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The Effect of Selected Motor Games on Executive Functions of Children with Developmental Coordination Disorders

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Abstract

Background: This study aimed to determine the effect of selected motor games on executive functions of children with developmental coordination disorders.

Methods: This was an experimental study with pretest-posttest design conducted in Tehran, Iran. The participants were 30 children who were identified and selected based on diagnostic criteria in two stages and were randomly divided into experimental and control groups. The experimental group performed motor games for 24 sessions during eight weeks, three sessions per week, every other day, and each session for 45 to 60 minutes. In the pretest and posttest, the Coolidge Executive Functioning scale (2002) was used to measure the Executive Functions of the subjects. Disorder Levels were measured using the data analyzed through SPSS software version 22.

Results: The results showed that after controlling the pretest levels, organizing, inhibition, decision making-planning, and the overall score of executive functions in the experimental group were significantly lower than the control group, in the posttest ($p < 0.05$).

Conclusion: Based on the results, the motor games intervention for eight weeks effectively improved the executive functions of children with developmental coordination disorders and can be used as an appropriate intervention.

Key Words: Childhood, Cognitive development, Developmental Coordination Disorders, Motor game, Motor interventions.

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1- INTRODUCTION

The Developmental Coordination Disorder (DCD) occurs in childhood, with a 6% prevalence in children (1); and 3 to 7 times more likely to occur in boys than in girls (2). Children and adolescents with this disorder are less likely to engage in activities requiring physical and motor responses and show intolerance, failure, and low self-esteem (3, 4). Studies have shown that children with the disorder have difficulty not only in motor control (5), but also in psychosocial adaptation (such as low self-confidence, depression, anxiety, and loneliness), cognitive control (6, 7), and also in executive functions (7). Executive functions are responsible for the individual's participation in purposeful and organized perceptions, emotions, thoughts, and actions dependent on brain function, especially the Prefrontal Cortex (8), and review and regulate cognitive processes during complex cognitive tasks (9). Studies in children with developmental coordination disorders have shown that these children suffer from failure in some components of executive functions such as organization, decision making, planning, purposeful movements, adjusting speed and new movements, working memory, inhibition, and executive attention (10, 11). In case of the lack of an early diagnosis and proper treatment for neuropsychiatric disorders such as executive dysfunction, such problems persist at an older age, resulting in problems for children in doing homework and social behaviors (12). It has been suggested that early educational and psychological interventions are effective in improving basic skills or growth indicators, including executive functions and children's attention (13, 14); therefore, such problems in children can be resolved by timely interventions, such as play therapy. According to Piaget and Vygotsky, play is the main factor in a child's cognitive development. Neuromuscular and perceptual-cognitive development is due to the early games during brain development, quantitatively and qualitatively. The golden period of a child's development goes through play, and children first understand and know themselves and then the world in the natural process of games (15). This study examines the effect of the selected motor games on the executive functions of these children due to the weakness of children with developmental coordination disorders in executive functions and the need for play-based intervention programs.

2-MATERIALS AND METHODS

2-1. Study design and population

This study was experimental with a pretest-posttest design, and a control group. The statistical sample included 30 elementary school students in Tonekabon selected by purposeful sampling. First, 50 children suspected of developmental coordination disorder were identified by school physical educators. Then, their parents were asked to complete the DCDQ questionnaire. Children who scored less than 45 on the questionnaire were considered as children with DCD. After obtaining written parental consent, 30 students were selected as the sample and randomly divided into experimental (15 children) and control (15 children) groups. Parents were also assured that all relevant information would be kept confidential.

2-1.1. Inclusion and exclusion criteria

Inclusion criteria were the developmental coordination disorder, parental consent, calendar age of 9 to 12 years, and lack of physical and motor problems and exclusion criteria were not completing the questionnaire, not attending the posttest on time, and more than three sessions absence.

2-2. Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki, approved by the Department of Psychology and Educational Sciences Ethics Committee, and written informed consent was obtained from all subjects prior to inclusion.

2-3. Assessment Tools

The data collection instruments, in the present study, were the Developmental Coordination Disorder Questionnaire (DCDQ) and the Coolidge Executive Functioning Scale.

