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Original Article

Mixed-Method Investigation with SEM Modelling of How Home-Based Physical Activity and Fundamental Motor Skills Influence Early Motor Development in Preschool Children

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Abstract

Introduction: The early motor development of preschool-aged children is shaped by a combination of environmental and behavioral influences, particularly home-based physical activity (HBPA) and fundamental motor skills (FMS).
Objective: This research focused on exploring the relationships between HBPA, FMS, and motor competence in preschool-aged children. Additionally, it aimed to assess the mediating effect of FMS through a mixed-method approach that incorporated structural equation modeling.
Methods: A total of 315 preschool children, aged 3 to 5 years, along with their caregivers, took part in the study. Preschool-age Physical Activity Questionnaire, the Test of Gross Motor Development-Third Edition and the Movement Assessment Battery for Children-2 were utilized for measuring research variables. SEM and semi-structured interviews were used for data analysis.
Results: The analysis indicated a positive correlation between HBPA (β=0.53) and FMS (β=0.18) with motor competence. Furthermore, FMS was found to significantly mediate the relationship between HBPA and motor competence, evidenced by an indirect effect of β=0.33. Qualitative findings highlighted that factors such as parental involvement, opportunities for daily active play, and a supportive home environment contributed positively to the development of FMS, while constraints like limited space and excessive screen time posed significant barriers.
Conclusion: HBPA plays a crucial role in early motor development, influencing FMS both directly and indirectly. To enhance motor competence in preschoolers, interventions should prioritize parental involvement and promote skill-oriented active play within the home environment.

Keywords: Preschool Child, Motor Skills, Physical Activity, Child Development, Structural Equation Modeling

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1. Introduction

Early childhood is a pivotal stage for motor development, where essential motor skills such as locomotion and object control begin to form and strengthen (1). These fundamental motor skills (FMS) serve as crucial components that enable children to engage in physical activity (PA), foster social connections, and promote overall well-being (2,3). Achieving proficiency in FMS during the preschool years not only enhances immediate motor abilities but also lays the groundwork for long-term physical literacy, sustained PA, and cognitive and psychosocial growth (5,6). However, research exploring the relationship between home-based physical activity (HBPA) and FMS in early childhood is still sparse, particularly studies that combine quantitative modeling with qualitative perspectives.

FMS are generally divided into two categories: locomotor skills, such as running, hopping, and jumping, and object-control skills, including throwing, catching, and kicking (2,3). These skills are crucial for developing more advanced motor behaviors and are vital for children's overall motor competence, which includes coordination, balance, agility, and strength. Studies have shown that preschoolers who demonstrate higher proficiency in FMS are more inclined to participate in physical activities, foster positive self-perceptions regarding their movement abilities, and achieve superior motor outcomes as they grow older (6,7). In contrast, delays or shortcomings in FMS can hinder children's involvement in active play, sports, and organized activities, potentially leading to increased sedentary behavior and associated health issues, such as early childhood obesity (8).

While schools play a vital role in fostering PA through structured programs, the home environment is equally important for early motor skill development (9,10). HBPA includes various activities that children engage in outside of school, such as unstructured play, family games, and casual exercise. Research indicates that the frequency, variety, and quality of HBPA are positively linked to the development of FMS and overall

motor competence (2,11-13). Parental involvement - through encouragement, providing adequate space and equipment, and demonstrating active behaviors - significantly influences children's activity levels and motor learning (5). However, there is a lack of comprehensive studies that have quantitatively assessed the impact of HBPA on motor development in preschool-aged children or that have incorporated these effects into structural models that account for both direct and indirect influences, such as mediation through skill proficiency or engagement in activities.

Motor development is a complex process shaped by a variety of biological, behavioral, and environmental influences (14,15). While quantitative research effectively identifies patterns and correlations, qualitative methods offer deeper insights into individual experiences, motivations, and obstacles (16-18). Employing a mixed-methods approach that combines survey assessments, objective motor skill measurements, and detailed interviews or focus groups enables a comprehensive exploration of how HBPA and FMS impact early motor development. This methodology enhances triangulation, bolsters validity, and yields practical recommendations for parents, educators, and policymakers.

Structural equation modeling (SEM) provides a powerful tool for analyzing intricate relationships among both observed and latent variables (19). This methodology enables researchers to investigate proposed causal pathways, assess direct and indirect effects, and address measurement errors in latent constructs like FMS or HBPA quality. Recent research in motor development has utilized SEM to reveal the reciprocal interactions between PA, motor competence, and psychosocial outcomes, thereby highlighting its effectiveness in elucidating early developmental trajectories (20,21). In the realm of home-based interventions, SEM can elucidate the impact of HBPA on early motor development, both directly and through intermediary factors such as skill proficiency, confidence, and motivation.

