded (0 for control, 1 for intervention), with latent constructs defined for motor development as including TGMD-3 locomotor and object-control scores, alongside positive loadings for MVPA and a negative loading for sedentary behavior. Model fit was assessed through various indices, including a chi-square/degree of freedom ratio below 3, a Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) both at or above 0.95, a Root Mean Square Error of Approximation (RMSEA) of 0.06 or less, and a Standardized Root Mean Square Residual (SRMR) of 0.08 or below. Additionally, bootstrapping with 5,000 samples was conducted to estimate 95% confidence intervals for indirect effects, with statistical significance determined at  $p < 0.05$ . Missing data, which constituted less than 5%, were addressed using full information maximum likelihood (FIML) estimation.

## 3. Results

### 3.1. Participant Characteristics

A total of 305 children participated in the study, comprising 152 individuals in the intervention group (78 boys and 74 girls) and 153 in the control group (76 boys and 77 girls). Analysis revealed no significant differences at baseline regarding age, sex distribution, BMI, or TGMD-3 scores between the two groups (all  $p > 0.05$ ). Detailed demographic information can be found in [Table 1](#).

**Table 1.** Demographic Characteristics of Participants at Baseline.

Variable	Intervention (n=152)	Control (n=153)	p-Value
Age (years)	7.9 $\pm$ 1.2	8.0 $\pm$ 1.3	0.57
Boys, n (%)	78 (51.3%)	76 (49.7%)	0.78
BMI ( $\text{kg/m}^2$ )	17.2 $\pm$ 2.5	17.4 $\pm$ 2.6	0.61
TGMD-3 Total Score	42.8 $\pm$ 8.9	43.1 $\pm$ 9.2	0.73
MVPA (min/day)	48.7 $\pm$ 15.3	47.9 $\pm$ 14.8	0.64
Sedentary Time (min/day)	374.5 $\pm$ 52.7	377.2 $\pm$ 50.8	0.58

### 3.2. Descriptive Statistics and Correlations

Post-intervention, the intervention group demonstrated higher TGMD-3 scores and MVPA, and lower sedentary behavior compared with controls. Correlations among variables are presented in [Table 2](#).

FMS proficiency was positively correlated with MVPA ( $p < 0.001$ ) and negatively correlated with sedentary time ( $p < 0.001$ ). MVPA and sedentary time were inversely correlated ( $p < 0.001$ ).

**Table 2.** Pearson Correlations Among Key Variables (n=305).

Variable	TGMD-3	MVPA	Sedentary
TGMD-3	1	0.41**	-0.38**
MVPA	0.41**	1	-0.52**
Sedentary	-0.38**	-0.52**	1

\*\* $p < 0.01$

### 3.3. SEM Results

A SEM was developed to investigate both the direct and indirect impacts of a play-based FMS intervention on motor development, with MVPA and sedentary behavior serving as mediating variables. The latent construct for motor development was defined by the total score from the TGMD-3, which had a positive

loading, alongside MVPA (also positively loaded) and sedentary time (negatively loaded). The SEM exhibited a strong fit, evidenced by the following indices:  $\chi^2/\text{df} = 2.12$ , CFI = 0.971, TLI = 0.963, RMSEA = 0.048 (90% CI = 0.041-0.056), and SRMR = 0.042. The analysis revealed significant direct effects of the intervention on motor development ( $\beta = 0.46$ ), MVPA ( $\beta = 0.39$ ), and a negative effect on sedentary behavior ( $\beta = -0.34$ ). Additionally,

MVPA positively influenced motor development ( $\beta = 0.37$ ), while sedentary behavior had a negative impact ( $\beta = -0.29$ ). Indirect effects, assessed through bootstrapping, indicated that the intervention's influence on motor development was partially

mediated by MVPA ( $\beta = 0.14$ ) and sedentary behavior ( $\beta = 0.10$ ). These findings suggest that both MVPA and sedentary behavior play a mediating role in the relationship between the intervention and motor development.

