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# The Effect of Selected Motor Games on Fine Motor Skill Development in Children with Developmental Coordination Disorder

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## Abstract

**Background:** Effective interventions for motor impairments in children with developmental coordination disorder (DCD) remain a critical need.

**Objectives:** This study investigated the efficacy of a structured motor games program in improving fine motor skills among children with DCD.

**Methods:** In a pretest-posttest controlled design, 40 children with DCD (diagnosed via the Wilson DCD Assessment) were randomly assigned to either an experimental or control group. The experimental group participated in 18 sessions (60 minutes each) of selected motor games, while the control group received no intervention. Motor proficiency was assessed before and after the intervention using the Bruininks-Oseretsky Test of Motor Proficiency (BOT-2). Data were analyzed using ANCOVA in SPSS ($\alpha = 0.05$).

**Results:** The experimental group showed significant improvements from pre to post-test in response speed, visual-motor control, upper-limb speed and agility, and overall fine motor scores ($p < 0.05$). Post-test comparisons also revealed statistically significant differences between groups in these variables.

**Conclusions:** The findings support the effectiveness of structured motor games in enhancing fine motor skills in children with DCD. Integrating such programs into therapeutic protocols may help address developmental coordination deficits.

*Keywords:* Childhood, Developmental Coordination Disorder, Fundamental Motor Skills, Sensitive Period

## 1. Background

Developmental coordination disorder (DCD) is defined as a severe, long-lasting, and chronic impairment of children's motor skills coordination development that lowers their functional performance and is not brought on by intellectual retardation, pervasive developmental disorder, or any other neurological condition (1). Children diagnosed with DCD are often stigmatized as clumsy or demonstrating poor coordination, and their performance in both fine and gross motor skills during game and sports activities is consistently inferior to their age-matched peers (2). Motor skills serve as the foundational underpinning for the development of more complex motor abilities, and their profound impact on an individual's social and personal life throughout childhood and adulthood underscores their significance (3). The delayed reaction time hypothesis posits that children with developmental disorders exhibit a slower processing speed, taking longer to perceive and respond to environmental stimuli compared to their typically developing counterparts (2). Furthermore, deficits in fundamental motor skills, coupled with attentional and memory impairments, contribute substantially to challenges in academic, cognitive, social, and motor functioning among individuals with DCD (4). Consequently, DCD has been a persistent concern for parents, educators, and researchers in the fields of kinesiology and rehabilitation, leading to the development of various interventions aimed at



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ameliorating or mitigating the associated symptoms (5). The efficacy of interventions designed to enhance motor proficiency in children diagnosed with DCD is a subject of considerable interest. A substantial body of research indicates that diminished motor skills are correlated with decreased participation in physical activities and group games. Moreover, reduced motor competence can adversely impact self-perceived competence and self-esteem, often leading to avoidance of sports and physical activities (6). While numerous studies have demonstrated the potential of interventions to mitigate the motor difficulties associated with DCD, the specific efficacy of various intervention modalities remains inconclusive. For instance, Jokar Tang Karami et al. (7) reported significant improvements in gross motor skills following a 12-week selected physical activity program. Similarly, Shahrbanian and Hashemi found that an eight-week core stability training program led to notable enhancements in balance and reaction time (8). Furthermore, research has consistently indicated that selected exercise interventions can improve sensory-motor functions and manipulation skills in children with DCD (9, 10). However, the results of intervention studies have not been uniformly positive. De Milander et al. (11) found no significant improvements in motor proficiency following a ten-week sensory-motor training program. Likewise, Kordi et al. reported significant improvements in static balance but not dynamic balance following a 12-week strength training intervention (12). Given the inconsistent findings in the literature and the core motor impairment underlying DCD, it is imperative to conduct further research to delineate the optimal types of motor training for enhancing motor proficiency in this population (6).

Game, a fundamental aspect of early childhood development, serves as a catalyst for significant developmental milestones. Simple, rudimentary game acts as a precursor to the acquisition of complex motor skills and athletic performance, thereby facilitating overall motor development (13). Furthermore, game fosters social interaction, cooperation, and a sense of belonging, laying the foundation for social competence (14). Motor game, in particular, serves as an intrinsic motivator, enhancing children's enjoyment of life. Activities such as imitative game involve a multitude of motor exercises that can encourage children to engage in physical activity (15). The cumulative impact of motor game extends beyond physical development, positively influencing learning, self-esteem, and academic performance in typically developing children (15). Despite the growing interest in the use of games, limited research has examined their specific effects on the development of fine motor skills in children with DCD. Key gaps remain in understanding how games affect fine motor skills such as response speed, visual-motor control, and limb dexterity, which are essential for effective child development. Thus, the present study sought to investigate the efficacy of an eight-week game-based intervention in enhancing fine motor skills in this population.

