

Enhancing physical literacy in preschool children through play

WENYUE LIU¹, DENISE KOH², ZHIHAO ZHANG³, JIANGUO QIU⁴, LILI WANG⁵

^{1,2,3,5}Faculty of Education, Universiti Kebangsaan Malaysia, Bangi, Selangor Malaysia, 43600, MALAYSIA

⁴Department of Physical Education, Ludong University, Yantai, Shandong, CHINA

Published online: May 31, 2025

Accepted for publication: May 15, 2025

DOI:10.7752/jpes.2025.05122

Abstract :

Background and Objective: The global decline in physical activity among young children has raised serious concerns about their physical and psychological health. Physical literacy—which includes motivation, confidence, physical competence, knowledge, and understanding to participate in physical activities—is a key factor in promoting lifelong health and an active lifestyle. However, the lack of structured opportunities, coupled with increasing sedentary behaviors in preschool-aged children, underscores the need for effective, developmentally appropriate interventions. This study examines the impact of a structured, play-based intervention on improving physical literacy in preschool children. **Methods:** A total of 146 children aged 5–6 years from kindergartens in Shandong Province, China participated in the study. They were assigned to either an intervention group (n = 68) or a control group (n = 78). Both groups maintained similar daily routines and physical activity schedules, with the only difference being the implementation of the intervention in the former. The three-month intervention program was developed based on expert consultations, feedback from early childhood educators via questionnaires, and previous empirical research. It focused on varied, engaging, and age-appropriate play activities designed to improve fundamental movement skills (FMS), physical fitness (PF), and physical motivation. **Results:** Pre-intervention assessments showed no significant differences between the two groups ($p > 0.05$). After the intervention, the intervention group outperformed the control group significantly across all 13 FMS tests ($p < 0.05$). Significant improvements were observed, particularly in speed, power, coordination, and hand–eye coordination. Additionally, significant gains in flexibility, agility, and balance were recorded ($p < 0.001$). However, grip strength and standing long jump showed no significant differences ($p > 0.05$). Moreover, children in the intervention group exhibited a considerable increase in motivation and enjoyment of physical activities ($p < 0.001$). **Conclusion:** Play-based interventions provide an effective, child-centered method for improving physical literacy in early childhood. Future programs should incorporate strength-building components along with interactive and engaging formats to promote sustained interest and encourage long-term participation in physical activity.

Keywords: Physical literacy, preschool children, play-based intervention, motor skills, physical fitness, motivation for physical activity.

Introduction

Overweight and obesity have become major public health issues in Shandong Province (Rujiu, Koh, & Wang, 2024). A national survey identifies Inner Mongolia, Shandong, and Hebei as the top three regions in China with the highest obesity rates. In Shandong, the overweight rate is 19.7%, and the obesity rate is 37.1%, ranking it second only to Inner Mongolia (Chen et al., 2023). Among school-aged children (6–18 years), overweight and obesity prevalences are 17.93% and 6.79%, respectively. The highest rates are in central, northern, and eastern parts of Shandong, with hotspots in Yantai and Weihai (Han, Fu, Liu, Jia, & Wang, 2020).

Physical literacy refers to an individual's ability to move effectively, their motor skills, confidence in engaging in physical activities, as well as their understanding and attitude toward exercise (Mahardika, Mustafa, Lufthansa, Anugrah, & Shafi, 2024). For preschool children, developing physical literacy not only improves physical health but also supports psychological and social well-being (Cairney, Dudley, Kwan, Bulten, & Kriellaars, 2019). Early childhood is a critical period for developing physical literacy, establishing the foundation for lifelong active participation (Barratt, Dudley, Stylianou, & Cairney, 2024). During this vital stage of development, children begin a journey of exploration, curiosity, and learning that lays the foundation for their movement skills (Bicenturk, 2024). Fundamental movement skills (FMS) are the essential building blocks for more advanced activities, including crawling, walking, running, and jumping (Newell, 2020). While young children already have these movement skills, they often exhibit high confidence in their physical abilities (Brian et al., 2018). At this time, a positive self-perception is key in shaping children's physical activity habits (Lane et al., 2022). An increasing number of studies emphasize the importance of focusing on physical literacy to address the issue of insufficient physical activity among children (Portes, Da Silva, & De Oliveira, 2024). Therefore, this topic has attracted the attention of governments and organizations around the world (Tremblay et al., 2018).

