Rheumatol. Forum
2022, vol. 8, No. 1, 14–26

ISSN: 2720-3921, e-ISSN: 2720-3913
DOI: 10.5603/RF.2022.0003

VIA MEDICA
www.journals.viamedica.pl

ORIGINAL ARTICLE

Kinga Litwin, Anna Kostiukow, Piotr Poniewierski, Dominika Janowska, Karolina Biel, Włodzimierz Samborski

Chair and Department of Rheumatology, Rehabilitation and Internal Medicine Poznan University of Medical Sciences, Poland

The use of selected parameters of the mini-golf game for screening the motor assessment of children for Developmental Coordination Disorder — preliminary report

ABSTRACT

Introduction: Developmental Coordination Disorder (DCD) affects from about 6% to even 8% of children. In Poland, this disorder is still very rarely diagnosed despite the existing motor problems in children. This may be due to a lack of awareness and knowledge about DCD. Education in this direction is recommended. Diagnostic criteria The DSM-V include: the achievement of motor skills manifested by clumsiness is inadequate to age, the influence of motor difficulties on the activities of daily living, the onset of symptoms in the early period, and the lack of explanation of the motor deficits present by disability.
Aim: The study aimed to screen children for early symptoms of motor disorders characteristic of Developmental Coordination Disorder. It was assessed whether there are correlations between the results of the ABC-2 and BOT-2 motor tests and the results of the mini-golf set created for the study.
Material and methods: 200 primary school children were tested using the Movement Assessment Battery for Children Second Edition (ABC-2), Bruininks-Oseretsky Test of Motor Proficiency Second Edition (BOT-2) motor tests and a mini-golf set designed for the study. The obtained results were subject to statistical analysis.
Results: The ABC-2 test showed that 87.5% of children had no motor difficulties. On the other hand, the remaining 12.5% have motor difficulties. In the results of the BOT 2-58%, there are no difficulties or they are insignificant, and significant difficulties are presented in 42%. The greater the overall BOT 2 score, the greater the average impact force. Additionally, it has been noticed that the larger the Aiming and Catching is, the lower the Average Impact Force. And the greater the Fine Manual Control, the lower the Average Ball Speed and Average Stroke Force.
Conclusions: The difficulties examined in parametric tests are confirmed by the difficulties of the subjects with mini-golf. Thanks to the game of minigolf on a specially prepared field, you can explore; the number of strokes to place the ball in the hole, average ball speed, average impact force, the force of hitting the ball with the dominant and non-dominant upper limb. The assessed parameters can be used for the motor screening assessment of children.

Rheumatol. Forum 2022, vol. 8, No. 1: 14–26

KEY WORDS: DCD; developmental coordination disorder; minigolf; ABC-2; BOT-2

Address for correspondence:
mgr Piotr Poniewierski
Chair and Department of Rheumatology, Rehabilitation and Internal Medicine Poznan University of Medical Sciences, Poland
e-mail: piotrponiewierski@wp.pl

INTRODUCTION

Currently, more and more children in school or kindergarten class teams present non-specific symptoms of movement disorders that do not fit into the classical diagnostic criteria of the most common developmental disorders affecting the paediatric group of patients. Hence, in most cases, these are children who have never been properly diagnosed and are described as naughty, hyperactive and chaotic.

Developmental Coordination Disorder (DCD) has been classified as a neurodevelopmental disorder in the Diagnostic and Statistics Manual of Mental Disorders V (DSM-V) [1, 2]. According to the medical classification DSM-V, developmental coordination disorder is a significant impairment of the development of motor coordination and motor skills, which significantly affects the achievement of school and daily duties/tasks/activities. Also in the ICD 10 classification, there is the same unit called Specific Developmental Disorder of Motor Function with the symbol F82 — describing symptoms as in DCD. There is a characteristic impairment in the development of motor coordination, unrelated to congenital or acquired neurological disorders or intellectual disability [3–5]. In both cases, the importance of the physiotherapist in this group of patients is emphasized [1].

It is very common to see limitations/disturbances in motor coordination in these children, which in turn may lead to a wide range of developmental abnormalities. Among them, the most important are problems with speech and communication, perception (most of them present disorders in the field of sensory integration), abstract or logical thinking [6]. The postural control of these children is poor, there are difficulties with balance, problems in the area of fine and gross motor skills [2]. The discussed disorders, subtly beginning and generally referred to as motor clumsiness, such as a "snowball", induce serious problems with achieving individual stages of education [7] (due to problems with memory, concentration, among others), with social contacts, establishing relationships, starting a family, or mental health [8]. The subject of aggressive side effects is not without significance here, which is nowadays almost a common phenomenon in Polish schools.

In clinical practice and scientific literature, the discussed group of children is defined as children: dyspraxic, with Clumsy Child Syndrome, Developmental Coordination Disorder (DCD), Minimal Brain Dysfunction, with difficulties in learning motor skills (Motor Learning Difficulty), perceptual-motor dysfunction (Perceptuo-motor Dysfunction) and others.

