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A ten-week motor skills training program increases motor coordination in children with Developmental Coordination Disorder

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Abstract: The present study aimed to investigate the effect of a motor skills training program in children with DCD considering their gender. The Movement Assessment Battery for Children (MABC-2) classified the children and assessed skill changes over time. The study was implemented at four kindergartens in the Khorezm region of Uzbekistan. In the study, all children had DCD (5.17 ± 0.70 years; 10 girls), and all indicators on MABC-2 were less than 16 percent. Participants were divided into an experimental group (n=17) receiving ten weeks of motor skills training program for 45 min twice per week, the control group (n=7) proceeded with exercises of everyday living. All children in the experimental group had a significant increase in total percentile rank of MABC-2 and concerning each domain (manual dexterity; throwing and catching; balance). In the control group, a significant decrease in the total percentile rank of MABC-2 and each domain of MABC-2 was observed. The effectiveness of the intervention program was similar across both genders. The study supports that a period of 10 weeks of a motor skills training program can increase the quality of children's motor coordination and represent a valuable procedure for physical education specialists to enhance motor skills for children with DCD.

Keywords: Developmental coordination disorder (DCD); Motor skills training program; MABC-2

1. Introduction

Developmental coordination disorder (DCD) is characterized by a delay in developing motor skills, especially the coordination of movements, which visibly impairs the child's movements and daily tasks accomplishment [2]. Besides, the feelings of inadequacy accompanying poor motor coordination may be invariably reinforced through relationships with peers [18]. DCD may decrease motivation to attend the physical activity and decrease opportunities to develop motor skills and fitness [22]. Rivilis had previously mentioned that children with DCD, in addition to their motor problems, present lower levels of health-related physical activity. If not treated in time, symptoms of movement problems will persist in a large percentage of individuals into adulthood. Children with movement difficulties tend to be less physically active and engage in less physical activity [32].

However, spare time or recreational physical activity is essential for children and adolescents' healthy social and physical development [9]. Consequently, DCD has received significant attention from scientists across disciplines, including pediatrics, occupational therapy, physiotherapy, kinesiology, and psychology [37]. Researchers and health professionals have developed several types of interventions focused on motor skills training programs to overcome the DCD problem. These programs are based on daily motor skills, exercises, and activities involving fundamental motor skills. The majority of investigators studying this domain agree that these programs enhance the quality of movement and diminish the DCD difficulties in children [14]. There have been different movement-based approaches to intervention for DCD [26], ordinarily grouped into two wide ranges: those that utilize movement to target main performance problems, frequently focused to as process-oriented approaches [37], and those that use activity to address the performance itself, frequently focused to as task-oriented approaches [26]. In a review about the efficacy of motor interventions for children with DCD, it was observed that task-oriented approaches were more effective than process-oriented approaches, yielding better functional performance results in less time for children with DCD [5].

The investigation about gender differences and their importance on motor competence expression has been emphasized for several authors, for example, [12, and 31]. These authors found,

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in children without DCD, some evidence favoring boys. Boys outperforming girls was also observed in the study of Moreno-Briseño [28], about visuomotor coordination combined with catching or hitting a ball. However, other authors like Nolan [31] found that girls might be superior to boys in developing postural control. In addition, these authors suggest that gender differences in body height may also be partially responsible for gender differences in balance. Concerning children with DCD, Rodrigues [35] systematically analyzed the differences in motor performance between genders in studies that used only the MABC-2 [19]. Results revealed that gender differences in performance were consistent across studies; since boys had more success and ease in activities involving gross motor skills, and girls did better the activities involving fine motor skills. Differences in balance were not conclusive. Since few studies aimed to explore possible gender differences and the role of the environmental context in fundamental motor skill programs with children with motor problems [4], it remains less explored whether such interventions are efficient in a similar way regarding the gender of the child with DCD. Therefore, if boys and girls respond differently to motor intervention programs to overcome DCD, then the motor programs must be adapted, taking into account the differences between genders, to maximize the reduction of movement difficulties in each one. The main objective of the current study is to study the effectiveness of a motor skills training program in children with DCD and to analyze possible differences between the sexes.

2. Methods

2.1. Participants

With the consent of the Department of Preschool Education of the Khorezm region (Uzbekistan), from the earliest periods of the COVID- 2019 rule mitigation period, scientific research was launched among four kindergartens in the northwest region of Uzbekistan. First, 63 children aged 4-6 years old were tested with MABC-2. Among those children, 27 children were identified with DCD and invited to participate in the intervention study. Written parental consent was obtained. It should be noted that 3 out of 27 children involved in the study could not participate in the post-test due to not wanting to attend kindergarten by their parents (Figure 1).

