Fun game–based learning improves gross motor skills in early primary school children

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ABSTRACT

Background: Children who face difficulties in gross motor skill development may withdraw from physical activities, experience low self-esteem, and suffer from social anxiety. Physical education plays a vital role in fostering gross motor development, especially when delivered through enjoyable and engaging activities such as fun games.

Objectives: This study aimed to investigate the impact of fun game–based learning on the development of gross motor skills in early primary school children.

Methods: The study employed a quasi-experimental design with a non-equivalent control group. A total of 36 second-grade students from SDIT Mutiara Hati in Malang participated in this study. Participants were assigned to one of three groups: a control group, a group-based fun games intervention, and an individual-based fun games intervention. The interventions were implemented three times a week for 30 minutes over a period of seven weeks. Gross motor skills were measured before and after the intervention using the Test of Gross Motor Development–Third Edition (TGMD-3), a reliable and validated instrument. Data were analyzed using homogeneity and normality tests, paired-sample t-tests, one-way ANOVA, and Tukey's HSD post hoc tests, with a significance level set at $p < 0.05$ (SPSS version 25).

Results: Both the individual and group fun game–based learning interventions produced significant improvements in gross motor skills compared with the control group ($p < 0.05$). Moreover, a significant difference was found between the two intervention types, indicating that the mode of fun game delivery influences outcomes ($p < 0.05$).

Conclusions: Fun game–based learning, whether delivered individually or in groups, effectively enhances gross motor skills among early primary school children. Additionally, individual fun game–based learning demonstrated a significantly greater improvement compared to group-based learning.

Keywords: fun games, gross motor skills, primary school children, quasi-experimental design.

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INTRODUCTION

Data on children's gross motor skills in Indonesia indicate a condition that requires serious attention. Kemenkes (2018) reported that the prevalence of children with low gross motor skills reached 12.4%. This figure is reinforced by Setiawan (2023), who reported that approximately 51% of lower-grade elementary school students fall into the low category in terms of gross motor skills. This disorder highlights the importance of developing gross motor skills at a young age, particularly for children between the ages of 6 and 10, who are undergoing a crucial developmental stage. Ludyana et al. (2022) emphasized that the early developmental stage serves as the primary foundation influencing motor skill quality from adolescence through adulthood. Therefore, appropriate intervention strategies are necessary to prevent more complex developmental problems.

Gross motor development plays a crucial role in supporting children's movement abilities during early growth and has long-term implications that extend into adolescence and adulthood (Anjelina et al., 2022; Ludyana et al., 2022). Barnett et al. (2016) asserted that well-developed gross motor skills form the basis for daily activities as well as participation in sports. On the other hand, kids who struggle with gross motor abilities are more likely to struggle with social anxiety, peer rejection, and social environment adaptation (Leonard, 2016). Other studies have shown correlations between motor delays and lower participation in physical activity, an increased risk of obesity, reduced self-confidence, and suboptimal academic achievement (Dapp et al., 2021). These findings demonstrate that gross motor development is closely linked to physical health, mental well-being, and academic performance.

Limited motor experiences also have significant impacts on neural development. Cameron et al. (2016) revealed that weak motor skills may hinder neural connectivity between the sensorimotor cortex and the cerebellum, which are essential for planning and refining movements. This impairment is exacerbated by delayed myelination in motor pathways, leading to suboptimal transmission of motor signals. Fu et al. (2022) highlighted that low gross motor skills may negatively affect brain structures related to movement, such as the vestibular and visual-motor systems. These findings reinforce the notion that gross motor development is not merely a physical concern but is also closely linked to children's neurological health.

In addition to physical and neurological impacts, low gross motor skills also have severe psychological consequences. Children with limited motor abilities tend to experience social anxiety, withdraw from group activities, and feel less competent compared to their peers (Lodal & Bond, 2016). Weiss (2020) even found a link between low motor skills and decreased self-confidence, reduced social interaction, and the emergence of mild depressive symptoms (Mancini et al., 2016). Such psychological conditions may further deteriorate children's quality of life, considering that self-confidence and social engagement are critical factors for healthy personality development. As a result, gross motor development has several ramifications that affect both psychological and physical health.

Children with well-developed gross motor skills demonstrate various advantages across physical, cognitive, and social domains. Gümüşdağ (2019) emphasized that good motor skills improve overall quality of life, cardiometabolic health, and physical fitness. Children with better motor skills tend to achieve higher academic performance and engage more broadly in social activities (McClelland & Cameron,

2019). This demonstrates that gross motor abilities are necessary for both academic performance and healthy social interactions, in addition to being vital for physical health. Therefore, it is essential to consider gross motor development as a long-term investment in children's overall health.