Currently, a lot of scientific research is carried out in the world, looking for the causes of these atypical symptoms, which, if not diagnosed and without appropriate therapy, can lead to significant problems in the everyday life of an adult and affect the quality of his life.

The DSM-5 classification gives the following diagnostic criteria for DCD:

— achieving motor skills manifested by clumsiness is not appropriate to age, lack of precision/accuracy and slowness in performing motor skills;
— the impact of motor difficulties on everyday activities, productivity at school, play or leisure;
— early onset of symptoms;
— lack of explanation of the occurring motor deficits with intellectual disability, visual impairment or a neurological condition that could affect movement (eg cerebral palsy) [9].

The Movement Assessment Battery for Children Second Edition (ABC-2) motor test has been documented for diagnostic use. The DSM-V provides diagnostic criteria for DCD that are largely in line with the results of children tested with ABC-2. Therefore, this test is considered important in the clinical diagnosis of children with DCD [10]. It is therefore the most widely used test for screening for Developmental Coordination Disorder. This test has been described as reliable, it presents a normative approach to functional skills. It consists of eight subtests, three of which assess manual skills, two aim and catch, and three determine balance [11].

The Bruininks-Oseretsky Test of Motor Proficiency Second Edition (BOT-2) is also an effective tool for the assessment of motor disorders in children [12]. It consists of eight decks and examines fifty items by assessing a wide range of a child's abilities. The assessment includes, among others: precision, dexterity of the upper limbs, visual-motor control, balance, coordination. However, it is less sensitive than ABC-2. Moreover, the test process is much longer, which can be quite a challenge for children with attention and concentration problems [11].

It is recommended that children are not diagnosed with DCD until the age of 5. The exceptions are cases of severe handicap, however, under certain conditions. Motor tests should then be performed twice, 3 months apart [11].

The difficulties arising from Developmental Coordination Disorder should be reflected in ICF levels, i.e. function and structure, daily living activities (ADL), participation, and personal and environmental factors. The structure and function include motor efficiency, basic motor functions, perceptual functions, executive functions, and they are especially important in the diagnostic process. Participation is defined here as social integration, while environmental factors are socio-economic resources and coping. Personal factors, on the other hand, reflect individual resources, quality of life, well-being, satisfaction (11). Daily activities are a key element because they are important both in the diagnostic process, constitute indications for treatment, and also provide a solid basis for assessing the effectiveness of interventions [11, 13].

An important aspect is to consider the consequences of not treating DCD. In many cases, the difficulties persist into adolescence, while up to 70% of adults still struggle with various deficits. The adult population often associated with DCD also has problems that are not directly related to motor skills. These include, among others: low self-esteem, depression, problems with anxiety, and executive functions. Children with DCD are less physically active than their peers with a neurotypical profile, and they lead a sedentary lifestyle much more often [14, 15]. There are reports that there may be a link between the prevalence of DCD and obesity in the male population [11].

Planning of therapeutic intervention should be based on the child's strengths and weaknesses in an environmental context to improve motor function, activity and participation. It is also very important to consider the psychosocial aspects. Therapeutic intervention should target deficit areas that constitute the basic and specific motor skills of people with DCD [11]. It is recommended that the interventions be focused on physical activity and functionality [16]Smits-Engelsman, Polatajko, & Wilson, 2012 and improvement of physical fitness [17]. There are reports on the effectiveness of the use of target-oriented group intervention [18].

PURPOSE

The study aimed to test children for early symptoms of motor dysfunction characteristic of developmental coordination disorder (DCD).

The specific objectives were to determine whether there are correlations between the results of mini golf and the results of standardized motor tests (Movement Assessment Battery for Children Second Edition [ABC-2] and Bruininks-Oseretsky Test of Motor Proficiency Second Edition [BOT-2]). Confirmation of the difficulties resulting from the game of mini-golf in the ABC-2 and BOT-2 motor tests would provide the basis for introducing the game of mini-golf as a proposal of a screening tool for assessing the child's motor development towards DCD. This tool, inexpensively and attractively for children, would provide information on selected aspects of the child's motor development, using the conditions of play at school/kindergarten/clinic.

It should be emphasized that early detection of difficulties enables early implementation of interventions, which in turn translates into improved functioning of children and better prognosis for the future.

Table 1. Characteristics of the examined group

Variables	Study group N = 200 (%)
Sex of Child	
Girl	90 (45.0%)
Boy	110 (55.0%)
Child age	
Min	7
Max	10
M	8.76
SD	0.91
Parents filling in the questionnaire	
Mother	138 (69.0%)
Father	10 (5.0%)
No data available	52 (26.0%)

Source: own research

MATERIAL AND METHODS

STUDY SUBJECTS

The study assessed 200 children aged 8 on average, 45% of which were girls and 55% boys. All these people attend primary mass schools in the Greater Poland Voivodeship. Table 1 presents the detailed characteristics of the examined group.