Despite the increasing interest in FMS and early motor development, several significant gaps remain. There is a notable lack of integration between home-based activity data and objective assessments of motor skills, as most research tends to concentrate on school-based programs or structured physical education. Additionally, the limited application of mixed-methods designs restricts our understanding of qualitative factors—such as parental attitudes, environmental constraints, and child preferences—that could influence the relationship between HBPA and motor outcomes. Furthermore, the infrequent use of SEM hinders our comprehension of the direct, indirect, and mediated pathways connecting HBPA, FMS, and early motor competence. Lastly, research often overlooks preschool-aged children (3–5 years), who are crucial for establishing lifelong movement behaviors, in favor of studies focused on primary-school-aged children. Addressing these gaps is essential for developing evidence-based strategies that enhance home-based interventions, encourage parental involvement, and optimize motor development trajectories in early childhood.

This study aims to explore the impact of HBPA and FMS on the early motor development of preschool children, employing a mixed-methods approach that incorporates SEM. The research will quantify the relationships between HBPA, FMS proficiency, and overall motor competence, while also identifying both direct and indirect pathways through which HBPA influences motor development, with FMS potentially serving as a mediator. Additionally, the study will gather qualitative insights from parents and caregivers about their children's experiences with HBPA, including the barriers and facilitators they encounter. We hypothesize that higher levels of HBPA will correlate positively with FMS proficiency and motor competence, that FMS proficiency will mediate the relationship between HBPA and motor competence, and that qualitative findings will uncover contextual factors, such as parental support and the home environment, that contribute to variations in HBPA and motor outcomes.

2. Methods

2.1. Study Design

This research utilized a convergent mixed-methods approach, combining quantitative measures of HBPA, FMS, and early motor development with qualitative interviews from parents and caregivers. A cross-sectional SEM technique was employed to explore both direct and indirect relationships between HBPA, FMS proficiency, and overall motor competence. The qualitative insights enriched the analysis by providing a contextual framework for understanding the home-based factors that influence these developmental aspects.

2.2. Participants

A total of 315 preschool children, aged between 3 and 5 years, along with their primary caregivers, were recruited from various early childhood education centers through stratified convenience sampling. The inclusion criteria specified that participants must be within the designated age range, have no diagnosed developmental disorders affecting motor function, and possess informed parental consent for their involvement. Conversely, children with neuromuscular or orthopedic impairments, chronic medical conditions that restrict PA, or those unable to follow instructions during motor assessments were excluded from the study. Among the 315 participants, 158 were boys (50.2%) and 157 were girls (49.8%), with an average age of 4.2 years (± 0.7). Socioeconomic status was assessed based on parental education and household income, which facilitated stratified analyses. With a sample size of 315 participants, this study surpasses the recommended 10:1 ratio of cases to estimated SEM parameters, ensuring adequate statistical power to detect medium effects and achieve a robust model fit. This sample size also facilitates meaningful thematic saturation in the parental interviews conducted.

2.3. Measurements

2.3.1. Home-Based Physical Activity

HBPA was evaluated using the Preschool-age Physical Activity Questionnaire (Pre-PAQ), a validated tool designed for parents of children aged 3 to 5 years (22). The Pre-PAQ effectively measures the frequency, duration, and intensity of both structured and unstructured physical activities, as well as indoor and outdoor play, family-facilitated movement, and daily

routines. It has demonstrated high reliability, with a Cronbach's alpha of 0.82, and shows moderate to strong validity when compared to accelerometer data (r = 0.61). For the analysis, total weekly HBPA was quantified in minutes. Eleven experts confirmed the validity of this scale with CVI of 0.90 and CVR of 0.88. Reliability of this scale was also confirmed by Cronbach's alpha of 0.93.

2.3.2. Fundamental Motor Skills

The assessment of FMS was conducted using the Test of Gross Motor Development-Third Edition (TGMD-3) (23). This evaluation focuses on both locomotor and object-control skills. The TGMD-3 demonstrates excellent reliability, with an intraclass correlation coefficient (ICC) ranging from 0.88 to 0.95, and it possesses strong validity within preschool populations. Eleven experts confirmed the validity of this scale with CVI of 0.92 and CVR of 0.90.

