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Original Research Article

Health and Skill Related Physical Fitness in Adolescents with Motor Difficulties Compared to their Peers without Motor Difficulties

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Abstract

Developmental coordination disorder (DCD) is a neurodevelopmental disorder characterized by motor difficulties that affect individuals' activities of daily living, and pose an increased risk to their health, and psychosocial development. The purpose of the study was to compare abdominal, and hip-flexors muscle strength, and endurance, flexibility of the lower back, and hamstrings muscles, Body Mass Index (BMI) and lower body explosive power between adolescents with motor difficulties and their peers without motor difficulties in a physical education setting. The initial sample consisted of 250 adolescents, 12-15 years old, who were assessed using Movement Assessment Battery for Children-2-Motor Test (MABC-2). Twenty-three adolescents who felt below the 15th percentile, according to the Battery's Norm, formed the motor difficulties (MD) group. Twenty-three age- and sex-matched peers with MABC-2 scores equal to, or above the 16th percentile were selected randomly, forming the non-motor-difficulties (NMD) group. Adolescents in both groups were measured, individually, in the "sit-up test", the "sit & reach test", the "standing long jump test" and the "vertical jump test". Body mass index (BMI) was also calculated. Independent of gender, the presence of motor difficulties was linked to significantly lower levels of the above examined variables, except BMI. Independent of the occurrence of motor difficulties, boys outperformed girls in all the above variables, except flexibility. Conclusively, results of the current study support previous findings regarding the detrimental effect of motor learning difficulties on adolescents' physical fitness. Therefore, improving physical fitness should be one of the main goals of any physical education intervention program and future research should focus on this issue.
Keywords: Developmental Coordination Disorder, muscle strength, flexibility, Body Mass Index (BMI), explosive power.

INTRODUCTION

Developmental Coordination Disorder (DCD) is a neurodevelopmental disorder distinguished by lower acquisition and implementation of coordinated motor skills than that expected, given the individual's chronological age (APA, 2013). It leads in motor difficulties in different life domains and thus affects functional performance in daily activities, and it has secondary consequences in mental health, educational achievements (Harrowell, Hollén, Lingam, & Emond, 2017; Harrowell, Hollén, Lingam, & Emond, 2018), in physical and leisure activities involvement (Izadi-Najafabadi, Ryan, Ghafooripoor, Gill, & Zwicker, 2019; APA, 2013; Barnett & Hill, 2019) and in physiological characteristics (Wright, Furzer, Licari, Thornton, Dimmock, Naylor *et al.*, 2019) like poor physical fitness (Rivilis, Hay, Cairney, Klentrou, Liu, & Faught, 2011), and obesity (Hendrix, Prins, & Dekkers, 2014). According to Katartzi and Vlachopoulos (2011), motor difficulties engage adolescents into a negative cycle, as they avoid participation in physical activities due to their low motor competence, adopting a sedentary lifestyle which decreases further their motor competence. This, in turn, has a negative impact in physical fitness levels, an important health factor, and in overall health and well-being, according to the activity deficit hypothesis (Green, Lingam, Mattocks, Riddoch, Ness, & Emond, 2011; Schoemaker & Smits-Engelsman, 2015; Dewey & Volkovinskaia, 2018).

Having difficulty in performing daily activities fast and accurately (tying shoelaces, handwriting, using tools with accuracy, catching a ball, playing sports, etc.) and showing a deficit in motor skills (bumping into things, throwing things) are some examples of the challenges that adolescents with DCD are facing (DSM-5, 2013). Taking into consideration that this disorder tends to persist in adulthood, and the severity of motor difficulties may be correlated with functional performance in important activities of daily living, such as handwriting and organizing/finding objects (Kirby, Edwards, Sugden, & Rosenblum, 2010), stresses the need for assessing physical fitness levels finding motor weaknesses and thus, promoting participation in physical activity programs in school physical education settings.

According to Haga (2007) and Hands and Larkin (2006) adolescents with low levels of motor competence have lower physical fitness levels and lower physical activity participation. In social and physical competitive settings such as sports and recreation, Harter (1999) has found that adolescents with poor motor competence are particularly vulnerable to non-participation in physical activity and, thereby, they miss the health benefits from it. With progressively negative impressions of physical activity during teenage years, it is possible that low motor competence would have a negative impact in health and skill related fitness in adolescents. Hands and Parker (2019) proposed that physical fitness education approach, as a part of the school's curriculum, should raise awareness, improve motor competence and motivation in adolescents with DCD, in a setting that is also applicable for after-school participation in sport clubs. Given that DCD is a motor learning disability that most physical education teachers are unaware of, and financing of individual therapy programs is limited, school physical education, and extra curriculum exercise programs should be an excellent avenue to develop motor skills and promote physical activity participation in adolescents with motor difficulties (Hands & Parker, 2019).