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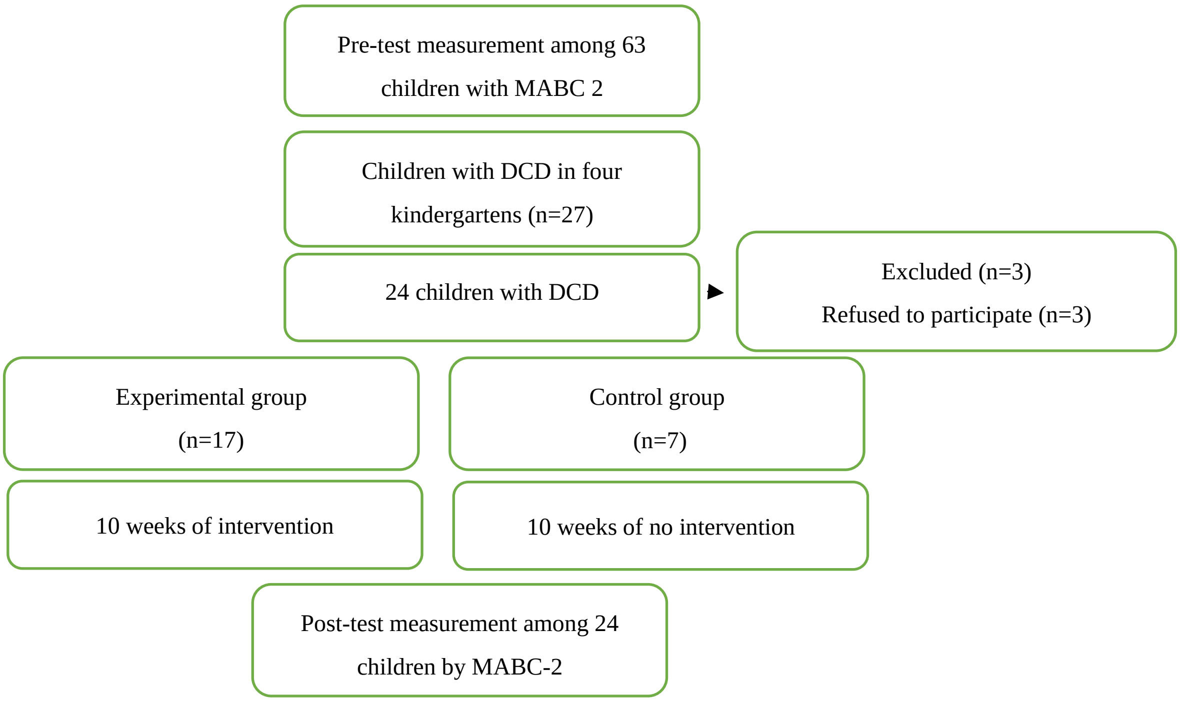

Figure 1. CONSORT flow diagram

The inclusion criteria consisted of children´s performance falling between the 5th and the 16th percentile (probable DCD) or below the 5th (at risk of DCD) on the total score of MABC-2 and having not indicated of any neurological or physical impairment. Descriptive statistics on gender, age, and manual preference, and MABC-2 scores can be found in table 1.

Table 1. Experimental and control groups. Characteristics of participants by age (years), sex (male; female), manual preference (right; left), and MABC-2 pre-test scores.

	Experimental group (n=17)	**Control group (n=7)**
Age year, mean (SD)	5.47 ± 0.514	4.71 ± 0.756
Gender (m/f)	10/7	4/3
Manual preference (R/L)	15/2	5/2
MABC-2 Total Score	5.76 ± 1.39	5.29 ± 1.11

2.2. Instrument

It was applied the MABC-2 test, executed following the MABC-2 manual, to measure the effects of the training program on both groups [19]. MABC-2 has been an appropriate instrument to assess the development of motor competencies of preschool children, and acceptable overall evidence of validity and reliability of the MABC-2 for age band one has been found [20, 37]. The authors propose the following cutoff points from the test manual ≤ 5% atypical motor performance, which indicates DCD; 6th to 15th percentile, which means r-DCD; and any percentile higher than 16 percent, which indicates TD. MABC-2 assesses three items (manual dexterity, aiming and catching, and balance) that differ according to the age band. For this age band, manual dexterity tests were posting coins, threading beads, drawing trails; aiming and catching tests were: catching beanbags and throwing beanbags; and for balance, tests were: static balance, walking heels, and jumping. A score between 0 and 5 was given to each item, with a higher score indicating worse performance. Afterward, item scores were added up to obtain scores on sub-scale score tests. Adding lower-scale points results in general level distortion points (TIS), converted to percentage levels. In pre-and post-tests, each child was assessed by the same tester and recorded on video.