2-3-1. Developmental coordination disorder questionnaire

This is a suitable criterion for children with DCD. This questionnaire should be responded to by the parents to identify 5-to-15- year-old DCD children. It has 15 questions on a 5-point Likert scale. Children with a score below 45 on this questionnaire are considered to suffer from DCD. The validity and reliability of the present questionnaire are reported as 88% and 83%, respectively (16).

2-3-2. Executive Functioning questionnaire

Coolidge Executive Functioning scale (2002) was developed to examine some neuropsychological and behavioral disorders in 5-to-17-year-old children and adolescents. This questionnaire assesses executive function deficits. Each disorder in this test has a specific and separate subscale that two of these subscales with 19 items evaluate executive functions. This test has a 4-point scale: 1- never, 2- sometimes, 3- usually, 4- always. So never is assigned 0, sometimes 1, usually 2, and always 3. Questions 1 to 8 assess the planning decision-making function, questions 9 to 16 organization, and questions 17 to 19 inhibition. In Coolidge et al., Cronbach's alpha reliability coefficient for this scale was 0.84, and its test-retest reliability was 0.81 (17). Cronbach's alpha showed an internal consistency of 0.91 and 0.81 for organization, 0.82 for decision-making, and 0.52 for inhibition (18).

2-4. Intervention

The Selected games are played for 24 sessions (eight weeks), three sessions per week, every other day, and each session for 45 to 60 minutes (**Table 1**). Each session consists of a 10-minute warm-up, a 45-min movement intervention, and a 5-min cool down. The warm-up phase includes walking and stretching exercises specified for each child. Selected games include children's sensory-motor and creative games, gross and fine movements, ball exercises, and balance. Also, light and gentle stretching movements are performed to cool down for five minutes at the end of each session (19-21). In the implementation phase, the executive functions were first assessed using a questionnaire. Then, the experimental group performed a movement program including the selected games in 24 sessions. The control group performed daily activities during the intervention and did not have any other practical and regular sports activities. Parents were again asked to complete the Executive

Functioning Scale at the end of the last session.

Table-1: Game-based movement intervention in the present study

Session	objective	Content
1	Coordination	plate skating, hop, paper plates, and Wheel mill
2	Perception	Receive balls of different sizes and weights with both hands and one hand, hit the ball to the ground and catch it, throw the ball in the air and catch it
3	Fine skills	Painting with both hands, painting with water, clock game, and rhythmic movements
4	Sensory-motor	Jumping and hopping on a trampoline, throwing, catching, and touching
5	Gross skills	Walking like different animals (elephant, rabbit, crab, cat, and duck), toy box and walking on the line
6	balance	Walk on a straight line, walk on heels and toes and move on paths drawn on the ground
7	Coordination	plate skating, hop, paper plates, and Asiyab Becharkh, throw the ball in the air and catch it
8	Perception	Receive balls with different sizes and weights with both hands and one hand, hit the ball to the ground and catch it, throw the ball in the air and catch it
9	Fine skills	Painting with both hands, painting with water, clock game, and rhythmic movements
10	Sensory-motor	Jumping and hopping on a trampoline, throwing, catching, and touching.
11	Gross skills	Walking like different animals, stone - footprint, toy box, walking on the line and throwing the ball towards the wall
12	balance	Walk in different directions and different step sizes and on different surfaces
13	Coordination	plate skating, hop, paper plates, and Asiyab Becharkh, throw the ball in the air and catch it
14	Perception	Receive balls with different sizes and weights with both hands and one hand, hit the ball to the ground and catch it, throw the ball in the air and catch it
15	Fine skills	Painting with both hands, painting with water, clock game, and rhythmic movements
16	Sensory-motor	Jumping and hopping on a trampoline, throwing, catching, and touching
17	Gross skills	Walking like different animals (elephant, rabbit, crab, cat, and duck), stone - footprint, toy box, walking on the line, throw the ball towards the wall
18	balance	Walking on the ground with a ball and in different directions
19	Coordination	Throw the ball with one hand and both hands forward and backward in sit and stance positions and Static Dribbling with the ball with both hands and one hand
20	Perception	Throw in the air the ball and catch it, balloon volleyball, chasing a balloon, and hitting a balloon in the air
21	Fine skills	Play with fingers, cut paper with scissors with the dominant and non-dominant hand
22	Sensory-motor	Jumping and hopping on a trampoline, throwing, catching, and touching
23	Gross skills	Zigzag jump in large and small steps, jump from a mat on another mat, throw a large ball and kick it
24	balance	Walking and running on marked paths on the ground

2-5. Data Analysis

For data analysis, the Smirnov Kolmograph test and analysis of covariance were used. The significance level was $p < 0.05$.