PROCEDURE

All parents voluntarily consented to the participation of their children in the study. The research was approved by the Bioethics Committee at the Medical University of Poznań and was carried out between September and November 2021 in primary schools in the Greater Poland Voivodeship.

TOOLS

For the study, the following were performed:

— physiotherapeutic assessment, with particular emphasis on coordination skills and eye-hand coordination with the use of MINIGOLF — GoDiag.me 1.0. — equipment — objective and quantitative assessment;
— physiotherapeutic evaluation using typical motor tests — Movement Assessment Battery for Children Second Edition (ABC-2) and Bruininks-Oseretsky Test of Motor Proficiency Second Edition (BOT-2);
— psychological assessment based on J. Kagan's MFF Test, the revised version of the Attention and Concentration Test (d2-R), the Quick Naming Test (TSN-M and TSN-S), and the Visual Memory Test Benton (BVRT, version C).

To evaluate the motor skills of children with the use of mini-golf equipment, it was reasonable to place sensors in the stick (at the top to assess the grip strength of the hand, at the bottom to assess the acceleration) in the hole and the ball. Balls of different gravity (balls 1, 2 and 3) were used to assess the ability to kinaesthetic differentiation of movements. It is one of the coordination skills. It was checked whether the appropriate force was applied to the movement with a heavy, medium and light ball to maintain effectiveness - economy of movement, i.e. to introduce the ball into the hole. Attempts to hit the ball into the hole from a certain distance to the starting sound signal were proposed. It was aimed at assessing hearing-motor coordination and spatial-temporal orientation.

The parameters of the game were analysed, i.e.:
— time of trial,
— number of strokes to place the ball in the hole,
— average ball speed,
— average impact force,
— the force of hitting the ball with the dominant and non-dominant upper limb.

Children were also assessed with a standardized motor test used all over the world — Movement Assessment Battery for Children Second Edition (ABC-2), whose authors are: Sheila E Henderson, David A. Sugden, Anna Barnett. The 7–10-year-old test is divided into three parts — Manual Dexterity, Aiming & Catching, Balance. Manual Dexterity consists of the subtests: Placing Pegs, Threading Lace, Drawing Trial 2. Aiming & Catching consists of subtests: Catching with Two Hands, Throwing Beanbag onto Mat. Balance is divided into Balance Static (One-Board Balance) and Balance Dynamic (Walking Heel-to-Toe Forwards, Hopping on Mats). The duration of the test for one child is about 20 minutes. The results were coded according to the instructions and statistically analysed.

The Checklist is also included in ABC-2. It is a questionnaire that is completed by parents in three sections. Section A — Movement in a Static and/or Predictable Environment — is divided into Self-Care Skills, Classroom Skills, PE/Recreational Skills. Section B - Movement in a Dynamic and/or Predictable Environment — is divided into parts: Self Care/Classroom Skills, Ball Skills, PE/Recreational Skills. Possible answers for selection in the first two sections were: 0 = Very Well, 1 = Just OK, 2 = Almost, 3 = Not Close, NO = Not Observed. Part C was Non-motor Factors that Might Affect Movement. The answer options are Yes or No.

The Bruininks-Osterestsky Test of Motor Proficiency Second Edition (BOTTM-2) research tool created by Robert H. Bruininks and Brett D. Bruininks was also used. The 4–21-year-old test is divided into four parts: Fine Manual Control consists of subtests: Fine Manual Precision and Fine Motor Integration. Manual Coordination consists of the subtests: Manual Dexterity and Upper-Limb Coordination. Body Coordination consists of subtests: Bilateral Coordination and Balance. Strength and Agility consist of the subtests: Running Speed and Agility and Strength. The four main parts of the test are part of the Total Motor Composite. The results were coded according to the instructions and statistically analysed.

For the psychological assessment of the study group, several tests were used to make a psychometric diagnosis. Each of them is made individually. The first one is J. Kagan's Test of Comparing Known Shapes (MFF), translated by Anna Matczak. The test consists of 14 tasks (including 2 trial tasks) which consist in finding in a group similar pictures identical to the presented pattern. The purpose of the test is to assess the child's cognitive style. Each task has a higher degree of difficulty than the previous one; time is measured at each trial.

