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ESTIMATION OF PHYSICAL ABILITIES OF CHILDREN WITH DEVELOPMENTAL COORDINATION DISORDER

Key words: developmental coordination disorder, physical abilities, physical education.

ABSTRACT

Children with the developmental coordination disorder have difficulties in performing several movement tasks. The present study examined the role of the developmental coordination disorder in children's physical fitness in the context of Greek primary education. One hundred fifty-four pupils participated in the study. The Movement Assessment Battery for Children was used to assess their motor coordination and to classify the children in groups (Henderson & Sugden, 1992). The Youth Fitness Test was used for the estimation of children's physical abilities (AAHPERD, 1980). Kruskal-Wallis and Mann-Whitney analysis revealed statistically significant differences between the groups in 50-yard sprint, 600-yard running, shuttle run, sit-ups and standing long jump. Children with severe and moderate motor difficulties achieved much lower scores. The results of the study showed that the developmental coordination disorder was associated with poor physical fitness. These findings support the development of programs to reinforce and help children with poor motor coordination in the educational system.

INTRODUCTION

Developmental Coordination Disorder is characterized by impairment and inability to successfully perform various motor tasks [44]. The poor motor ability has negative consequences for both social and academic functioning [4]. The percentage of children with the Developmental Coordination Disorder is between 5% and 9% of school population. This fact places it among the most common developmental disorders [4].

Motor skills are motor actions performed under the control of the central nervous system control. The sufficient and effective performance of motor skills is defined by speed, precision, amount of energy that is demanded, easiness and adaptation [47]. Motor skills are necessary for performing academic tasks, constructions, games and sports that comprise the basic elements of children's daily activities.

Children with motor difficulties present delays in performing motor tasks that demand fine motor skills. While they perform movements their motor patterns show inconsistency, perseverance, mirroring, asymmetry, loss of dynamic balance, extraneous movements, inability to maintain a rhythmical pattern, inability to control force and inappropriate motor planning [12, 23, 17]. Furthermore, there may be delays in motor development and in such basic motor skills as running, jumps or throws [13].

The lack of motor skills influences the psychological, social and cognitive domain of children with DCD. A field which has not been examined closely as yet is physical fitness, which depends on the level of physical abilities. Physical

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abilities constitute an important indicator of children's health and well-being. Health benefits from physical activity in youth are multiple [7, 6, 15, 1, 5]. School is the most important factor in promoting physical fitness in children and adolescents, and its main goal is to prepare them for a lifetime of physical activity [36].

A number of studies have reported that the anaerobic capacity of poorly coordinated children is well below average as performances of tasks considered to test explosive power (sprinting, hopping, and jumping) were diminished [26, 28, 33, 29].

Faught, Hay, Cairney and Flouris (2005), studied 571 elementary school children, and examined the cardio-respiratory fitness and relative body fat. These two factors contribute to the incidence of the coronary vascular disease. Children with DCD showed low levels of cardiovascular fitness and high percentages of relative body fat. Physical activity was another significant factor in the above relationships.

Rogers, Fay, Whitefield, Tomlinson and Grunau (2005) compared aerobic capacity, strength, flexibility and activity levels of 53 teenagers (M = 17.3) of extremely low birth weight (≤ 800g.). An interesting finding was that these children were diagnosed with DCD at high percentages (51%). From the results it was revealed that children with extremely low birth weight displayed much lower levels of physical activity.

Paton (1986) reported that children with DCD performed the tasks of abdominal endurance, leg power, flexibility and cardiovascular endurance below the 30th percentile.

Having taken the above studies into account it appears that the physical abilities of children with DCD were examined partially using different methodological approaches. Namely, there are various assessment tools for the evaluation of motor abilities of children with motor difficulties. Each uses a part and/or parts of the above mentioned evaluation tools. In this line of work a different methodological approach was used to investigate physical abilities such as speed, endurance, agility, maximum strength, explosive strength, and muscular endurance. This research will examine all the above mentioned parameters in the educational context. Therefore, the purpose of the present study is to assess the physical abilities of children with different levels of motor skills.

METHODS

The research sample consisted of 154 pupils; 82 boys and 72 girls aged 10.9 years (*SD* = 0.68). The pupils were healthy, attended regular school classes and participated in physical education lessons. School directors and teachers were granted the formal written consent permitting the study. Parents were informed about the purpose of the study at their annual meeting of the Board of Parents and they provided informal consent allowing their children to participate in the study. The sample was divided into three groups according to the level of their motor ability. The first group included 10 pupils with serious coordination difficulties, the second group included 16 pupils with moderate coordination difficulties, and the third group consisted of 125 pupils with no measured coordination difficulties.