Using play—a natural and engaging activity—effectively increases children's physical literacy (Barnett et al., 2023). Play is a fundamental activity for preschool children, allowing them to freely explore, experiment, and develop a range of motor skills (Lunga, Esterhuizen, & Koen, 2022). Activities such as jumping, running, and climbing help develop balance, coordination, and flexibility (Ruban et al., 2024). Moreover, play strengthens teamwork, communication, and problem-solving abilities while improving self-assurance and social skills. Therefore, play is a highly effective approach for fostering early childhood physical development (Lai, Ang, Por, & Liew, 2018), and play-based interventions can comprehensively improve children's physical health and well-being (Elston, 2024).

Although the China strongly encourages physical education for young children, Chinese preschoolers' actual participation rate remains relatively low. Contributing factors include underqualified kindergarten physical education teachers (Liang, Ju, Hao, Yang, & Liu, 2024), single teaching method (Pan, Fan, Wang, & Li, 2022), and lack of scientific and systematic activity design (Xiaojuan, Xiaozan, Qinglei, Jian, & Jun, 2021). These limitations impede children's comprehensive physical literacy development, potentially affecting their social development and mental well-being (Wang, Pa, Ling, & Koh, 2024). Therefore, implementing developmentally appropriate and evidence-based intervention strategies is crucial for effectively promoting physical literacy in early childhood.

To address the abovementioned challenges, this study designed and implemented a 12-week quasi-experimental intervention. The intervention, based on manipulatively simple games, aimed to develop a play-based program for increasing physical literacy. The study investigates the impact of this intervention on various components of physical literacy in 5–6-year-old children, ultimately aiming to promote overall physical literacy development and prevent early childhood obesity.

Materials and Methods

Participants and Study Design

Based on sample size calculations using G*Power version 3.1 (Heinrich Heine University Düsseldorf, Düsseldorf, North Rhine-Westphalia, Germany), the target sample size for this study was 154 preschool children aged 5–6 years. Although the original plan was to use random cluster sampling from kindergartens in Shandong Province, financial limitations made it impractical to perform research across multiple locations. Consequently, Yantai, a representative city in Shandong Province, was selected as the research site. After collaborating with the local education bureau, six districts agreed to participate. To minimize confounding factors, two kindergartens with comparable characteristics were randomly chosen for the intervention and control groups. The intervention group received a 12-week play-based physical literacy intervention implemented by their teachers, while the control group continued with their usual curriculum. The research team obtained informed consent from all 154 child participants and their parents/guardians prior to their involvement in the study. The Ludong University Ethics Committee reviewed and approved all study procedures (Approval No: LDU-IRB202408001).

Procedure

The Test of Gross Motor Development-3 (TGMD-3), the National Student Physical Fitness Testing Standards (Preschool Version), and the Pre-Play Questionnaire were used to assess children's physical literacy levels. Specifically, these tools evaluated FMS, physical fitness (PF), motivation, and interest one week before and one week after the intervention.

Intervention

The intervention program used play-based activities to improve various components of physical literacy. Implemented three times a week, with each session lasting 30 min, the 12-week intervention was divided into three phases. Weeks 1–4: Basic Phase – Focused on developing FMS. Weeks 5–8: Enhancement Phase – Introduced more complex movement challenges. Weeks 9–12: Consolidation Phase – Reinforced previously learned skills and promoted retention. Each weekly session was structured across three levels, incorporating progressively challenging tasks to expand children's abilities while ensuring the activities remained enjoyable. The intervention was designed based on the Information-Motivation-Behavioral Skills (IMB) Model and incorporated scenario-based challenge games to stimulate children's interest in physical activity and encourage active participation.

To further promote motivation and enjoyment, the program incorporated a reward system. Children received incentives for completing all activities, which fostered a sense of accomplishment and increased their interest in movement. Verbal feedback also played a key role, encouraging peer modeling: children who demonstrated correct movement techniques received specific praise (e.g., "You did a great job!"), while those with less developed skills were given positive encouragement to build their confidence in physical activities.

