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The Influence of Physical Activity, Play Facilities, and Teacher Roles on Early Childhood Development

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Abstract

This study investigated the combined effects of physical activity, play facilities, and teacher roles on gross motor skill development, kinesthetic intelligence, and learning readiness in 4-6-year-old children enrolled in early childhood education institutions in South Sulawesi. The study used a cross-sectional quantitative design and employed Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the complex relationships between these variables. The study utilized instruments such as the Physical Activity Questionnaire for Children (PAQ-C), Test of Gross Motor Development (TGMD-III), and Bracken School Readiness Assessment (BSRA-4) to collect data. The results revealed that physical activity significantly influenced gross motor skills, kinesthetic intelligence, and learning readiness. Play facilities positively contributed to motor development and learning readiness, while teacher roles significantly improved gross motor skills. Furthermore, gross motor skills and kinesthetic intelligence were found to mediate the relationship between physical activity, play facilities, and readiness to learn. This study contributes to the growing literature on early childhood education by providing empirical evidence supporting an integrated approach to education that emphasizes the roles of physical activity, play, and teacher roles in child development. The findings suggest that education policies should prioritize active learning environments that foster both physical and cognitive development. Further research should focus on longitudinal studies to explore the long-term efficacy of this integrated approach. These findings also emphasize the importance of incorporating active learning environments that support children's physical and cognitive development.

Keywords: Gross Motor Skill, Kinesthetic Intelligence, Learning Readiness, Physical Activity

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Abstrak

Penelitian ini menyelidiki efek gabungan dari aktivitas fisik, fasilitas bermain, dan peran guru terhadap perkembangan keterampilan motorik kasar, kecerdasan kinestetik, dan kesiapan belajar pada anak usia 4-6 tahun yang terdaftar di lembaga pendidikan anak usia dini di Sulawesi Selatan. Penelitian ini menggunakan desain kuantitatif cross-sectional dan menggunakan Partial Least Squares Structural Equation Modeling (PLS-SEM) untuk menganalisis hubungan yang kompleks di antara variabel-variabel tersebut. Penelitian ini menggunakan instrumen seperti Kuesioner Physical Activity Questionnaire for Children (PAQ-C), Test of Gross Motor Development (TGMD-III), dan Bracken School Readiness Assessment (BSRA-4) untuk mengumpulkan data. Hasil penelitian menunjukkan bahwa aktivitas fisik secara signifikan mempengaruhi keterampilan motorik kasar, kecerdasan kinestetik, dan kesiapan belajar. Fasilitas bermain berkontribusi positif terhadap perkembangan motorik dan kesiapan belajar, sementara peran guru memiliki pengaruh terbesar dalam meningkatkan keterampilan motorik kasar. Selain itu, keterampilan motorik kasar dan kecerdasan kinestetik memediasi hubungan antara aktivitas fisik, fasilitas bermain, dan kesiapan belajar. Penelitian ini berkontribusi pada literatur yang berkembang tentang pendidikan anak usia dini dengan memberikan bukti empiris yang mendukung pendekatan terpadu terhadap pendidikan yang menekankan peran aktivitas fisik, bermain, dan peran guru dalam perkembangan anak. Temuan ini menunjukkan bahwa kebijakan pendidikan harus memprioritaskan lingkungan belajar aktif yang mendorong perkembangan fisik dan kognitif. Penelitian lebih lanjut harus berfokus pada studi longitudinal untuk mengeksplorasi keampuhan jangka panjang dari pendekatan terpadu ini. Temuan ini juga menekankan pentingnya menggabungkan lingkungan belajar aktif yang mendukung perkembangan fisik dan kognitif anak.

Kata Kunci: Keterampilan Motorik Kasar, Kecerdasan Kinestetik, Kesiapan Belajar, Aktivitas Fisik

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INTRODUCTION

Early childhood development is an important period in forming the basis of skills and abilities that will affect their lives in the future. Some of the aspects that support children's development are physical activity, adequate play facilities, and the role of effective teachers, which greatly influence children's growth and development, especially in gross motor aspects, kinesthetic intelligence, and readiness to learn (Bao et al., 2022; Bassul et al., 2021; Fillol et al., 2024; Graber et al., 2024; Mears et al., 2020; Wang et al., 2021; Wang et al., 2024). Research on the factors that influence this development shows that proper physical stimulation can improve children's motor skills, which in turn supports their ability to learn and interact with the environment. In addition, kinesthetic intelligence as a form of multiple intelligences plays a role in children's readiness for further learning (Califf, 2020; Hatira & Sarac, 2024; Yöntem et al., 2021).