The test used to test attention and concentration was d2-R by Rolf Brickenkamp, Lothar Schmidt-Atzert and Detlev Liepmann (in the Polish adaptation of Iwona Bac and Joanna Stańczak). It consists of a worksheet divided into 14 lines. Each line contains 47 different characters (combinations of dip letters,

Table 2. Problems related to Movement in a Static and/or Predictable Environment, Problems Movement in a Dynamic and/or Predictable Environment and Problems Non-motor Factors that Might Affect Movement, Movement ABC and BOT 2 a measurement of Mini Golf ball 1 — Spearman's rho correlation test (N = 200)

	Mini Golf Measurements — ball 1					
	Time of trial	Total number of strokes	Average ball speed	Average impact force	Average grip strength of the dominant hand	Average grip strength of the non-dominant hand
Problems Movement in a Static and/or Predictable Environment	–0.054	–0.065	–0.010	0.028	0.030	0.045
Problems Movement in a Static and/or Predictable Environment	–0.115*	–0.162*	–0.005	–0.117*	–0.036	0.055
Problems Non-motor Factors that Might Affect Movement	0.029	0.036	0.019	0.028	0.043	0.112*
ABC movement in general	–0.054	–0.063	0.091	0.064	0.013	0.026
Manual Dexterity	0.041	–0.026	0.051	0.078	–0.058	–0.022
Aiming and Catching	–0.059	–0.067	0.084	0.107	–0.010	0.014
Balance	–0.105	–0.027	0.123*	–0.102	0.070	0.094
Total BOT 2	0.030	–0.051	0.081	0.123**	0.074	0.012
Fine Manual Control	–0.088	–0.097	–0.037	0.092	0.116*	0.054
Manual Coordination	0.016	–0.092	0.062	0.177**	0.150*	0.008
Body Coordination	0.072	0.084	0.058	0.005	–0.052	–0.010
Strength and Agility	0.014	0.035	0.130*	0.007	–0.046	–0.037

*$p < 0.05$, **$p < 0.01$
Source: Author's own compilation

followed by dashes). The task of the subject was to catch and cross out each letter d with two lines. The time limit for each line was 20 seconds.

Another of the tests used for psychometric evaluation was the Quick Naming Test (TSN), developed for children aged 5–7 (TSN-M) and for children aged 8–12 (TSN-S). The test requires the child to name the presented stimuli as quickly as possible, time is measured in each part of the test. The version for younger children (TSN-M) consists of 3 parts (objects, colours and mixed material), while the version for older children consists of 5 parts (objects, colours, numbers, letters, mixed material). Regardless of the version, each part contains 48 stimuli.

The last of the tests used to conduct the psychological part of the study was the Benton Visual Memory Test (BVRT) by Abigail Benton Sivan. It is used to assess memory and visual perception as well as visual-constructive abilities. Version C and method C of the test were used. It consists of the child copying the patterns from the presented notebook to the answer sheet. The test consists of 10 patterns, each containing one or more geometric figures. The test is carried out without any time limit.

RESULTS

DESCRIPTIVE STATISTICS OF VARIABLES

The results of the Kolmogorov-Smirnov test carried out in the first place indicated the lack of compliance with the normal distribution of all examined variables, therefore non-parametric tests will be used to verify the assumptions made: Spearman's rho.

Correlation: Problems related to the Checklist (Movement in a Static and/or Predictable Environment, Problems Movement in a Dynamic and/or Predictable Environment and Problems Non-motor Factors that Might Affect Movement, Movement ABC and BOT 2 and the measurements of Mini Golf ball 1.

The results of the Spearman's rho test presented in Table 2 indicate that the problems related to the parameter Movement in a Dynamic and/or Predictable Environment have a weak negative correlation with Test time, Number of all strokes and Average impact force, Problems related to the parameter Non-motor Factors that Might Affect Movement weakly positively correlated with the average grip strength of the non-dominant hand, the Balance parameter weakly positively correlated with the Average ball speed, the

Table 3. Problems related to Movement in a Static and/or Predictable Environment, Problems Movement in a Dynamic and/or Predictable Environment and Problems Non-motor Factors that Might Affect Movement, Movement ABC and BOT 2 a measurement of Mini Golf ball 2 — Spearman's rho correlation test (N = 200)

	Mini Golf Measurements — ball 2					
	Time of trial	Total number of strokes	Average ball speed	Average impact force	Average grip strength of the dominant hand	Average grip strength of the non-dominant hand
Problems Movement in a Static and/or Predictable Environment	–0.065	–0.029	–0.005	–0.038	0.029	0.051
Problems Movement in a Static and/or Predictable Environment	–0.033	–0.007	–0.023	–0.030	–0.099	–0.050
Problems Non-motor Factors that Might Affect Movement	–0.071	0.101	–0.024	–0.053	0.071	0.164*
ABC movement in general	0.097	0.081	0.003	0.007	–0.015	–0.059
Manual Dexterity	0.076	0.036	0.058	0.053	–0.017	–0.068
Aiming and Catching	0.036	0.012	–0.021	–0.031	–0.111*	–0.099
Balance	0.012	0.060	0.079	–0.006	0.103	0.081
Total BOT 2	0.009	0.023	0.117	0.017*	–0.008	–0.054
Fine Manual Control	–0.052	0.010	0.010	0.005	0.059	0.062
Manual Coordination	0.081	–0.019	0.118*	0.120*	0.089	–0.059
Body Coordination	–0.013	–0.016	0.093	–0.021	–0.094	–0.085
Strength and Agility	0.030	0.075	0.126*	–0.054	–0.045	–0.083

*p < 0.05, **p < 0.01
Source: Author's own compilation

overall result of the BOT 2 test was weakly positively correlated with the average impact force, Fine Manual Control slightly positively correlated with the Average grip strength of the dominant hand, Manual Coordination correlated weakly positively with the mean force of hitting and the mean power of the grip of the dominant hand, while Strength and Agility has a weak positive correlation with the mean ball speed.