Training of Project Leaders

To properly implement the program, kindergarten teachers from the intervention sites received comprehensive training. These training sessions were carefully recorded to support future replication efforts. The training was designed to increase the teachers' understanding of physical literacy concepts, the specific components of the intervention, and the overall objectives of the program. After the training, teachers received

detailed lesson plans and instructional videos via email, both to reinforce what they had learned and to ensure that the intervention was delivered consistently across all classrooms.

Measures

The variables measured in this study include several indicators of physical literacy. According to Whitehead (2010), physical literacy encompasses three key components: fundamental movement skills, physical fitness, and motivation and enjoyment. Each of these indicators was assessed separately in the study.

Fundamental Movement Skills

FMS will be assessed using the Test of Gross Motor Development–Third Edition (TGMD-3) (Valentini, Duarte, Zanella, & Nobre, 2022). The assessment consists of two main subtests: the locomotor subtest and the ball skills subtest.

Physical Fitness

To measure PF, the study used the "National Physical Fitness Measurement Standards (Revised in 2023)" (Children's Part) (Xie et al., 2023). This tool is used in China to monitor the physical health of children aged 3–6. This standard includes assessments of body shape (height, body mass index) as well as various measures of PF, such as grip strength, standing long jump, sitting forward bend, two-foot continuous jump, 15-m obstacle run, and walking balance beam.

Motivation and Enjoyment

Motivation and enjoyment will be measured using the Preschool Physical Literacy Assessment (Pre-PLAY), developed by Sport for Life and the INCH Lab at McMaster University (Cairney et al., 2018). Pre-PLAY is an observational tool designed to assess various aspects of children's physical literacy. The scale includes components related to motor ability, coordination, and motivation and enjoyment. In this study, items 15–18 from the Pre-PLAY scale were used specifically to assess motivation and enjoyment.

Results

The study began with 154 children who agreed to participate. However, 8 children did not complete the baseline assessment. Thus, the final sample size was 146, with 68 children in the intervention group and 78 children in the control group. Importantly, all participants in both the intervention and control groups completed the post-test assessments.

Demographic Statistics

Before analyzing the intervention's effects, we performed a systematic analysis of sociodemographic characteristics to describe the baseline profile of the children in both the intervention and control groups. This analysis, designed to provide contextual support for interpreting the study results, included biological age, height, and weight. Descriptive statistics were used, and comparisons were made across gender and group assignment. Full details of this analysis can be found in Table 1.

Table 1 Demographic characteristics of participants

Index	Gender	Intervention group			Control group		
		N	Mean	Std. Deviation	N	Mean	Std. Deviation
Age	Boys	40	5.58	0.38	48	5.58	0.44
	Girls	28	5.46	0.30	30	5.50	0.44
Height	Boys	40	114.60	4.92	48	116.50	5.09
	Girls	28	113.07	4.42	30	114.08	2.93
Weight	Boys	40	22.38	3.69	48	24.37	3.70
	Girls	28	20.59	2.48	30	22.34	1.88

(1) Age Analysis

Because biological age is a key indicator of children's physiological development, we compared it between the intervention and control groups to assess their baseline developmental status. The analysis showed no significant differences in biological age, either between the groups or across genders. Although boys had a slightly higher average biological age than girls, the difference was minimal, indicating that gender had little influence on this variable in our sample.

(2) Height Analysis

Because height is a key indicator of children's growth and development, we compared the heights of children in the intervention and control groups to initially assess their growth status. The analysis showed that, on average, both boys and girls in the control group were slightly taller than boys and girls in the intervention group.

(3) Weight Analysis

Because weight is a crucial indicator of nutritional status and growth development in young children, a weight comparison between the intervention and control groups was performed. This comparison revealed that, on average, boys and girls in the control group had significantly higher body weights than boys and girls in the intervention group. Furthermore, the weight distribution was more dispersed among boys in the intervention group ($SD = 3.69$) compared to a more concentrated distribution among

girls in the control group (SD = 1.88). This suggests that there was greater variability in weight among boys in the intervention group compared to the other subgroups examined.

Comparison of Baseline Characteristics Between Intervention and Control Groups
Pre-test Analysis of Fundamental Movement Skills

An independent samples t-test was performed to examine differences in FMS between the intervention and control groups before the intervention. The results are presented in Table 2.

