International Journal of Sociologies and Anthropologies Science Reviews
Volume 5 Issue 4: July-August 2025: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index

Construction of Gross Motor Development Test and Evaluation for Kindergarten Students of Guangzhou, China

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Received 09/02/2025 Revised 18/02/2025 Accepted 18/03/2025

Abstract

Background and Aims: Kindergarten student development is crucial as it lays the foundation for lifelong learning and social skills. Proper nurturing in cognitive, emotional, and physical aspects helps children adapt, grow, and succeed in future academic and personal endeavors. This research aims to develop and validate a comprehensive evaluation scale that accurately assesses kindergarten students' gross motor skills, including stability, locomotion, and object control.

Materials and Methods: A mixed-methods approach was employed, integrating both quantitative and qualitative research methodologies. The Delphi method and expert focus groups were used to refine evaluation indicators. The study population comprised 21 experts in early childhood education, including 7 university administrators, 7 professionals, and 7 practical instructors, each with over 10 years of experience. A purposive sample of 19 experts participated in the final expert validation process. For field testing, a random sample of 342 kindergarten students from eight kindergartens across 11 districts in Guangzhou City was assessed. The quantitative analysis was conducted using SPSS 23.0, SUPSSAU, and Excel, ensuring statistical reliability and validity. The qualitative analysis included a thematic analysis of expert interviews and focus group discussions, providing contextual insights into the evaluation framework's applicability.

Results: The findings led to the development of a preliminary evaluation scale for assessing kindergarten students' basic motor skills. The scale comprises three dimensions and 15 test actions, with systematically assigned index weights. It demonstrates appropriate levels of difficulty, strong discriminatory power, and robust reliability and validity. A comprehensive evaluation reference standard was established, revealing no significant gender differences. Additionally, the scale enables both situational and individual diagnostics, providing a nuanced understanding of children's motor skills development.

Conclusion: This study contributes to the advancement of motor skills assessment in early childhood education by establishing a scientifically validated testing tool and evaluation framework for Chinese preschoolers. These findings enrich the theoretical foundation of motor development research and offer practical implications for educators and policymakers.

Keywords: Gross Motor; Early Childhood; Development Test; Motor Skills

Introduction

The development of basic motor skills in early childhood is crucial for lifelong physical health and well-being. A lack of physical activity is a key contributor to childhood obesity, which has been steadily rising in China. According to the 2017 China Children Obesity Report, the obesity rate among children under seven is 4.3%, affecting 4.76 million children, and is projected to increase to 6% by 2030 (Ma, 2017). Obese children are at a higher risk of developing chronic illnesses, including diabetes and cardiovascular diseases (Sahoo et al., 2015). While many interventions focus on exercise duration and intensity, motor skill competence plays a vital role in a child's willingness and ability to participate in sports (Fisher, 2015). The Pyramid Model of Human Motor Development suggests that fundamental motor skills provide the foundation for advanced movement abilities and long-term engagement in physical activity (Seefeldt, 1980).

Recognizing this, the Chinese government has introduced several policies promoting early childhood physical development. The 2019 Guidelines for Learning and Development of Children Aged 3–6 emphasize age-appropriate physical activities (Ministry of Education, PRC, 2019). The 2020 Implementation Plan for the Prevention and Control of Obesity in Children and Adolescents mandates at

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least two hours of outdoor activity daily in kindergartens (National Health Commission, 2020). Furthermore, the 2021 Guidelines for Kindergarten Admission Preparation Education encourage daily outdoor play to develop coordination, flexibility, and fundamental movement skills (Ministry of Education, PRC, 2019). Despite these initiatives, gaps remain in implementation. Many kindergartens lack dedicated physical education teachers, and most preschool sports programs focus on specialized sports training rather than holistic motor skill development (Tao, 2021).

To address these gaps, this study aims to develop a scientifically validated evaluation system for assessing motor skills in young children. Using the Delphi method, expert consensus will be gathered to establish evaluation indicators (Juan, 2019). The Zone of Proximal Development (ZPD) theory will inform structured learning support for motor skills acquisition (Zhang, 2019). Additionally, the Analytic Hierarchy Process (AHP) will be used to determine the importance of each evaluation criterion (Juan, 2019). Statistical analyses, including reliability and validity tests, will ensure the assessment tool's effectiveness.

