

RESEARCH ARTICLE

The impact of a game-based educational program on enhancing coordination and balance in elementary school students

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Abstract

Aim: The purpose of this study was to investigate the potential effects of a game-based educational program on enhancing compatibility and equilibrium among elementary school students. **Method:** The study involved 50 participants divided into two groups of 25 each, with one group designated as the experimental group and the other as the control group. The groups were carefully selected to ensure their similarity and equivalence. The educational program comprised 12 sessions, during which two assessments were conducted to measure motor compatibility and two additional assessments were carried out to assess balance. **Results:** Statistical analysis, including mean calculation, standard deviation determination, and t-testing, revealed that the game-based educational program had a positive impact on the participants' balance, adaptability, and related attributes. **Conclusion:** The findings suggest that activity-focused programs can contribute to the overall development and progress of individuals, as evidenced by the differences between the experimental and control groups. Therefore, integrating game-based programs into physical education and sports curricula may have a more significant influence than traditional approaches, as demonstrated by the improvements in balance and coordination observed in this study.

Keywords: Balance, coordination, games, primary school, program, students.

Introduction

Numerous studies have shown that elementary education plays a crucial role in a child's socialization, development, and academic success. It is a vital stage in the acquisition of knowledge and is widely recognized as an effective way to equip future generations with the necessary skills for success in future careers (Hassan, 2020). Different teaching methods can be used to enhance elementary education, allowing educators to tailor their approaches to meet the needs of diverse learners.

Game-based learning, both digital and non-digital, has been highlighted as an effective tool for learning and acquiring new concepts and skills (Grace, 2019). Kula and Syafii (2021) recommend integrating game-based learning into educational programs to enhance children's learning and educational outcomes. Boctor (2013) suggests that game-based learning can motivate students to apply knowledge from various areas and make decisions, as well as show them the consequences of their choices on game outcomes.

Furthermore, game-based learning encourages students to interact with their peers, discuss game-related strategies, and improve their social skills through collaboration (Adipat et al., 2021).

The importance of regular physical activity for children's physical development is supported by the World Health Organization and the American Academy of Pediatrics. They recommend daily, high-quality physical education classes from kindergarten to high school to enhance

academic performance, physical health, and fundamental motor skills through structured learning programs (Seghir et al., 2024). However, in Algeria, surveys show that primary schools only allocate an average of 45 minutes per week to physical education (Zerf, 2016), leading to a sedentary lifestyle and a decline in fundamental motor skills, affecting psychomotor and cognitive development (Oktarifaldi et al., 2020).

Based on the above and the importance of coordination and balance on psychomotor and cognitive aspects in primary school children, our aim in this study is: 1) Examining the influence of two proposed programs on motor coordination and balance among samples. 2) Examine the impact of the play-based educational program versus traditional physical education on motor coordination and balance development.

Research hypothesis

Taking into consideration the previous issues, the researchers formulated the following hypotheses: 1) There are significant differences in favor of all the post-tests compared to the pre-tests. 2) All post-tests show a preference for the proposed program over traditional physical education lessons.

Methods

The researchers decided to use the experimental method as it was the most suitable approach for the research and the specific problem at hand.

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Participants and procedure

The research cohort consists of students from Amir Abel Kader Primary School in the Ben Dawud municipality. The school has a five-grade class system and a total enrollment of 2000 male students. The study focused on 50 fourth-grade students, representing 20% of all fourth graders in the province. These students were divided into two classes taught by the same teacher. To ensure research equivalence and homogeneity, variables such as gender (25 males), grade level, age in months, weight in kilograms, height in centimeters, and the specific test used in the study were considered.

Table 1. Equivalence and homogeneity of the samples (Mean $\pm$ SD).

Variables	EG (n: 25)	CG (n: 25)	<i>t</i>	<i>p</i>
Age (month)	10.56 $\pm$ 1.22	10.62 $\pm$ 1.51	0.44	NS
Weight (kg)	33.85 $\pm$ 1.58	34.02 $\pm$ 1.45	1.34	NS
Height (cm)	136.22 $\pm$ 1.02	136.88 $\pm$ 1.05	0.87	NS
JR (point)	2.48 $\pm$ 0.73	2.36 $\pm$ 0.69	0.50	NS
NC (point)	15.20 $\pm$ 1.74	14.36 $\pm$ 1.71	1.35	NS
TTM (sec)	4.80 $\pm$ 0.86	4.92 $\pm$ 0.82	0.40	NS
TSF(sec)	37.04 $\pm$ 4.12	38.75 $\pm$ 3.52	1.26	NS

EG: Experimental group; CG: Control group; JR: Jump rope; NC: Numbered Circuits; TTM: Transition test over the marks; TSF: Test of standing foot.