Table 2 Independent samples t-test statistics for fundamental movement skills index

Index	M ± SD		t	p
	Intervention group (n = 68)	Control group (n = 78)		
Run	5.868 ± 1.744	5.744 ± 1.566	0.453	0.651
Gallop	4.706 ± 1.612	4.641 ± 2.026	0.215	0.830
Hop	3.853 ± 1.895	3.885 ± 1.529	-0.110	0.912
Skip	2.721 ± 2.101	2.782 ± 1.392	-0.205	0.838
Horizontal jump	4.721 ± 1.638	4.679 ± 1.264	0.168	0.867
Slide	5.426 ± 1.124	5.500 ± 1.577	-0.327	0.744
Two-handed strike of a stationary ball	4.647 ± 1.033	4.718 ± 1.385	-0.353	0.725
One-handed forehand strike of a self-bounced ball	2.265 ± 1.288	2.282 ± 1.779	-0.068	0.946
One-handed stationary dribble	2.985 ± 1.086	2.782 ± 1.345	0.995	0.321
Two-hand catch	2.397 ± 1.306	2.308 ± 0.916	0.472	0.638
Kick a stationary ball	4.426 ± 1.285	4.372 ± 1.538	0.231	0.818
Overhand throw	4.103 ± 1.649	4.038 ± 1.607	0.239	0.812
Underhand throw	3.412 ± 1.212	3.397 ± 2.134	0.051	0.960

* p < 0.05 ** p < 0.001

An independent samples t-test was performed on the 13 fundamental movement skill indicators listed in Table 2 to compare the intervention and control groups. The results showed no significant differences between the groups for any of the indicators (p > 0.05). This indicates that the two groups were comparable in all fundamental movement skills before the intervention, confirming baseline consistency and the absence of pre-existing differences.

Pre-test Comparison of Physical Fitness Between Intervention and Control Groups

The independent samples t-test results for pre-test physical fitness indicators, presented in Table 3 Independent samples t-test for pre-experiment physical fitness indicators, show no significant differences between the intervention and control groups across all measured variables. This confirms that both groups had comparable baseline levels, ensuring a solid foundation for scientifically evaluating the effectiveness of the intervention.

Table 3 Independent samples t-test for pre-experiment physical fitness indicators

Index	M ± SD		t	p
	Intervention group (n = 68)	Control Group (n = 78)		
Grip strength	5.387 ± 2.1954	5.6 ± 1.7045	-0.648	0.518
Standing long jump	90.35 ± 16.958	92.44 ± 14.73	-0.794	0.429
Seated forward bending	4.546 ± 6.7656	4.594 ± 5.7201	-0.046	0.963
Two-foot continuous jumping	5.787 ± 1.7021	5.467 ± 1.1706	1.338	0.183
15-m obstacle course running	7.716 ± 1.0285	7.832 ± 0.8705	-0.737	0.462
Walking on the balance beam	10.066 ± 5.8613	11.373 ± 7.83	-1.128	0.261

The baseline assessment revealed no significant differences between the intervention and control groups across the six PF indicators (p > 0.05), confirming group comparability before the intervention. Specifically, the results were as follows: grip strength (t = -0.648, p = 0.518), standing long jump (t = -0.794, p = 0.429), seated forward bending (t = -0.046, p = 0.963), two-foot continuous jump (t = 1.338, p = 0.183), 15-m obstacle course running (t = -0.737, p = 0.462), and walking on the balance beam (t = -1.128, p = 0.261). These findings confirm that both groups had similar PF levels at baseline, providing a reliable foundation for evaluating the effects of the intervention.

Pre-test Comparison of Motivation and Enjoyment Levels Between Intervention and Control Groups

Table 4 shows that the intervention group had a mean ± standard deviation (M ± SD) of 10.985 ± 3.392, while the control group's M ± SD was 11.539 ± 3.555. An independent sample t-test yielded a t-value of -0.958

with a p-value of 0.34, indicating no statistical significance ($p > 0.05$). This means there was no significant difference between the intervention and control groups for this measure.

Table 4 Comparison of Motivation and Enjoyment Levels Between Intervention and Control Groups Before the Experiment

Group	N	M $\pm$ SD	t	p
Intervention group	68	10.985 $\pm$ 3.392	-0.958	0.34
Control group	78	11.539 $\pm$ 3.555		

Post-Test Comparison Between Intervention and Control Groups

Post-test Analysis of Fundamental Movement Skills

This study performed an independent samples t-test to investigate differences in FMS between the intervention and control groups after the intervention. The findings are shown in Table 5 Analysis of fundamental movement skills indicators in the intervention and control groups after the experiment.