By developing a comprehensive motor skills evaluation framework, this research contributes to policy implementation, early childhood education, and public health interventions. Providing kindergarten teachers with a structured assessment tool will support evidence-based teaching practices and enhance motor skill development. This study aims to lay a scientific foundation for improving physical activity engagement among Chinese preschoolers, fostering a healthier and more active generation.

Objectives

1. To develop a standardized gross motor development assessment for kindergarten students in Guangzhou, China.
2. To establish a comprehensive evaluation framework for assessing the gross motor skills of kindergarten students in Guangzhou, China.

Literature Review

Gross motor skills encompass a child's ability to coordinate large muscle movements necessary for physical activities such as walking, running, and jumping. Researchers categorize these skills into three primary dimensions: stability (balance skills), mobility (locomotor skills), and object control (manipulative skills) (Payne & Isaacs, 1999; Gallahue & Ozmun, 2006). These skills develop through progressive stages: Initial Stage (2–3 years old): Movements are uncoordinated and lack precision. Transitional Stage (3–5 years old): Children improve coordination and balance. Mature Stage (5–6 years old): Skills become refined, allowing for more complex activities (Gallahue & Ozmun, 2006).

Theoretical Foundations of Motor Skill Development

Neurological and physiological factors significantly impact children's motor skill development. Neural maturation, particularly within the cerebellum, enhances coordination and balance, enabling children to perform increasingly complex motor activities (Newell, 1986). Piaget's Cognitive Development Theory (1952) and Vygotsky's Sociocultural Theory (1978) both emphasize that motor skill acquisition is influenced by environmental stimuli and guided learning. Vygotsky's concept of the Zone of Proximal Development (Vygotsky, 1978) further suggests that children develop motor competencies more effectively when supported by parents, teachers, or peers.

Assessment Methods for Gross Motor Skills

Assessing young children's motor skills is essential for understanding their developmental progress and identifying areas for improvement. Various international and domestic assessment tools have been developed, including the Test of Gross Motor Development (TGMD-2/3), which evaluates locomotor and object control skills (Ulrich, 2020). Peabody Developmental Motor Scales (PDMS): Measure motor coordination and stability (Eddy et al., 2020). National Physical Fitness Standards (China): Provides benchmarks for assessing children's physical performance (Liang, 2020). Additionally, researchers such as Diao (2019) have developed region-specific evaluation tools like the Basic Motor Skill Development Test for children aged 3–10 in Shanghai, emphasizing the need for localized assessment frameworks.

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Relationship Between Gross Motor Skills and Physical Activity

Research demonstrates a strong link between fundamental motor skills and children's overall physical activity levels. Studies by Zhang (2019) and Zhou (2021) indicate that children with higher motor skill proficiency are more likely to engage in physical activities, leading to improved cardiovascular health and reduced obesity risks. However, some studies (e.g., Wan, 2019) suggest that the correlation between motor skills and physical activity varies based on testing methodologies. Fisher (2015) supports the notion that improving children's confidence in motor skills encourages sustained physical activity participation.

In summary, the literature emphasizes the importance of early motor skill development for shaping children's long-term physical health and activity levels. While numerous theoretical frameworks and assessment tools exist, there remains a need for standardized and culturally relevant evaluation systems. This study seeks to address this gap by developing an evaluation framework for gross motor skills tailored to kindergarten students in Guangzhou, providing a more comprehensive approach to assessing and enhancing motor development.

Conceptual Framework

This study is grounded in established theoretical models that explore motor development, learning processes, and assessment methodologies. The conceptual framework integrates the pyramid model of motor development, sociocultural theory, and the ecological dynamics framework, providing a structured approach to evaluating gross motor skill acquisition in kindergarten students.