This means that the greater the Problems related to the Movement in a Dynamic and/or Predictable Environment parameter, the shorter the trial time, the smaller the number of all strokes needed to hit and the lower the average force of the impact, the greater the Problems related to Non-motor Factors that are Might Affect Movement, the greater is the Average grip strength of the non-dominant hand. The greater the Balance, the greater the Average Ball Speed. The greater the overall BOT 2 test result, the greater the Average Stroke Force, the greater the Fine Manual Control, the greater the Average Grip Force of the Dominant Hand, the greater the Manual Coordination, the greater the Average Stroke Force and the Average Grip Force of the Dominant Hand. and the greater the Strength and Agility, the greater the Average Ball Velocity.

Correlation: Problems connected to Checklist (Movement in a Static and/or Predictable Environment, Movement in a Dynamic and/or Predictable Environment and Non-motor Factors that Might Affect Movement, Movement ABC i BOT 2 and Mini Golf ball 2.

The results of the Spearman's rho test presented in Table 3 indicate that the Problems related to Non-motor Factors that Might Affect Movement correlate weakly positively with the average grip strength of the non-dominant hand, Aiming and Catching slightly negatively correlate with the average grip strength of the dominant hand, the overall result of the BOT 2 test has a weak positive correlation with the mean hitting force, Manual Coordination has a weak positive correlation with mean ball speed and mean hitting force, while Strength and Agility has a weak positive correlation with mean ball speed.

This means that the greater the Problems related to Non-motor Factors that Might Affect Movement, the greater the Average Grip Strength of the non-dominant hand. The greater the Aiming and Catching is, the lower the Average Grip Strength of the Dominant Hand is. The greater the overall BOT 2 score, the greater the Average Hit Force, the greater the Manual Coordination, the greater the Average Ball Speed and Average Hit Force, and

Table 4. Problems related to Movement in a Static and/or Predictable Environment, Problems Movement in a Dynamic and/or Predictable Environment and Problems Non-motor Factors that Might Affect Movement, Movement ABC and BOT 2 a measurement of Mini Golf ball 3 — Spearman's rho correlation test (N = 200)

	Mini Golf Measurements — ball 3					
	Time of trial	Total number of strokes	Average ball speed	Average impact force	Average grip strength of the dominant hand	Average grip strength of the non-dominant hand
Problems Movement in a Static and/or Predictable Environment	0.082	–0.045	–0.061	–0.195**	–0.040	–0.001
Problems Movement in a Static and/or Predictable Environment	0.053	–0.049	0.015	–0.157*	0.026	0.023
Problems Non-motor Factors that Might Affect Movement	0.063	0.002	–0.115*	–0.148*	0.010	0.033
ABC movement in general	–0.059	0.007	–0.032	–0.002	–0.038	–0.028
Manual Dexterity	–0.028	–0.027	–0.005	0.002	0.039	–0.038
Aiming and Catching	–0.064	0.052	–0.079	–0.149*	–0.103	–0.031
Balance	–0.023	0.010	0.105	0.027	0.009	0.072
Total BOT 2	–0.005	0.017	0.032	–0.065	0.043	0.028
Fine Manual Control	0.003	0.058	–0.145*	–0.225**	–0.004	0.004
Manual Coordination	–0.053	–0.033	0.090	–0.063	0.085	0.005
Body Coordination	0.053	0.041	0.049	0.007	–0.018	–0.033
Strength and Agility	0.056	0.033	0.075	0.010	0.041	0.029

*p < 0.05, **p < 0.01
Source: Author's own compilation

the greater the Strength and Agility, the greater the Average Ball Speed.

Problems related to Movement in a Static and/or Predictable Environment, Problems Movement in a Dynamic and/or Predictable Environment and Problems Non-motor Factors that Might Affect Movement, Movement ABC and BOT 2 a measurement of Mini Golf ball 3

The results of the Spearman's rho test presented in the Average Ball Speed and Average Stroke Force Table 4 indicate that Problems related to Movement in a Static and/or Predictable Environment and Movement in a Dynamic and/or Predictable Environment have a weak negative correlation with the mean impact force, Problems related to Non-motor Factors that Might Affect Movement has a weak negative correlation with Average ball speed and Average impact force, Aiming and Catching has a weak negative correlation with Average impact force, Fine Manual Control has a weak negative correlation with Average ball speed and Average impact force.