2.3.3. Motor Competence

Motor competence was assessed using the Movement Assessment Battery for Children-2 (MABC-2) Preschool Version (24), which evaluates manual dexterity, aiming and catching, and balance. Age-adjusted standardized scores were utilized for this assessment. The MABC-2 exhibits strong test-retest reliability, with correlation coefficients ranging from 0.83 to 0.91. Eleven experts confirmed the validity of this scale with CVI of 0.93 and CVR of 0.90.

2.4. Qualitative Data Collection

Semi-structured interviews were carried out with 315 primary caregivers to investigate their daily routines and opportunities for home HBPA, as well as the perceived barriers and facilitators influencing PA levels. Additionally, the study examined parental attitudes towards skill development and structured play. Each interview, lasting between 20 to 30 minutes, was audio-recorded, transcribed verbatim, and subjected to thematic content analysis. The identified themes were then integrated with quantitative data to provide a comprehensive understanding of the relationships between HBPA and motor outcomes.

2.5. Procedures

Parents filled out the Pre-PAQ and demographic questionnaires from the comfort of their homes. Subsequently, trained examiners, who were unaware of the children's HBPA scores, conducted individual assessments of the children's FMS using the TGMD-3 and motor competence through the MABC-2 at preschool centers. Parent interviews were held either in person or through secure video calls. All collected data were systematically entered into a secure database to facilitate SEM analysis.

2.6. Statistical Analysis

The quantitative data analysis involved descriptive statistics, including means and standard deviations, to summarize demographics, HBPA, FMS, and motor competence. Pearson correlations were utilized to explore the relationships between HBPA, FMS, and motor competence. SEM was conducted using AMOS 29.0 to evaluate the proposed pathways, specifically the mediated model of HBPA influencing FMS, which in turn affects motor competence. The analysis estimated both direct and indirect standardized regression coefficients, with model fit indices indicating acceptable thresholds (CFI and TLI≥0.90; RMSEA and SRMR≤0.08). Additionally, bootstrapping with 5,000 samples was performed to generate 95% confidence intervals for the indirect effects. The qualitative data were analyzed through thematic analysis, which led to the identification of codes, subthemes, and overarching themes related to opportunities, barriers, and parental strategies concerning HBPA. These qualitative findings were then triangulated with the SEM results to provide a comprehensive interpretation of the quantitative relationships.

3. Results

3.1. Participant Demographics

A total of 315 preschool children (ages 3–5 years) and their caregivers participated. Demographics are summarized in Table 1.

Table 1. Demographic Characteristics of Participants (N=315).

Variable	n (%)	Mean ± SD
Age (years)	—	4.2 ± 0.7
Sex		
Boys	158 (50.2%)	—
Girls	157 (49.8%)	—
Socioeconomic Status		
Low	92 (29.2%)	—
Middle	158 (50.2%)	—
High	65 (20.6%)	—
Parental Education		
Primary	48 (15.2%)	—
Secondary	176 (55.9%)	—
High-School	91 (28.9%)	—

3.2. Descriptive Statistics of Key Variables

Table 2 presents mean scores, standard deviations, and ranges for HBPA, FMS (TGMD-3), and motor competence (MABC-2). Children averaged ~6–7 hours/week of HBPA, and FMS scores indicate moderate to high proficiency relative to age norms.

Table 2. Descriptive Statistics of HBPA, FMS, and Motor Competence.

Variable	Mean ± SD	Range
HBPA (minutes/week)	412.5 ± 95.3	180–650
TGMD-3 Total Score	68.3 ± 10.7	42–90
TGMD-3 Locomotor	34.1 ± 5.5	20–46
TGMD-3 Object-Control	34.2 ± 6.2	22–48
MABC-2 Standard Score	10.9 ± 2.4	5–16

3.3. Correlation Analysis

Pearson correlation analysis indicated significant associations among HBPA, FMS, and motor competence, as detailed in Table 3. The analysis revealed a moderate correlation between HBPA and both FMS (r = 0.52) and motor competence (r = 0.48). Additionally, a strong correlation was found between FMS and motor competence (r = 0.65).

Table 3. Pearson Correlations Among Key Variables (N=315).

Variable	1	2	3
1. HBPA	–		
2. TGMD-3 Total	0.52**	–	
3. MABC-2 Standard Score	0.48**	0.65**	–

Notes: p < 0.001 for all correlations.