Testing Procedures

Jump Rope Test: The purpose of the test is to assess the coordination between the eyes and the upper and lower limbs.

Equipment: A 60.96 cm rope with two knots marked 30.48 cm apart.

Test Procedure: The tester holds the rope at the designated points, jumps over the rope as it passes in front of and under the feet, and repeats this sequence five times.

Scoring: One point is awarded for each successful attempt, with a maximum score of 5 points.

Implementation Instructions:

- Observe the teacher's demonstration and attempt to replicate the technique.
- Focus on the task upon receiving the starting signal and assume the correct position.
- Jump over the rope and through the hands.
- Land with both feet together.
- Avoid touching or disrupting the rope during the test.
- Maintain balance and prevent any falls during the test (Hasanein, 1999).

Numbered Circuits Test: This test is designed to assess the coordination between the eyes and lower limbs.

Equipment: Eight circles, each with a 20 cm diameter, are marked on the ground and numbered. A timer is used to measure the time taken.

Test procedure: The tester starts in circle number 01 and, upon the signal, jumps with both feet together to circle number 02, and then progresses through the remaining circles in numerical order up to 08, aiming to complete the task in the shortest time possible.

Results recording: The time taken for the tester to move from circle 01 to 08 is recorded.

Execution instructions:

- Notify the lab to proceed swiftly without any interruptions.
- Demonstrate the technique of jumping with both feet while following the numbered circles.
- Ensure that the task is finished by the conclusion of the 8th circle (Hassanein, 2000).



Figure 1. Rope jumping test.

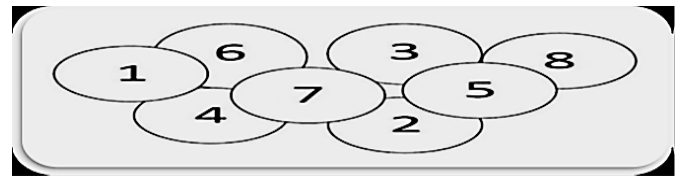


Figure 2. Numbered circuits test.

Transition test for balance assessment (TM):

Test objective: Evaluate the capacity to maintain balance during movement.

Equipment needed: Ten circles arranged in a broken line, stopwatch, colored adhesive tape, colored chalk, measuring tape.

Performance specifications: The tester stands at the starting mark with their right foot and then jumps to mark number 01 with the ball of their left foot, ensuring the entire mark is covered. They aim to hold this position for as long as possible, up to a maximum of 5 seconds, and continue in the same manner until reaching mark number 10. The tester must switch the landing foot for each jump, and the distance between marks is 30 cm.

To record the results, the tester earns 10 points for each jump attempt. Five points are given for a correct jump where the landing is on the ball of the foot, completely covering the mark. The remaining five points are awarded if the tester can jump again after landing correctly, resulting in a total score of 10/10.

Execution instructions:

- Making efforts to adjust models post-implementation.
- Leap up and then forward with the foot beside the circle.

- Clear the hurdle and aim to maintain the position for up to 5 seconds.
- Maintain consistency in the task until completion (Hassanein, 2004).

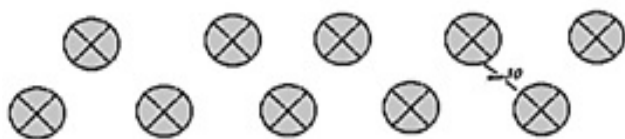


Figure 3. Test of transition over markers.

Test of standing foot: Objective of the test is to assess static balance by having the subject stand on the ground on the ball of the foot.

Equipment needed: Stopwatch, designated work area.

Test procedure: The tester stands on one foot, preferably the take-off foot, with the other foot placed on the inner side of the knee of the standing leg. Hands are placed in the middle, and upon a signal, the tester lifts the heel off the ground and maintains balance for as long as possible without moving the toes or touching the heel to the ground.

Recording results: The best time is determined from three attempts, starting from when the heel lifts off the ground until performance errors or loss of balance occur.

Execution instructions: Standing tall and facing ahead.

The man positioned the worker before the task.

- Keep your hands still and avoid any sudden movements to stay balanced.
- The man will not be altered while working.
- There is no set time limit for the task (Ibrahim, 1999).



Figure 4. Toe stand test.