The school setting is an ideal community to monitor students' physical fitness levels, because all children and adolescents attend primary and secondary school and consequently can be consistently monitored (Stoddard, Kubik, & Skay, 2008). Schools may play a critical role in diagnosing children with low fitness levels via standardized field tests but feasibility and safety are major concerns in testing (Suni, Miilunpalo, Asikainen, Laukkanen, Oja, Pasanen, Bos, &Vuori, 1998). However, studies examining these matters in children and adolescents are limited. Moreover, gender is a factor that affects physical fitness in adolescents. According to Round, Jones, Honour and Nevill (1999), there are differences in power between boys and girls. Quadriceps' strength is proportionate to height and weight for girls, while for boys there is an extra factor which can be fully accredited to the increased levels of testosterone which is a major factor that explains the differences in strength between genders. In the post-pubertal phase some other stimulus, such as a direct action of hormones on the muscle, must be responsible for the continued increase in boys' strength (Parker, Round, Sacco & Jones, 1990). According to Saskia *et al*., (2007) boys spend more time on sedentary behaviors but also more time on physical exercise than girls. Watching TV and exercising less increased the risk of girls being overweigh. González-Gálvez *et al*., (2014) found that a six-week Pilates exercise program is effective in improving trunk strength and hamstring flexibility in adolescents. However, there were no gender differences.

In the present study, it was anticipated that most adolescents with motor difficulties would have lower scores in health and skill related fitness indexes. It was, firstly, hypothesized that adolescents with motor difficulties would be differentiated from their peers without motor difficulties, in all health and skill related fitness variables, such as, abdominal, and hip-flexors muscle strength and endurance, flexibility of the lower back and hamstrings muscles, Body Mass Index (BMI) and lower body explosive power, regardless of their gender. A second hypotheses, was that adolescents with motor difficulties would be differentiated from their peers without motor difficulties, in all the above-mentioned health and skill related fitness indexes, with regard to their gender. In addition, a third hypothesis was that boys and girls would be differentiated in the above-mentioned health and skill related indexes, regardless of the occurrence of motor difficulties.

To test these hypotheses, firstly, two groups of adolescents were formed, a group with motor difficulties and a group with typically developed peers, using MABC-2 scores below the 15th and above the 16th percentile equivalent, respectively. Then, both groups were compared in health and skill related fitness indexes in order differences in their physical fitness status to be assessed. The main focus of the study was to raise understanding in the impact of motor difficulties in health and skill related fitness indexes regarding adolescents with motor difficulties compared to their peers without motor difficulties, because there is a lack of research in adolescents with motor difficulties as most of the related literature has been focused on children population, given that adolescents with poor motor competence are particularly vulnerable to non-participation in physical activity, missing all health benefits derived from this (Harter, 1999) As a result, the main purpose of the study was to compare abdominal, and hip-flexors muscle strength, and endurance, flexibility of the lower back, and hamstrings muscles, Body Mass Index (BMI) and lower body explosive power between adolescents with motor difficulties and their peers without motor difficulties in a physical education setting. A secondary aim was to examine these differences with regard to gender and, finally, to examine gender differences in the above-mentioned indexes in both groups.

MATERIAL & METHODS

Participants

The initial sample in this study was a convenient sample of two hundred and fifty adolescents (N=250) from a secondary school in a Metropolitan city of Greece, who were initially screened for motor difficulties, using Movement Assessment Battery for Children Second Edition (MABC-2), (Henderson, Sugden, & Barnett, 2007). Then, two groups were formed. One (N=23) consisted of adolescents with motor difficulties (MDgroup) who met the Diagnostic, and Statistical Manual of Mental Disorders 5th Edition (DSM-5) criteria for DCD and had scores in MABC-2 below the 15th percentile. Twenty-three (N= 23) age- and sex-matched peers among those who exhibited MABC-2 scores which according to the Battery's Norms were equal to or above the 16th percentile were selected randomly, forming the non-motor-difficulties (NMD) group. Group demographics are depicted in Table 1.