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2.3 Procedures

In the task-oriented approach, the focus was on training functional tasks, which included those that involved mainly body stability (e.g., standing) and those that required body transport (e.g., hopping, skipping, running, jumping, walking, and galloping) [10].The children in the experimental group were involved for 45 minutes twice a week for ten weeks. The participants were divided into four groups corresponding to the four kindergartens, and the number of participants in each group was 3-6 children. Each training session included two main components: initial, 5-min warm-up, and a 40-min motor skill training (group training are outlined in Table 2). All children of the experimental group completed the intervention, and all intervention sessions were videotaped. The DCD control group and the experimental group also performed their regular classroom activities, physical education classes, and physical activities as scheduled, but only the experimental group participated in any extra training for the duration of this research. They received an average of 15 hours of training during the ten weeks. Due to various circumstances like kindergarten activities and dentist visits, several children missed one or more training sessions, which resulted in slightly different total training hours between the children in the experimental group (13.30 ± 1.02 hours). Common motor problems experienced by children with DCD, such as poor agility, balance, core stability, and movement coordination, were addressed through a range of functional activities and exercises. The motor tasks were modified as the training continued to guarantee successful task execution while also offering a sufficient challenge to the child's motor ability.

Table 2. Motor skills training program. Examples of activities.

Domain	Examples of activities
Manual Dexterity	Placing small beads on the side by plastic clamps Sorting and placing small products of different types with fingers Passing the lacing through the marked holes Hanging nuts on the bolts Hang the plastic clamps in the specified direction To tie clothing buttons Putting the buttons on the marked line Browsing a book and other similar games
Aiming and Catching	Catching three different balls (Robo-ball, tennis ball, football ball) Throwing three different balls to designated areas (Robo-ball, tennis ball, football ball) Bowling with twist **Ping Pong Ball Catch (**Get out those plastic red Solo cups and a few Ping-Pong balls) **Bowling (**Set up your bowling “lane” with some painter’s tape and use plastic bottles or cups for pins) Different delays and other similar games
Balance	Walk on the marked line Picking up items “Night and morning” (when it is said night, they jump into a circle, and when it is said morning they jump out of the circle) Book balance game (Holding the book in the head without dropping it) Different delays and other similar games

Data analysis

One-way analysis of covariance (ANCOVA) was applied to examine differences in post-test scores of all M-ABC domain variables among intervention and control groups controlling for pre-test scores [19]. The pre-test score of each domain variable was a covariant, the different groups were independent variables, and the post-test score was the dependent variable.

Then, the program effect was tested using a Wilcoxon test for repeated measure analysis in each group (EG and CG) and Mann-Whitney to test gender differences within groups and moments.

The dependent variables included the abilities in the domains of manual dexterity, aiming and catching, balance, and total MABC-2 scores.

Statistical analyses were performed using SPSS 26.0, and statistical significance was assessed using an alpha level of .05. An estimate of the effect size for the intervention group, partial eta

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squared (ηp2), was calculated for each dependent variable. According to Cohen's [11] guidelines, 0.0099 constitutes a small effect, 0.0588 a medium effect, and 0.1379 a large effect.

3. Results

The CONSORT flow diagram, illustrated in Figure 1, presents 63 children meeting the inclusion criteria. Of these, twenty-four children diagnosed with DCD by the MABC-2 program were included in the study. There were no significant differences in perinatal and social factors or motor performance between recruited children and non-participants. The 24 recruited children with DCD were randomized to either experimental group (n = 17; mean corrected age 5.47 ± 0.514; 10 males) or control group (n = 7; mean corrected age 4.71 ± 0.756; 4 males).

From pre to post-intervention, all children from the experimental group with probable DCD or at risk showed no motor impairment after an intervention. Nevertheless, in the control group, the majority remained with motor impairment and even got worse, and one fell above the 16 percentile. In the second part of the study, the MABC-2 percentile of all children. In the second part of the study, the MABC-2 percentile of all children in the experimental group exceeded the 16th percentile, but the children's performance in the control group remained virtually unchanged (table 3).

