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Original Article

Effect of game-based motor coordination (GBMC) on enhancing positive experiences for early talent development in primary school

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Abstract
Pedagogy in physical education (PE) has traditionally been characterized by drill-style teaching. While this traditional approach influences the range of skills developed in school learning contexts, it does not adequately demonstrate students' competencies in applying these skills in complex game situations. Therefore, educators should consider implementing educational theoretical models that support more effective pedagogical approaches. This study investigated the impact of a Game-Based Motor Coordination (GBMC) learning model on improving motor coordination in 9-year-old Indonesian children. A pretest and posttest were used to investigate the effectiveness and feasibility of an 8-week intervention program using the four subtests of the Körperkoordinationstest für Kinder (KTK3+), where 60 children were tested in two groups, intervention and control, for motor coordination skills. One school was designated as the control group (32 students, aged eight years), and the other was designated as the intervention group (28 students, aged eight years). The scores from each of the four subtests were summed into the KTK total raw score (RS). Children in the intervention group showed significantly higher RS scores than children in the control group (192.54 ± 21.82 vs 187.75 ± 25.10). Boys from the intervention group performed better than children in the control group in moving sideways and eye-hand coordination ($p < 0.05$). The improvement in the balance beam and jumping sideways was similar between boys and girls. The findings of this study indicate that teachers should use game-based models to enhance enjoyable and efficient learning environments that support practical pedagogical approaches, foster early talent development, and ensure effective learning within the PE domain.
Keywords: **physical education, primary school, intervention, motor coordination, pedagogy**

Introduction

Structured and measurable talent development (TD) is attributed to part of the foundation for international sporting success and many modern elite sports systems have applied the normative talent development model (Bjørndal et al., 2015). In addition, a structured sports system has been the key to national success in Olympic sports (De Bosscher et al., 2006). Bailey and Collins (2013) argue that contemporary TD models share similar characteristics, such as assessments of early ability or physiological and/or anthropometric measures, and by removing large numbers of athletes from the system with the aim of progression from one level to the next. Nevertheless, implementing a TD standard is essential for the optimal realization of quality and the structured development process. Bailey and Collins (2013) have developed a standardized model of talent development (SMTD). However, while SMTD is a common model among elite sports policymakers, it has some limitations. For instance, it needs more conceptual validity because it assumes that development and performance in sports are conceptually simple, linear, and predictable. According to Bjørndal et al. (2015), no studies have investigated the empirical validity of SMTD. Furthermore, it is unclear whether alternative models can be found in other successful sporting contexts. Although several aspects can influence the developmental pathway toward elite sports performance, such as cultural conditions (Doncaster et al., 2020), there is a lack of knowledge regarding the specific organizational differences across various sports and sport cultures that can result in these variations. De Bosscher et al. (2006) proposed that further in-depth research is required to provide international and sport-specific comparisons.

Few structured models of TD exist in Indonesia, particularly for children. Implementing such models in elementary schools is crucial, as children aged 7-12 need to develop their motor skills (Bakhtiar, 2014). The acquisition of fundamental motor skills (FMS) provides a crucial foundation for children's ability to learn and master basic sports skills to their fullest potential (Bakhtiar et al., 2023; Mardiansyah et al., 2023). Additionally, the development of motor coordination (MC) skills between the ages of 7 and 12 plays a pivotal role in early TD and predicting future success for elite athletes (Pion et al., 2015). MC is the ability to perform various motor tasks, including fundamental motor skills (FMS) (Barnett et al., 2016) and plays an important role in growth, development, and the opportunity to lead an active lifestyle (Mardiansyah et al., 2024).

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MC is the building block for executing more complex movements required for the practice of sports activities across the age range (De Meester et al., 2020) and MC skills are beneficial for adapting movement patterns and adjusting forces to complete tasks successfully (Hulteen et al., 2023). Therefore, the primary goal when learning the basics of MC should be to adapt motor skills or create new solutions to complete tasks successfully (Biino et al., 2023). MC development can be influenced by several factors, including gender, age, weight status, geographical location, socioeconomic status, and home environment (Battaglia et al., 2021). Developing MC during childhood is crucial for engaging in appropriate sporting activities, later refined through sports training (Costa et al., 2021). Therefore, children with adequate levels of MC during development experience a positive impact on their daily life activities and demonstrate increased success and participation in sports activities (Lubans et al., 2010). However, although there is evidence that sports activity training has a positive effect on MC, this relationship has not been comprehensively studied. Indeed, very few studies have explored the potential influence of different sports training on MC development (Jaakkola et al., 2017; Marinkovic et al., 2022; Mostaert et al., 2022; Opstoel et al., 2015; Popović et al., 2020; Stanković et al., 2023).