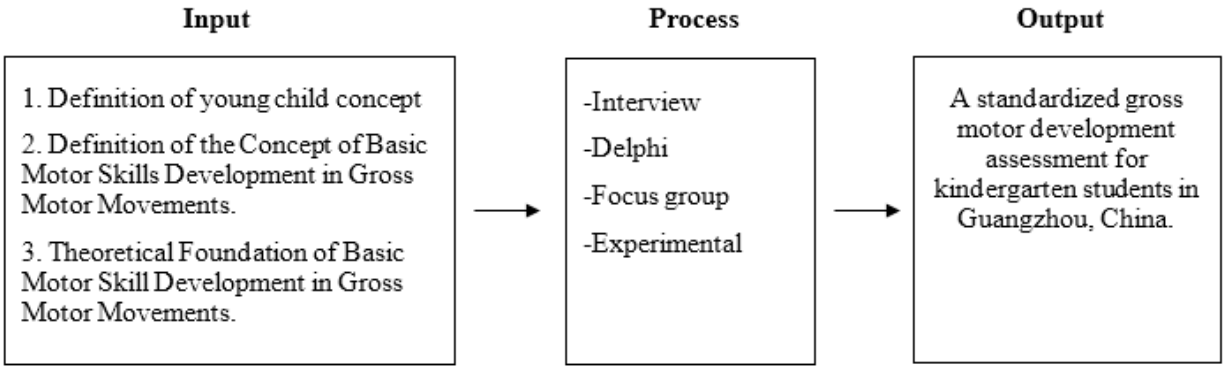

Figure 1 Conceptual Framework

Methodology

Population

This study involved two distinct populations: 1) Expert Panel: A total of 21 experts were selected, comprising: University administrators with expertise in early childhood education. Professionals are actively engaged in early childhood education. Practical instructors specializing in early childhood education. 2) Kindergarten Students: The study population included approximately 50,000 kindergarten students from 11 districts in Guangzhou City.

Sample Selection

The study utilized a purposive sampling method to select participants from a population of 21 experts in early childhood education. The final sample of 19 individuals included 5 university administrators with expertise in early childhood education, 7 professionals actively engaged in the field, and 7 practical instructors specializing in early childhood education. These experts played a key role in refining the assessment framework and ensuring methodological rigor. For the student sample, a simple random sampling method was used to ensure representativeness across different kindergarten levels. The formal testing phase involved a random selection of one kindergarten class from each of the big, medium, and

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small class categories in every district, resulting in a final sample of 397 preschoolers (191 boys and 207 girls).

Data Collection

This study adopted a comprehensive data collection approach to assess gross motor development among kindergarten students. Various methods were employed to ensure reliable and accurate data gathering, providing both theoretical and empirical foundations for the research. A literature review, online database searches, and consultation of educational policies from government sources were conducted to establish the context and framework for the study. Additionally, access to electronic resources related to lifelong physical activity and motor development provided a broad understanding of existing research and best practices in early childhood motor skill assessment. To refine and validate the evaluation indicators and scoring criteria, the Delphi method was utilized. This involved expert interviews where structured questionnaires were distributed to a panel of early childhood education specialists. By systematically analyzing expert opinions and experiences, researchers were able to review, refine, and ensure that the assessment indicators were comprehensive, accurate, and methodologically sound. To maintain objectivity and reliability, video recording technology was extensively used during the motor skill assessments. Children's performances were recorded and systematically categorized based on predefined evaluation criteria, minimizing observer bias and enhancing measurement precision. Additionally, ethical considerations were strictly followed throughout the data collection process. Informed consent was obtained from parents or legal guardians before testing, ensuring their full understanding and agreement with the research procedures. Teacher approval was also secured to ensure child safety and well-being. These measures reinforced the legality and ethical integrity of the study, ensuring compliance with research ethics and child protection standards.

Data Analysis

This study employed a systematic data analysis approach to derive meaningful insights into gross motor development in preschool children. Statistical analyses were conducted using SPSS 23.0 and Excel, focusing on item difficulty, item discrimination, reliability, and validity of the assessment instrument.

To ensure measurement accuracy, correlation and factor analyses were performed to evaluate reliability and validity, while hierarchical analysis (SPSSAU) determined the weighting of evaluation indicators. Descriptive statistics (mean, median, standard deviation) were analyzed for raw scores, and t-tests assessed gender differences in motor skills. Additionally, Pareto analysis and radar charts provided insights into developmental trends and individual motor skill profiles.