Table 3 - Number of children scoring in each MABC-2 percentile band at pre- and post-intervention.

Motor difficulty category, *n*	**Experimental group (n=17)**		**Control group (n=7)**	
	Pre	**Post**	**Pre**	**Post**
No motor difficulty (MABC-2 > 16th percentile)	0	17	0	1
Probable DCD (5th percentile < MABC-2 ≤ 16th percentile)	11	0	3	1
At risk of DCD (MABC-2 ≤ 5th percentile)	6	0	4	5

Program effect

Manual dexterity

The ANCOVA showed differences between groups in the post-test ($F_{(1, 20)}$ = 18.703, p= 0.000) considering the pre-test values ($F_{(1, 20)}$ = 2.229, p= 0.150) (see table 4).

The Wilcoxon test revealed for the EG statistically significant differences between moments (Z= 3.422, p = 0.001) but not for the CG (Z= -1.890, p = 0.059) (see table 5).

MABC 2 indicators improved in the post-test experiment group, but the indicators decreased from the first to the second moment in the control group.

Aiming and Catching

The ANCOVA showed differences between groups in the post-test ($F_{(1, 20)}$ = 9.734, p= 0.005; η2 = 0.317) considering the pre-test values ($F_{(1, 20)}$ = 0.245, p= 0.626; η2 = 0.012), (see table 4). The Wilcoxon test revealed for the EG statistically significant differences between moments (Z= 3.160, p = 0.002) but not for the CG (Z= 0.420, p = 0.674) (see table 5).

These effects indicated a positive overall intervention effect over time and different levels of ball skills between groups of children.

Balance

The ANCOVA showed differences between groups in the post-test ($F_{(1, 20)}$ = 35.140, p= 0.000; η2 = 0.626) considering the pre-test values ($F_{(1, 20)}$ = 0.039, p=0.845; η2 = 0.002), (see table 4).

The Wilcoxon test revealed for the EG statistically significant differences between moments (Z= 3.209, p = 0.001) but not for the CG (Z= -0.843, p = 0.399) (see table 5). The performance improved in the experimental group than the control group from the first to the second moment.

Total Test Score MABC-2

The ANCOVA showed differences between groups in the post-test ($F_{(1, 20)}$ = 66.093, p= 0.000; η2 = 0.759) considering the pre-test values ($F_{(1, 20)}$ = 1.129, p=0.300; η2 = 0.051) (see table 4).

The Wilcoxon test revealed for the EG statistically significant differences between moments (Z= 3.647, p = 0.000) but not for the CG (Z= -0.740, p = 0.459) (see table 5). These results indicated was a positive overall intervention effect over time, with the EG showing an improved performance compared to the CG and a decline in the performance for the CG from the first to the second moment.

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Table 4 - Means and standard deviation for post-test M-ABC domains by groups

MABC-2	Group	Mean ± SD	*p*
Manual Dexterity	**Experimental group**	7.76 ± 2.25	.000
	Control group	4 ± 1.73	
Aiming and Catching	**Experimental group**	13.9 ± 2.24	.003
	Control group	9.3 ± 3.35	
Balance	**Experimental group**	11.1 ± 1.96	.920
	Control group	6.0 ± 1.63	
Total Test Score	**Experimental group**	81.6 ± 5.911	.524
	Control group	51.43 ± 11.85	

Table 5 Experimental and Control groups. Results from MABC-2 domains at pre-and post-intervention.

		Experimental group		**Control group**	
MABC-2		**Mean ± SD**	*p*	**Mean ± SD**	*p*
Manual Dexterity	**Pre-test**	3.82 ± 1.18	.001	4.86 ± 1.86	.059
	Post-test	7.76 ± 2.25		4.00 ± 1.73	
Aiming and Catching	**Pre-test**	9.47 ± 2.80	.002	8.29 ± 2.69	.674
	Post-test	13.18 ± 2.24		9.29 ± 3.35	
Balance	**Pre-test**	8.00 ± 2.34	.001	7.00 ± 2.30	.399
	Post-test	11.12 ± 1.96		6.00 ± 1.63	
Total Percentile Rank	**Pre-test**	5.76 ± 1.39	.000	5.29 ± 1.11	.459
	Post-test	10.65 ± 1.53		4.71 ± 1.89	

Gender effect

The results of the Mann-Whitney showed no statistical differences between sexes in both groups and moments (table 6 and table 7).

Table 6 Pre-intervention. Gender effect in each group at MABC-2 domains.

