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ORIGINAL ARTICLE

Coordination Disorder in Children with Dyslexia

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Abstract
One of the most common characteristic of children with dyslexia is poor motor coordination. The aim of the current study was to investigate the above hypothesis through the assessment of motor coordination of children with dyslexia. Participants were 122 children, (68 boys and 54 girls) aged 108 to 143 months (M= 120.3, SD=10.8). Sixty one children with dyslexia (34 boys and 27 girls) formed the experimental group, whereas sixty one children without dyslexia of the same age and gender comprised the control group. The Movement Assessment Battery for Children (MABC, Henderson & Sugden, 1992) was used for motor assessment. It has been designed to identify movement difficulties through the assessment of three motor domains: manual dexterity, ball skills, static and dynamic balance. The statistical analysis revealed that the motor proficiency of the experimental group was higher in comparison to the one of the control group. In addition to that, participants of the experimental group exhibited definite or probable Developmental Coordination Disorder (DCD) whereas all participants of the control group were classified as typically-developed children. Further statistical analysis revealed significant differences between the two groups regarding all motor domains, all in favour of the control group. Within its limitations, the current study seems to be in agreement with the international bibliography, which states that children with cognitive learning disabilities, such as dyslexia, very often appear to face severe motor coordination difficulties, such as DCD. Conclusively, the results of the current study stress the importance of early and detailed motor assessment, which will lead to the application of proper intervention programs regarding all development domains of children with dyslexia.

Key words: DCD, learning disabilities, comorbidity

Introduction

Children with dyslexia are characterised by different mental processing, which presents with difficulties in reading, writing and spelling. Dyslexia can also be associated with deficits in cognitive processes, such as memory, processing speed, time management, coordination and skill automatisation. In addition to this, visual and/or phonological deficits can occur, as well as difficulties in academic performance (Reid, 2009). It is now well established that Dyslexia is a neurological and cognitive disorder with a hereditary origin. But the precise nature of the disorder is still hotly debated (Ramus, 2012). Reading achievement, as measured by individually administered standardized tests of reading accuracy or comprehension, is substantially below that expected given the person's chronological age, measured intelligence, and age-appropriate education (APA, 1994). Dyslexia affects an important percentage (5%) of students and is the most common learning disability, representing 80% of diagnosed cases in Greece (Alahiotis, 2009). According to Getchell, Pabreja, Neeld and Carrio (2007), dyslexia is also the most commonly occurring learning disability in the United States, characterized by difficulties with word recognition, spelling, and decoding.

A growing body of literature suggests that deficits in motor skill performance exist in the dyslexic population. Despite the lack of underlying pathology, children with dyslexia may exhibit motor deficits (Miyahara, 1994). According to Reid (2009), a significant number of dyslexic children may exhibit poor motor coordination, which can lead in problems in manual dexterity, in ball skills, as well as in balance skills (Emck, Bosscher, Beek, Doreleijers ,2009; Kourtessis et al.,2008; Reid, 2009). Developmental Coordination Disorder (DCD) refers to motor performance that is substantially below expected levels, given the person's chronologic age, which significantly interferes with activities of daily living during childhood, and is not due to a known general medical condition (APA, 1994). In their study including children with DCD, Attention Deficit Hyperactivity Disorder (ADHD) and Reading Disability (RD, the term used in the USA to describe children with dyslexia), Kirby, Sugden, Beveridge, Edwards and Edwards (2008), highlighted the overlap and discusses why patterns of overlap are important to recognize when assessing an individual. According to this study, the number of co-occurring, with DCD, disorders is associated with the severity of visual perceptual dysfunction (Crawford & Dewey, 2008).

The current study aimed to assess the motor coordination of children diagnosed with dyslexia in Greece. Even though there have been previous attempts to evaluate the motor coordination of Greek students with learning disabilities (i.e. Kourtessis, Thomaidou, Liveri-Kantere, Michalopoulou, Kourtessis & Kioumourtzoglou, 2008), this is the first attempt of assessing the motor coordination of children with a specific learning disability (i.e. dyslexia). In the present study the term "probable DCD" and "poor motor coordination" will be used interchangeably because a) the assessment was based on the scores of only one diagnostic instrument and b) the second criterion described by Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV), (i.e. limitations in activities of daily living, APA, 1994) was not measured.