Table 5 Analysis of fundamental movement skills indicators in the intervention and control groups after the experiment

Index	M $\pm$ SD		t	p
	Intervention group (n = 68)	Control group (n = 78)		
Run	7.029 $\pm$ 0.863	6.038 $\pm$ 1.391	5.241	<.001**
Gallop	5.647 $\pm$ 1.609	4.679 $\pm$ 1.964	3.226	<0.05*
Hop	5.015 $\pm$ 1.758	4.308 $\pm$ 1.790	2.401	<0.05*
Skip	4.206 $\pm$ 1.512	3.090 $\pm$ 1.443	4.559	<.001**
Horizontal jump	6.015 $\pm$ 1.344	5.205 $\pm$ 1.144	3.933	<.001**
Slide	6.662 $\pm$ 1.101	6.077 $\pm$ 1.421	2.749	<0.05*
Two-handed strike of a stationary ball	5.706 $\pm$ 1.210	5.064 $\pm$ 1.272	3.110	<0.05*
One-handed forehand strike of a self-bounced ball	3.544 $\pm$ 1.275	2.615 $\pm$ 1.956	3.439	<.001**
One-handed stationary dribble	4.632 $\pm$ 1.050	3.205 $\pm$ 1.252	7.401	<.001**
Two-hand catch	3.750 $\pm$ 1.297	2.513 $\pm$ 1.054	6.266	<.001**
Kick a stationary ball	5.721 $\pm$ 2.014	4.974 $\pm$ 1.206	2.667	<0.05*
Overhand throw	5.265 $\pm$ 1.452	4.179 $\pm$ 1.857	3.892	<.001**
Underhand throw	4.618 $\pm$ 1.796	3.859 $\pm$ 1.374	2.834	<0.05*

* $p < 0.05$ ** $p < 0.001$

The post-test analysis of FMS used an independent samples t-test to evaluate the impact of group assignment on 13 movement skills. Results showed significant differences ($p < 0.05$) in all skill indicators between the intervention and control groups, demonstrating the intervention's effectiveness in improving children's movement skills. Specifically, the intervention group achieved significantly higher mean scores in several fundamental movement skill indicators compared to the control group: running ($t = 5.241$, $p < 0.001$), galloping ($t = 3.226$, $p < 0.05$), single-leg hopping ($t = 2.401$, $p < 0.05$), skipping ($t = 4.559$, $p < 0.001$), and horizontal jump ($t = 3.933$, $p < 0.001$). These findings suggest that the intervention group experienced significantly greater improvements in speed, strength, and explosive power compared to the control group.

Furthermore, the intervention group outperformed the control group in hand-eye coordination tasks, with significant differences observed in lateral sliding ($t = 2.749$, $p < 0.05$), two-handed strike of a stationary ball ($t = 3.110$, $p < 0.05$), forehand strike of a dropped ball ($t = 3.439$, $p < 0.001$), and stationary one-handed dribbling ($t = 7.401$, $p < 0.001$). Additional analysis revealed that the intervention group also scored significantly higher in two-handed catching ($t = 6.266$, $p < 0.001$), stationary kicking ($t = 2.667$, $p < 0.05$), overhand throwing ($t = 3.892$, $p < 0.001$), and underhand tossing ($t = 2.834$, $p < 0.05$). These findings indicate that the intervention effectively improved coordination, strength control, and throwing skills, further confirming its positive impact on children's overall motor skill development.

In conclusion, the intervention group significantly outperformed the control group on all 13 fundamental movement skill indicators. Results from the independent sample t-tests confirm the intervention's effectiveness in enhancing children's movement skills, especially in running, jumping, coordination, and throwing. These findings underscore the value of play-based interventions for improving FMS and offer important guidance for improving future training programs.

Post-test Comparison of Physical Fitness Between Intervention and Control Groups

As shown in Table 6, statistical analysis comparing six physical fitness indicators between the intervention and control groups revealed that the intervention program had significant effects on several measures.