		Experimental group		**Control group**	
MABC-2	Gender	**Mean ± SD**	*p*	**Mean ± SD**	*p*
Manual Dexterity	**Male**	3.90 ± 1.28	.887	5.50 ± 1.73	.400
	Female	3.71 ± 1.11		4.00 ± 2.00	
Aiming and Catching	**Male**	9.80 ± 2.48	.536	8.50 ± .577	1.000
	Female	9.00 ± 3.36		8.00 ± 4.58	
Balance	**Male**	8.20 ± 2.39	.669	6.75 ± 1.89	1.000
	Female	7.71 ± 2.43		7.33 ± 3.21	
Total Test Score	**Male**	58.6 ± 9.45	.536	56.7 ± 4.57	.629
	Female	56.2 ± 8.57		53.6 ± 8.08	

Table 7 Post-intervention. Gender effect in each group at MABC-2 domains.

		Experimental group		**Control group**	
MABC-2	Gender	**Mean ± SD**	*p*	**Mean ± SD**	*p*
Manual Dexterity	**Male**	7.80 ± 2.56	.813	4.00 ± 1.82	1.000
	Female	7.71 ± 2.56		4.00 ± 2.00	
Aiming and Catching	**Male**	12.9 ± 2.07	.669	9.25 ± 3.94	1.000

	Female	13.5 ± 2.57		9.33 ± 3.21	
Balance	Male	11.1 ± 1.96	1 .000	5.50 ± 1.91	.400
	Female	11.1 ± 2.11		6.67 ± 1.15	
Total Test Score	Male	81.9 ± 7.18	.887	49.5 ± 16.0	.629
	Female	81.1 ± 3.93		54.0 ± 4.35	

It was found during our study that the exposure rate equality of the intervention program given to children with DCD was equal for both girls and boys in both groups and all variables ($p > 0.05$).

4. Discussion

The purpose of the present study was to analyze the effect of a motor skills training program in children with DCD considering their gender. For this reason, the motor skill acquisition was carefully monitored for ten weeks, and the effectiveness of the motor skills training program was examined in a sample of children with different levels of DCD. Importantly, our study confirmed that except for children in the control group, all children with DCD displayed improvement after a 10-week training period.

The topic was also studied by Farhat [13], Cacola [8], Hung [20], and Zanella [41] with different research methodologies that did not consider gender elements in focus. Our results are compatible with evidence from several studies providing support for the motor skill-training program to improve motor skills in children with DCD [20,41]. As such, the current findings inevitably constitute a challenge to those who believe that improved motor performance relates to improved physical literacy through appropriated motor intervention programs [26]. According to Whitehead, physical literacy goes beyond the concept of physical activity, and insofar it involves throughout motor learnings the feelings of motivation, resilience, confidence, physical competence, knowledge, and understanding of all motor activities. In addition, according to this perspective, appropriate motor intervention programs should promote the habits of participation in physical activities throughout the life course. For children with DCD participating in such programs, the ending of the intervention should not imply the ending of the involvement in an active lifestyle.

As gender is concerned, our results are not in line with Bardid [4] because they found that their intervention was gender-specific. These authors, using the TGMD-2, observed that boys and girls showed a similar gain in locomotors skills, but only the girls' object control skills benefited from the 10-week practice.

Inspection of the intervention group's findings indicated that 17 children (100%) improved to the point where they could be categorized in a different performance category on the MABC and moved from the clinical to the normal range.

The main finding of our study is that the results of the post-study MABC-2 program of girls and boys in the intervention group were almost identical. However, it was observed to have a more negative effect on boys than girls without intervention in a 10-week study period.

Involvement of teachers, parents, and physical education is likely to ensure that the learned skills will continue to be used after the formal intervention and to maximize transfer into daily life, and ensure longer-term progress [4]. More studies are needed to study the most effective strategy that parents and teachers can be engaged in instruction.

Limitations

The study has potential limitations. The period of determining the coordination ability of 63 children through the MABC-2 program coincided with the period when the COVID-19 quarantine restrictions were first released. This period may have led to some differences in research results that can be considered the research's limitation. Moreover, the COVID-19 quarantine restrictions did not allow a maintenance test. The long-term benefits effectiveness of this intervention could not be examined so it is suggested that in other studies this should be addressed.

5. Conclusion

In conclusion, the present study results indicate that the motor skills training delivered in a pre-school setting improves the functional motor skills of children with DCD. Moreover, the motor skill-training program is the same positive effect for both genders.

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