Preliminary observations at SDIT Mutiara Hati, Malang City (November 25, 2024), revealed that routine activities without structured game variations still dominated physical education learning. The physical education teacher stated that no game-based approach had been specifically designed to enhance students' gross motor skills. As a result, some students struggled with basic movements such as jumping, throwing, and running in a balanced manner. This condition signals the need for innovation in physical education models that are more engaging, adaptive, and aligned with children's developmental needs, one of which is the implementation of Fun Games.

Enhancing gross motor abilities, including balance, coordination, and motor control, has been demonstrated to be significantly aided by physical education. Cleland et al. (2017) emphasized that game-based activities create more enjoyable and meaningful learning experiences for students. The Fun Games approach in physical education is considered adequate because it enhances both motivation and movement skills (Engels & Freund, 2020). Masrun et al. (2023) even found that Fun Games had a significant impact on locomotor skills and student concentration ($p < 0.05$). Another study by Navarra et al. (2022) also reported that game-based learning improved motor skills, while Barba et al. (2020) highlighted the positive contributions of Fun Games to gross motor development and physical activity levels. Thus, this approach can serve as a promising alternative for enhancing the quality of physical education learning in schools.

Although previous studies have demonstrated the benefits of Fun Games for improving motor skills, few have directly compared the effectiveness of individual-based versus group-based Fun Games. Furthermore, the application of standardized instruments, such as the Test of Gross Motor Development–Third Edition (TGMD-3), remains limited, particularly in Indonesian primary schools. This highlights a research gap in understanding how different modes of fun game implementation influence children's gross motor development when assessed using validated measures.

Therefore, this study aims to compare the effects of individual and group Fun Game–based learning on the gross motor skills of early primary school children using the TGMD-3 instrument. The study is expected to contribute new empirical evidence to physical education pedagogy, particularly by demonstrating the relative effectiveness of individual and group play contexts in enhancing gross motor skills among young learners.

METHODS

Study Design and Participants

This study employed a three-arm, parallel, pretest–posttest quasi-experimental design involving 36 participants, equally allocated to three groups ($n = 12$ per group). Participants were recruited through purposive sampling from the Integrated Islamic Elementary School (SDIT) Mutiara Hati in Malang, Indonesia. Although random sampling was not feasible, group allocation was conducted using stratified randomization based on pretest TGMD-3 scores, which were generated using the

random number function in IBM SPSS Statistics version 25. To minimize allocation bias, allocation concealment was implemented using sealed, sequentially numbered envelopes, ensuring that group assignments were made without researcher influence.

Ethical approval statement

The study received approval from the Ethics Committee at Universitas Negeri Malang, with the assigned approval number No. 01.05.04/UN32.14.2.8/LT/2025. All participants were given a detailed explanation of the study's objectives, procedures, and potential benefits or risks. Informed consent was obtained from each participant and their legal guardian before inclusion.

Research Instruments

This study was conducted over seven weeks, with three sessions per week, resulting in a total of twenty-one intervention sessions. All activities were carried out on Mondays, Wednesdays, and Fridays at SDIT Mutiara Hati Malang, located in Cemorokandang, Kedungkandang District, Malang City. Each session began with a joint prayer and attendance check led by the accompanying teacher. Before the intervention program was implemented, a pre-test was conducted using the Test of Gross Motor Development – Third Edition (TGMD-3) to assess the students' baseline gross motor skills. The results of this initial assessment were then used as the basis for group allocation through the ordinal pairing method, ensuring comparable baseline conditions across groups. The intervention consisted of two Fun Games models: individual games (Alphabet Games) and group games (Team Games). Each session lasted 30 minutes with a structured format: two minutes for warm-up, 26 minutes for the main activities, and two minutes for cooldown. The session design followed a predefined progression to ensure gradual and systematic skill development. The interventions were conducted three times a week for seven consecutive weeks, facilitated by the physical education teacher and the researcher, while the classroom teacher participated as an observer. Prior to the study, all intervention facilitators received special training on game protocols, implementation procedures, and assessment criteria to ensure uniformity in program delivery. Intervention fidelity was monitored through attendance records, protocol compliance checklists, and weekly evaluations to maintain consistency and quality throughout implementation. After the intervention period concluded, students completed the TGMD-3 post-test to evaluate changes in their gross motor skills. Gross motor skills were assessed using the official English version of the TGMD-3, which consists of two subtests: locomotor skills and ball skills. Standardized procedures were followed, with each skill performed in two trials.