Proposed Learning Program

Based on our research of scientific sources on games (Adipat et al., 2021), we developed our program proposal with the following guidelines: Both groups were comprised of 12 educational units, each lasting 45 minutes.

The educational units in the proposed games program featured the same games as the control group's model. The key difference between the two programs was the incorporation of educational instructions. While the traditional PE lessons used competitive games to evaluate student performance and progress, the proposed program focused on assessing both motor skills and cognition by integrating colors and numbers as indicators.

The initial four weeks were dedicated to familiarizing participants with the proposed games, followed by four weeks focused on addressing cognitive errors, and concluding with four weeks dedicated to evaluating cognitive performance through rapid problem-solving tasks. For example, one game involved "jumping inside circles" arranged in a straight line. In a conventional lesson, success was determined by the speed of jumping inside the circles. However, in the proposed program, we introduced additional challenges by assigning colors to the circles, such as jumping in red circles and avoiding blue circles. Participants were instructed to jump inside even-numbered circles while avoiding odd-numbered circles.

Statistical Analysis

Mean and standard deviations (SD) were calculated using descriptive statistics, and independent t-tests were used to compare between-group differences at baseline. Paired t-tests were conducted to compare within-group performance differences between the pre-intervention and post-intervention periods.

Results

Table 2 displays notable enhancements in post-test scores for students in the control group, which the researchers attribute to the physical education lesson incorporating numerous small and motor games that directly enhanced motor fitness.

Table 2. Shows the results of pre- and post-test in rope test of control group.

Variables	Upper	Lower	Mean	SD	t	p
Pre-test	04	01	2.36	0.69	3.98	NS
Post-test	04	02	3.04	0.54		

Table 3 shows a significant improvement in the test scores of students in the experimental group, which the researchers credit to a program that specifically targeted motor fitness.

Table 3. Results of pre-post-test in rope test of experimental group.

Variables	Upper	Lower	Mean	SD	t	p
Pre-test	04	01	2.48	0.73	6.60	$p < .05$
Post-test	05	02	4.24	0.66		

Table 4 demonstrates notable enhancements in the post-test scores of the control group students, which the researchers attribute to the inclusion of various small and motor games in the physical education lesson that directly enhanced motor fitness.

Table 4. Results of the pre-post-test numbered circuit test of the control group.

Variables	Upper	Lower	Mean	SD	t	p
Pre-test	19	11	14.36	1.71	1.97	$p < .05$
Post-test	20	08	12.92	3.11		

Table 5 demonstrates a notable enhancement in post-test scores among students in the experimental group, attributed by the authors to the incorporation of motor games and cognitive directives that improved eye and lower limb coordination. These findings are consistent with the research conducted by Othmani & Haddouchv (2022) and are supported by the inclusion of the Numbered Circuits Test as a control measure in this study.

Table 5. Results of the pre-post-test in the numbered circuit test of the experimental group.

Variables	Upper	Lower	Mean	SD	t	p
Pre-test	20	11	15.20	1.74	14.95	$p < .05$
Post-test	10	06	08.16	0.96		

The results from Table 6 on coordination tests involving eye-hand and eye-foot coordination indicate that the experimental group exhibited more favorable outcomes compared to the control group.

Table 6. Results of post-test in coordination tests used between experimental and control group.

Post-Test	EG		CG		t	p
	Mean	SD	Mean	SD		
Jump Rope	4.24	0.66	3.04	0.54	2.58	NS
NC	08.16	0.96	14.36	1.71	3.24	$p < .05$

NC: Numbered Circuits

Table 7 demonstrates a notable enhancement in post-test outcomes for students in the control group, attributed by the authors to the motor games physical education program that improved Dynatec balance. These findings are consistent with the research of Othmani & Haddouchv (2022) and are supported by the inclusion of the Transition test as a control measure in this study.

Table 7. Results of pre-post test results in the transition test above the marks for the control group.

Variables	Upper	Lower	Mean	SD	t	p
Pre-test	07	03	4.92	0.82	2.00	$p < .05$
Post-test	08	03	5.40	1.13		

Table 8 demonstrates a notable enhancement in post-test scores for students in the experimental group, attributed by the authors to the program-based game designed to improve Dynatec balance. These findings are consistent with the research of Othmani & Haddouchv (2022) and are supported by the inclusion of the Transition test as a control measure in this study.

Table 8. Results of the pre- and post-test in the transition test above the marks for the experimental group.