In order to estimate children's motor efficiency the Movement Assessment Battery for Children was used [24]. The specific battery is a new version of the Test of Motor Impairment [42]. The Movement Assessment Battery for Children consisted of eight tests grouped into three sets. Each set is used for evaluation of different motor activities. The first set was developed to evaluate manual dexterity and consisted of three tests: turning pegs, cutting-out an elephant, and following the flower trail. The second set was developed to evaluate ball skills and included one-hand catch and throwing at a wall target. The third set evaluated dynamic and static balance with three tests: two-board balance, jumping and clapping, and walking backwards.

The performance of each pupil was assessed by the researchers on a 6-point scale ranging from 0 to 5. A pupil's performance was estimated by the researchers on the basis of criteria developed by Henderson and Sugden (1992). The sum of the scores on all eight tests provided the pupil's total score. The total score ranged from 0 (children with no difficulties in executing the tests) to 40 (children with severe developmental coordi-nation disorder). Total scores ranging from 0 to 10 indicated proper motor coordination, while scores from 11 to 14 indicated moderate coordination difficulties. Scores above 15 indicated severe difficulties in motor coordination. Henderson and Sugden (1992) set the 5th centile as the cut-off point to indicate severe coordination difficulties, and the 15th centile as the cut-off point for moderate coordination difficulties. The use of the Movement Assessment Battery for

Children to assess develop-mental coordination disorder as well as the cut-off points were further supported by Geuze, Jongmans, Schoemaker, and Smits-Engelsman (2001) after a review of approximately 200 studies.

A preliminary test of the battery's reliability was performed with 30 pupils. Two independent examiners applied the battery to the pupils over a mean time of two weeks and assessed its reliability using the intra-class correlation coefficient. The results of the analysis provided evidence for the reliability of the battery (r = 0.82–0.95).

The AAHPERD YFT was developed by a group of physical educators who had selected logic-based tests. In 1975 major changes were introduced into the YFT. The straight-leg sit-up was replaced with the bent-leg sit-up, and throw-for-distance was dropped because of the risk of musculoskeletal injuries. In 1976, a normative survey was completed and the norms for the YFT were revised (AAHPERD, 1976). The six tests with national normative data are 1) pull-up (boys) or flexed-arm hang (girls); 2) sit-up flexed leg, 60-second time limit); 3) shuttle run; 4) standing long jump; 5) 50-yard dash; and 6) 600-yard run.

Several reliability studies on the AAHPER YFT have been reported in literature. Safrit (1981) summarized these studies which had been conducted mostly on elementary and secondary pupils. The range of reliability coefficients for various items varied between 0.65 and 0.98.

The Movement Assessment Battery for Children was applied to each child separately. The completion of the battery lasted approximately 20 to 25 minutes per child. After the whole sample was tested, the battery of Youth Fitness Test was administered to the children under the researchers' supervision. The entire testing process lasted over four months.

RESULTS

The Kruskal-Wallis test was used to examine possible differences between children's motor abilities and the level of developmental coordination disorder. Bonferroni-Dunn correction was applied to adjust statistical significance for the large number of comparisons. There were statistically significant differences among the coordination groups

Table 1. Differences between children with adequate motor skills and children with moderate motor difficulties in motor abilities

	Children with adequate motor skills (n = 125)			Children with moderate motor difficulties (n = 16)						
	M	SD	Mean Rank	M	SD	Mean Rank	Mann-Whitney U	p	Critical values	ES
50 yard	8.85	1.01	68.46	9.60	0.52	110.09	442.50	0.00	0.000–0.999	0.93
600 yard	198.39	40.1	71.33	217.00	35.03	93.97	697.50	0.04	0.048–0.951	0.49
Shuttle run	12.33	1.03	68.40	13.52	0.94	117.53	351.00	0.00	0.000–0.999	0.41
Sit-up	31.13	11.02	82.70	23.31	11.85	48.03	539.00	0.00	0.002–0.997	0.68
Standing long jump	131.75	30.35	81.90	118.06	20.99	51.25	599.00	0.00	0.009–0.990	0.52
Pull-up (Boys)	2.06	2.20	38.20	0.62	0.74	22.88	147.00	0.04	0.045–0.095	0.40
Flexed-arm (girls)	9.49	6.4.3	29.45	4.7	3.91	16.31	94.50	0.02	0.029–0.97	0.40

Ns = Non significant

Table 2. Differences between children with adequate motor skills and children with severe motor difficulties in motor abilities