Each trial was scored as one if the movement met the set criteria and zero if it did not. The raw scores were then converted into scaled scores, percentiles, and Gross Motor Quotients (GMQ) according to TGMD-3 guidelines. All assessments were conducted by two independent raters who had completed the official TGMD-3 video tutorial training prior to the assessments. To ensure scoring reliability, intra-rater and inter-rater reliability tests were first conducted using a sample of ten students outside the leading study group. The reliability threshold was set at an Intraclass Correlation Coefficient (ICC) of 0.80 or higher to ensure consistency of scores. Moreover, to minimize potential bias, the raters conducting the post-test were blinded to participants' intervention group assignments. According to Salami et al. (2019), the TGMD-3 has demonstrated inter-rater reliability above 0.85 and intra-rater reliability

above 0.80 across all subtests, confirming its validity and reliability for assessing gross motor skills in children aged 7–9 years.

Data Analysis

Statistical analyses were conducted using IBM SPSS Statistics version 25. A 2 × 3 mixed-design ANOVA (Time: pretest vs. posttest × Group: individual fun games, group fun games, control) was performed to examine the interaction and main effects of time and Group on gross motor skill scores. Significance was set at $\alpha = 0.05$ (two-tailed). A formal power analysis was not conducted due to limited preliminary data; this limitation is acknowledged in the discussion.

RESULTS

Table 1 shows that both Individual Fun Games and Group Fun Games interventions improved students' gross motor skills compared to the control group. The Group Fun Games group achieved the highest mean difference, particularly among male students (10.50), increasing from 94.00 (SD = 5.367) to 104.50 (SD = 4.135). In the Individual Fun Games group, males improved by 8.80 points and females by 6.00 points, while the Control Group showed the smallest gains, with mean differences of 7.00 for males and 5.83 for females.

Table 1. Gross Motor Skill Scores Before and After Intervention (Mean ± SD)

Group	n	Pre (Mean ± SD)	Post (Mean ± SD)	Mean Change ± SD	t(df)	p
Individual Fun Games – Male	5	96.40 ± 6.15	105.20 ± 5.36	+8.80 ± 2.17	9.08(4)	0.001
Individual Fun Games – Female	7	100.43 ± 8.38	106.43 ± 6.43	+6.00 ± 3.87	4.10(6)	0.006
Group Fun Games – Male	6	94.00 ± 5.37	104.50 ± 4.14	+10.50 ± 1.64	15.65(5)	0.000
Group Fun Games – Female	6	98.00 ± 8.20	105.17 ± 6.03	+7.17 ± 2.95	9.55(5)	0.000
Control – Male	6	94.00 ± 5.69	101.00 ± 6.20	+7.00 ± 2.45	7.00(5)	0.001
Control – Female	6	98.50 ± 7.53	104.33 ± 5.99	+5.83 ± 2.23	6.41(5)	0.001

The results of the normality test using the Shapiro–Wilk test showed that all data were normally distributed ($p > 0.05$), as shown in Table 2. Therefore, the analysis could proceed with a homogeneity test. Furthermore, the results of the Levene homogeneity test show that all data have homogeneous variance ($p > 0.05$), as listed in Table 3. Based on the analysis using the paired sample t-test, there is a significant effect of individual fun games and group fun games-based learning on gross motor skills ($p < 0.05$), as presented in Table 4.

Table 2. Normality Test Results

Group	Gender	Pretest			Posttest		
		Statistic	df	Sig.	Statistic	df	Sig.
Individual Fun Games	Male	0.862	5	0.236	0.876	5	0.292
	Female	0.896	7	0.307	0.915	7	0.431
Group Fun Games	Male	0.933	6	0.607	0.857	6	0.178
	Female	0.874	6	0.242	0.982	6	0.963
Control Group	Male	0.914	6	0.466	0.918	6	0.493
	Female	0.873	6	0.240	0.847	6	0.148

Table 3. Homogeneity Test Results

Group	Levene Statistic	df1	df2	Sig.
Pretest	0.774	5	30	0.576
Posttest	0.777	5	30	0.574

Table 4. Comparison of Gross Motor Skill Improvements Between Groups (One-Way ANOVA)

Source of Variation	Sum of Squares	df	Mean Square	F	p
Between Groups	126.056	2	63.028	13.369	0.000
Within Groups	155.583	33	4.715		
Total	281.639	35			

Note. $p < 0.05$ considered statistically significant.

Table 5. Post-hoc (Tukey HSD)

Comparison	Mean Difference	Standard Error	p
Group Fun Games – Individual Fun Games	+2.33	0.89	0.033
Group Fun Games – Control	+4.58	0.89	0.000
Individual Fun Games – Control	+2.25	0.89	0.041

$p < 0.05$ was considered statistically significant.