## 2. Objectives

This study sought to evaluate the impact of eight weeks of selected games on the development of fine motor skills in children with DCD, with the aim of demonstrating its potential as an effective rehabilitation strategy tailored to the unique needs of children with DCD.

## 3. Methods

### 3.1. Subjects

This study employed a quasi-experimental pretest-posttest design with a control group. The sample size was determined using G*Power software (effect size = 0.5, $\alpha = 0.05$, power = 0.95), yielding 34 participants for a *t*-test. Forty boys aged 7 - 11 with DCD were selected based on inclusion criteria: Absence of cardiovascular, neurological, musculoskeletal, vestibular, or visual impairments; no postural abnormalities or mobility limitations; and parental consent. Exclusion criteria included orthopedic injuries during the study, withdrawal of consent, failure to complete post-testing, or missing more than three training sessions. Participants were randomly assigned to experimental (n = 20) and control (n = 20) groups via a random number generator.

### 3.2. Apparatus and Task

#### 3.2.1. Fine Motor Skill Development Assessment

The bruninks-oseretsky test of motor proficiency (BOTMP) was used to assess motor proficiency. The BOTMP is a standardized, norm-referenced test that evaluates gross and fine motor skills. Higher scores

indicate better motor performance. The BOTMP has been standardized on a sample of 756 children, matched on age, gender, race, and geographic region. The test-retest reliability and validity coefficients were reported to be 0.87 and 0.84, respectively (16). The validity and reliability of this tool in Iran have been reported to be above 0.75 and have been used frequently in recent studies (17).

### 3.3. Procedure

Following the approval of the research ethics committee (IR.PNU.REC.1402.261), an initial meeting was conducted with teachers and parents to provide information about DCD and to request their assistance in identifying potential participants. To ensure ethical compliance, parents were formally invited and kept informed about their children's involvement in the study. Children were provided with adequate information and gave informed consent to participate. Parents were asked to complete the Wilson DCD Questionnaire. Forty children diagnosed with DCD were subsequently recruited. Both the experimental and control groups completed a pre-test assessing fine motor skills (response speed, visual-motor control, and upper extremity speed and agility). To prevent possible bias, participants were randomly assessed in the pre-test and post-test phases.

The control group participated only in the pre-test and post-test, engaging in their usual daily activities and no additional structured physical activity. The experimental group participated in a 24-session (8-week) game-based intervention program, with three sessions per week, every other day, and each session lasting 60 minutes. Each session included a 10-minute warm-up, a 45-minute intervention, and a 5-minute cool-down. The warm-up consisted of walking and stretching exercises tailored to each child, while the cool-down involved light stretching (18). Following the final session, both groups completed a post-test to assess the dependent variables. To analyze the data and test the research hypotheses, a covariance analysis was employed (Table 1).

## 4. Results

Table 2 presents descriptive statistics and ANCOVA results examining the effect of the independent variable on the dependent variables. After confirming normality (Shapiro-Wilk) and homogeneity of variance (Levene's test) for fine motor skills, response speed, visual-motor control, and upper extremity speed/agility, three ANCOVAs were conducted with group (experimental/control) as the independent variable, pretest scores as covariates, and posttest scores as dependent variables.

The research findings regarding response speed indicated that, after controlling for pre-test scores, the effect of group on response speed was statistically significant ($F_{(1,\ 37)} = 17.942$, $P < .05$). This implies a significant difference in post-test response speed between the experimental and control groups. Similarly, for visual-motor control, the results showed a significant group effect after controlling for pre-test scores ($F_{(1,\ 37)} = 25.68$, $P < 0.05$), suggesting a significant difference in visual-motor control between the two groups. Moreover, the results for upper extremity speed and agility indicated that, after controlling for pre-test scores, the effect of group on upper extremity speed and agility was statistically significant ($F_{(1,\ 37)} = 23.612$, $P < 0.05$), signifying a significant difference in upper extremity speed and agility between the experimental and control groups. The results for fine motor skills demonstrated that, after controlling for pre-test scores, the effect of group on fine motor skills was statistically significant ($F_{(1,\ 37)} = 35.973$, $P < 0.05$), indicating a significant difference in overall fine motor skills between the experimental and control groups.