Several recent studies have investigated the relationship between physical activity and children's gross motor skills. Some studies have shown that well-designed physical activity can improve gross motor skills in young children (Aoyama et al., 2023; Burns et al., 2022; Dapp et al., 2021; Shi et al., 2024; Voznesenskiy et al., 2016; Zhao et al., 2024). Adequate play facilities are also proven to accelerate gross motor skills and stimulate children's kinesthetic intelligence (Cheung & Zhang, 2020; Khalilollahi et al., 2024). Meanwhile, the role of teachers in supporting children's gross motor skills and kinesthetic intelligence demonstrates that trained teachers can create an environment that supports learning through direct interaction with children (Khalfaoui et al., 2021; Lapėnienė & Neverauskienė, 2023).

Nevertheless, while several studies have addressed the influence of these factors, there is limited research examining the combined influence of physical activity, play facilities and teacher roles on gross motor skills, kinesthetic intelligence, and learning readiness of 4-6-year-old children. Some studies suggest the importance of a more holistic approach in looking at the interrelationship of these factors (Condello et al., 2021; Jeon & Jun, 2021; Koen et al., 2021; Salminen et al., 2021; Wu et al., 2024), but few have explored the specific interactions between the three in the context of early childhood education.

Although several studies emphasize the importance of improving each factor separately, a more integrated approach that considers the interplay between physical activity, play facilities, and teacher role is necessary to understand their collective impact on early childhood development. Many studies primarily focus on the direct effects of physical activity on gross motor skills, yet they overlook how other factors, such as the availability of play facilities and the active role of teachers, contribute to the overall developmental process. Combined, these factors may have synergistic effects, enhancing motor development and contributing to cognitive and emotional growth.

Kinesthetic intelligence, integral to physical activity, plays a pivotal role in children's learning readiness. However, there is limited research examining the specific relationship between kinesthetic intelligence and the broader concept of learning readiness, which encompasses not only cognitive development but also emotional and social preparedness for school (Gunawan et al., 2023; Hariono et al., 2024; Hidayat & Hermawan, 2024; Riyadi et al., 2023). This gap in the literature underscores the need for a more nuanced understanding of how kinesthetic intelligence interacts with other factors, such as teacher roles and play environments, to influence children's ability to succeed academically and socially.

Further, physical activity, play facilities, and teacher roles are interconnected factors that jointly influence children's developmental milestones. Physical activity enhances motor skills, while play facilities stimulate both motor development and kinesthetic intelligence. Conversely, teachers provide the necessary guidance and emotional support that help children translate physical activity and play into cognitive and social skills. Together, these elements create a holistic learning environment that supports children's academic readiness, emotional well-being, and social integration (Der Rowe, 2022; Johnstone et al., 2018; Webster et al., 2015).

Learning readiness, therefore, is not solely dependent on cognitive factors but is also deeply influenced by physical and emotional aspects. By focusing on the interaction between physical activity, play facilities, and teacher roles, this study aims to shed light on how these three factors collectively contribute to children's readiness to engage in formal schooling and their overall development (Ertem et al., 2018).

Hence, this study aims to investigate the effect of physical activity, play facilities, and teacher roles on gross motor skills, kinesthetic intelligence, and learning readiness of 4-6-year-old children. The hypotheses of this study are:

H_1: Physical activity (X_1) has a positive effect on gross motor skills (Y_1), kinesthetic intelligence (Y_2), and learning readiness (Y_3)
H_2: Play facilities (X_2) have a positive effect on gross motor skills (Y_1), kinesthetic intelligence (Y_2), and learning readiness (Y_3)
H_3: The role of the teacher (X_3) has a positive effect on gross motor skills (Y_1), kinesthetic intelligence (Y_2), and learning readiness (Y_3)
H_4: Kinesthetic intelligence (Y_2) has a positive effect on learning readiness (Y_3)

The novelty of this research lies in its synthesis of existing studies, combining physical activity, play facilities, and teacher roles into one structural model. By using SmartPLS analysis, this study aims to provide a deeper understanding of how these factors interact and influence early childhood development, addressing a gap in the literature. This research aims to fill the gap in the literature by integrating these factors into a cohesive framework, offering insights into their combined influence on children's developmental outcomes.

The scope of this study was limited to children aged 4-6 years enrolled in various schools and kindergartens in South Sulawesi. This study not only focuses on individual factors such as physical activity but also considers the role of teachers and educational environment in supporting children's gross motor skills, kinesthetic intelligence and learning readiness.

METHODS

Research Design

This study used a cross-sectional quantitative design to examine the influence of physical activity, play facilities, and teacher roles on gross motor skills, kinesthetic intelligence, and school readiness in children aged 4-6. The cross-sectional approach is appropriate for collecting data at one point while simultaneously assessing several variables. Structural Equation Modeling (SEM) using partial least squares (PLS-SEM) in SmartPLS 4.0 was chosen for its ability to analyze complex relationships among latent constructs with small to medium sample sizes. PLS-SEM is also robust to non-normal data distributions, making it suitable for educational research where strict parametric assumptions may not hold (Sarstedt et al., 2019).