The results of the analysis using the One-Way ANOVA test showed a significant difference between individual fun games-based learning and group fun games-based learning on gross motor skills ($p < 0.05$), as shown in Table 5. This finding is reinforced by the results of the Tukey HSD follow-up test, which also shows a significant difference between the two learning models in improving gross motor skills ($p < 0.05$).

DISCUSSION

The results of the study revealed that individual Fun Games-based learning had a significant impact on improving the gross motor skills of lower primary school students, both male ($p = 0.001$) and female ($p = 0.006$). This finding is consistent with the study by Nicolosi et al. (2024), which also reported significant improvements in gross motor skills through similar interventions. Hilavi et al. (2022) further supported these results by showing that children's engagement in individual physical play had a more substantial impact on enhancing gross motor skills while also fostering greater intrinsic motivation. The improvement in motor skills is likely to result from a structured seven-week intervention designed to stimulate children's motor systems progressively.

Individual play-based learning has been scientifically proven to stimulate brain activity, particularly in relation to cognitive and gross motor development. Such activities provide multisensory stimulation that contributes to synaptogenesis and brain plasticity, which serve as the neurological foundation for motor skill improvement (Diamond & Ling, 2016). Play activities that involve movement coordination, balance, and spatial orientation activate the primary motor cortex, cerebellum, and basal ganglia—three key brain regions responsible for regulating coordinated movements (Stodden et al., 2021). Furthermore, physical activities enhance cerebral blood flow and trigger the release of neurotransmitters such as dopamine and endorphins, which not only strengthen intrinsic motivation but also accelerate motor learning processes (Tomporowski et al., 2015). From a neuromuscular perspective, individual games elicit adaptations in motor unit recruitment and muscle contraction efficiency, leading to more optimal gross motor skill development (Ludyga et al., 2019). The early primary school years represent a critical phase of motor control development, and play-based interventions at this

stage are highly effective due to the high neural plasticity and responsiveness to motor learning experiences (Veldman et al., 2016).

The study findings also indicated that male students exhibited greater improvements in gross motor skills compared to females. This aligns with evidence suggesting that boys tend to respond more positively to competitive and dynamic play activities (Flôres et al., 2016). Kober et al. (2020) emphasized that boys often demonstrate higher cognitive and motor responsiveness during competitive games, reflected in greater physical engagement and focus. Play activities incorporating speed and challenge elements tend to be more appealing to boys, thereby enhancing motor performance and attention (Khan et al., 2017). Additionally, interactive game designs have been shown to prolong attention spans and increase males' engagement levels (Chiang, 2021).

Group-based Fun Games learning was also found to significantly improve gross motor skills among lower primary school students, both boys and girls ($p = 0.000$). These results align with those of Gavigan et al. (2023), who demonstrated that pleasurable fundamental movement therapies significantly enhanced motor skills for both males and females. This demonstrates how effectively game-based techniques can improve gross motor abilities, particularly in school physical education settings. Further supporting the idea that cooperative play has a beneficial effect on children's motor development, Bonney et al. (2019) found that group play therapies significantly enhanced coordination and motor abilities in both boys and girls.

The observed improvements in gross motor skills through group-based Fun Games interventions are also attributed to the structured seven-week program. This learning model emphasized not only physical aspects but also complex neurocognitive and social processes. Group play activities activate the primary motor cortex, cerebellum, and basal ganglia, which are essential for motor coordination, balance regulation, and motor learning processes (Myer et al., 2015). Moreover, play-based activities enhance synaptic plasticity and sensorimotor integration, both of which are crucial for developing motor control (Pesce et al., 2016). Repeated stimulation through enjoyable group play strengthens neural connectivity supporting fundamental motor skills (Sutapa et al., 2021). Additionally, active play promotes cardiovascular capacity, muscle strength, and neuromuscular coordination, forming the foundation for gross motor skill development (Asal & Angelo, 2021).

Other studies reported that group Fun Games learning often produced greater effects on boys, especially in improving locomotor and manipulative skills (Bayburtlu et al., 2024). This may be attributed to males' preference for competitive and dynamic activities, whereas girls tend to choose cooperative and expressive play activities (Farsari & Nitsiou, 2025). The competitive elements in group play are also known to stimulate the brain's reward system, including the orbitofrontal cortex and ventral striatum, particularly in males (Reilly et al., 2017). Dopamine release in these brain regions enhances motor motivation and attentional focus. Thus, the enjoyment factor in play becomes a primary driver of engagement, positively affecting gross motor performance, especially among males (Chiang, 2021).