Table 1: Participants' demographics in both groups (Mean ± SD)

	MDgroup *(N=23)*		**NMD group** *(N=23)*				
	M	*SD*	*M*	*SD*	*F(1,46)*	*p*	η^2
Age (years)	13.59	.79	13.73	.77	.405	.528	.009
Body weight (kg)	58.73	15.53	58.00	11.82	.033	.857	.001
Body height (cm)	165.52	8.94	167.73	7.63	.817	.371	.018

METHODS AND MATERIALS

For the screening of motor difficulties and the formation of groups in the initial sample (N=250), the Movement Assessment Battery for Children, Second Edition (MABC-2), (Henderson et al., 2007) was used. The MABC-2 test had acceptable validity, and reliability -inter-rater reliability .92 to 1.00 / test–retest reliability from .62 to .92 (Henderson et al., 2007). It has been consisted of three age bands and in the present study the items of the third age band (11-16 years old) were used and was consisted of eight items of gross and fine motor skills grouped into three motor components: manual dexterity, aiming and catching, and balance (static - dynamic). Manual dexterity component included three items: turning pegs (both hands were tested), triangle with nuts and bolts (a timed bimanual task), and a drawing trail task (preferred hand tested). Each adolescent had one practice attempt and two formal attempts were recorded. Aiming and catching component included two items, catching with one hand (both hands were tested) and throwing at a wall target using a tennis ball. Each adolescent had five practice attempts and ten formal attempts were recorded. Balance component included a static two board balance task for up to 15 seconds as a practice attempt and a maximum of two up to 30 seconds as formal attempts and two dynamic balance tasks, such as walking toe-to heel backwards in a 4.5 meters line, taped down on the floor. Each adolescent had one practice attempt and a maximum of two formal attempts, up to 15 steps, or to the end of the line. The third balance item was a zig-zag hopping task during which each adolescent had one practice attempt and two formal attempts for each leg tested (Henderson et al., 2007). The raw scores were converted into standard scores and percentile equivalents, for each motor component and for the total score. Total test scores (up to and including 56) equivalent to a range at or below the 5th percentile denoted a significant motor difficulty; between the 5th to 15th percentiles (total test scores: 57-67 inclusive) suggested the adolescent was "at risk" of having a movement difficulty; monitoring was required and above the 15th percentile (total test score: any score above 67) denoted that no movement difficulty detected (Henderson et al., 2007). Each adolescent completed the test in 15 minutes, but the adolescents with typical motor coordination completed it, in 8 minutes. For the present study, total score below 67, equivalent to a range at or below the 15thpercentile denoted motor difficulties and formed the motor difficulties group (MD group). In addition, any total test score above 67, equivalent to a range above the 16th percentile was used for the adolescents' assignment to the NMD group.

For health-related physical fitness the following field tests were used:

- The sit-up test was used to assess the abdominal, and hip-flexors muscle strength, and endurance. The score of this test was the number of sit-up repetitions in 30 seconds an adolescent was able to execute (the maximum number of correctly performed sit-ups repetitions indicated better health-related physical fitness). A demonstration of the correct technique took place before the students started their attempt. This test formed part of the EuroFit Testing Battery (Eurofit, 1993).
- The sit & reach test measured flexibility of the lower back, and hamstrings muscles (high scores indicated better flexibility), (Wells & Dillon, 1952). Adolescents sat with their legs straight and without shoes with their feet touching a box. Palms were facing downwards, and they were trying to reach as far as they could on the box. They were

given a practice attempt and their second attempt was recorded. This test formed part of the EuroFit Testing Battery (Eurofit, 1993).

- Body Mass Index (BMI = kg/m^2) was calculated from body mass (BM in kilograms), and body height (BH in meters). The higher the score the higher levels of body fat and risk associated with obesity, according to the norms of ALPHA Fitness Test Battery for Children, and Adolescents (Ruiz, España, Castro, Artero, Ortega, Cuenca, Jiménez et al., 2011). For children and adolescents, BMI is age and sex specific and is often referred to as BMI-for-age. After BMI was calculated in the present study, it was expressed as a percentile obtained from a graph. The BMI-for-age percentile growth charts are the most used indicators to measure size and growth patterns in children and adolescents (Table 2). Body weight was measured by a mechanical body weight scale and body height by a portable stadiometer height-rod (Centers for disease control and prevention, 2020).