Research Subject

The population of this study consisted of early childhood (4-6 years old) enrolled in early childhood education (ECE) or kindergarten institutions in the South Sulawesi region. The sampling technique was cluster random sampling to ensure sample representativeness by considering sociodemographic variations and characteristics of educational institutions (Etikan & Bala, 2017). Inclusion criteria included: (1) children in the age range of 48-72 months without a history of diagnosed motor or neurological developmental disorders (verified through parent and teacher reports), (2) active participation in the ECE program for at least three months prior to the study, and (3) obtained informed consent from parents/guardians. This age group was selected based on the critical period of gross motor development and pre-academic maturity, where neural plasticity reaches its peak for basic kinesthetic and cognitive abilities (Fisalma et al., 2023; Martins et al., 2023). Sample size determination (N=150-200) refers to the 10-times rule in PLS-SEM (Hair et al., 2017), considering the maximum number of indicators in the model, while gender and age composition were proportionally balanced (50% male, 50% female; 33% per age group 4, 5, and 6 years) to control for potential confounding variables.

Research Instruments

The research instrument was comprehensively designed by integrating psychometric and direct observation approaches to ensure the latent variables' construct validity and measurement reliability. For the exogenous variables, physical activity was measured using an internationally validated adaptation of the Physical Activity Questionnaire for Children (PAQ-C) (Kowalski et al., 1997). It includes the frequency, duration, and intensity of children's physical activity in a naturalistic context. Play facilities were assessed through the modified Early Childhood Environment Rating Scale (ECERS-3) (Early et al., 2018), which measures aspects of the physical quality of the play environment, including safety, variety of equipment, and accessibility. The role of the teacher was evaluated using an instrument based on the Classroom Assessment Scoring System (CLASS) (Pianta et al., 2012), which measures the dimensions of emotional support and teacher instructional scaffolding during physical activity. For the endogenous variable, gross motor development was measured objectively through the Test of Gross Motor Development-III (TGMD-III) (Rizkyanto et al., 2024). In comparison, kinesthetic intelligence was assessed through a structured observation rubric based on multiple intelligences theory (Gardner, 2011), which focuses on coordination, rhythm and expression of movement. Learning readiness was measured using the Bracken School Readiness Assessment (BSRA-4) (Bracken, 2023), comprehensively assessing cognitive, language and pre-academic skills. Each instrument has gone through a process of cultural adaptation and field testing to ensure suitability to the local context and meet the criteria of content validity (expert judgment) and reliability (inter-rater reliability > 0.80), to capture the research construct in a multidimensional and cross-method manner.

Table 1. Research Instruments and Measurement Methods

Construct/ Variable	Instrument/ Method	Description
Physical Activity (X_1)	Adapted PAQ-C (Parent/ Teacher Report)	Measures frequency, duration, and intensity of physical play (5-point Likert scale).
Play Facilities (X_2)	Modified ECERS-3 (Observation Checklist)	Assesses availability, safety, and accessibility of play equipment (e.g., swings, climbing structures).
Teacher's Role (X_3)	CLASS Toddler (Teacher Survey)	Evaluates instructional support and emotional engagement during physical activities.
Gross Motor Skills (Y_1)	TGMD-III (Direct Observation)	Tests locomotor (run, hop) and object-control (throw, catch) skills.
Kinesthetic Intelligence (Y_2)	Gardner-Based Rubric (Observation)	Scores rhythmic coordination, balance, and expressive movement imitation.
School Readiness (Y_3)	BSRA-4 (Standardized Test)	Measures cognitive, linguistic, and socio-emotional readiness for formal schooling.

Data Collection Technique

Data collection techniques in this study were designed by methodological triangulation to ensure ecological validity and reliability of results through the integration of three main approaches. First, standardized questionnaires (PAQ-C, ECERS-3, and CLASS Toddler) were completed by teachers and parents using a 5-point Likert scale, enabling the measurement of perceptions of physical activity, play facilities, and teachers' roles while minimizing bias by adapting internationally validated instruments. Second, structured observations by trained researchers (inter-rater reliability $\kappa > 0.80$) using the TGMD-III protocol and Gardner's theory-based kinesthetic intelligence rubric recorded children's motor and kinesthetic performance in natural settings during structured and spontaneous play activities. Third, the individually administered BSRA-4 standardized test measured readiness to learn with standardized procedures to ensure objectivity. The data collection process was conducted under controlled conditions (e.g. consistent observation time, distraction-free environment) with attention to ethical principles of pediatric research, including informed consent and adaptation of physical tasks for children with special needs. This combination of subjective-objective methods not only fulfills the principle of multimethod assessment but also mitigates the inherent limitations of each technique, such as response bias in questionnaires or context variability in observations.

Data Analysis Technique

Data analysis in this study utilized Structural Equation Modeling (SEM) based on Partial Least Squares (PLS-SEM) with SmartPLS 4.0 to examine the causal relationships between physical activity, play facilities, and teacher roles (exogenous variables) on gross motor development, kinesthetic intelligence, and readiness to learn (endogenous variables). The first stage involved evaluating the measurement model (outer model) to ensure construct validity and reliability, where convergent validity was confirmed through Average Variance Extracted (AVE > 0.50) and factor loading (> 0.70), while reliability was tested with Composite Reliability (CR > 0.70) and Cronbach's Alpha ($\alpha > 0.60$), and discriminant validity through Fornell-Larcker criteria and Heterotrait-Monotrait Ratio (HTMT < 0.85).