	Children with adequate motor skills (n = 125)			Children with severe motor difficulties (n = 10)						
	M	SD	Mean Rank	M	SD	Mean Rank	Mann-Whitney U	p	Critical values	ES
50 yard	8.85	1.01	68.46	10.29	1.80	115.65	240.50	0.00	0.001–0.998	0.92
600 yard	198.39	40.1	71.33	231.20	43.58	105.60	344.00	0.01	0.018–0.981	0.78
Shuttle run	12.33	1.03	68.40	13.25	1.27	104.55	324.00	0.01	0.011–0.988	0.48
Sit-up	31.13	11.02	82.70	19.60	9.34	37.05	249.00	0.00	0.001–0.998	0.49
Standing long jump	131.75	30.35	81.90	112.00	17.47	41.90	289.00	0.00	0.004–0.099	0.79
Pull-up (Boys)	2.06	2.20	36.74	1.00	2.00	22.25	112.50	Ns		
Flexed-arm (girls)	9.49	6.4.3	26.27	4.75	3.40	16.63	56.00	Ns		

Ns = Non significant

Table 3. Differences between children with moderate motor difficulties and children with severe motor difficulties in motor abilities

	Children with moderate motor difficulties (n = 16)			Children with severe motor difficulties (n = 10)				
	M	SD	Mean Rank	M	SD	Mean Rank	Mann-Whitney U	p
50 yard	9.60	0.52	12.75	10.29	1.80	14.70	68.00	Ns
600 yard	217.00	35.03	12.56	231.20	43.58	15.00	65.00	Ns
Shuttle run	21.23	30.88	14.47	25.04	37.25	11.95	56.50	Ns
Sit-up	23.31	11.85	14.34	19.60	9.34	12.15	66.50	Ns
Standing long jump	118.06	20.99	13.81	112.00	17.47	13.00	75.00	Ns
Pull-up (Boys)	0.62	0.74	7.81	1.00	2.00	7.08	21.50	Ns
Flexed-arm (girls)	4.7	3.91	6.00	4.75	3.40	7.50	12.00	Ns

Ns = Non significant

in 50 yards ($H = 21.69$, $p = 0.00$), 600 yards ($H = 8.70$, $p < 0.01$), shuttle run ($H = 22.50$, $p = 0.00$), sit up ($H = 17.42$, $p = 0.00$) and standing long jump ($H = 13.48$, $p = 0.00$). Mann-Whitney U analysis demonstrated statistically significant differences between children with severe and moderate developmental coordination disorder and children without coordination problems. Children with severe and moderate developmental coordination disorder scored lower than children without coordination difficulties (Tables 1, 2, 3).

DISCUSSION

The purpose of the present study was to investigate the role of developmental coordination disorder in the development of children's physical fitness in primary schools in Greece. The obtained results revealed that children with moderate and severe motor difficulties displayed a lower level of physical fitness as compared with other children. Differences were not present between groups with moderate and severe motor difficulties No statistical difference was found in the maximum upper-body strength, even though the level of statistical significance was on the borderline (0.07 and 0.06), and the mean scores were higher in the group with adequate motor competence.

As far as the assessment of the 50m sprint results is concerned, it was concluded that the children with motor difficulties were less competent compared with the rest of the children. This finding is consistent with the results of O'Beirne, Larkin and Cable (1994), who examined the anaerobic performance of 24 boys with DCD using exactly the same task. Noteworthy is the fact that during the cycling test both teams displayed similar heart rate responses during warm-up and prior to the end of the test. This means that although both teams achieved the same level of performance, the children with motor difficulties were less competent. They appear unable to maintain a high percentage of their peak power for the entire test, and they get tired earlier. This difference cannot be attributed to the diminished motor programming and control by the central nervous system. The low anaerobic performance is probably attributed to the diminished concentration of anaerobic substrates (creatine phosphate, adenosine triphosphate and glycogen). An inactive lifestyle might limit the production of these substrates, which results in the anaerobic power output and contributes to lower anaerobic performance. Besides various reports indicate that in children with motor difficulties the propulsion and the use of anaerobic sources of energy were lower than those observed in well-coordinated children [26].

As far as the aerobic endurance is concerned, the findings of the present study remainh in accordance with prior studies. Children with motor difficulties were found to demonstrate lower levels of aerobic endurance as compared with other children. This is probably attributed to the lower participation of children with DCD in physical activities. Cairney, Hay, Faugth, Mandigo and Flouris (2005) found that children with motor difficulties participated in fewer organized and recreational play activities than children without the disorder. Similar findings are also demonstrated by other authors in their studies of physical activities undertaken place during school breaks [10, 45]. These children received negative reinforcement from parents, teachers, and their well-coordinated schoolmates and were discouraged to participate in sport activities. On the other hand, when they participated in various competitive activities during PE classes, they had limited learning opportunities. Grineski (1996) found that 75% of contacts were made by merely 40% of players during a third-grade soccer game, while Wilson (1976) concluded that 35% of players never caught the ball, while 52% of players never threw the ball during a fifth-grade kickball game.