Method

Participants

The sample consisted of 122 students, 68 boys and 54 girls, aged 108 to 143 months (M= 120.3, SD=10.8), recruited from 16 public elementary schools of the second region of Athens, Greece. The experimental group comprised of 61 children with a diagnosis of dyslexia, 34 boys and 27 girls, who were attending inclusion classes in their schools. The remaining 61 children, who were matched for age and gender, did not have a diagnosis of dyslexia and formed the control group. According to their age, the participants of the experimental group were subdivided into Experimental $Group_1$ ($EG_{1)}$, with 45 children,(25 boys and 20 girls) and a mean age of 114.13 months (SD=4.93), and Experimental $Group_2$ (EG_2), with 16 children (9 boys and 7 girls) and a mean age of 136.94 months (SD=4.09). Accordingly, the control group was subdivided into Control $Group_1$ (CG_1), (M=115months, SD=5.51) and Control $Group_2$ (CG_2) (M=136 months, SD=3.01). This was done in order to meet the age criteria of the Movement Assessment Battery for Children (MABC, Age Band 3, Age Band 4), which includes different tasks for each age group in all three motor domains.

Teachers who were in charge of the inclusion classes were asked to provide the researchers with information regarding the eligibility for participation in the study (i.e. Dyslexia diagnosis from a Center for Differential Diagnosis & Support). The Centers for Differential Diagnosis and Support for Learning Disabilities (LD) are public centers which are accredited for assessing and diagnosing LD in the Greek school population. As soon as the information data were gathered, consent forms were sent to the parents, informing them about the aim and the procedures of the study. The children who participated in the study were the ones that their parents signed and returned the consent form.

Under the term DCD the DSM-IV (APA, 1994) has both inclusive and exclusive criteria. Exclusive criterion D refers to the presence of mental retardation (MR). This is often called learning difficulties or learning disabilities in countries outside of North America, and usually involves an IQ score below 70 points. Although this is not specified in the criteria, a recent consensus meeting, "The Leeds Consensus" (Sugden, 2006), reached an agreement that a child with an IQ score below 70 would not be given a diagnosis of DCD, noting there is usually a much higher prevalence of motor difficulties below this IQ score (Kirby et al., 2008). All children with dyslexia who participated in the present study had an IQ score at or above 70.

Measurements and Procedure

The MABC (Henderson & Sugden, 1992) was used for the motor assessment. This battery was designed to identify and evaluate movement difficulties that can arise during childhood through the assessment of three domains of motor development: a) Manual Dexterity, b) Ball Skills, and c) Balance. It consists of 32 exercises, which are organized in four age bands (8 tasks for each age band), covering an age range from 4 to 12 years. In the current study the 3rd and 4th band (ages 9-10 and 11-12) were used. For each task children can receive a score from 0 (success) to 5 (failure-severe movement difficulties). The total impairment score is the sum of eight sub-scores producing a score between 0 (for a child with no difficulties) and 40 (for a child with extremely severe movement difficulties). The total motor score represents the degree of the motor impairment, compared to the normative data concerning his/her age. In the manual (Henderson & Sugden, 1992), the 5th and the 15th percentiles are suggested as cut-off scores. Scores between the 5th and 15th percentile suggest a degree of difficulty that is borderline. A score at or below the 5th percentile is indicative of a definite motor problem. The validity and reliability scores of MABC are satisfactory (Ellinoudis, Kourtessis, Kiparissis, 2008a; Ellinoudis, Kourtessis, Kiparissis, Kampas & Mavromatis, 2008b; Henderson & Sugden, 1992; Venetsanou, Kambas, Ellinoudis, Fatouros, Giannakidou, & Kourtessis, 2011).

The motor assessment was conducted individually in especially customized rooms in the children’s schools. The evaluation of each task was done according to the instructions suggested by the manual in order to preserve the characteristics of each age band. The examiner visited the children’s schools prior the examination day, in order to get familiar to the children and to minimize the possible anxiety in the day of the actual assessment. In addition to that, the examiner also spent 10-15 minutes before the individual evaluation, explaining in detail to each child what he/she was expected to do.