**Table 3.** Standardized Direct and Indirect Effects of the Intervention on Motor Development.

Path	$\beta$	SE	p-Value	95% CI
Intervention → Motor Development	0.46	0.07	<0.001	0.32–0.60
Intervention → MVPA	0.39	0.06	<0.001	0.27–0.51
Intervention → Sedentary	-0.34	0.06	<0.001	-0.46–0.22
MVPA → Motor Development	0.37	0.05	<0.001	0.27–0.47
Sedentary → Motor Development	-0.29	0.05	<0.001	-0.39–0.19
Intervention → MVPA → Motor Dev	0.14	0.03	<0.01	0.08–0.21
Intervention → Sed → Motor Dev	0.10	0.03	<0.01	0.05–0.16

#### 4. Discussion

This study examined the impact of a 12-week play-based intervention focused on FMS on the motor development, MVPA, and sedentary behavior of primary school children. Using SEM, the research assessed both direct and indirect effects of the intervention. Findings revealed significant enhancements in children's motor skills and an increase in MVPA, alongside a decrease in sedentary behavior. Additionally, SEM analysis suggested that behavioral mediators played a partial role in these outcomes, underscoring the importance of PA intensity and reduced sedentary time in fostering MC.

This research strongly supports the effectiveness of play-based interventions in improving FMS among children. The intervention group demonstrated significantly higher scores on the TGMD-3 after the program compared to the control group, aligning with existing studies that highlight the role of enjoyable, structured play in skill development (20,21). Factors such as intrinsic motivation, repetitive practice, mastery experiences, and cooperative gameplay likely fostered high levels of engagement, which are crucial for motor learning. In contrast to conventional physical education programs, play-based interventions create a relaxed, child-focused atmosphere that encourages repeated practice of locomotor and object-control skills, facilitating the necessary neural and biomechanical adaptations for skill enhancement. These findings highlight the critical need for early intervention in motor skill development. The ages of 6 to 10 represent a pivotal stage for children, as they experience significant neural plasticity and improvements in coordination and movement confidence, which are particularly receptive to structured skill training (22). By incorporating diverse and enjoyable FMS activities during this developmental window, the intervention not only improves immediate motor skills but also encourages sustained participation in physical activities, thereby laying the groundwork for lifelong healthy habits.

The intervention resulted in significant improvements in daily MVPA and a reduction in sedentary behavior, suggesting that play-based FMS training can enhance overall PA patterns. This aligns with existing literature indicating that children with better motor skills are more likely to engage in active play, sports, and a variety of PAs (21). By fostering improvements in both locomotor and object-control skills, the intervention likely bolstered children's confidence in engaging in physical activities, potentially diminishing avoidance behaviors and

reducing sedentary lifestyles. SEM results further indicated that MVPA and sedentary behavior partially mediated the intervention's impact on motor development. These results align with theoretical frameworks, such as the one proposed by Stodden et al. (2008), which suggest a bidirectional relationship between MC and PA: children with better motor skills tend to be more active, and increased activity levels further enhance skill within a SEM framework, offering empirical support for both direct and indirect pathways that connect FMS interventions to motor development outcomes.

The observed improvements can be attributed to several mechanisms. Firstly, the systematic repetition of essential skills fosters better neuromuscular coordination, timing, and movement efficiency, which are reflected in higher TGMD-3 scores (25). Secondly, the enjoyment and social interaction inherent in play-based activities likely boost intrinsic motivation, leading to consistent participation and engagement crucial for skill acquisition (15). Furthermore, by encouraging frequent MVPA, the intervention may have improved cardiovascular and musculoskeletal fitness, thereby enhanced overall MC and decreased the risk of prolonged sedentary behavior (12). Additionally, the relationship between MVPA and reduced sedentary time underscores the significance of behavioral pathways; children who are more active and less sedentary have greater opportunities for motor practice outside of structured sessions, aiding in skill consolidation and generalization (6). This dual approach - combining direct skill training with the promotion of an active lifestyle - indicates that interventions designed to integrate both elements may be particularly effective in supporting comprehensive motor development.