Kristiansen and Houlihan (2017) explain that activities in early sports participation play an important role in talent development. Therefore, the role of PE teachers in encouraging children's sports participation at school is crucial. However, there are still many problems supporting early TD in Indonesia. Sudarso et al. (2019) found that the quality of pedagogical competence for PE teachers in Indonesia has not reached the standard, even though pedagogical competence is very important for successful learning. This problem should be of special concern to the Ministry of Education in Indonesia. Every child has talent, but excellent teachers, coaches, and the environment must support it. To facilitate the early TD of children in elementary school, we have developed a game-based motor coordination (GBMC) learning model. This model offers a series of enjoyable exercises that integrate various games from several sports related to motor coordination. In addition, intellectual quality is a feature of the GBMC learning model, and its focus on the intellectual aspects of the game sets it apart from traditional technique-focused approaches. The GBMC model's focus on higher-order thinking skills (HOTS) aligns with the emphasis on intellectual quality in the Teaching Quality Framework. Therefore, this research is an exploratory study of the possible relationship between PE and MC skills development, leading to improved education quality. GBMC pedagogy can be used to meet teaching quality expectations by providing high-quality learning in the teaching of games. Here we suggest pedagogical uses of the GBMC model that can be applied to other aspects of the physical education (PE) curriculum where MC and FMS are of primary concern.

Creating a game for TD tailored to primary school children involves designing an interactive and engaging platform that nurtures their talents, skills and physical activity in a fun and educational manner. Bailey and Morley (2006) highlighted the relationship between natural talent and PE, explaining that implementing programs in schools needs to be built on a foundation of high-quality PE in a general and structured manner (Usher et al., 2015). Thus, PE should be considered an adequate starting point and a key method for identifying gifted children in sports, similar to the identification process used in other school subjects.

Several years ago, research on using games in PE began to focus on elementary schools (Papagiannopoulos et al., 2023). However, there has been no focus on providing game-based learning models related to talent development. Thus, although teachers have learning models that also use games, there is a gap in further talent development. In this context, it is important to provide procedures, information, and tools for PE programs that promote the development of motor coordination, support the development of motor skills, and increase the participation of boys and girls in PE through fun and effective learning models. This study aims to determine the effect of GBMC learning model in elementary school as the starting point of talent development.

Methods

Participants

Sixty children aged 9 from one primary school in the western part of Indonesia (Sijunjung) participated in this study. One school was used as the intervention group, and one school was used as the control group. Of the participants, 32 (53%) were girls while 28 children were boys (47%). In both schools, qualified teachers managed the physical education classes. Permission was obtained from the schools and parents.

Intervention

The intervention program was developed based on previous research utilizing the Teaching Games for Understanding approach (Holt et al., 2002). However, our focus was more on learning coordination through various sports games. We selected motor coordination to improve basic skills for preparing future athletes and facilitating early talent development in physical education settings.

GBMC learning model in PE

We conducted a quasi-experimental study using a two-group design (intervention vs. control group) to analyze the effects of the GBMC learning model on motor coordination skills. For eight weeks, the physical education class in the intervention condition engaged in the GBMC learning model for 45 minutes twice a week, while the class in the control condition conducted a regular physical education class without any additional treatment. We measured all variables in both groups with time points before starting the intervention at the first meeting (pretest) and after completing all lessons at the 14th meeting (posttest). The GBMC learning model was arranged as follows:

1. *GBMC instruction.* The PE teacher informed the students that their MC performance would be evaluated twice. The students engaged in a series of sports games between the two assessments designed to enhance their coordination. Additionally, the PE teacher provided a brief (20-25 seconds) reminder of the game's objective before each lesson commenced. The PE teacher also provided a concise overview of the game's format and demonstrated the game's execution once.
2. *GBMC pair practice.* The researchers designed the game model utilized in each meeting. The teacher provided motivational instructions during the game. Each child in a pair was required to complete the game until the end, after which they had to alternate with another pair until all children had completed the game.