The study revealed significant differences between individual and group Fun Games-based learning interventions in improving the gross motor skills of lower primary school students ($p = 0.000$). These findings align with Bayburtlu et al. (2024), who compared hybrid (individual and group) play programs on motor development in primary school children. Their results showed that group approaches were more effective in improving motor coordination and cooperative movement, while

individual approaches were more beneficial for specific motor skills and motor concentration. Similarly, Sgro et al. (2019) emphasized that group-based methods fostered more motor interactions among individuals, accelerating the mastery of more complex motor skills.

Individual games provided intensive stimulation to the corticospinal tract, enhancing internal motor control through repetitive training, ultimately supporting synaptic plasticity and basic motor skills (Tallent et al., 2021). Conversely, group play stimulates social brain areas, such as the prefrontal cortex and limbic system, which are associated with social-motor coordination and emotional regulation, thereby supporting collaborative movements (Li et al., 2025). Individual games also improved neuromuscular efficiency by strengthening specific neuro-muscular connections through repetitive exercises (Fort et al., 2016). Meanwhile, group play offered more diverse physical challenges, stimulating cardiovascular and respiratory systems, thereby enhancing endurance and multisensory coordination (Carcelén et al., 2025). Individual play has been shown to improve movement consistency and fine motor skills (Sabzi, 2025). In contrast, group play was more effective in enhancing motor competence through complex social interactions and varied physical stimulation (Ojeda & Campos, 2025). Group activities even triggered the release of oxytocin and dopamine, which enhance motivation and engagement, while individual games focused more on self-control and internal focus (Foley, 2017).

The improvements in gross motor skills observed in the control group were likely influenced by children's daily physical activities outside the intervention program, which were beyond the researchers' complete control. Primary school-aged children naturally engage in outdoor free play activities such as running, jumping, climbing, cycling, or playing traditional games. These activities constitute unstructured physical activity, which has been shown to contribute to gross motor development (Sivapalan et al., 2024). From a child development perspective, the play environment represents a natural ecosystem rich in movement stimulation, allowing children to repeatedly explore and develop their motor skills in an enjoyable, pressure-free context. This gradually enhances coordination, muscle strength, agility, and balance (Tandon et al., 2022). Even without formal learning interventions, children can still develop motor skills through spontaneous daily play, such as chasing games, ball games, or overcoming natural environmental obstacles (Iserbyt et al., 2016). Cattuzzo et al. (2016) further emphasized that consistent free physical activity, particularly in socially supportive environments that encourage movement exploration, significantly contributes to gross motor development even in the absence of formal physical education programs.

Limitations of the study

This study has several limitations that should be acknowledged. First, the relatively small sample size and single-site design may limit the generalizability of the findings to other school contexts. Future research should include larger and more diverse samples across multiple schools or regions to enhance external validity. Second, although inter-rater reliability for the TGMD-3 was established before data collection, post-intervention reliability was not reassessed, which could affect scoring consistency. Third, the absence of an a priori power analysis restricts the ability to determine whether the study was adequately powered to detect small effect sizes. Fourth, the study did not monitor students' physical activity outside of school, which may have influenced gross motor development. Lastly, the short-term intervention

and immediate post-testing prevented evaluation of the long-term sustainability of the observed improvements. Future studies should include follow-up assessments three to six months after the intervention to evaluate retention effects.

From a practical perspective, the findings provide valuable guidance for physical education practitioners. Incorporating fun game–based learning into early primary school physical education can serve as an effective pedagogical strategy to enhance students' gross motor skills while maintaining engagement and enjoyment. Teachers are encouraged to integrate 30-minute fun game sessions at least three times per week for a minimum of seven weeks, combining both individual and group activities to address diverse learning needs. Professional development workshops should be organized to train teachers in designing and implementing fun games that are developmentally appropriate, inclusive, and safe. Additionally, collaboration between teachers, parents, and administrators is essential to ensure that playful motor activities are supported both within and beyond the school setting, thereby maximizing the benefits of the intervention.

CONCLUSIONS

This study demonstrated that both individual and group Fun Games–based learning significantly improved gross motor skills among early primary school students ($p < 0.05$), with group-based activities showing slightly greater gains. The findings indicate that integrating structured, enjoyable game-based learning three times per week for seven weeks effectively enhances children's locomotor and object control abilities. Practically, teachers are encouraged to incorporate both individual and group fun games into physical education to promote engagement and motor development. Future research should involve larger, multi-site samples and longitudinal follow-ups to examine the sustainability and broader applicability of these interventions.

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DATA AVAILABILITY

All data supporting the findings of this study are included in the article and its supplementary materials. Additional datasets are available from the corresponding author upon a reasonable request.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest with any party in the implementation of this research.

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