Table 6 Statistical comparison of physical fitness indicators between intervention and control groups

Inbex	M ± SD		t	p
	Intervention group (n = 68)	Control group (n = 78)		
Grip strength	7.425 ± 1.9789	7.156 ± 1.873	0.842	0.401
Standing long jump	104.1 ± 11.391	100.41 ± 13.633	1.761	0.08
Seated forward bending	5.024 ± 5.4433	0.503 ± 4.9526	5.254	<.001**
Two-foot continuous jumping	5.319 ± 0.8822	6.273 ± 2.0573	-3.722	<.001**
15-m obstacle course running	6.622 ± 0.7801	7.069 ± 0.7721	-3.474	<.001**
Walking on the balance beam	7.143 ± 2.4727	11.86 ± 11.8673	-3.427	<.001**

In the grip strength test, the mean difference between the intervention and control groups was not statistically significant ($t = 0.842$, $p = 0.401$), indicating limited effectiveness of the intervention in improving strength. Similarly, in the standing long jump test, the intervention group showed a slightly higher mean score (104.1 ± 11.391) compared to the control group (100.41 ± 13.633), but this difference was also not statistically significant ($t = 1.761$, $p = 0.08$). Although the p-value approached the 0.05 significance threshold, it was insufficient to confirm a meaningful improvement in lower limb explosive power attributed to the intervention. However, in the sit-and-reach flexibility test, the intervention group achieved a significantly higher mean score (5.024 ± 5.4433) compared to the control group (0.503 ± 4.9526). The t-test results ($t = 5.254$, $p < 0.001$) confirmed a significant positive effect of the intervention on flexibility. Additionally, in the two-foot continuous jump test—where shorter times indicate better performance—the intervention group significantly outperformed the control group (5.319 ± 0.8822 vs. 6.273 ± 2.0573), further demonstrating the intervention's effectiveness. The difference was statistically significant ($t = -3.722$, $p < 0.001$), confirming that the intervention effectively improved lower limb explosive power, especially in fast movements and coordination. In the 15-m obstacle run, the intervention group (6.622 ± 0.7801) significantly outperformed the control group (7.069 ± 0.7721), with the difference also statistically significant ($t = -3.474$, $p < 0.001$). This further supports the positive effect of the intervention on improving speed and agility.

Similarly, in the walking balance beam test, the intervention group (7.143 ± 2.4727) performed significantly better than the control group (11.86 ± 11.8673), with the difference also statistically significant ($t = -3.427$, $p < 0.001$). This indicates that the intervention was essential in improving children's balance abilities, and the task design effectively stimulated their balance potential. Overall, the intervention program resulted in significant improvements in flexibility, speed and agility, and balance. It also had a positive impact on coordination. However, gains in strength and lower limb explosive power were less pronounced, suggesting that future programs should include more targeted training to develop these areas.

Post-test Comparison of Motivation and Enjoyment Levels Between Intervention and Control Groups

As shown in Table 7, the intervention group achieved a mean score of 17.147 with a standard deviation of 2.009, compared to the control group's mean score of 11.385 and standard deviation of 3.020. An independent sample t-test revealed a statistically significant difference ($t = 13.722$, $p < 0.001$), indicating that the intervention group's mean score was significantly higher. This demonstrates that the intervention had a strong positive impact on improving the measured indicators, underscoring the effectiveness of the intervention design in improving the targeted abilities.

Table 7 Post-test statistics on motivation and enjoyment in the intervention and control groups

Group	N	M ± SD	t	p
Intervention group	68	17.147 ± 2.009	13.722	<.001**
Control group	78	11.385 ± 3.020		

Discussion

This study systematically evaluated the effectiveness of the intervention by comparing movement skills, PF, and motivation and enjoyment levels between the intervention and control groups before and after the experiment. Results indicated that after the intervention, the intervention group showed significant improvements in all 13 fundamental movement skill tests ($p < 0.05$), confirming the intervention's positive impact on children's movement abilities. Specifically, the intervention group performed significantly better in running, horse stance running, single-leg hopping, skipping, and standing long jump ($p < 0.001$ or $p < 0.05$), demonstrating a strong effect of the intervention on increasing speed, strength, and explosive power. Additionally, in tasks requiring hand-eye coordination—such as lateral sliding, two-handed strike of a stationary ball, forehand strike of a dropped ball, and stationary one-handed dribbling—the intervention group significantly outperformed the control group. This indicates that the intervention effectively improved coordination skills.

These results are consistent with existing research, confirming the importance of structured movement interventions in promoting children's motor skill development.