Research Process

This study followed a structured eight-step research process to develop a comprehensive assessment of gross motor skill development in kindergarten students.1) Literature Review 2) Conceptual Framework Development 3) Delphi Method for Expert Consultation 4) Video Recording Analysis for Scorer Reliability 5) Formal Testing 6) Data Collection 7) Data Analysis and 8) Conclusion and Report Writing

Results

The study aimed to construct an appropriate assessment system for evaluating children's gross motor skills, focusing on the core dimensions of stability, mobility, and control. The data collected from various expert consultations, field tests, and participant evaluations form the basis of this analysis.

Table 1 Selection of Indicators for Basic Motor Skills Assessment

Primary Indicator	Secondary Indicator	Description	Source of Indicator
Stability Skills	Single-leg standing	Ability to maintain balance on one leg	Adapted from TGMD-2, KTK
	Walking on an air cushion	Balance maintenance during dynamic movement	Expert consultation

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Primary Indicator	Secondary Indicator	Description	Source of Indicator
Mobility Skills	Running	Forward propulsion with coordination	TGMD-2, National Physical Fitness Standards
	Forward slide step	Controlled forward movement with rhythm	Peabody Developmental Motor Scales (PDMS)
	Side slide step	Lateral movement control	TGMD-2
	Standing long jump	Explosive lower limb strength	KTK, Bruce Sports Skill Proficiency Test
	Hop	Single-leg propulsion and landing	Expert consultation
	Stepping jump	Alternating leg propulsion with coordination	Expert consultation
Control Skills	Two-hand catching	Eye-hand coordination in receiving objects	Peabody, TGMD-2
	One-handed dribbling	Object control through dribbling	Expert consultation
	Kicking a stationary ball	Lower limb coordination in striking objects	National Physical Fitness Standards

Table 1 outlines a standardized framework for assessing gross motor skills in kindergarten students, categorizing skills into three primary dimensions: stability skills, mobility skills, and object control skills. These indicators were selected based on validated motor development tools, including the Test of Gross Motor Development (TGMD-2), Peabody Developmental Motor Scales (PDMS), and National Physical Fitness Standards, along with expert consultation.

Stability skills include single-leg standing (assessing static balance) and walking on an air cushion (evaluating dynamic balance). Mobility skills measure locomotion efficiency, featuring tasks like running, forward slide, side slide, standing long jump, hopping, and step-hop, which test coordination, speed, and lower limb strength. Object control skills, crucial for fine motor coordination, include two-handed catching, one-handed dribbling, and kicking a stationary ball.

Table 2 Analysis of Difficulty of Basic Motor Skills Test Movements (N=144)

Test Action	Mean (M) ± SD	Full Score	Difficulty Index (P-Value)
Single-leg standing	4.75 ± 0.702	6	0.79
Walking on an air cushion	4.64 ± 0.920	6	0.77
Digging ground with foot/hoof	6.03 ± 1.405	8	0.75
Forward slide	5.64 ± 1.891	8	0.71
Side slide step	5.34 ± 1.818	8	0.67
Standing long jump	6.56 ± 1.207	8	0.82
Hopping	6.25 ± 1.582	8	0.78
Step on the pad	2.66 ± 2.194	6	0.44

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Test Action	Mean (M) ± SD	Full Score	Difficulty Index (P-Value)
Two-hand catching	4.83 ± 1.328	6	0.81
One-handed dribbling	4.31 ± 1.887	6	0.72
Throwing a ball	4.47 ± 1.466	6	0.75
Underhand toss	3.91 ± 1.783	6	0.65
Kicking a stationary ball	4.14 ± 1.261	6	0.69
Total Stability Skills Score	9.39 ± 1.246	12	0.78
Total Mobility Skills Score	33.38 ± 3.567	46	0.73
Total Control Skills Score	28.18 ± 4.08	42	0.67
Total Basic Motor Skills Score	70.95 ± 8.959	100	0.71

Table 2 evaluates the difficulty levels of basic motor skills among kindergarten students using mean scores, standard deviations, and difficulty indices (P-values). The difficulty index (P-value) reflects the percentage of children who completed each task, helping assess motor task complexity.

Findings indicate that standing long jump (P = 0.82) and two-hand catching (P = 0.81) were among the easiest tasks, while stepping on the pad (P = 0.44) was the most difficult. Stability skills (P = 0.78) were easier than mobility skills (P = 0.73) and control skills (P = 0.67), suggesting that fine motor control tasks require additional training.