3- RESULTS

The demographic characteristics of the participants are demonstrated in **Table 2**.

Table-2: Demographic characteristics of the participants.

Groups	Age (years) (Mean± SD)	Weight (kg) (Mean± SD)	Height(cm) (Mean± SD)
Experimental	10.8±0.4	34.3±5.6	137.7±9.5
Control	10.6±0.5	33.9±5.9	136.5±7.5

The results of Kolmogorov-Smirnov test the normal distribution of the data ($p > 0.05$). After examining the assumptions of analysis of covariance, four series of analysis of covariance were used for intergroup comparisons in which the group variable (experimental / control) as an independent variable, the number of decision making-Planning, organizing, inhibition and overall executive functions was considered as dependent variables and pretest values of the variables were considered as a control variable.

The results of these analyzes are presented in **Table 3**. The results regarding the Decision making-planning showed that after controlling the effect of the pretest, the impact of the group on decision making-planning is statistically significant ($\eta^2 = 0.39$, $p = 0.001$, $F = 17.437$), meaning that there is a significant difference between the experimental and control groups in the posttest. Also, the results regarding the Organizing showed that after controlling the effect of the pretest, the impact of the group organizing is statistically significant ($\eta^2 = 0.48$, $p = 0.001$, $F = 29.112$), meaning that, in the posttest, there is a significant difference between the experimental and control groups in this variable. Also, the Inhibition results showed that after controlling the effect of the pretest, the impact of the group on the inhibition was statistically significant ($\eta^2 = 0.33$, $p = 0.001$, $F = 13.747$), meaning that there is a significant difference between the experimental and control groups in the posttest. Also, the results of the overall score of executive functions showed that after controlling the effect of the pretest, the impact of the group on executive functions is statistically significant ($\eta^2 = 0.54$, $p = 0.001$, $F = 32.844$), meaning that there is a significant difference between the experimental and control groups in the posttest. Considering the mean values of the groups in the posttest, it can be concluded that the score of decision making-planning, organizing, inhibition, and the overall score of executive functions in the experimental group is significantly lower than that in the control group. In other words, the motor games had a significant effect on decision making-planning, organizing, inhibition, and children's overall executive functions score. ETA also indicates that 39% of the reduction in Decision making-

planning, 48% of the decrease in Organizing, 33% of reduction in Inhibition, and 54% of reduction in the overall score of executive functions in children is derived from the effect of motor games.

Table-3: summary of covariance analysis results

Variables	Phase	Experimental (n=15)	control (n=15)	F	P	η2
		Mean ± SD	Mean ± SD			
Decision making-Planning	Pretest	12.6±5.5	12.3±5.8	17.437	0.001	0.39
	Post-test	10.7±5.4	12.1±5.5			
organizing	Pretest	9.4±3.5	9.5±3.6	29.112	0.001	0.48
	Post-test	6.7±3.1	9.2±3.3			
inhibition	Pretest	4.8±2.3	4.7±2.2	13.747	0.001	0.33
	Post-test	3.4±2.1	4.6±2.3			
executive functions (overall)	Pretest	23.7±5.6	23.3±5.8	32.844	0.001	0.54
	Post-test	21.4±4.4	22.9±4.6			

SD: Standard Deviation.

4- DISCUSSION

This study examines the effectiveness of the selected motor games on executive functions of children with developmental coordination disorders. The results showed that the eight-week motor games increased children's executive functions compared to the control group. Also, the ETA squared showed that motor games contribution was 48% of the increase in organizing, 34% increase in inhibition, 39% increase in decision-planning, and 54% increase in executive functions of children with developmental coordination disorders. These findings are consistent with Benzing et al. (22), Pan et al. (23).