3.4. Structural Equation Modeling Results

The proposed SEM framework examined both the direct and indirect impacts of HBPA on motor competence through FMS. The model demonstrated a good fit, with indices indicating an acceptable level of alignment with the data: χ^2/df=2.15, CFI=0.94, TLI=0.92, RMSEA=0.057 (90% CI:0.045-0.069), and SRMR=0.046. Findings revealed that HBPA exerted a moderate direct influence on FMS (β=0.53), suggesting that increased engagement in home-based activities correlates with enhanced motor skill proficiency. Furthermore, FMS was a strong predictor of motor competence (β=0.62), and the significant indirect effect of HBPA on motor competence through FMS (β=0.33) indicated a mediating relationship. Additionally, HBPA had a smaller direct effect on motor competence (β=0.18). These results imply that HBPA plays a crucial role in shaping early motor competence, both directly and indirectly through the development of FMS (Table 4 and Figure 1).

Table 4. Standardized Path Coefficients.

Path	Standardized β	p-value
HBPA → FMS	0.53	<0.001
FMS → Motor Competence	0.62	<0.001
HBPA → Motor Competence (direct)	0.18	0.004
HBPA → Motor Competence (indirect via FMS)	0.33	<0.001

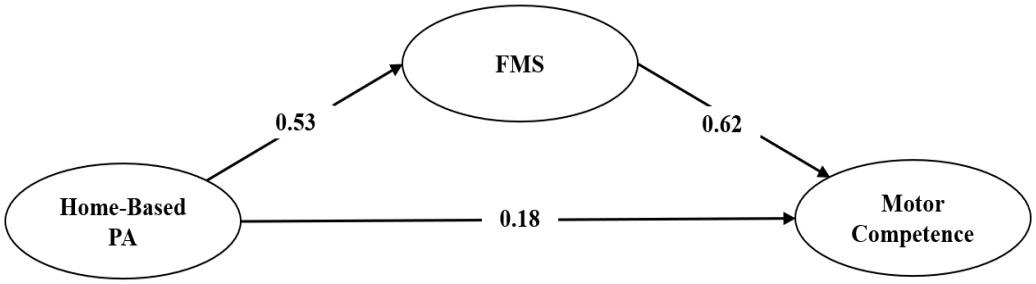

Figure 1. Research model presented by β coefficient.

3.5. Qualitative Findings

Parental interviews involving 315 participants highlighted several significant themes regarding children's PA. Most children engaged in structured play at home three to four times a week, while unstructured active play was a daily occurrence. However, barriers such as limited indoor space, safety concerns, and competing screen time often hindered activity levels. Parents played a crucial role in facilitating FMS development through active encouragement, modeling behaviors, and participating in play. Additionally, there was a strong awareness among parents about the importance of motor skills for their children's readiness for school and social interactions. The integration of qualitative and quantitative data reinforces the Social-Ecological Model (SEM) findings, indicating that the home environment and parental support are vital factors influencing HBPA and FMS, which are essential for early motor development.

4. Discussion

This study explored the impact of HBPA and FMS on the early motor development of preschool children, employing a mixed-methods approach with SEM. The findings reveal a significant relationship where HBPA enhances FMS proficiency, subsequently improving overall motor competence. Additionally, qualitative insights shed light on the importance of the home environment, parental involvement, and daily routines in facilitating motor development. The discussion situates these results within the context of existing literature, theoretical frameworks, and their practical implications.

This research demonstrates a moderate association between HBPA and both FMS and motor competence. SEM analysis indicates a direct influence of HBPA on FMS and an indirect effect on motor competence through FMS. This implies that children who participate in more physical activities at home tend to develop enhanced locomotor and object-control skills, which in turn foster overall motor competence. These findings support the stability and variability theories of motor development, which emphasize the importance of practice and diverse movement experiences for skill acquisition (25-27). While prior studies have highlighted the significance of structured PA programs in preschool settings for motor skill enhancement, our findings underscore the critical role of the home environment, especially during early

childhood when children are often outside formal educational contexts. Research utilizing accelerometry or parent-reported activity measures has shown similar correlations, indicating that active play at home complements structured programs and offers essential daily opportunities for movement learning (28-30).

A key finding of this research is the mediating effect of FMS on the relationship between HBPA and motor competence. SEM results reveal that while HBPA exerts a modest direct influence on motor competence, its indirect impact through FMS is significantly greater. This mediation underscores the importance of quality motor skill development as a crucial mechanism by which PA fosters overall motor competence. FMS are recognized as essential building blocks for more advanced motor tasks and sports involvement, as outlined in the Developmental Model of Motor Competence (2,31,32). This model posits that early proficiency in FMS is a predictor of sustained PA and motor skill advancement. Our findings lend empirical support to this framework, demonstrating that even activities conducted at home can improve FMS, which subsequently enhances broader motor competence. Notably, this highlights that mere frequency of activity is insufficient; rather, engagement focused on skill development is vital for effective motor growth.