GBMC performance

A new edition of the Körperkoordinationstest für Kinder (KTK3+) (Body Coordination Test for Children) (Coppens et al., 2021; Kiphard & Schilling, 1974, 2007) was used to assess MC performance. This test is a widely used, valid, and reliable instrument for evaluating MC performance (Ahnert et al., 2009; de Niet et al., 2021; Mardiansyah et al., 2023; Vandorpe et al., 2011). The KTK3+ battery consists of four items:

1. Balance Beam (BB): The child maintains balance by walking backward on a 3-meter-long, 5-centimeter-high beam. The child performs this backward walk on three beams of different widths: 6 cm, 4.5 cm, and 3 cm. Three repetitions are conducted for each beam. The maximum score for one attempt is eight steps, and for three attempts, it is 24 steps. The total number of steps completed is recorded as the final score.
2. Jumping Sideways (JS): The child jumps sideways, left and right, on a block (60 cm x 4 cm x 2 cm) as many times as possible within 15 seconds, with two attempts. The number of jumps from both attempts is summed to obtain the final score.
3. Moving Sideways (MS): The child starts with both feet on one of two wooden platforms (25 cm x 25 cm x 5.7 cm) while holding the other platform. The child then places the held platform on the floor with both hands, steps onto it, picks up the previous platform, and repeats the process within 20 seconds, performing two repetitions. The number of steps taken during the two repetitions is counted and summed to obtain the final score.
4. Eye-Hand Coordination (EHC): The child throws and catches a tennis ball against a wall from a distance of 1 meter, performing the task for 30 seconds with two repetitions. The child throws the ball with the right hand and catches it with the left hand, continuing this pattern. The total number of successful catches across both repetitions is recorded as the final score.

All children were assessed under the same conditions during PE classes at school. The testers were physical education students and alumni who were trained to ensure that the test protocol was standardized. Before each subtest, the children received instructions on the test procedure. Following the guidelines, the participants performed each test barefoot. The raw scores from the overall KTK3+ test and each subtest were used for analysis.

Analysis

For the four categories of the KTK3+ subscale (BB, JS, MS, EHC, and the overall KTK3+ score) for 9-year-olds, mean scores and standard deviations were calculated for pretest and posttest scores by group (control, experimental) and gender. Repeated measure analysis of variance (ANOVA) was used to test for differences between intervention and control groups, both gender groups, and differences in KTK3+ scores over time. In a between-subjects analysis, group effects indicate the difference in mean scores at pretest and posttest between the control and experimental groups.

The interaction effect between group and measurement indicates how the differences between the control and experimental groups change over time. An alpha level of 0.05 was adopted for all significance tests.

Result and Discussion

Table 1 presents the means and standard deviations for the raw overall KTK3+ scores at pretest and posttest. Significant main effects were found for group (Wilks' $\lambda = 0.47$; $F = 6.98$; $p < 0.05$; partial $\eta p^2 = 0.533$) and gender (Wilks' $\lambda = 0.51$; $F = 3.58$; $p < 0.05$; partial $\eta p^2 = 0.488$). Figure 1 presents the improvement in KTK3+ raw scores from the pretest to the posttest for each subtest and the overall score.

A comparison of the pretest scores revealed that children in the control group (M = 184.97, SD = 25.62) demonstrated higher mean scores on the overall KTK3+ than children in the intervention group (M = 160.75, SD = 25.70). In contrast to the posttest scores, the intervention group (M=192.54, SD=21.82) demonstrated a greater total KTK3+ score than the control group (M=187.75, SD=25.10).

Table 1. Raw scores (mean and standard deviation) for the four subtests of the KTK3+ and KTK3+ overall boys and girls, and overall score of children.

	Intervention (n = 28)				**Control (n = 32)**			
	Pretest		**Posttest**		**Pretest**		**Posttest**	
	M1	***SD***	***M2***	***SD***	***M1***	***SD***	***M2***	***SD***
Overall								
Total	160.75	25.16	192.54	21.36	184.97	25.26	187.75	24.75
Boys	179.50	10.74	217.17	13.04	182.95	25.31	187.55	26.16
Girls	154.50	25.48	184.33	16.79	188.14	24.84	188.07	22.35
BB								
Total	62.5	9.29	70.29	4.03	62.53	8.11	63.86	8.79
Boys	63.5	7.29	70.83	2.86	61.64	9.51	62.27	9.42
Girls	62.17	10.04	70.11	4.40	63.93	5.24	66.36	7.33
JS								
Total	49.75	9.03	59.96	7.23	62.83	14.08	63.56	11.80
Boys	54.17	7.14	64.83	3.76	60.36	13.63	63.27	12.87
Girls	48.28	9.28	58.33	7.44	66.71	14.40	64.00	10.36
MS								
Total	35.92	6.42	41.38	6.96	40.61	5.98	40.69	4.95
Boys	40.83	5.60	49.50	6.32	41.23	5.69	40.68	5.46
Girls	34.28	5.93	38.67	4.77	39.64	6.51	40.71	4.21
EHC								
Total	12.58	8.9	20.92	10.65	19.00	11.27	19.64	11.46
Boys	21.00	5.55	32.00	8.83	19.73	10.87	21.32	11.76
Girls	9.78	8.05	17.22	8.52	17.86	12.21	17.00	10.87