Table 2: The BMI-for-age percentile growth charts (Centers for disease control and prevention, 2020)

Weight Status Category	**Percentile Range**
Underweight	Less than the 5th percentile equivalent to BMI less than 18.5 kg/m^2 at 19 years.
Normal or Healthy Weight	5th percentile to less than the 85th percentile equivalent to BMI 18.5 to 24.9 kg/m^2 at 19 years.
Overweight	85th to less than the 95th percentile equivalent to BMI 25 kg/m^2 at 19 years.
Obese	Equal to or greater than the 95th percentile equivalent to BMI 30 kg/m^2 at 19 years.

For performance/skill related physical fitness, the vertical jump test and the standing long (broad) jump test were used to measure lower body explosive power.

In vertical jump test, a tape measure was set vertically along a flat wall and participants were asked to stand next to a wall and reach dominant hand as high as possible, along the tape measure. This reach height value was then recorded. Participants were instructed to complete three maximum vertical jump attempts and reach the dominant hand as high as possible, hitting the wall at the highest point of the jump. The highest height of their hand along the wall within the three attempts was recorded and subtracted by the reach height for the final score in centimeters.

In standing long jump test, the participant was standing behind a line. From the starting position immediately behind the line, standing with the feet approximately shoulder's width apart, the participant jumped with both feet as far forwards as possible, on a non-slip hard surface. Three maximal attempts were completed and the highest score in centimeters was recorded.

Instructions and familiarization trials were given before all testing trials. Participants had 3 minutes between trials and 5-minute rest between each explosive power test (Ruas, Punt, Pinto, & Oliveira, 2014). This test formed part of the EuroFit Testing Battery (standing broad jump), (Eurofit, 1993). In a review by Aertssen (2020), it was suggested that vertical jump test and standing long jump were shown to be reliable, in typically developing children and adolescents.

Procedures

Approval to conduct this study was obtained by the Greek Ministry of Education and the Departmental Research Ethics Committee. Adolescents' parents were informed about the research requirements and procedures and signed informed consents. Prior to data collection, permission to conduct the study was obtained by the school's headmaster, where the research took place, and the school's physical education teacher assisted researchers in data collection. Adolescents' participation was voluntary, and their names and any identifying information were not collected. To ensure health and safety of the participants, testing took place, individually, in the school-gym.

Statistical Analysis

Descriptive statistics were performed for better representation of the averages through data tables. A frequency analysis was used for the classification of adolescents in terms of motor difficulties (MD) and for their assignment to two motor competence groups. An independent samples t-test was conducted for demographics (age, body weight and body height), between motor competence groups in all participants and in both genders, too. A multivariate analysis of variance was conducted and the interaction of MD by gender was examined on sit-up test, sit & reach test, vertical jump test, standing long jump test and BMI scores. Univariate ANOVA's were conducted using students' age, body weight and body height, as covariates. To calculate the strength of the results, partial-eta-squared were applied (η^2=.01 small, η^2=.06 medium and η^2=.14 large), (Field, 2010) and Cohen's *d* values were also calculated (Cohen, 1988; Sawilowsky, 2009). Statistical significance was set at the p< .05 level.

RESULTS

Adolescents with movement difficulties versus peers without motor difficulties

MD and NMD groups of adolescents were compared for descriptive purposes on the demographics of age, body height and body weight using a one-way MANOVA. There was not a significant multivariate effect [Wilk's lambda = .945, $F_{(3, 43)}$ = .809, p = .496, partial eta squared = .055]. Follow-up univariate one-way ANOVAs also revealed no significant effects for age [$F_{(1, 46)}$ = .405, p = .528, partial eta squared = .009], body height [$F_{(1, 46)}$ = .817, p = .371, partial eta squared = .018], body weight [$F_{(1, 46)}$ = .033, p = .857, partial eta squared = .001]. Results for demographics are depicted in Table 1.

A two-way MANCOVA was estimated to examine the effects of the interaction between motor difficulties (MD) and gender on scores of the sit-up test, sit & reach test, the BMI, the vertical jump test, and the standing long jump test, using as covariates age, body height and body weight. No significant MD by gender multivariate interaction effect was revealed [Wilk's lambda = .961, $F_{(4, 42)}$ = .286, p = .918, partial eta squared = .039]. Follow-up two-way ANCOVAs revealed no significant interaction effects for the sit-up test [$F_{(1, 46)}$ = .024, p = .877, partial eta squared = .001], sit & reach test [$F_{(1, 46)}$ = .024, p = .877, partial eta squared = .001], BMI [$F_{(1, 46)}$ = .652, p = .424, partial eta squared = .016], vertical jump test [$F_{(1, 46)}$ = .361, p = .551, partial eta squared = .009] and standing long jump test scores [$F_{(1, 46)}$ = .196, p = .660, partial eta squared = .005].