Statistical Analysis

Descriptive statistics were used to present the sample’s distribution according to the normative data of the battery. Multivariate analysis of variance was also used in order to investigate possible differences between the two groups in the three motor domains of the MABC. Dependent variables were: “manual dexterity”, “ball skills” and “balance skills” whereas the independent variable was “Group” (children with or without dyslexia). Furthermore, multivariate analysis of variance was used to examine the possible differences between the two groups in the eight items of the MABC. Dependent variables where the eight items of the battery while the independent variable was “Group” (children with or without dyslexia). Finally, a univariate analysis of variance was perfumed to investigate differences between the children with and without dyslexia, regarding “Total Motor Score”. “Group” (children with or without dyslexia) served as the independent variable.

Results

The statistical analysis served two purposes. The first one was to investigate probable differences between the children with and without dyslexia regarding the three major motor domains as well as the total motor scores. The second purpose was to investigate differences regarding each task of the battery taking into account the specific age group of the child. The distribution of children for both groups is presented based on their performance and the norms given by MABC are presented on Table 1.

Table 1. Distribution of children for both groups based on their performance and the norms given by the Movement Assessment Battery for Children.

	Percentile					
	*<5%**		*6-15%***		*>15%****	
Group	*N*	*%*	*n*	*%*	*N*	*%*
Experimental (n=61)	47	77%	8	13,2%	6	9,8%
Control (n=61)	2	3,3%	2	3,3%	57	93,4%

* A score at or below the 5th percentile is indicative of a definite motor problem
** Scores between the 5th and 15th percentile suggest a degree of difficulty that is borderline
*** A score at or above the 16th percentile indicates absence of motor difficulties

The multivariate analysis of variance, revealed statistically significant differences regarding the three major motor domains of the battery as well as regarding the total motor score (Wilks' λ=.406, $F_{(4,115)}$=40.01, p<.001, η^2=.59). The univariate analysis table showed significant differences between the two groups in the manual dexterity task ($F_{(1,118)}$=93.29, p<.001, η^2 = .44), in ball skills ($F_{(1,118)}$= 57.94, p<.001, η^2=.33), in balance ($F_{(1,118)}$=83.99, p<.001, η^2 =.42), and in the general motor performance ($F_{(1,118)}$=171.35, p<.001, η^2=.59). The typically developed children outperformed their peers with dyslexia in all four dependent variables (Table 2).

Table 2. Means and standard deviations of the performance of children with and without dyslexia in the three motor domains of motor development and the total motor score (higher score denotes more severe difficulties).

		Manual Dexterity		Ball Skills		Balance		Total Motor Score	
Group	*N*	*M.*	*S.D.*	*M.*	*S.D.*	*M.*	*S.D.*	*M.*	*S.D.*
Children without Dyslexia	61	2.26	1.97	.75	1.39	3.02	1.87	6.11	3.30
Children with Dyslexia	61	6.62	3.01	3.48	2.88	7.16	2.99	17.24	6.15

Age Band 3 ($C.G._1$ vs $E.G._1$)

The multivariate analysis of variance, revealed statistically significant differences between the two groups of 9-to-10 year-old children regarding the eight tasks of the battery (Wilks' λ=.362, $F_{(8,81)}$=17.90, p<.001, η^2=.64). The univariate analysis table showed significant differences between the two groups in manual dexterity task 1 ($F_{(1,88)}$=25.06, p<.001, η^2 =.22), in manual dexterity task 2 ($F_{(1,88)}$=11.42, p<.05, η^2 =.115), and in manual dexterity task 3 ($F_{(1,88)}$=60.52, p<.001, η^2 =.41). Regarding ball skills, significant differences were revealed in task 1 ($F_{(1,88)}$=10.81, p<.05, η^2 =.11), as well as in task 2 ($F_{(1,88)}$=38.15, p<.001, η^2 =.30). Finally, significant differences were shown in the static balance task ($F_{(1,88)}$=13.32, p<.001, η^2=.13) as well as in the dynamic balance task 1 ($F_{(1,88)}$=58.23, p<.001, η^2 =.40) and task 2 ($F_{(1,88)}$=12.13, p<.05, η^2 =.12), All the above differences stemmed from the better performance of the children without dyslexia compared to their dyslexic peers (Tables 3, 4 & 5).