Note. KTK3+ = The modifikasi Körperkoordinationstest für Kinder (KTK3+); BB = Balance Beam; JS = Jumping Sideways; MS = Moving Sideways; MS = Moving Sideways; EHC = Eye-Hand Coordination

Regarding the development of MC performance over four weeks, an interaction effect between measurement and group was found, indicating that children in the intervention group improved their scores more than those in the control group (Wilks' $\lambda = 0.57$; $F = 44.69$; $p < 0.001$; partial $\eta p^2 = 0.435$). Therefore, boys in the intervention group performed better than those in the control group in moving sideways $F (1, 56) = 13.35$, $p < 0.05$, and eye-hand coordination, $F (1, 56) = 9.93$, $p < 0.05$. No other significant interaction effects were observed between the pre and posttest scores on the subtests. The improvement in the balance beam and jumping sideways was similar between boys and girls.

As shown in Table 1, the mean value of children in the intervention group had an overall increase in KTK of 31.79 + 14.48, and that of children in the control group was 2.78 + 17.24.

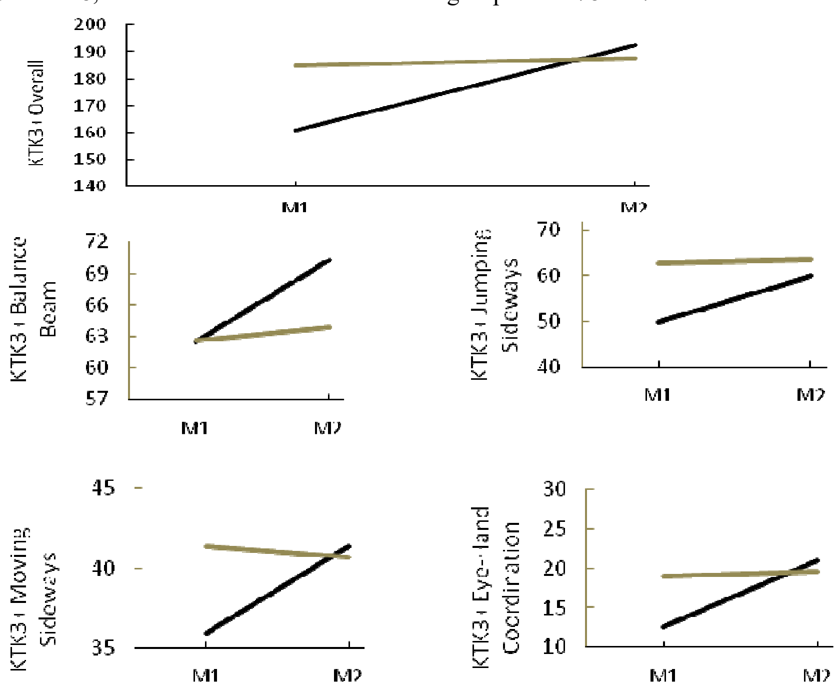

Figure 1. Raw scores before and after each KTK3+ test item for boys and girls are shown. The solid black line indicates the mean score of the intervention group, while the solid gray line represents the control group's mean score.

Conclusion

This study aimed to evaluate the effectiveness of an intervention program using the GBMC learning model, which was systematically applied to physical education classes in elementary schools. The primary purpose of this intervention was to enhance students' positive experiences and enjoyment of physical education as an initial step in talent development. Additionally, we investigated the GBMC learning model's effect on improving motor coordination skills in 9-year-old boys and girls. This study demonstrated a significant direct effect of GBMC games on enhancing movement coordination abilities in the intervention group, whereas the control group exhibited a comparatively smaller direct effect.

The large improvement in mean from subtests KTK3+ prepost test for the intervention group compared with the control group who followed a regular class is expected to be the result of the GBMC learning model. The importance of utilizing game-based learning strategies for exercise quality has been previously demonstrated among children (Astuti et al., 2023; Cocca et al., 2020; Engels & Freund, 2020).