Regarding PF indicators, the study found that the intervention had significant effects on specific areas. The intervention group significantly outperformed the control group in flexibility (sit-and-reach test), speed and agility (15-m obstacle run), and balance ability (walking on the balance beam test) ($p < 0.001$), demonstrating improvements in flexibility, reaction speed, and body control. This suggests that targeted physical training improves not only muscle strength but also neuromuscular coordination, improving overall movement performance. Moreover, in the two-foot continuous jump test, the intervention group performed significantly better ($p < 0.001$), demonstrating the intervention's effectiveness in improving lower limb explosive power and coordination. However, for grip strength and standing long jump, although the intervention group had slightly higher mean scores than the control group, these differences were not statistically significant ($p > 0.05$). This indicates that the intervention had a limited effect on upper limb strength and lower limb explosive power. Future research could include resistance training or weighted exercises in the intervention to better support children's strength development.

Additionally, the study found that the intervention group scored significantly higher in motivation and enjoyment compared to the control group ($p < 0.001$). This suggests that the intervention not only improved children's movement skills but also increased their interest and enthusiasm for physical activity. This demonstrates that a well-designed training program can both improve physical abilities and promote active participation, thereby maximizing the overall effectiveness of the intervention.

Conclusion

The findings confirm the intervention's positive impact on children's multi-dimensional movement skill development. The intervention group exhibited significant improvements, especially in flexibility, agility, balance, and coordination, surpassing the control group in these aspects. Nonetheless, limitations were noted in improving upper limb strength and explosive power, indicating that future programs could be optimized for more comprehensive movement development. Additionally, the study showed that the intervention effectively increased children's motivation and enjoyment of physical activities, which is crucial for sustaining long-term participation in sports and exercise. Future research could explore improving the intervention by incorporating stronger resistance training components alongside more engaging and interactive methods to further increase its effectiveness and support comprehensive motor development in children.

Author Contributions

Wenyue Liu was responsible for conceptualization, methodology design, investigation, data analysis, and drafting the original manuscript. Denise Koh provided overall supervision, methodological guidance, project administration, and manuscript review. Zhihao Zhang assisted with data curation, software processing, visualization, and critical manuscript revisions. Jianguo Qiu coordinated fieldwork, provided resources, and supported funding acquisition. Lili Wang managed participant recruitment, intervention implementation, and data collection. All authors reviewed and approved the final version of the manuscript.

Acknowledgments

The authors would like to thank Falcon Scientific Editing (<https://falconediting.com>) for proofreading the English language in this paper.

References

- Barnett, L. M., Jerebine, A., Keegan, R., Watson-Mackie, K., Arundell, L., Ridgers, N. D., . . . Dudley, D. (2023). Validity, reliability, and feasibility of physical literacy assessments designed for school children: a systematic review. *Sports Medicine*, 53(10), 1905-1929.
- Barratt, J., Dudley, D., Stylianou, M., & Cairney, J. (2024). A conceptual model of an effective early childhood physical literacy pedagogy. *Journal of Early Childhood Research*, 22(3), 381-394.
- Bicenturk, F. (2024). *Investigating benefits of creative dance of cognitive, social and creative development with children aged 6-7 years*. Canterbury Christ Church University,
- Brian, A., Bardid, F., Barnett, L. M., Deconinck, F. J., Lenoir, M., & Goodway, J. D. (2018). Actual and perceived motor competence levels of Belgian and United States preschool children. *Journal of Motor Learning and Development*, 6(s2), S320-S336.
- Cairney, J., Clark, H. J., James, M. E., Mitchell, D., Dudley, D. A., & Kriellaars, D. (2018). The preschool physical literacy assessment tool: testing a new physical literacy tool for the early years. *Frontiers in pediatrics*, 6, 138.
- Cairney, J., Dudley, D., Kwan, M., Bulten, R., & Kriellaars, D. (2019). Physical literacy, physical activity and health: Toward an evidence-informed conceptual model. *Sports Medicine*, 49, 371-383.
- Chen, K., Shen, Z., Gu, W., Lyu, Z., Qi, X., Mu, Y., . . . for the Meinian Investigator, G. (2023). Prevalence of obesity and associated complications in China: A cross-sectional, real-world study in 15.8 million adults. *Diabetes, Obesity and Metabolism*, 25(11), 3390-3399. doi:<https://doi.org/10.1111/dom.15238>
- Elston, D. (2024). Exploring the Impact of Arts Integration and Play-Based Learning on Student Mental Health