Table 3. Means and standard deviations of all groups for the three tasks of the motor subsection “manual dexterity” (higher score denotes more severe difficulties)

			Manual Dexterity Task 1		Manual Dexterity Task 2		Manual Dexterity Task 3	
	Group	n	M.	S.D.	M.	S.D.	M.	S.D.
Age Band 3	$C.G._1$	45	1.66	1.60	.600	1.13	.200	.547
	$E.G._1$	45	3.31	1.50	1.71	1.89	2.15	1.59
Age Band 4	$C.G._2$	16	1.47	1.69	.188	.400	000	000
	$E.G._2$	16	2.47	1.37	.169	1.74	1.00	1.21

Table 4 Means and standard deviations of all groups for the two tasks of the motor subsection “ball skills” (higher scores denotes more severe motor difficulties).

		Ball Skills Task 1		Ball Skills Task 2	
Group	n	M.	S.D.	M.	S.D.
$C.G._1$	45	.467	1.09	.222	.517
$C.G_2$	16	.319	0.70	.625	.880
$E.G._1$	45	1.53	1.87	1.77	1.60
$E.G._2$	16	1.84	1.73	2.31	1.74

Age Band 4 ($C.G._2$ vs $E.G._2$)

Regarding Age Band 4, the multivariate analysis of variance, revealed statistically significant differences between the two groups of 11-to-12 year-old children in all eight tasks of the battery (Wilks’ λ =.179, $F_{(8,23)}$=13.22, p<.001, η^2=.82). The univariate analysis table did not reveal significant differences between the two groups in manual dexterity task 1 ($F_{(1,30)}$=3.40, p=.076, η^2=.10). Significant differences between the two groups were shown in manual dexterity task 2 ($F_{(1,30)}$=11.28, p<.05, η^2=.27), and in manual dexterity task 3 ($F_{(1,30)}$=10.90, p<.05, η^2=.27). Regarding ball skills, significant differences were revealed in task 1 ($F_{(1,30)}$=10.76, p<.05, η^2=.26), as well as in task 2 ($F_{(1,30)}$=11.95, p<.05, η^2=.28). Finally, significant differences were shown in the static balance task ($F_{(1,30)}$=25.79, p<.001, η^2=.46) as well as in the dynamic balance task 1 ($F_{(1,30)}$= 4.45, p<.05, η^2=.13) and task 2 ($F_{(1,30)}$=13.80, p<.05, η^2=.35), All the above significant differences stemmed from the better performance of the children without dyslexia compared to their dyslexic peers (Tables 3, 4 & 5).

Table 5. Means and standard deviations of all groups for the three tasks of the motor subsection “balance” (higher scores denotes more severe motor difficulties).

		Static Balance		Dynamic Balance Task 1		Dynamic Balance Task 2	
Group	n	M.	S.D.	M.	S.D.	M.	S.D.
$C.G.._1$	45	2.53	1.17	1.67	.40	.51	.77
$C.G._2$	16	.81	1.33	1.25	1.24	.75	.77
$E.G._1$	45	3.55	1.46	1.72	1.30	1.64	1.81
$E.G._2$	16	3.56	1.71	2.25	1.44	2.31	1.49

Discussion and Conclusion

The aim of this study was the assessment of the motor coordination of children with dyslexia. The international literature reports that children with dyslexia often exhibit poor motor coordination and many of them usually face DCD (Fawcett, Nicholson & Dean, 1996;

Mortimore, 2003; Thomson, 2001). According to the results of the present study, 47 out of 61 children with dyslexia (77%) exhibited motor performance that corresponded to the lowest level for their age range, while only two children (3.3%) of the control group were at the same level. The present findings are in agreement with the literature, where prevalence studies indicate that at least 50% of children with LD are identified with concomitant DCD (Jongmans, Bowien, Smits-Englesman & Schoemaker, 2003; Kaplan, Wilson, Dewey & Crawford, 1998; Kourtessis et al., 2008; Rintala, Pienimäki, Ahonen, Cantell & Kooistra, 1998; Sugden & Wann, 1987; Visser, 2003).