This means that the greater the Problems related to Movement in a Static and/or Predictable Environment and Movement in a Dynamic and/or Predictable Environment, the lower the Average impact force, the greater the Problems related to Non-motor Factors that Might Affect Movement, the lower the Average ball speed and the average impact force. Additionally, it has been noticed that the larger the Aiming and Catching is, the lower the Average Impact Force. And the greater the Fine Manual Control, the lower the Average Ball Speed and Average Stroke Force.

Correlation: Between TSN-M, TSN-S, BVRT, D2-R and MFF test results and Mini Golf ball 1 measurements

The results of the Spearman's rho test presented in Table 5 show that Numbers and Letters, and Letters, Numbers, Colours (TSN-S) correlate weakly and moderately negatively with the Test Time, respectively. errors (BVRT) weakly positively correlated with the number of all strokes, Accuracy (D2-R) slightly negatively correlated with the average impact force, while Impulsivity-Reflectivity (MFF) slightly negatively correlated with the Number of all strokes.

This means that the longer the time of restoring the names of objects: numbers and letters and letters, numbers, colours by older children (8–10 years), the shorter the trial time, the greater the number of correct answers (BVRT), the smaller the number all strokes needed for a hit, the greater the Error Count (BVRT), the greater the number of all strokes needed to hit, the greater the Accuracy (D2-R), the lower the Average impact force, and the greater the reflectivity (MFF), the lower the total number of strokes required to hit.

Table 5. TSN-M, TSN-S, BVRT, D2-R and MFF versus Mini Golf ball 1 measurement — Spearman's rho correlation test (N = 200)

		Mini Golf Measurements — ball 1					
		Time of trial	Total number of strokes	Average ball speed	Average impact force	Average grip strength of the dominant hand	Average grip strength of the non-dominant hand
TSN-M (n=73)	Subjects	0.184	–0.057	0.145	0.047	–0.131	–0.272
	Colours	–0.019	–0.117	0.068	–0.025	0.019	0.073
	Items and Colours	0.183	0.006	0.156	0.016	–0.111	–0.036
TSN-S (n=127)	Items and Colours	–0.073	–0.071	–0.032	0.062	–0.203	–0.139
	Numbers and Letters	–0.297*	–0.050	–0.132	–0.097	0.081	–0.045
	Letters, numbers, colours	–0.424**	–0.152	–0.075	–0.010	–0.031	–0.119
BVRT	Number of Correct Answers	–0.125	–0.223*	–0.077	0.124	–0.004	0.053
	Error Counts	0.123	0.239*	0.048	–0.130	–0.001	–0.057
D2-R	Concentration	–0.078	–0.064	0.015	–0.069	0.002	0.006
	Pace of work	–0.130	0.027	–0.052	–0.184	0.016	0.084
	Accuracy	0.111	0.174	–0.150	–0.252*	–0.010	0.023
MFF	Impulsivity-Reflectivity	–0.137	–0.248*	0.135	0.093	–0.103	–0.040

*p < 0.05, **p < 0.01
Source: Author's compilation

Table 6. TSN-M, TSN-S, BVRT, D2-R and MFF versus Mini Golf ball 1 measurement — Spearman's rho correlation test (N = 200)

		Mini Golf Measurements — ball 2					
		Time of trial	Total number of strokes	Average ball speed	Average impact force	Average grip strength of the dominant hand	Average grip strength of the non-dominant hand
TSN-M (n=73)	Subjects	0.008	–0.030	0.151	0.028	–0.170	–0.145
	Colours	–0.109	0.094	0.086	0.060	–0.095	0.252
	Items and Colours	–0.073	–0.017	0.388*	0.410*	0.142	0.067
TSN-S (n=127)	Items and Colours	0.096	–0.231	0.008	0.094	–0.173	–0.032
	Numbers and Letters	–0.226	–0.216	–0.055	0.014	–0.111	–0.176
	Letters, numbers, colours	–0.211	–0.274	0.009	–0.068	–0.055	–0.235
BVRT	Number of Correct Answers	–0.097	–0.099	0.057	–0.075	0.079	–0.037
	Error Counts	0.087	0.128	–0.094	0.003	–0.095	0.051
D2-R	Concentration	0.191	–0.056	–0.066	–0.111	–0.142	–0.168
	Pace of work	0.281*	0.013	–0.210*	–0.162	–0.133	–0.087
	Accuracy	0.056	0.082	–0.188	–0.017	0.033	0.186
MFF	Impulsivity-Reflectivity	0.051	–0.141	0.043	–0.099	–0.139	–0.249*

*p < 0. 05, **p < 0.01
Source: Author's own compilation

Correlation: Between TSN-M, TSN-S, BVRT, D2-R and MFF test results and Mini Golf ball 1 measurements

The results of the Spearman's rho test presented in Table 6 show that Objects and Colours (TSN-M) correlate moderately positively with Average ball speed and Average impact force, Work pace (D2-R) correlates weakly positively with Test time and weakly negatively with Average speed. balls, while Impulsivity-Reflectivity (MFF) has a weak negative correlation with the mean grip strength of the non-dominant hand.