Subsequently, main effects were examined for motor difficulties (MD) and gender separately. There was a significant multivariate main effect for MD group [Wilk's lambda = .539, $F_{(4, 42)}$ =5.989, p = .000, partial eta squared = .461]. Univariate effects were significant for the sit-up test [$F_{(1, 46)}$ = 25.573, p = .000, partial eta squared = .396], sit & reach test [$F_{(1, 46)}$ = 8.769, p = .005, partial eta squared = .184], vertical jump test [$F_{(1, 46)}$ = 13.146, p = .001, partial eta squared = .252] and standing long jump test [$F_{(1, 46)}$ = 6.959, p = .012, partial eta squared = .151]. Only for BMI a significant main effect was not found [$F_{(1, 46)}$ = .241, p = .626, partial eta squared = .006]. For all the physical fitness variables except BMI adolescents with motor difficulties reported significantly lower mean scores compared to peers without motor difficulties (Table 3).

For gender, there was also a significant multivariate main effect [Wilk's lambda = .396, $F_{(4, 42)}$ = 10.675, p = .000, partial eta squared = .604]. Significant univariate effects emerged for the sit-up test [$F_{(1, 46)}$ = 11.023, p = .002, partial eta squared = .220], sit & reach test [$F_{(1, 46)}$ = 6.86, p = .012, partial eta squared = .150], vertical jump test [$F_{(1, 46)}$ = 18.031, p = .000, partial eta squared = .316] and standing long jump test [$F_{(1, 46)}$ = 29.297, p = .000, partial eta squared = .429]. No significant main effect was found only for BMI [$F_{(1, 46)}$ = .844, p = .364, partial eta squared = .021]. For the physical fitness variables except flexibility of the lower back, and hamstrings muscles, boys reported significantly higher means compared to girls (Table 3).

Cohen's *d* effect sizes (*ES*) for each one of the physical fitness variables, MD and NMD group comparisons are presented in Table 4. A *d* value of .01 denotes a very small *ES*, a .20 denotes a small *ES*, a value of .50 a medium *ES*, a value of .80 a large *ES*, a value of 1.20 a very large and a value of 2.0 a high *ES* (Cohen, 1988; Sawilowsky, 2009). Except BMI with a small *ES* (*d* = .23) and sit & reach with a medium to large ES value (*d* = .75), the remaining variables corresponded to a large *ES* (values ranging .95 to 1.56), (Table 4).

Cohen's *d* effect sizes (*ES*) for each one of the physical fitness variables, gender group comparisons are presented in Table 4. Except BMI with a small to medium *ES* (*d* = .43), and sit & reach with a medium to large ES value (*d* = .72), the remaining variables corresponded to a large and a high *ES* (values ranging, .92 to 2.26), (Table 4).

Table 3: Means, standard deviations, two-way MANCOVA (group*gender) for all fitness variables

Fitness variables	**MD group N=23**		**NMD group N=23**		**MD main effect df=1**			**Gender main effect df=1**			**Interaction effects (MD*gender) df=42**		
	Male (N=9)	*Female (N=14)*	*Male (N=13)*	*Female (N=10)*	*F*	*p*	η^2	*F*	*p*	η^2	*F*	*p*	η^2
	M±SD	*M±SD*	*M±SD*	*M±SD*									
Sit ups (rep)	19.4 ±5.72	15.07 ±4.15	27.9 ±6.07	22.9 ±5.38	25.5	.000	.396	11.0	.002	.220	.276	.603	.009
Sit & reach (cm)	20.4 ±8.42	26.9 ±8.69	27.1 ±4.93	35.00 ±7.40	8.76	.005	.184	6.86	.012	.150	.024	.877	.001
Vertical Jump (cm)	23.4 ±11.1	16.2 ±5.75	32.8 ±6.87	24.3 ±6.01	13.1	.001	.252	18.0	.000	.316	.361	.551	.009
Standing long jump (cm)	137.1 ±34	97.2 ±18.8	163.3 ±34.9	121.2 ±15.5	6.95	.012	.151	29.2	.000	.429	.196	.660	.005
BMI	21.9 ±5.72	20.9 ±3.40	21.5 ±2.78	18.9 ±2.35	.241	.626	.006	.844	.364	.021	.844	.424	.016