The impacts of cognitive rehabilitation have been well documented on children's executive functions with DCD, and the knowledge is growing, but the effects of motor games on executive functions are unknown. According to the findings of the present study, the eight-week motor games impact and improve the executive functions of children with developmental coordination disorders. Motor games require children to organize their behaviors and process information and make decisions about movement, so it seems that these games engage the mind and body of children in this study, regulate children's behaviors and improve executive functions in these children. These results are in line with the present study's findings regarding the positive effect of motion game interventions on improving executive functions in Children with DCD. Therefore, it can be said that although the executive functions of children with DCD are weaker than healthy children, the effect of motor games on the executive functions of these children is significant and important. This can help solve their problems to some extent (24). Improving executive functions due to motor games can also be used to activate the nervous system (25), increase visual perception along with increasing visual signals (26), and improve nervous and cognitive health (27), increase information

processing performance (28), and increase the efficiency of neurotransmitters (29). For example, executive functions are a function of the prefrontal cortex (30). The prefrontal cortex is a large area in front of the precentral gyrus which includes most superior, middle, and inferior frontal gyrus, orbital gyri, most of the internal frontal gyrus, and Anterior cingulate gyrus (31). The prefrontal cortex acts in close contact with the motor cortex to plan complex patterns and sequences of motor actions. Most of the output signals from the prefrontal cortex to the locomotor system pass through the caudal portion of the basal-thalamus feedback circuit for motor programming. This part provides many parallel and sequential components of motor stimulation. The prefrontal cortex is essential for long-term thought processes in the brain. This is probably due to some of the same capabilities of the prefrontal cortex that make it possible to plan motor activities. This area can also process non-motor information from large areas of the brain, and as a result, makes non-motor types of thinking possible along with motor types of thinking, and a type of short-term memory called working memory is saved in this area (32). Also, inhibition, which is one of the executive functions, is formed in the prefrontal cortex. The brain is a flexible organ that can regain its lost function. In the brain recovery process, other brain areas gradually take over the functions of the damaged parts, and new neural pathways are formed. Cognitive and motor activities minimize the adverse effects of brain damage by helping the brain recognize and shape these alternative pathways (33). This evidence provides a possible explanation for the findings of the present study that the participants' executive functions improved through motor games. The results of the present study showed that selected motor games impacted the function of the organization and improved the function of the organization in the experimental group as compared to the control group. Poor organization function is the cause of many of DCD children's behavioral disorders in planning and optimal use of time, the correct use of paper in writing (34), academic performance, and routine homework. In fact, it can be said that the inability of the child to organize challenging and new tasks is probably due to the weakness of children with developmental coordination disorders in the organization function. Past research has shown that organization is mainly related to the proper functioning of the frontal and prefrontal cortex (35) and that motor activities such as taekwondo improve sensory organization and balance in children with developmental coordination disorders (36). Other results of the present study showed that selected motor games impacted the decision-planning function and improved the decision-planning function compared to the control group. The decision making-planning function has a significant role in academic performance, planning, relative motor strength, and voluntary movements (37). This finding helps researchers better understand the cause of poor academic performance and motor planning in children with developmental coordination disorder. The decision-making function allows the child to delay the acquisition of the reinforcer and to engage in homework and daily activities in a task-oriented manner. As in previous research, the present study's findings showed that

motor games significantly improve decision-making (38, 39). Also, regarding the inhibition variable, the findings indicated that the selected motor games impacted the inhibition function and improved the inhibition function compared to the control group. Based on the inhibition model (40), it is suggested that the proper functioning of executive functions depends on the proper inhibition function in the frontal and prefrontal cortex. In other words, when inhibition functioning is not performed properly, the executive functions will not function properly, and as a result, the person has difficulty in motor control and construction. This finding is consistent with the research that shows that cognitive exercise improves inhibition function (41, 42). The findings of the present study suggest that teachers, parents, and therapists should be informed on the limitations and relative benefits of different treatments, and it should be, further, taken into account that the treatments such as play therapy do not require formal situations and special instruments and can be applied in a different situation and have associated with fewer dependencies and side effects. Therefore, it is recommended that motor games be used as an independent intervention to address the weakness in the executive functions of children with developmental coordination disorders.

4-1. Limitations of the study

One limitation of this research was that the subjects were from only one gender. Additionally, we faced non-cooperation of some parents, and the lack of accurate screening of children in terms of psychological status. Furthermore, the findings should be generalized carefully because the samples were not selected from specific centers.

5- CONCLUSION

According to the results, motor games are beneficial in improving executive functions in children with developmental coordination disorder, because along with being attractive and pleasant, they can meet motor requirements and challenge motor and cognitive systems.

6- CONFLICT OF INTEREST

None

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