Furthermore, eta-squared values indicated that 32% of the variance in response speed, 41% of the variance in visual-motor control, 39% of the variance in upper extremity speed and agility, and 49% of the variance in overall fine motor skills in children with DCD could be attributed to the intervention.

## 5. Discussion

The present study aimed to investigate the selected motor games on development of fine motor skills in students with DCD. Results revealed that selected motor games intervention significantly enhanced fine motor skills, including response speed, visual-motor control, upper extremity speed, and agility. Visual-motor control exhibited the most significant improvement, while response speed demonstrated the least. According to the findings, motor-based interventions accounted for 32% of the variance in response speed, 41% of the variance in visual-motor control, 39% of the variance in

**Table 1.** Game-Based Movement Intervention in the Present Study (18)

| Session | Goal | Content |
|---|---|---|
| 1 | Coordination | Playing skateboarding, doing flips, jumping on paper plates and spinning the mill |
| 2 | Perception | Receiving balls of different sizes and weights with two hands and one hand, hitting the ball on the ground and catching it, throwing the ball in the air and catching it |
| 3 | Fine skills | Drawing with two hands, painting with water, playing clockwork and rhythmic movements |
| 4 | Sensory-motor | Jumping and leaping on a trampoline, throwing, catching and touching |
| 5 | Gross skills | Walking like different animals (elephant, rabbit, crab, cat and duck), placing stones - footprints, playing boxes and walking on a line |
| 6 | Balance | Walking on a straight line, walking on heels and toes and moving on paths drawn on the ground |
| 7 | Coordination | Playing skateboarding, doing flips, jumping on paper plates, spinning the mill, throwing the ball in the air and catching it |
| 8 | Perception | Receiving balls of different sizes and weights with two hands and one hand, hitting the ball on the ground and catching it, throwing the ball in the air and catching it |
| 9 | Fine skills | Drawing with two hands, painting with water, playing clockwork and rhythmic movements |
| 10 | Sensory-motor | Jumping and Jumping on a trampoline, throwing, catching and touching. |
| 11 | Gross skills | Walking like different animals, stepping stones - footprints, playing boxes, walking on a line and throwing a ball against a wall |
| 12 | Balance | Walking in different directions and sizes and on different surfaces |
| 13 | Coordination | Playing disc skating, lily pad, jumping on paper plates, spinning a mill, throwing a ball in the air and catching it |
| 14 | Perception | Receiving balls of different sizes and weights with two hands and one hand, hitting the ball on the ground and catching it, throwing the ball in the air and catching it |
| 15 | Fine skills | Drawing with two hands, painting with water, playing clock and rhythmic movements |
| 16 | Sensory-motor | Jumping and bouncing on a trampoline, throwing, catching and touching |
| 17 | Gross skills | Walking like different animals (elephant, rabbit, crab, cat and duck), placing stones - footprints, playing box, walking on a line, throwing a ball towards the wall |
| 18 | Balance | Walking on the floor with a ball in different directions |
| 19 | Coordination | Throwing a ball with one hand and two hands forward and backward while sitting and standing and dribbling in place with the ball with two hands and one hand |
| 20 | Perception | Throwing a ball in the air and catching it, playing volleyball with a balloon, chasing a balloon and hitting a flying balloon |
| 21 | Fine skills | Playing with Fingers, cutting paper with scissors with dominant and non-dominant hands |
| 22 | Sensory-motor | Jumping and bouncing on trampoline, throwing, catching and touching |
| 23 | Gross skills | Zigzag jumping in large and small sizes, jumping from mat to mat, throwing a large ball and kicking |
| 24 | Balance | Walking and running on marked paths on the ground |

upper extremity speed and agility, and 49% of the overall variance in fine motor skills among children with DCD. These results underscore the positive impact of motor-based interventions on the development of fine motor skills in this population. Consistent with the current findings, previous studies have demonstrated the efficacy of various physical activities in enhancing fine motor skill development, including cognitive rehabilitation (19), specialized physical activity (20), task-oriented training (21), virtual reality training (22), and functional learning programs (19). The observed improvements in fine motor skills can be attributed to the nature of the motor-based interventions employed in this study, which often require rapid responses and precise movements, thereby facilitating the development of fine motor skills. Moreover, some of the interventions involved manipulation and control, enhancing participants' visual-motor control.