Table 3 Correlation Analysis Between Test Actions and Motor Skill Dimensions

Motor Task	Stability Skills (r)	Mobility Skills (r)	Object Control Skills (r)	Total Score (r)
Single-leg standing	0.685**	—	—	0.420**
Walking on an air cushion	0.831**	—	—	0.412**
Running	—	0.566**	—	0.450**
Side sliding step	—	0.563**	—	0.475**
Standing long jump	—	0.539**	—	0.533**
Two-hand catching	—	—	0.414**	0.431**
One-handed dribbling	—	—	0.550**	0.422**
Kicking a stationary ball	—	—	0.420**	0.406**

(** $p < 0.01$) 1. Interpretation of Correlation Values (r) The correlation coefficient (r) measures the strength of the relationship between motor tasks and their skill dimensions. A higher r-value (closer to 1) indicates a stronger correlation, suggesting that the test action is a valid indicator of that skill dimension.

Table 3 analyzes the correlation between motor skill test actions and their respective skill dimensions. The findings reveal that walking on an air cushion (r = 0.831) and single-leg standing (r = 0.685) exhibit the strongest associations, confirming their effectiveness in assessing stability skills. Running (r = 0.566) and side slide step (r = 0.563) show moderate correlations, supporting their validity in measuring locomotion control.

In object control skills, one-handed dribbling (r = 0.550) had a higher correlation than two-handed catching (r = 0.414), indicating that catching ability might be influenced by external factors like reaction time. The total motor skill score correlations (0.406–0.533) suggest that all test actions contribute meaningfully to the overall evaluation.

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Table 4 Weight Coefficients for Gross Motor Skill Indicators

Primary Indicator (Skill Dimension)	Relative Weight	Secondary Indicator (Test Item)	Relative Weight	Composite Weight
Stability Skills	0.26	Single-leg standing	0.33	0.09
		Walking on an air cushion	0.67	0.17
Mobility Skills	0.41	Running	0.3	0.12
		Forward slide step	0.17	0.07
		Side slide step	0.15	0.06
		Hopping	0.07	0.03
		Standing long jump	0.21	0.09
		Step-hop	0.1	0.04
Object Control Skills	0.33	Two-hand catching	0.15	0.05
		One-handed dribbling	0.15	0.05
		Kicking a stationary ball	0.23	0.07

Table 4 outlines the weight coefficients assigned to different motor skill categories using the Analytic Hierarchy Process (AHP). Mobility skills (0.41) received the highest weight, emphasizing the importance of movement efficiency, followed by object control skills (0.33) and stability skills (0.26).

At the secondary indicator level, walking on an air cushion (0.17) had the highest stability weight, while running (0.12) and standing long jump (0.09) were the most weighted mobility tasks. Kicking a stationary ball (0.07) ranked highest among object control tasks.

Conclusion

This study successfully developed a standardized gross motor skill assessment framework for kindergarten students in Guangzhou, China. By integrating stability skills, mobility skills, and object control skills into a comprehensive evaluation model, the research ensures a structured and objective methodology for assessing early childhood motor development. The selection of scientifically validated indicators, establishment of weight coefficients, and correlation analysis confirm the reliability and practical applicability of the assessment framework.

Findings indicate that mobility skills, particularly tasks such as running, hopping, and jumping, exhibit the highest variability, necessitating structured training interventions. Stability skills, such as single-leg standing and balance tasks, provide a foundational role in postural control, while object control skills, including dribbling and catching, require advanced coordination and precision. The correlation analysis further validates the contribution of each test action to the overall motor skill assessment, reinforcing the robustness of the framework.

The implementation of a percentile-based scoring system and radar analysis framework enables objective classification of children into different proficiency levels, facilitating early identification of motor deficiencies. This classification allows educators and policymakers to design targeted interventions that support optimal skill development. Additionally, the weight coefficients ensure a proportional representation of each motor dimension, strengthening the validity of the assessment system.

This research has significant implications for early childhood educators, physical education curriculum designers, and policymakers. The developed framework provides a scientific basis for tracking motor development trends, enabling the early detection of movement difficulties and the application of specialized training programs. Furthermore, the study establishes a foundation for longitudinal research, allowing future investigations to examine developmental progressions, environmental influences, and intervention effectiveness in improving motor skills.