It means that the longer the time of recreating the names of objects: Objects and Colours (TSN-M) by younger children (up to 7 years old), the shorter the trial time, the higher the Work Pace (D2-R), the longer the trial time and the lower the Average ball velocity, while the higher the reflexivity (MFF), the lower the Average grip strength of the non-dominant hand.

Table 7. TSN-M, TSN-S, BVRT, D2-R and MFF versus Mini Golf ball 3 measurement — Spearman's rho correlation test (N = 200)

		Mini Golf Measurements — ball 3					
		Time of trial	Total number of strokes	Average ball speed	Average impact force	Average grip strength of the dominant hand	Average grip strength of the non-dominant hand
TSN–M (n=73)	Subjects	0.037	–0.003	0.162	0.055	–0.215	–0.372*
	Colours	0.154	–0.051	–0.034	–0.153	–0.270	–0.100
	Items and Colours	–0.018	–0.155	0.024	0.158	–0.136	–0.181
TSN–S (n=127)	Items and Colours	–0.036	–0.119	0.057	0.205	–0.373*	–0.232
	Numbers and Letters	–0.229	0.101	0.046	0.191	–0.408**	–0.229
	Letters. numbers. colours	–0.102	–0.115	0.184	0.163	–0.373*	–0.312*
BVRT	Number of Correct Answers	0.015	0.031	–0.015	–0.010	–0.014	0.034
	Error Counts	0.007	–0.005	–0.012	–0.039	–0.011	–0.071
D2–R	Concentration	–0.027	0.090	0.078	–0.077	–0.010	0.079
	Pace of work	0.096	0.163	0.027	–0.097	0.033	0.178
	Accuracy	0.245*	0.137	–0.075	–0.001	0.071	0.161
MFF	Impulsivity–Reflectivity	0.045	–0.012	–0.025	0.011	–0.209*	–0.257*

*p < 0.05, **p < 0.01
Source: Author's own compilation

Correlation: Between TSN-M, TSN-S, BVRT, D2-R and MFF test results and Mini Golf ball 3 measurements

The results of Spearman's rho test presented in Table 7 show that Objects (TSN-M) correlate moderately negatively with the mean grip strength of the non-dominant hand, Objects and Colours and Numbers and Letters (TSN-S) correlate moderately negatively with the Mean grip strength of the dominant hand, Letters, Numbers, Colours (TSN-S) correlate moderately negatively with the mean grip strength of the dominant and non-dominant hand, Accuracy (D2-R) slightly positively correlated with the Test Time, while Impulsivity-Reflectivity (MFF) slightly negatively correlated with the Average grip strength of the dominant hand and non-dominant.

This means that the longer the time of recreating the names of objects: Objects (TSN-M) by younger children (up to 7 years), the lower the average grip strength of the non-dominant hand, the longer the time of recreating the names of objects: Objects and Colours and Numbers and Letters (TSN-S) by older children (8–10 years old), the smaller is the Average grip strength of the dominant hand, and the longer the playing time of objects Letters, Numbers, Colours, the smaller is the Average grip strength of the dominant and non-dominant hand, the greater it is Accuracy (D2-R), the longer the trial time, while the higher the reflexivity (MFF), the lower the average grip strength of the dominant and non-dominant hand.

DISCUSSION

DCD is a relatively rarely diagnosed disorder in children in Poland. The prevalence of DCD varies between 5 and 6%, and there are even indications that this number reaches even 8% (1,2,19,20). This may be due to the low awareness of the nature of this disorder, even among healthcare professionals. Just over half of all related health professionals and 33% of physicians report that they have diagnosed DCD. A definite minority, just over 20% of them, believe that the DSM-V contains sufficient information on this [21]teachers (n = 149.

Parents often visit podiatrists looking for abnormalities in the lower limbs. Most pedologists in Australia are unfamiliar with DCD but have expressed a wish to educate in this direction. It is recommended to educate physicians about the diagnosis of DCD [22]and activities of daily living. Literature surrounding interventions for DCD has focused mostly on physical and occupational therapies. However, it is known that children with DCD present to podiatrists as these children often also have abnormalities in lower limb functioning associated with the condition. This study aimed to determine current knowledge of Australian podiatrists regarding presentation, assessment, and management of children with developmental coordination disorder.\nMethods: A single-round survey, developed using SurveyMonkey®, was completed by a sample of

Australian podiatrists. Data were collected through either online or paper means. Participants were asked about their familiarity with DCD and depending on their response, were directed via skip logic to questions on presentation, assessment and management strategies of DCD in children. Participants were also asked about their willingness and preferences for further education on DCD. Descriptive statistics were used to describe the data.\nResults: There were 365 Australian podiatrists who completed the survey. There were 30% (n = 109.