Children in the intervention and control groups attended two 45-minute PE classes per week for four weeks. PE teachers were instructed to use the GBMC learning model to improve motor coordination performance in the intervention group. Other studies have demonstrated the value of play-based learning in enhancing children's performance and enjoyment of learning (Cocca et al., 2020; Engels & Freund, 2020; Martínez-Santos et al., 2020). In line with our results, the intervention group demonstrated a 32% increase in overall score on KTK3+ from pretest to posttest, while the control group exhibited a 3% increase (see figure 1). Additionally, significant improvements were observed in the intervention group for all variables related to KTK3+. These findings provide evidence supporting the positive effects of the developed model. This combination of methods is thought to stimulate motor coordination learning and improve motor coordination performance. However, only a small amount of time in the learning process was given to the intervention group to play games associated with motor coordination (twice per week for four weeks).

For gender, there was a significant difference in score improvement between boys and girls, with boys showing superior improvement. This result is not surprising, as boys in rural areas of Indonesia are more physically active than girls and tend to spend more of their free time outdoors. The findings of this study indicate that, at the age of 9, children are in a more favorable phase for enhancing their motor coordination abilities compared to younger ages. The greater improvement in motor coordination abilities observed in 9-year-olds can be attributed to their more comprehensive understanding of the implementation and learning objectives, as well as their ability to maximize performance more effectively due to a better understanding of the teacher's instructions. In this way, 9-year-olds are expected to engage in more structured and maximized early talent development exercises, serving as a foundational step in further talent development (Mardiansyah et al., 2023).

In consideration of the findings of this study, one important question remains as to whether there is a sustained or long-term effect due to improved motor coordination performance after the four weeks. However, some studies have shown that the differences in children's motor skill performance measured over a short period remain the same or improve after four months to two years (Matvienko & Ahrabi-Fard, 2010; Platvoet et al., 2016). Even short periods of exercise have beneficial long-term effects on motor coordination. For children in rural Indonesia, exercise often occurs no more than twice a week for 45 minutes, and sometimes more. Therefore, it is important to develop interventions that can effectively improve children's motor coordination performance with long-term effects. Therefore, this should always be considered, given the importance of improved motor coordination performance for enhancing sport-specific skills and learning in PE, as well as providing greater opportunities for children to find activities they enjoy and excel at (Clark & Metcalfe, 2002; Stodden et al., 2008).

It has been suggested that children who participate in sports and achieve higher levels of motor coordination during childhood and adolescence are more likely to remain active participants in physical activity into adulthood (Lopes et al., 2011). In fact, Tammelin et al. (2003) demonstrated in their study that participation in sport-related activities during childhood is a strong indicator of physical activity in childhood, adolescence, and adulthood. The information presented by Lopes and Tammelin provides a basis for hypothesizing the importance of developing motor skill competence as a critical approach to influencing physical activity levels and addressing obesity.

An important question that remains after this study is whether the improved motor coordination (MC) performance observed following the use of the GBMC learning model over four weeks has sustained long-term effects. Several studies have shown that differences in children's motor performance measured in the short term tend to remain stable or even increase after four months to two years (Haga, 2009; Matvienko & Ahrabi-Fard, 2010; Platvoet et al., 2016). It appears that well-improved MC performance, even after a short period of exercise, can have lasting effects. Given that children typically engage in physical activity for an average of 45 minutes twice a week at school and no more than twice a week outside of school in rural areas, it is highly relevant to develop interventions that can effectively enhance children's MC performance with long-lasting benefits. This is crucial because well-developed MC performance is important for learning and improving sport-specific skills, as well as providing children with greater opportunities to participate in activities they enjoy and excel in.

Except for football, which many children in Indonesia start at the age of 6 to 9, as did one of the children in this study, most children are not yet involved in organized sports activities. We do not have information on how much children learn motor coordination outside of PE classes or what environmental influences are involved, such as physical factors (e.g., opportunities for outdoor play, transportation to school) and social factors (e.g., parents, peers, extended family). This factor may influence individual differences in improving motor coordination performance using the GBMC learning model. A further limitation of this study is that it was conducted in only one rural school. Future research needs to increase the sample size for future implementations of this model. Indirectly, the children who demonstrated greater improvement likely engaged in more motor coordination practice outside the PE class setting. While research has demonstrated the environment's influence on improving motor coordination skills (e.g., Pereira et al., 2021), further research is still needed. In conclusion, the results of this study indicate that the environment (PE class) in which the GBMC learning model is implemented can improve motor coordination abilities over four weeks. Children who did not experience the GBMC learning model environment are expected to show less improvement in motor coordination. Considering the significance of well-developed motor coordination skills, it is important to educate PE teachers on implementing the GBMC learning model in their classrooms.

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Conflict of interest
There is no conflict of interest between the authors

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