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Discussion

The development of a standardized gross motor skill assessment framework for kindergarten students in Guangzhou represents a significant advancement in early childhood education. Assessing motor skills through a validated framework allows for objective, quantifiable, and reliable measurement, which is essential in detecting early motor deficiencies and preventing long-term developmental delays (Barnett et al., 2016). This study integrates stability skills, mobility skills, and object control skills into a multi-dimensional assessment system, ensuring applicability across both educational and research settings (Gallahue & Ozmun, 2019).

The findings from this study hold significant implications for educators, curriculum designers, and policymakers. By employing a percentile-based scoring system and radar analysis, the framework enables the early classification of motor skill proficiency levels, facilitating targeted interventions for movement skill enhancement (Logan et al., 2018). The use of weight coefficients further strengthens the validity of the assessment system, ensuring that each motor skill dimension is proportionally represented by established physical education standards (Cohen et al., 2014).

One key finding is the variability observed in mobility skills such as running, hopping, and jumping, reinforcing the necessity of structured and individualized training programs (Robinson et al., 2015). Previous research suggests that gross motor competency in early childhood is strongly correlated with long-term participation in physical activities and overall health outcomes (Stodden et al., 2008). Therefore, incorporating mobility-focused interventions in preschool curricula could enhance movement competence and reduce the risk of motor delays, supporting the long-term development of physical literacy.

Additionally, object control skills, including dribbling, catching, and throwing, were found to be more challenging for children compared to stability and mobility skills. This finding aligns with research indicating that fine motor coordination develops at a slower rate than gross motor movements (Haywood & Getchell, 2021). Structured ball-handling exercises, reaction-based drills, and coordination-enhancing activities should be integrated into early childhood programs to support motor proficiency and hand-eye coordination development (Goodway et al., 2019).

This study also highlights the necessity for further research in several key areas. Longitudinal studies should be conducted to track motor skill progression over time, allowing for the identification of developmental patterns and ensuring continued improvement in assessment methodologies (Lubans et al., 2010). Additionally, gender-specific benchmarks must be refined to enhance assessment accuracy, given potential sex-based differences in motor skill acquisition (Brian et al., 2019). Research into the effectiveness of different intervention strategies is needed to evaluate training methodologies that best support motor skill enhancement (Cools et al., 2009). Finally, the integration of motion tracking and AI-driven assessments should be explored to improve objectivity, efficiency, and real-time analysis of motor performance (Fischman et al., 2021).

In conclusion, this study contributes significantly to the field of early childhood motor development by establishing a scientifically rigorous assessment framework. The implementation of standardized assessment tools validated scoring methods and weight coefficients ensures the framework's reliability and adaptability for both educational and research purposes. Moving forward, incorporating technological advancements and refining assessment techniques will enhance the accuracy and applicability of motor skill evaluations, ultimately supporting early intervention strategies that promote lifelong physical competence.

Recommendation

Based on the findings of this study, the following recommendations are proposed to enhance motor skill assessment and intervention in early childhood education:

1. Implementation of a Structured Motor Skill Curriculum: Schools and early childhood education centers should integrate standardized motor skill training programs that focus on improving stability, mobility, and object control skills.

2. Early Identification and Intervention Programs: Educators and policymakers should establish screening processes to identify children with motor deficiencies early and provide targeted interventions to support their development.

3. Teacher Training and Professional Development: Training programs should be developed for educators to ensure they have the necessary skills to administer gross motor skill assessments effectively and implement evidence-based training strategies.

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Recommendation for Further Research

This study provides a comprehensive evaluation framework for assessing the gross motor skill development of kindergarten students in Guangzhou, China. However, further research is necessary to enhance the validity, applicability, and generalizability of the findings. The following areas are recommended for future exploration:

1. Expansion of the Study Population: The current study focused on kindergarten students in Guangzhou. To enhance the applicability of the evaluation system, future research should expand the sample size to different regions in China and compare the motor skill development of children from urban and rural areas.

2. Relationship Between Motor Skills and Cognitive Development: Future research should investigate the extent to which gross motor skills influence academic performance and cognitive growth in early childhood. Understanding this relationship could lead to the development of integrated movement-based learning programs in preschool education.

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