Qualitative interviews with parents offered valuable insights into the factors influencing the quantitative relationships observed in the study. Parents indicated that children frequently engaged in active play, often supported by family participation, which correlated with higher levels of HBPA. However, they also identified obstacles such as limited space, excessive screen time, and safety concerns that hindered PA, suggesting that home environments can either facilitate or restrict motor development. Additionally, parents emphasized the significance of modeling behaviors and providing encouragement, reinforcing theoretical frameworks that highlight the importance of social interaction and parental support in early motor skill acquisition (33,34). This qualitative data enhances the findings from SEM, demonstrating that HBPA encompasses not just the frequency of movement but also the quality of engagement and support from caregivers.

This research supports previous studies that highlight the positive connections between PA, FMS, and motor competence in preschool-aged children (9,35). Unlike most existing research that concentrates on school-based interventions or structured programs, our study uniquely focuses on home-based activities and their mediating factors. The significant correlation found between FMS and motor competence aligns with earlier research, underscoring the importance of FMS as foundational elements for the development of broader motor skills (36). Furthermore, our robust sample size (N = 315) and the application of validated measurement tools (TGMD-3, MABC-2, Pre-PAQ) enhance the reliability and generalizability of our findings compared to studies with smaller samples or single-method approaches. The inclusion of qualitative insights also enriches the ecological validity of our research, shedding light on real-world factors that influence HBPA and skill development, which are frequently neglected in purely quantitative analyses.

Our research provides theoretical support for Stodden's developmental model of motor competence, which emphasizes the interactive relationship between PA and the development of motor skills. Specifically, children participating in HBPA gain valuable experience that enhances their FMS, thereby fostering ongoing engagement in PA and further motor competence. Notably, our findings expand this model by illustrating that HBPA, in addition to structured school programs, play a significant role in these developmental pathways. Additionally, these results resonate with ecological systems theory (37), underscoring the impact of microsystem-level factors - such as parental involvement, the home environment, and access to play areas - on motor development. Qualitative insights further indicate that parents can act as facilitators or obstacles to active play, influenced by their attitudes, availability, and support.

The findings of this study offer valuable insights for parents, educators, and policymakers. Families are encouraged to foster environments that promote both structured and unstructured physical activities, focusing on skill development and diverse movement experiences. Parents play a crucial role by modeling active behaviors, providing positive reinforcement, and participating in play with their children to enhance motor skills. Additionally, creating safe and accessible play spaces in homes and neighborhoods can support regular PA and motor learning. Managing screen time is also essential, as reducing sedentary behaviors allows children more opportunities for movement, which is vital for their physical and motor development. For early childhood educators, the research highlights the importance of aligning school-based programs with home activity plans to optimize the development of FMS and overall motor competence. Incorporating parent education into interventions can further reinforce the skills children practice at school within the home environment.

The study presents several strengths, including a substantial sample size of 315 participants, which significantly enhances the statistical power of the findings. The research employs validated and reliable instruments such as the TGMD-3, MABC-2, and Pre-PAQ, ensuring the accuracy of the data collected. Additionally, the mixed-methods design offers a holistic understanding by integrating both objective measures and contextual factors. The use of SEM further enriches the analysis by allowing for the exploration of direct and indirect pathways, thereby capturing potential mediation effects. However, the study is not without limitations; its cross-sectional design restricts the ability to draw causal inferences, necessitating longitudinal studies to validate developmental trajectories. The reliance on parent-reported questionnaires for HBPA may introduce biases related to recall or social desirability, although the Pre-PAQ demonstrates strong validity. Furthermore, qualitative interviews may not fully represent the diversity of home environments across various cultural and socioeconomic backgrounds. Future research should aim to incorporate longitudinal mixed-methods designs, utilize objective activity measures such as accelerometers, and investigate the interactions between home, school, and community contexts to better elucidate the mechanisms underlying early motor development.

4.1. Conclusion

This study highlights the significant role of HBPA in fostering early motor development, particularly by

improving FMS. FMS acts as a crucial link between PA and overall motor competence. The qualitative insights reveal the vital role of parental engagement, nurturing home environments, and consistent opportunities for active play. These results not only enhance existing theoretical frameworks of motor competence but also stress the ecological factors influencing early motor development. Furthermore, they offer practical recommendations for families and educators, suggesting that promoting diverse, skill-oriented physical activities at home, in conjunction with school initiatives, can effectively support motor skill advancement in preschoolers, ultimately establishing a foundation for lifelong PA and 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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