This research aligns with previous studies that highlight the effectiveness of structured motor skill programs in enhancing children's MC (23,25). However, this study offers new perspectives by incorporating both MVPA and sedentary behavior as mediators within a SEM framework, which provides a deeper understanding of the mechanisms through which interventions affect motor development. Unlike earlier research that primarily examined pre- and post-intervention skill changes or MVPA outcomes, this approach acknowledges the intricate relationships between motor proficiency, activity levels, and sedentary habits. The evidence of partial mediation indicates that while targeted skill training is vital, it is equally important to enhance activity behaviors to optimize developmental results. Additionally, the play-based design of this intervention sets it apart from

many traditional programs that rely on repetitive drills or teacher-led instruction. Such play-oriented methods may foster greater sustainability and enjoyment, thereby improving adherence, especially among younger children. These findings support the emerging consensus that engagement, enjoyment, and autonomy are essential elements of successful motor skill interventions (26).

The current research offers valuable insights for educators, coaches, and policymakers. It emphasizes the need to incorporate play-based FMS activities into primary school physical education curricula to foster skill development and promote active lifestyles. Additionally, interventions should aim to address both MVPA and sedentary behaviors, as altering these patterns can enhance the effectiveness of skill training. The study also highlights the significance of the Social-Ecological Model in understanding the intricate relationships between behavioral and motor outcomes, which can inform the creation of evidence-based interventions that optimize both direct and indirect impacts. Furthermore, early engagement in enjoyable FMS activities may yield long-term advantages that extend beyond immediate motor skills, as it can build confidence, motivation, and active habits, ultimately encouraging sustained participation in sports and recreational activities throughout childhood and adolescence, thereby promoting lifelong health and mitigating the risks of obesity and sedentary-related diseases.

Despite the merits of this study, several limitations warrant consideration. The quasi-experimental design, while strong, lacks full randomization, which may restrict the ability to draw definitive causal conclusions. Additionally, although accelerometry data is generally reliable, it may not encompass all context-specific activities, such as swimming or cycling. The absence of follow-up assessments beyond the 12-week intervention period leaves the long-term retention of skills and activity behaviors uncertain. Future research should aim to include longitudinal follow-ups, a more diverse participant pool, and assessments across various contexts to better understand the sustainability of intervention effects. Furthermore, while SEM offers a sophisticated approach to analyzing direct and indirect effects, unmeasured factors like parental support, environmental resources, and peer influences may also play significant roles in children's motor development and activity behaviors. Incorporating these variables in future studies could enhance the understanding of the factors influencing MC.

#### 4.1. Conclusion

This study concludes that a 12-week play-based intervention focused on FMS significantly improves motor development, boosts MVPA, and decreases sedentary behavior among primary school children. SEM analyses indicate that the enhancements in PA and the reductions in sedentary time serve as partial mediators of these outcomes, underscoring the significance of both skill-oriented and behavior-oriented approaches. The results advocate for the incorporation of engaging, developmentally suitable motor skill programs into school curricula as a means to foster both immediate and sustained MC and PA participation. By promoting skill mastery, active lifestyles, and enjoyment in physical movement, such

interventions can lead to healthier, more active childhoods and lay the groundwork for lifelong physical health.

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#### Footnotes

**Authors' Contribution:** This study was carried out solely by the corresponding author.

#### Conflicts of Interest

Non to declare.

**Data Availability:** The data that support the findings of this study are openly available upon request from the corresponding author.

**Ethical Approval:** The author confirms that all steps and requirements of this study comply with ethical guidelines. Participants were informed about the characteristics of the study and gave written informed consent.

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