Children with DCD present various psychological and social problems such as low self-esteem, self-confidence, high anxiety, behavioral problems and social rejection, which act as inhibitors to their participation in physical activities [37, 38, 40, 41, 25]. It was found that these children did not put all their effort while engaging in physical activities because they were certain that they would fail anyway.

The lower levels of aerobic competence can be attributed to the fact that children with motor difficulties refrain from physical activities. The limited physical activity of children with motor difficulties might have negative consequences such as increase of obesity, reduction of muscle mass and strength, decrease of bone density and 15-20% reduction of cardiorespiratory performance [30]. Due to their lower level of physical activity children with DCD run a greater risk to demonstrate the same negative biological adaptations as adults. Noteworthy is also the relationship between

decreased physical activity and the increased risk of cardiovascular diseases [8].

Taking into account possible harmful consequences that a non-athletic and unhealthy way of life can have on citizens' health, several organizations, such as the American Academy of Pediatrics Committees on Sports Medicine and School Health (1987) and the American College of Sport Medicine (1990), issued relevant guidelines, highlighting the need for daily physical activity. These guidelines have been used as the basis for anaerobic activity development programs. They include 20-min of moderate to vigorous activity three times per week (60-70% of the maximum consumption of oxygen or more than 3 Mets). The latest directives of the UK Expert Consensus Conference suggested that, "…all young people should participate in physical activity of at least moderate intensity for 1 hour per day." Young people who currently engage in little activity, such as children with DCD, should participate in physical activity of moderate intensity for at least half an hour per day [16]. As far as physical education classes are concerned, it is reported that each child should engage for 50% of the school hour in moderate and vigorous physical activities (50% of lesson time HR > 150).

To achieve these goals, programs should be chosen for children with DCD, which include easy, continuous activities with repetitive movements such as running, swimming, skating, skiing and cycling [27]. Moreover, during a physical education class, where the majority of programs consist of mobile team games and sport games, which promote the aerobic capacity, modifications should be made so that the children with motor difficulties can participate successfully. Some of the modifications that could be made include division of children into smaller teams of 2-3, where all children can have more opportunities to play, or changes of the rules. For instance, in order to perform a shot in soccer the ball has to be passed to all team players first or, in basketball, points should be given each time the ball hits the backboard and the basket, and not only when someone actually scores. Furthermore, special emphasis should be placed on participation and personal improvement and not only on competition and distinction [32].

Regarding the agility, the Mann-Whitney analysis revealed that the performance of children with motor difficulties was lower than that of children without any movement difficulties. No studies in have been found to examine this specific motor ability, so that there cannot be any comparison with prior findings. Agility is a complex physical ability and is influenced by speed, flexibility, and motor skills – much lower in children with DCD. The differences in agility are probably attributed to the fact that children with DCD generally refrain from physical activities. Thus they miss the chance offered to them by physical education classes to develop their motor abilities as well as the agility.

As far as the remaining variables are concerned, especially various forms of strength, strength endurance, explosive power and maximum endurance, it was found that children with DCD were lacking these forms as compared with children without motor difficulties. The findings from the present study are in agreement with the prior studies, where it had been found that differences at the neuromuscular skill level might contribute to a decrease in strength. First it was Paton (1986) who found that the scores at the tests assessing abdominal endurance and leg power of children with DCD were below the 30^{th} percentile. What is noteworthy is the author's remark that in tasks which do not demand high motor adaptation, like push-ups, there were children who could not perform even one try. Similar results were also reported in a study examining the isometric and isokinetic strength of children with motor difficulties using a Biodex dynamometer [33]. Furthermore, Rogers et al. (2005) concluded that children with extremely low birth weight, 51% of which showed DCD, demonstrated lower values of grip strength, leg power and vertical jump; could do fewer ups; and had less abdominal strength. The decreased strength of children with motor difficulties can be attributed to the fact that they do not participate in various physical and sports activities. From many studies it was concluded that sport games and team sports contributed to the development of various forms of strength and of explosive power in particular.

It can be concluded that children with DCD showed lower levels of physical fitness compared with other children. These conclusions seem particularly interesting because the population sample belonged to the developmental age of the late childhood period, when the physical abilities develop due to biological maturation. The low levels of physical abilities, in turn, can contribute to the decreased performance of motor skills because motor skills and physical abilities constitute two components of motor performance and develop-

ment. It appeared that children with DCD had a low level of physical abilities, and did not participate in physical activities. Finally, it is necessary to provide the relevant information to parents and teachers as early as possible, in order to encourage children with motor difficulties to participate in various physical and sports activities. This participation in sports activities would contribute to the improvement of their health condition, proper utilization of free time, formation of positive attitudes towards an active lifestyle as well as improvement of peer relationships, social skills and self-confidence. Moreover, children with DCD would develop their motor skills and abilities and secondary symptoms-impairments would be avoided.

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