Note: Statistically significant findings (p < 0.05)

Table 4: Cohen's *d* effect sizes (*ES*) for each one of the physical fitness variables for both MD and NMD group and gender group comparisons

Fitness variables	***Cohen's d***	
	MD & NMD groups	Genders
Sit ups (rep)	1.56	.92
Sit & reach (cm)	.75	.72
Vertical Jump (cm)	1.21	2.26
Standing long jump (cm)	.95	1.53
BMI	.23	.43

DISCUSSION

The main purpose of the study was to compare abdominal and hip-flexors muscle strength and endurance, flexibility of the lower back and hamstrings muscles, Body Mass Index (BMI) and lower body explosive power between adolescents with motor difficulties and their peers without motor difficulties in a physical education setting. A secondary aim was to examine these differences according to gender and finally to examine gender differences in the above-mentioned indexes in both groups.

According to the first hypothesis, the results showed that adolescents with motor difficulties scored lower in abdominal and hip-flexors muscle strength and endurance, in flexibility of the lower back and hamstrings muscles and in lower body explosive power, except BMI, compared to peers without motor difficulties. Moreover, in the field of abdominal strength and flexibility the results of the present study are in line with the results of a study in which 17 to 18 year-old boys without motor difficulties performed better than boys with motor difficulties, to a small extent (15 %), while no difference was observed for girls (Cantell, Crawford & Doyle-Baker, 2008). In addition, Cantell *et al*. (2008) reported that the group of children with motor difficulties had a lower score on the flexibility test compared to the group without motor difficulties. Cermak and Larkin (2002) reported that 73% of children with motor difficulties had either a very high, or a very low score indicating that the range of motion in the experimental group differed dramatically from that reported for children without motor difficulties who outperformed the group of children with motor difficulties, in flexibility, results which were in agreement with findings in the present study. Cairney, Hay, Faught and Hawes (2005) found that motor difficulties were a risk factor for obesity and overweight in childhood; 2% higher compared to boys without motor difficulties, even although for girls there were no differences due to the disorder. In the present study, however, no statistically significant differences were found in body mass index between adolescents with motor difficulties and their peers without motor difficulties, which is likely due to many factors such as diet, genetic factors, and extracurricular sports. Moreover, both groups had normal BMI scores, and this finding may be attributed to their attending physical education lessons three times per week, and many of the adolescents participated in extracurricular sports clubs.

As shown in literature, there has been a decrease in levels of participation in physical activities as children reach adolescence in general (Caspersen et al., 1994; Caspersen *et al*., 2000; Daniels *et al*., 2005) but, also, the low level of participation in physical activities, especially for children with motor difficulties compared to their peers without motor difficulties, leads to reduced performance in health-related fitness tests, which in turn has a negative impact in overall health and well-being, according to the activity deficit hypothesis (Green *et al*., 2011; Schoemaker & Smits-Engelsman, 2015; Dewey & Volkovinskaia, 2018). Furthermore, low levels of motor competence in adolescents lead to lower physical fitness levels and lower physical activity participation (Haga, 2007; Hands & Larkin, 2006) engaging them in a negative cycle which decreases further their motor competence (Katartzi & Vlachopoulos, 2011), complicating further their condition and, therefore, risks many health consequences associated with low fitness levels (Powell et al, 1989). Thus, they are even more at risk than younger children of entering and being trapped in the vicious circle of avoiding participation in physical activities. Mediating factors such as the need for supportive teaching strategies seem to be of high importance in physical education classes involving adolescents with motor difficulties and can potentially alter physical education participation, according to related studies which showed that adolescents with DCD reported significantly lower fulfillment of the need for relatedness, higher amotivation, lower PE enjoyment and higher levels of negative motivational experiences in school physical education compared to their typically developing peers (Vlachopoulos, Katartzi & Kontou, 2021a; Vlachopoulos, Katartzi & Kontou, 2021b; Katartzi & Vlachopoulos 2011).