The second stage tested the structural model (inner model) by bootstrapping (5,000 resampling) to evaluate path significance (β, $p < 0.05$), predictive power (R^2), and predictive relevance ($Q^2 > 0$). Mediation was analyzed through indirect effects and Variance Accounted For (VAF) to determine whether gross motor and kinesthetic intelligence act as mediators. In addition, goodness-of-fit tests (SRMR < 0.08; NFI > 0.90) ensured overall model fit. This approach allows the analysis of complex multivariate relationships while overcoming the limitations of non-normal data distributions and relatively small sample sizes, thus providing robust and interpretable results for pedagogical decision-making (Hair et al., 2017; Sarstedt et al., 2019).

RESULTS AND DISCUSSION

Descriptive Statistics

Descriptive statistical analysis was carried out to provide an overview of the data distribution characteristics of all indicators used in this study. Based on data processing results on 248 respondents, it can be explained that overall, all indicators showed a high value trend with an average (mean) ranging from 3.266 to 3.387 from a maximum scale of 4. The median value, generally 3.000 (for most indicators), indicates consistency with the mean value, although some indicators, such as GMS1, KI2, KI4, and PA2, had a median of 4.000, denoting the tendency of respondents to choose the highest value.

The relatively uniform standard deviation of around 0.763 to 0.790 suggests that the data were not too dispersed from their mean value. However, further analysis of the skewness measures, which were all negative (between -1.597 and -1.369), implies that the tail of the distribution extended to the left, meaning that most respondents tended to give ratings in the high category. This is reinforced by the positive excess kurtosis values (2.434 to 2.662), indicating a more leptokurtic distribution than the normal distribution. With all indicators having a value range of 1-4, no missing values (the number of observations is consistent, 248), and relatively uniform distribution characteristics, it can be concluded that this research data is suitable for further analysis. These results provide a strong basis for conducting further inferential statistical tests, while illustrating that respondents generally gave a positive assessment of all aspects measured in this study.

Measurement Model (Outer Model)

Convergent Validity

Based on the results of the outer loading analysis that has been carried out, it can be stated that all research indicators exhibited very satisfactory results in representing the latent variables measured. The outer loading values were above the 0.7 criterion limit recommended in the literature, and even most reached values above 0.8. This indicates that each indicator has a strong relationship with the construct to be measured. Based on the table above, all indicators on each latent variable meet the validity criteria with an outer loading value above 0.7. For example:

- Physical Activity Indicators (PA1-PA4) had loading values between 0.826-0.844.
- Play Facilities Indicators (PF1-PF4) ranged from 0.834-0.842.
- Teacher Role Indicators (TR1-TR4) ranged from 0.833 to 0.851.
- Gross Motor Skills Indicators (GMS1-GMS4) reached 0.829-0.851.
- Kinesthetic Intelligence Indicators (KI1-KI4) showed the highest values (0.843-0.857), and
- Learning Readiness Indicators (LR1-LR4) were consistent in the range of 0.837-0.850.

Table 2. Outer Loadings

Indicators	X_1	X_2	X_3	Y_1	Y_2	Y_3
PA1	0.826					
PA2	0.844					
PA3	0.839					
PA4	0.839					
PF1		0.838				
PF2		0.834				
PF3		0.842				
PF4		0.84				
TR1			0.848			
TR2			0.836			
TR3			0.833			
TR4			0.851			
GMS1				0.839		
GMS2				0.829		
GMS3				0.842		
GMS4				0.851		
KI1					0.853	
KI2					0.856	
KI3					0.857	
KI4					0.843	
LR1						0.850
LR2						0.847
LR3						0.837
LR4						0.850

This finding proves that this study's measurement model has met strict convergent validity standards. The high value of outer loading on all indicators implies that no single indicator needs to be eliminated from the model. These results not only strengthen the validity of the research instruments but also provide a solid foundation for continuing the analysis to the next stage, including reliability and discriminant validity tests. From a practical perspective, this finding assures that the research instruments have captured the essence of each latent variable studied. This measurement reliability is an important prerequisite to ensure that the research findings and implications generated later stand on a strong methodological basis and can be scientifically accounted for. Thus, this research has fulfilled the initial measurement validation stage with satisfactory results.

Table 3. Construct Reliability and Validity

Variables	Cronbach's Alpha	Average Variance Extracted (AVE)
X_1	0.858	0.701
X_2	0.859	0.703
X_3	0.863	0.709
Y_1	0.861	0.706
Y_2	0.875	0.727
Y_3	0.868	0.716

Based on the results of Construct Reliability and Validity testing, all variables in this study met the required reliability and validity criteria. Cronbach's Alpha and Composite Reliability values of all constructs exceeded 0.8. indicating excellent internal consistency. In addition, the AVE value above 0.7 indicates the construct could explain more than 70% of the indicator variance, so convergent validity was met. Thus, it can be concluded that the measurement of constructs in this study is reliable and valid.