Furthermore, the results of the current study revealed significant differences among the experimental and the control groups in all three motor domains and in the total motor score, with experimental group exhibiting significantly lower motor performance. The above finding comes in agreement with studies supporting that children with LD exhibit delays in fine motor coordination, ball skills and poor static and dynamic balance (Cermak & Larkin, 2002; Cratty, 1996; Kourtessis et al., 2008). Further analysis revealed that the same characteristic appeared for all, but one, individual items of MABC and for both age bands, with the typically developed children outperforming the children with dyslexia.

Regarding manual dexterity items, the 9-10 year-old children with dyslexia exhibited very poor motor coordination in all three tasks, which agrees with the relevant international literature. (Jongmans et al., 2003; Iversen, Berg, Ellertsen & Tonessen, 2005; Kourtessis et al., 2008; Ramus, Pidgeon & Ftith, 2003). On the other hand, their 11-to-12 year-old peers exhibited poor motor ability only for two out of the three manual dexterity tasks. The only item where there were no significant statistical differences was the “turning pegs” task in age band 4. According to Fawcett and Nicholson (1995), there seems to be a significant interaction between age and dyslexia. This statement combined to the fact that 11-to-12 year-old children with dyslexia were included in this study, attended inclusion classes for a longer period of time in comparison to the children of age band 3 may be a possible explanation for the aforementioned lack of significant difference. The additional intervention time might help with execution speed, which was the measured variable in the specific manual dexterity item. Also, the small size of participants in the specific age band could be an additional explanation.

In the both tasks of “ball skills”, all participants with dyslexia exhibited severe motor difficulties, a finding that is supported by the international literature (Henderson & Sugden, 1992; Kourtessis et al., 2008). There are some researchers who have mentioned that dyslexic children do not perform poor in ball skills (Critchley & Critchley, 1978; McPhillips & Sheeny, 2004), however this was not the case in the present study.

Finally, the participants with dyslexia in both age groups exhibited very poor balance skills, a fact which is in accordance with relevant references in the literature (Getchell, Pabreja, Neeld & Carrio, 2007; Patel, Magnousson, Lush, Gomez & Fransson, 2010; Rochellle, Talcott, 2006; Vixolainen, Aro, Crawford, Cantell & Kooistra, 2011). This finding is also being supported by the theory that dyslexia is related to an automatization deficit that affects both language and motor skills (Fawcett & Nicholson, 1992). According to Visser (2003), this effect may actually be limited to dyslexics who also show attention deficits, providing further evidence that the automatization deficit is a generalized disorder. Some studies suggest that poor coordination in movement and balance are more apparent in children who seem to have ADHD in parallel with DCD (Ramus, Pidgeon & Frith, 2003; Wimmer, Mayringer & Raberger, 1999).

The findings of the current study highlight the importance of early motor identification and assessment. It is widely known that children with poor motor coordination have low self-esteem as well as aggression (Piek, Barrett, Allen Jones & Louise, 2005; Skinner & Piek, 2001), that combined with the already diagnosed dyslexia, might exacerbate their emotional disorders. Strong evidence also indicates that children who appear to have “mild” motor difficulties go on to experience serious secondary social and emotional problems (Missiouna, Rivard & Pollock, 2004). Children with DCD experience a sense of low self efficacy when they participate in physical activities (Cairney, Hay, Faught, Corna & Flouris, 2005), thus they often exhibit low levels of fitness, which can subsequently lead to obesity and even more severe health problems (Faught, Hay, Cairney & Flouris, 2005). Recently Rivilis et al. (2011) reported that children with DCD are well below average standards in physical activity and also demonstrate low fitness levels. Furthermore, children with DCD exhibit limited participation diversity in which they participate less frequently and chose activities that are quiet and more socially isolate in comparison to typically developed children (Jarus, Gelberg, Engel-Yeger & Bart, 2011). Therefore, motor assessment could contribute in dealing with this phenomenon. In conclusion and within the limitations of the current study, it seems that the role of motor coordination in everyday life of the children with dyslexia may be seriously underestimated! There is a significant need to introduce motor assessment, as an integral part of the diagnosis process, in the Centers for Differential Diagnosis and Support for LD as well as in the public medical assessment centres for children with special needs.

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