Physical activity is important for the development and maintenance of many aspects of fitness, and therefore, reduced physical activity has a negative impact on fitness. Despite some controversy over the importance of basic motor skills in maintaining levels of physical activity (Fisher *et al*., 2005), children with motor difficulties often try to avoid opportunities for participation as a result of their poor performance (Cairney *et al*., 2005; Bouffard *et al*., 1996). Therefore, adolescents who have experienced a lack of practice, from a very young age, in basic motor skills and therefore are unable to participate in sports, or school activities, through which fitness levels increase, are even more at risk. The goal of all physical education programs at school should be the implementation of educational programs that take into consideration the adolescents' motor difficulties, or strengths so that students with motor difficulties are involved in the lesson, in order to improve their physical fitness with all the positive consequences in their health and skill performance. A physical fitness education approach, as a part of the school's curriculum, proposed by Hands and Parker (2019) would improve motor competence in adolescents with DCD. Moreover, all children and adolescents attend primary and secondary school and consequently their fitness levels can be consistently monitored in a school setting by the physical education teacher (Stoddard *et al*., 2008), via standardized field tests although, feasibility and safety should be major concerns in testing (Suni *et al*., 1998). In this way, school physical education, should be an excellent avenue to develop motor skills and promote physical activity participation in adolescents with motor difficulties (Hands & Parker, 2019).

According to the second hypothesis, the results showed that gender did not influence the above physical fitness variables with regard to motor difficulties. Moreover, despite studies showing that adolescent boys scored higher in health and skill related fitness indexes compared to girls, gender was not found to play a role in the differences presently studied between adolescents with motor difficulties and their peers without motor difficulties. That is, the emerging differences were found independent of gender, meaning that the influence of the motor difficulties condition was found to be much stronger on the variables studied compared to the possible influence of gender. Clearly, further research may be needed on this topic to substantiate these findings.

According to the third hypothesis, the results showed that boys had higher scores in abdominal and hip-flexors muscle strength and endurance and in lower body explosive power, compared to girls, independent of the presence of motor difficulties. On the other hand, girls outperformed boys in flexibility of the lower back and hamstrings muscles. But, in BMI no gender differences were found. These results are in line with results in studies conducted by Marta *et al*., (2012) who found that differences between prepubescent boys and girls in physical fitness were greater in the explosive strength of upper and lower limbs, and smaller in the flexibility index. Moreover, there are significant variations in power between adolescent boys and girls. Quadriceps' strength is in proportion to height and weight for girls, while for boys there is an added element which can be fully accredited to the increased levels of testosterone. Testosterone is an important factor that describes the differences in strength between genders (Round *et al*., 1999).

To sum up, in comparison to peers without motor difficulties, adolescents with motor difficulties showed lower performance on the abdominals and hip-flexors muscle strength and endurance test, the lower back and hamstrings muscle flexibility test, and the lower body explosive power test. The gender of participants did not affect health and skill-related fitness variables regarding motor difficulties. Independent of motor difficulties occurrence, boys scored higher in abdominal and hip-flexor muscle strength and endurance, as well as in lower body explosive power, in comparison to girls who, in contrast, performed better than boys in terms of flexibility of the lower back and hamstrings. Further research is encouraged.

CONCLUSIONS

- Adolescents with motor difficulties underperformed in the abdominal and hip-flexors muscle strength and endurance test, in the flexibility of the lower back and hamstrings muscles test and in lower body explosive power test, compared to their peers without motor difficulties.
- Gender did not influence health and skill related fitness variables, regarding motor difficulties.
- Independent of the occurrence of motor difficulties, boys had higher scores in abdominal and hip-flexors muscle strength and endurance and in lower body explosive power, compared to girls. On the other hand, girls outperformed boys in flexibility of the lower back and hamstrings muscles.

Conclusively, results of the current study supported previous findings regarding the detrimental effect of motor learning difficulties on children's physical fitness, extending the knowledge to adolescence. Therefore, improving physical fitness should be one of the main goals of any physical education intervention program and future research should focus on intervention programs in school settings through physical education lessons that help adolescents with motor difficulties to improve their physical fitness status in order to promote their participation in sport and physical activities, preventing in this way the secondary consequences of inactivity. There is generally more research on skill and health related fitness in children with motor difficulties (Powell *et al*., 1989) than in secondary school students, and as a result extensive research is required on physical education programs that aim to improve physical fitness in adolescents regardless of their motor competence. There were, also some limitations in the present study such as that the adolescents who participated derived from one secondary school in a metropolitan city; therefore the results cannot be generalized.

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