Discriminant Validity

Discriminant validity analysis using the Fornell-Larcker Criterion confirms that each construct in this study is unique and can be empirically distinguished from other constructs. This criterion is met if the square root of the AVE (diagonal value) is greater than the correlation between constructs (off-diagonal value) in the same row and column. Based on the discriminant validity analysis results using the Fornell-Larcker Criterion, this study revealed that all tested constructs met the discriminant validity criteria well. The square root value of AVE (Average Variance Extracted) on the main diagonal for each construct was higher than the correlation value between the corresponding constructs, as shown in the correlation matrix.

Table 4. Discriminant Validity (Fornell-Larcker Criterion)

	X_1	X_2	X_3	Y_1	Y_2	Y_3
X_1	0.837					
X_2	0.878	0.839				
X_3	0.883	0.862	0.842			
Y_1	0.870	0.862	0.872	0.840		
Y_2	0.871	0.868	0.881	0.876	0.852	
Y_3	0.862	0.868	0.858	0.874	0.849	0.846

This finding convincingly shows that each construct in this study has unique characteristics and can be empirically distinguished from other constructs. The absence of significant overlapping indications between constructs strengthens the measurement validity in this study. The results of this analysis complement previous findings regarding convergent validity and reliability, thus providing a strong basis for continuing structural model analysis and hypothesis testing.

This consistency in meeting the Fornell-Larcker criteria indicates no serious multicollinearity problem in the research model. Thus, it can be concluded that this research instrument is not only reliable and has good convergent validity but also has met strict discriminant validity standards.

Cross loadings analysis (as shown in Table 5) was then carried out to test discriminant validity by ensuring that each indicator had a stronger correlation with the construct that should be measured than with other constructs. Based on the test results, all indicators in this study met the criteria for discriminant validity, where the loading value of each indicator on the intended construct was higher than its loading value on other constructs.

Table 5. Cross Loadings

Indicators	X_1	X_2	X_3	Y_1	Y_2	Y_3
PA1	0.826	0.740	0.750	0.738	0.706	0.725
PA2	0.844	0.734	0.745	0.723	0.741	0.730
PA3	0.839	0.732	0.723	0.731	0.750	0.698
PA4	0.839	0.735	0.739	0.721	0.721	0.735
PF1	0.746	0.838	0.716	0.717	0.746	0.715
PF2	0.729	0.834	0.732	0.737	0.709	0.749
PF3	0.739	0.842	0.716	0.710	0.746	0.731
PF4	0.731	0.840	0.727	0.729	0.712	0.717
TR1	0.742	0.724	0.848	0.746	0.748	0.729
TR2	0.749	0.699	0.836	0.730	0.725	0.730
TR3	0.762	0.749	0.833	0.726	0.739	0.718
TR4	0.722	0.730	0.851	0.734	0.755	0.713
GMS1	0.717	0.739	0.722	0.839	0.742	0.736
GMS2	0.736	0.712	0.743	0.829	0.703	0.727
GMS3	0.742	0.741	0.732	0.842	0.756	0.742
GMS4	0.728	0.706	0.734	0.851	0.741	0.732
KI1	0.735	0.751	0.746	0.742	0.853	0.705
KI2	0.745	0.741	0.757	0.743	0.856	0.722
KI3	0.726	0.720	0.747	0.760	0.857	0.721
KI4	0.764	0.748	0.754	0.741	0.843	0.744
LR1	0.737	0.734	0.740	0.733	0.724	0.850
LR2	0.727	0.726	0.724	0.756	0.719	0.847
LR3	0.724	0.754	0.717	0.726	0.703	0.837
LR4	0.731	0.724	0.724	0.743	0.726	0.850

In the Physical Activity construct, the four indicators (PA1-PA4) showed dominant loading values on their own constructs (0.826-0.844) compared to other constructs (0.698-0.750). A similar pattern was seen in the Play Facilities indicator (PF1-PF4), having the highest loading on its own construct (0.834-0.842), as well as the Teacher's Role indicator

(TR1-TR4) with a loading of 0.833-0.851 on its own construct.

Consistent results are also exhibited by the Gross Motor Skills (GMS1-GMS4) indicator with a loading of 0.829-0.851. Kinesthetic Intelligence (KI1-KI4) had a loading of 0.843-0.857, and Learning Readiness (LR1-LR4) had a loading of 0.837-0.850 on their respective constructs. None of the indicators has higher loading values on other constructs than on the constructs they are supposed to measure.

This finding strengthens the discriminant validity of the research model, indicating that each indicator exclusively measured its intended construct and did not overlap with other constructs. The results of these cross-loading analyses complement the evidence of construct validity supported by previous Fornell-Larcker Criterion results, thus providing a strong basis for further hypothesis testing.