- and Academic Performance.
- Han, L., Fu, M., Liu, Y., Jia, J., & Wang, L. (2020). Spatial Differences of Overweight and Obesity among Schoolchildren in Shandong Province, China.
- Lai, N. K., Ang, T. F., Por, L. Y., & Liew, C. S. (2018). The impact of play on child development-a literature review. *European Early Childhood Education Research Journal*, 26(5), 625-643.
- Lane, C., Naylor, P.-J., Predy, M., Kurtzhals, M., Rhodes, R. E., Morton, K., . . . Carson, V. (2022). Exploring a parent-focused physical literacy intervention for early childhood: a pragmatic controlled trial of the PLAYshop. *BMC Public Health*, 22(1), 659. doi:10.1186/s12889-022-13048-5
- Liang, Y., Ju, F., Hao, Y., Yang, J., & Liu, Y. (2024). Teachers' perception on physical activity promotion in kindergarten children in China: a qualitative study connecting social-ecological model. *BMC Public Health*, 24(1), 2190.
- Lunga, P., Esterhuizen, S., & Koen, M. (2022). Play-based pedagogy: An approach to advance young children's holistic development. *South African Journal of Childhood Education*, 12(1), 1133.
- Mahardika, W., Mustafa, P. S., Lufthansa, L., Anugrah, T., & Shafi, S. H. A. (2024). Lifelong sports through the lens of physical literacy: Understanding definitions, benefits, and challenges. *Edumaspol Jurnal Pendidikan*, 8(1), 238-245.
- Newell, K. M. (2020). What are fundamental motor skills and what is fundamental about them? *Journal of Motor Learning and Development*, 8(2), 280-314.
- Pan, B., Fan, S., Wang, Y., & Li, Y. (2022). The relationship between trait mindfulness and subjective wellbeing of kindergarten teachers: The sequential mediating role of emotional intelligence and self-efficacy. *Frontiers in Psychology*, 13, 973103.
- Portes, L. A., Da Silva, E., & De Oliveira, N. C. (2024). Ten year trends in body composition and fitness of school children. *Journal of Physical Education and Sport*, 24(7), 1617-1624.
- Ruban, A., Radovenchyk, A., Semal, N., Bilohur, V., Chkhailo, M., & Dzhy, V. (2024). Sports Games in the Context of Developing Children's Coordination Ability as a Component of Physical Development.
- Rujia, G., Koh, D., & Wang, L. (2024). Mechanism of low-carbon sports tourism behavior based on an extended theory of planned behavior. *Journal of Physical Education and Sport*, 24(4), 905-914.
- Tremblay, M. S., Costas-Bradstreet, C., Barnes, J. D., Bartlett, B., Dampier, D., Lalonde, C., . . . Patton, R. (2018). Canada's physical literacy consensus statement: process and outcome. *BMC Public Health*, 18(2), 1-18.
- Valentini, N. C., Duarte, M. G., Zanella, L. W., & Nobre, G. C. (2022). Test of Gross Motor Development-3: Item Difficulty and Item Differential Functioning by Gender and Age with Rasch Analysis. *Int J Environ Res Public Health*, 19(14). doi:10.3390/ijerph19148667
- Wang, L., Pa, W. A. M. B. W., Ling, W., & Koh, D. (2024). Impact of Early Childhood Sports Intervention on the Discovery of Physical Fitness Potential of Young Children: Jiang Xi Province. *Journal of Ecohumanism*, 3(4), 553-562.
- Whitehead, M. (2010). *Physical literacy: Throughout the lifecourse*: Routledge.
- Xiaojuan, T., Xiaozan, W., Qinglei, F., Jian, Z., & Jun, C. (2021). Research on early exercise game intervention curriculum design for children aged 3~6 years old - Research evidence based on SKIP. *Journal of Beijing Sport University*.
- Xie, S., Zhou, Y., Yin, Y., Shao, R., Fang, L., & Shao, W. (2023). Effects of fundamental movement skills on health-related quality of life in Chinese school-age children: the mediating role of physical fitness level. *Frontiers in Public Health*, 11, 1023662.