The preschool years represent a critical period for the development of gross and fine motor skills in children with DCD (23). For instance, agility, which relies on coordination, speed, and balance, undergoes significant development during childhood (24). When children with DCD encounter difficulties in performing motor tasks or are unable to execute these skills proficiently, they often experience frustration and avoidance of motor activities. Consequently, these children may be subject to peer teasing and feelings of shame, leading to decreased motivation and self-esteem compared to their typically developing peers (25). As a result, the implementation of selected game-based interventions is crucial for enhancing motor proficiency in children with DCD, given that low motor proficiency negatively

**Table 2.** Comparison of Pre- and Post-intervention Fine Motor Skills Between Groups [a]

| Variables | Pre-test; (n = 20) | Post-test; (n = 20) | F | P | $\eta^2$ |
|---|---|---|---|---|---|
| **Response speed** | | | | 0.001 [b] | 0.32 |
| Experimental | 13.5 ± 0.23 | 14.75 ± 0.31 | 17.942 | | |
| Control | 13.5 ± 0.23 | 13.45 ± 0.31 | | | |
| **Visual-motor control** | | | | 0.001 [b] | 0.41 |
| Experimental | 10.45 ± 0.26 | 11.55 ± 0.27 | 25.68 | | |
| Control | 10.65 ± 0.35 | 10.75 ± 0.34 | | | |
| **Upper extremity speed and agility (sec)** | | | | 0.001 [b] | 0.39 |
| Experimental | 26.95 ± 0.35 | 29.05 ± 0.43 | 23.612 | | |
| Control | 27.15 ± 0.43 | 27.4 ± 0.44 | | | |
| **Fine motor skills** | | | | 0.001 [b] | 0.49 |
| Experimental | 51.4 ± 0.52 | 55.35 ± 0.57 | 35.973 | | |
| Control | 51.6 ± 0.57 | 51.75 ± 0.62 | | | |

[a] Values are express as mean ± SD.

[b] $P < 0.05$ was considered statistically significant.

impacts participation in physical activities and group games. Poor motor proficiency can also have a detrimental effect on perceived competence and self-esteem, leading to avoidance of sports and physical activities (6). Therefore, motor-based interventions, characterized by their diversity, motivating nature, and rejuvenating qualities, can significantly influence the development of fine motor skills.

In support of these findings, Newell's theory posits that novel motor behavior emerges as a result of changes in the individual, the environment, and task constraints. The process of growth, particularly motor development, must continually acknowledge the individual's unique characteristics. Each individual possesses a unique trajectory for acquiring motor abilities and skills (3). Overall, motor game is an integral part of childhood experiences that promote healthy motor development and foster positive environmental perspectives, attitudes, and values. Fjortoft (26) and Gill (27) have emphasized the importance of environmental stimuli in their research.

Moreover, the human brain requires environmental stimulation to function optimally. The significance of such stimulation for sensory-motor development during childhood is well-established. Consequently, motor game and perceptual-motor skills can serve as potent stimuli for the nervous system. Evidence suggests that the visual system, like other bodily systems, can be enhanced through specific visual training. Similar to the musculoskeletal system, the visual system responds well to overload principles. Even perceptual components of the visual system can be improved through visual-motor training (28). Furthermore, visual-motor skills, as a foundational perceptual-motor ability, are essential for executing fine motor skills. These skills develop concurrently with the growth of perception and the child's nervous system, facilitated by appropriate environmental conditions such as movement and game. The findings of this study align with the dynamic systems perspective. According to this view, the development of motor skills arises from the interaction of individual characteristics, task demands, and environmental constraints. Environmental affordances enable individuals to engage more actively with their surroundings. Examples of affordances include toys and opportunities for game. In other words, access to or lack of environmental affordances is a crucial factor in child development (29). The limitations of this study include the lack of female subjects and the lack of a follow-up test to determine the exact status of the subjects' performance in the long term.

Therefore, the generalizability of the results should be done with caution. The selected motor-based interventions implemented over an eight-week period provided children with DCD opportunities to engage more actively with their environment, thereby facilitating the development of foundational motor

skills in accordance with the dynamic systems perspective. Given the significant role of environmental enrichment in child development, it is recommended that these interventions be utilized to enhance the development of foundational motor skills in children with DCD.

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## Footnotes

**Conflict of Interests Statement:** The author declared no conflict of interest.

**Data Availability:** The data presented in this study are uploaded during submission as a supplementary file and are openly available for readers upon request.

**Ethical Approval:** Ethics approval was obtained by the ethics committee of Payame Noor University with the code of IR.PNU.REC.1402.261 . Also, written informed consent were obtained from parents of children.

**Funding/Support:** This study was conducted with the financial support of Payame University University.

**Informed Consent:** To ensure ethical compliance, parents were formally invited and kept informed about their children's involvement in the study. Participants' privacy was strictly maintained, with personal information such as names kept confidential.

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