Structural Model (Inner Model)

Path Coefficients

The following are the results of hypothesis testing using path analysis with the PLS-SEM method. Table 5 presents the Original Sample (O) value, which represents the strength of the relationship between variables, Standard Deviation (STDEV) as a measure of variability, T-statistics and p-values to determine statistical significance. The test criteria are based on T-statistic values > 1.96 (at 5% significance level) and p-values < 0.05. The analysis results generally show that all hypotheses (H_1 to H_{11}) proved significant, with p-values below 0.05 and T-statistics exceeding the critical limit. Some key findings that stand out include:

1. The effect of Physical Activity (PA) on Gross Motor Skills (GMS) (H_1: $\beta = 0.294$; $p < 0.001$), Kinesthetic Intelligence (KI) (H_2: $\beta = 0.182$; $p = 0.003$), and Learning Readiness (LR) (H_3: $\beta = 0.235$; $p < 0.001$) was significant, with the greatest strength of effect on GMS.
2. The role of Play Facilities (PF) was also significant on on Gross Motor Skills (GMS) (H_1: $\beta = 0.298$; $p < 0.001$), Kinesthetic Intelligence (KI) (H_2: $\beta = 0.226$; $p = 0.003$), and especially on Learning Readiness (H_6: $\beta = 0.327$; $p < 0.001$), suggesting that play facilities contribute importantly in improving learning readiness.
3. Teacher's Role (TR) had the strongest influence compared to other variables on Gross Motor Skills (H_7: $\beta = 0.355$; $p < 0.001$), indicating that the teacher's role is crucial in the development of children's gross motor skills.
4. The relationship between Gross Motor Skills (GMS) and Kinesthetic Intelligence (KI) (H_{10}: $\beta = 0.269$; $p < 0.001$) as well as between KI and Learning Readiness (LR) (H_{11}: $\beta = 0.157$; $p = 0.018$) was also significant, although with smaller effects than the other pathways.

These findings provide empirical support for the proposed theoretical model and reinforce the importance of physical activity, play facilities and the role of teachers in supporting children's motor development, kinesthetic intelligence and readiness to learn. Further analysis will address the implications of these results in practical and theoretical contexts.

Table 6. Path Coefficients

Path (Hypothesis)	O	STDEV	T-Statistics	P-Values
H_1: PA → GMS	0.294	0.066	4.433	0.000
H_2: PA → KI	0.182	0.061	2.985	0.003
H_3: PA → LR	0.235	0.067	3.532	0.000
H_4: PF → GMS	0.298	0.063	4.754	0.000
H_5: PF → KI	0.226	0.060	3.750	0.000
H_6: PF → LR	0.327	0.068	4.789	0.000
H_7: TR → GMS	0.355	0.057	6,213	0.000
H_8: TR → KI	0.291	0.062	4.706	0.000
H_9: TR → LR	0.231	0.067	3.428	0.001
H_{10}: GMS → KI	0.269	0.055	4.917	0.000
H_{11}: KI → LR	0.157	0.066	2.383	0.018

Discussion

The statistical analysis results of the data from 248 respondents exhibit scores that tend to be high on all indicators, with mean values ranging from 3.266 to 3.387 on a scale of 1 to 4. The median value for most indicators is 3.000, although indicators are as follows: GMS1, KI2, KI4, and PA2 showed a higher median value of 4.000, indicating a tendency for respondents to choose the highest rating. The standard deviation for this data is relatively consistent, ranging from 0.763 to 0.790, indicating that the data is not too spread out from its mean value. In addition, the skewness of the data is all negative, ranging from -1.597 to -1.369, denoting a left-skewed distribution, meaning that most respondents tend to give higher ratings. The positive excess kurtosis indicates the data's sharper (leptokurtic) distribution than a normal distribution. These characteristics support the reliability and validity of the data for further statistical analysis, providing a solid foundation for subsequent inferential testing.

Analysis of the measurement model (outer model) confirmed that all indicators in this study had adequate loading values, exceeding the recommended limit of 0.7. Indicators for Physical Activity, Play Facilities, Teachers' Role, Gross Motor Skills, Kinesthetic Intelligence, and Learning Readiness showed high loading values, ranging from 0.826 to 0.857, reinforcing the measurement model's robustness. Construct reliability, measured through Cronbach's Alpha, rho_A, and Composite Reliability, exceeded the 0.8 threshold, indicating excellent internal consistency. In addition, the Average Variance Extracted (AVE) for all constructs was above 0.7, confirming the convergent validity of the measures.