Variables	Upper	Lower	Mean	SD	t	p
Pre-test	07	03	4.80	0.86	10.41	$p < .05$
Post-test	10	06	8.16	1.10		

Table 9 displays a notable enhancement in post-test outcomes for students in the control group, attributed by the authors to the motor games physical education program that improved static balance. These findings are consistent with the research of Othmani & Haddouchv (2022) and are supported by the inclusion of the standing foot test as a control measure in this study.

Table 9. Results of the control group standing foot test in the pre- and post-test.

Variables	Upper	Lower	Mean	SD	t	p
Pre-test	49	32	38.75	3.52	1.90	$p < .05$
Post-test	47	33	40.48	3.45		

Table 10 displays a notable enhancement in post-test scores for students in the experimental group, attributed by the authors to the program suggested that improved static balance. These findings are consistent with the research of Othmani & Haddouchv (2022) and are supported by the inclusion of the standing foot test as a control measure in this study.

Table 10. Results of the pre- and post-test standing foot test for the experimental group.

Variables	Upper	Lower	Mean	SD	t	p
Pre-test	49	28	37.04	4.12	20.75	$p < .05$
Post-test	102	57	82.24	10.31		

The findings presented in Table 11 indicate that the experimental group outperformed the control group in balance assessments, whether they were dynamic or static.

Table 11. Results of post-tests in balance tests used between the experimental and control groups.

Post-Test	EG		CG		t	p
Transition	8.16	1.10	5.40	1.13	4.66	$p < .05$
Standing foot	82.24	10.31	38.75	3.52	9.44	$p < .05$

Discussion

Based on the pre-tests used in this study (Table 1), it is observed that there are no statistically significant differences between the two groups in the motor compatibility or balance test compared to the post-test. All paired t-tests show significant improvements for the experimental group. In contrast, the control group did not show significant progress in motor skills compared to the experimental group.

The researchers attribute the significant improvement in the experimental group to the specific program's emphasis on balance, coordination, and dynamic games involving the eyes, hands, feet, and whole body. The post-test results of the experimental group versus the control group were confirmed by Betker et al. (2006), who found that the use of interactive games in the exercise program motivated participants to extend their workout sessions and improve their focus.

Pin (2019) highlighted the close relationship between balance development and cognitive abilities. Integrating

visuospatial cognitive activities with balance training, as noted by Szturm et al. (2022), improved dynamic balance control in subjects, aligning with the characteristics of the age group and motivating children to achieve developmental objectives related to balance and other qualities, as discussed by Ndlovu et al. (2023) and Kouassah (2018).

Evridiki et al. (2004) emphasized that the most significant aspect of motor development is compatibility, which includes balance, rhythm, and movement speed.

The selected games in the program helped students adapt to various situations and improve coordination between the eyes and other body parts, leading to the development of motor speed, as discussed by Maamri et al. (2022).

The researchers also attribute the development of motor skills to the effectiveness of exercises performed at a lower speed and specific times and repetitions, as discussed by Hüseyin et al., (2023). Additionally, the development of neuromuscular compatibility through exercise fitness was found to enhance muscle contraction speed, as mentioned by Nikolaou (2024). These findings support the suggestions of Arischo et al. (2024) regarding the improvement of coordination, lateral balance, and speed through targeted exercises.

Therefore, we concur that integrating educational instruction into the proposed game-based program is beneficial. These complications are defined as challenges that necessitate heightened attention and focus. The results show an advantage for the experimental group over the control group, which underwent training with the same games but without mental challenges. The control group focused on solving game problems quickly. Given this, we recommend that physical education and sports teachers in elementary schools incorporate implicit learning through integrative poses or game complexities. This approach allows learners to manipulate the game environment and enhance their auditory or visual responses, thereby improving their motor skills and physical abilities in problem-solving tasks. It is important to emphasize the importance of diversifying challenges beyond time constraints to enhance a child's performance.

Conclusion

The study results confirm that specific game instructions, such as cognitive tasks like mental calculation or color adjustment, can improve hand-eye and foot-eye coordination, as well as static and dynamic balance in Algerian primary school children. The differences between the experimental group and the control group in the post-test study support the benefits of the experimental group. The inclusion of various responses in game instructions helps improve students' behavior and adaptation to motor problem-solving tasks, reducing both execution time and the total number of errors.

Authors' Contribution

Study Design: AAH, BK, MZ; Data Collection: AAH, BK; Statistical Analysis: MZ; Manuscript Preparation: AAH, BK, MZ.

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Conflict of Interest

The authors hereby declare that there was no conflict of interest in conducting this research.

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