This study's results align with existing literature emphasizing the significant impact of physical activity, play facilities and teacher roles on children's developmental outcomes. Previous research has shown that structured physical activity is essential for improving young children's gross motor skills and kinesthetic intelligence. This study extends these findings by showing that physical activity directly affects gross motor skills, kinesthetic intelligence, and readiness to learn, as evidenced by the significant path coefficients in the model. A simplified version of the structural model is depicted in Figure 1, while the complete version, including all indicators and path coefficients, is provided in Appendix (Figure 2) for detailed reference.. This finding is consistent with previous research highlighting the bidirectional relationship between physical activity and cognitive readiness to learn (Aoyama et al., 2023; Burns et al., 2022; Dapp et al., 2021; Shi et al., 2024; Voznesenskiy et al., 2016; Zhao et al., 2024) (see Figure 1).

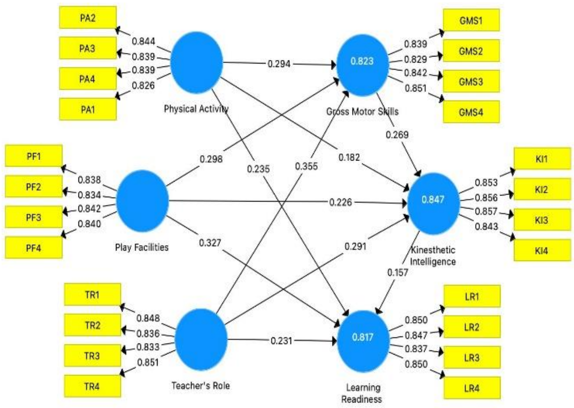

Figure 1. SEM Analysis Results

Furthermore, the positive influence of play facilities on children's development has been widely discussed in the literature. Research shows that resource-rich play environments support the development of motor skills and cognitive abilities. The findings in this study state that play facilities contribute significantly to gross motor skills and readiness to learn, corroborating these findings. Interestingly, the role of the teacher was found to be the most influential factor in gross motor skill development, which supports previous research on the importance of teacher-led interactions in early childhood education.

The current findings corroborate Gardner's theory of multiple intelligences, particularly his emphasis on kinesthetic intelligence, which highlights the role of movement in the learning process. This study advances Gardner's framework by integrating kinesthetic intelligence with physical activity and play facilities, offering a more comprehensive understanding of how movement supports cognitive and motor skill development in early childhood education.

The significant pathways between gross motor skills and kinesthetic intelligence, as well as the relationship between kinesthetic intelligence and learning readiness, enhance our understanding of how physical engagement influences cognitive development (Fisher et al., 2011; Zeng et al., 2017). This finding extends current theories by demonstrating the interconnectedness of physical and cognitive readiness in early childhood education, emphasizing the need for holistic approaches that integrate motor development with learning readiness. These findings are consistent with prior research that links physical activity to cognitive and academic readiness in young children. However, by integrating play facilities and teacher roles into the model, this study provides a more nuanced understanding of how these factors collectively impact children's developmental outcomes, positioning this model as a significant advancement in early childhood education frameworks. Furthermore, the significant role of teacher interaction in promoting gross motor skills strengthens Vygotsky's sociocultural theory, which posits that cognitive development is influenced by social interaction and guided learning (Karki & Karki, 2024; Panhwar et al., 2016).

This study contributes to Vygotsky's framework by incorporating the role of physical activity and play facilities, showing how teachers can support children's cognitive growth through both social interaction and physical engagement. In terms of practical implications, this study provides educators and policymakers with a framework for fostering environments that prioritize physical activity, play facilities, and teacher roles. Educators should consider creating learning environments that promote physical engagement, such as structured play activities, and incorporating kinesthetic learning techniques to support cognitive development. Policymakers should advocate for including physical activity and active learning spaces in early childhood curricula and school designs to enhance motor and cognitive skills in young children.

It also contributes to the theoretical understanding of the relationship between motor skills, kinesthetic intelligence and learning readiness. By examining these constructs within the framework of a structural equation model, this study provides empirical evidence supporting a theoretical model of child development that emphasizes the interrelationship between physical, cognitive and emotional growth. The holistic approach in early childhood education discussed in the literature is now validated by the empirical evidence found in this study.

As stated above, the current findings are consistent with Gardner's theory of multiple intelligences, particularly his view of kinesthetic intelligence, which emphasizes the importance of movement in the learning process. The significant pathways between gross motor skills and kinesthetic intelligence, as well as between kinesthetic intelligence and learning readiness, support the notion that physical engagement can enhance cognitive development. This aligns with previous research linking physical activity to early childhood cognitive and academic readiness. In addition, the important role of teacher interaction in supporting gross motor skills corroborates Vygotsky's sociocultural theory, which states that cognitive development is strongly influenced by social interaction and guided learning.

The research question of how physical activity, play facilities, and teacher roles contribute to children's gross motor skills, kinesthetic intelligence and readiness to learn has been answered through this study's findings. The study confirmed that all three factors significantly affect these developmental outcomes. The results also show that gross motor skills and kinesthetic intelligence mediate in the pathways of influence between physical activity, play facilities and learning readiness, illustrating the complex interactions that shape early childhood development. The findings contribute to the growing literature on early childhood education by offering empirical evidence for a model that combines individual and environmental factors.

The results further highlight the critical role of supportive physical and social environments in optimizing children's development, addressing a gap in the literature where these factors are often considered in isolation. However, the study's cross-sectional design and limited sample diversity constrain the strength of the conclusions and the broader applicability of the findings. Future research should focus on longitudinal studies to examine the long-term effects of physical activity, play facilities, and teacher roles on children's development. Intervention studies would also provide valuable insights into how these factors can be integrated into real-world educational settings and their lasting impact on children's cognitive, motor, and social skills over time. These future studies would help validate the proposed model's effectiveness and contribute to more generalizable conclusions.

CONCLUSION

This study has successfully explored the impact of physical activity, play facilities and teacher roles on gross motor skill development, kinesthetic intelligence and school readiness in 4-6-year-old children. The findings emphasize the significant role of these three factors in supporting the development of key competencies required for school readiness and overall cognitive and physical growth.

The results uncover that physical activity, integrated with adequate play facilities and supported by teacher roles, contributes positively to gross motor skill development and improved kinesthetic intelligence. These factors, in turn, significantly affect children's readiness to learn. The findings further emphasize the importance of creating an environment that supports children's holistic development, integrating their growth's physical, cognitive and emotional aspects.

While this study provides strong empirical evidence of the linkages between physical activity, play environments and teacher roles, it also highlights the need for a comprehensive approach in early childhood education. The research suggests that educators and policymakers focus on developing environments that promote active engagement through structured physical activity, well-designed play areas and teacher-led guidance, as these elements together support the achievement of developmental milestones necessary for children to thrive academically and socially.

Nonetheless, some limitations need to be noted. While effective in providing an overview of the relationship between the variables, the study's cross-sectional design does not allow for the establishment of long-term causal relationships. Future research may consider longitudinal studies to better understand these factors' long-term impact on child development. In addition, expanding the sample size and including more diverse educational settings may improve the generalizability of these findings.

In conclusion, this research significantly contributes to early childhood education by providing valuable insights into how physical, environmental and social factors interact to support children's development. It promotes an integrated approach that prioritizes the development of motor skills, kinesthetic intelligence and readiness to learn, which provides a foundation for future research and educational practice in the field of early childhood education.

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APPENDIX

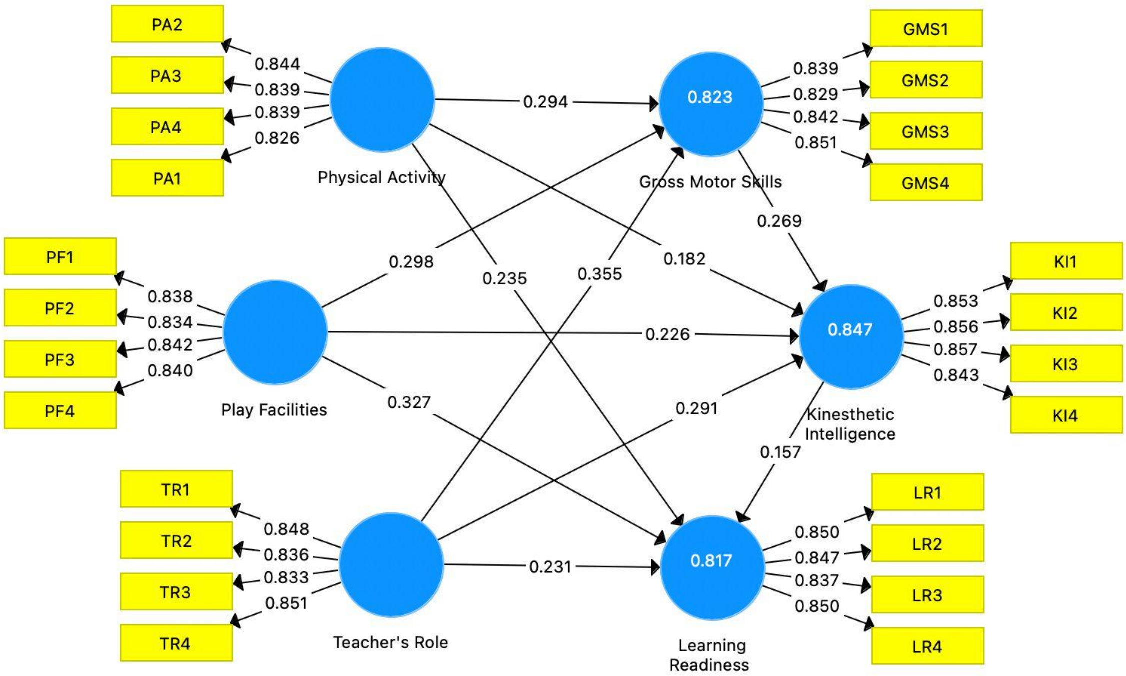

Figure 2. Full Structural Equation Model (Full Resolution)