Among the medical-related professions, occupational therapists are characterized by considerable awareness of DCD, but they lack current knowledge of the guidelines for assessment and diagnosis [23]. Teachers report their role in the ability to detect early motor disorders. A disturbing phenomenon is that 82% of teachers claim that children with motor difficulties are perceived as rebellious and lazy [21] teachers (n = 149.

It is also worth considering parents who struggle with the problem daily and cannot find professional help. Frustration and a feeling of helplessness accompany the search for the cause. Low awareness among medical specialists results in the exploration of knowledge and specialization in the subject by parents of children with DCD. It is recommended to educate and disseminate knowledge among medical professionals so that they can manage families and ensure psychological comfort and professional care [24].

There is a need to provide evidence-based information on interventions in people with DCD. It is recommended to create clearly targeted pathways, and raise awareness [25] education and skills. Most literature focuses on measurement of impairment and description of intervention approaches for individual children; little is known about the principles that should guide best practice and service delivery for children with DCD as a population. The purpose of this study was to identify these principles.\nMETHODS: A scoping review was used to 'map' the information available to inform intervention and service delivery. Scholarly and grey literature written in English was identified in six databases, using a combination of keywords (e.g. guidelines, management, models and DCD. The school curriculum for fundamental movement skills (FMS) has been proven to be effective. Due to the reduced physical activity of people with DCD, it is recommended to implement this type of activity due to the effectiveness in increasing movement and the joy associated with participating in physical activities [26]. Hippotherapy, on the other hand, supports developmental parameters in children with DCD and provides additional emotional, social, behavioural and gait support in these children [27]Co Galway, The Hunt Museum in Limerick City, Co. Limerick, and Fettercairn Youth Horse Project in Tallaght, Co. Dublin. Subjects: Eighty-three children (6-14 years. Dynamic balance training supported by Kinesio taping may also contribute to the improvement of gait quality [28]. Video game-based strategies have not been proven to be effective in improving motor skills [29–31]social and physical ability. Recent research has developed interventions that aim to improve motor outcomes in a variety of paediatric cohorts using video gaming equipment. Therefore, we aimed to systematically review the literature on virtual reality or video game interventions that aim to improve motor outcomes in children with DCD.\nMETHODS: Seven databases were searched for studies using the following criteria: a. Quiet eye training has been shown to affect target focus before casting and catching techniques. This training is an important element in working with children with DCD on eye-hand coordination [32]. Great emphasis should also be placed on the mental aspect. Emotional disturbances that may accompany the disease should be a key element in the treatment planning process [8].

The most frequently used diagnostic tool for DCD is the ABC-2 motor test [11]. After using the DSM-5 diagnostic criteria, DCD was detected in 10.94% (60 out of 548 children) compared to 12.77% (70 out of 548 children) with MABC-2. Therefore, it means that it is an effective diagnostic tool (10). The results of the above studies confirm the reliability of this test. In the research group, 10.5% of children were at risk of Developmental Coordination Disorder, 2% had significant motor difficulties prompting the detection of DCD in them. The Bruininks-Oseretsky Test of Motor Proficiency Second Edition (BOT-2), used by the researchers, is also used all over the world for the process of diagnosing motor disorders [12], but it is less sensitive than ABC-2. It takes much longer to carry out and can be a problem in children with inadequate attention [11].

From the present observations, the long duration is a significant limitation in everyday practice and some children had problems with concentration during its implementation. This could have influenced the children's results and would have falsely lowered them. It turns out that the pendulum running test and the 10 × 5 m sprint tests are reliable in children with DCD [12]. Another tool that could potentially detect children with motor problems is a protocol for assessing the ability to observe actions and imitate gestures. It examines basic manual and mimic skills. There are indications that the validation of this protocol would provide an effective tool for the diagnosis of DCD [33].

Our research also confirms that children with lower parameters measuring motor skills have difficulties with imitation and eye-hand coordination. DCDDaily — a tool for the objective and standardized clinical assessment of the daily activities of children with developmental coordination disorders (DCD) is another proposed proposal. The tool is divided into activities at home (e.g. buttering bread), school (e.g. writing), break (e.g. construction play), dressing (e.g. tying shoelaces) and leisure (e.g. ball games) [13].

Students with DCD require more time to learn how to write or read. A useful tool to measure the attention function (important in the learning process), e.g. the ability to selectively direct attention and focus is the d2-R test [34]. It also measures parameters related to impulsiveness (tendency to make mistakes) and inattentiveness [34]. Belgian researchers have noticed that people with DCD break down their movements into sequences. The result is the need for an extended time to complete the task [35]more insight in the gaze behaviour of this population during walking is required and crucial for gaze training interventions as a possible means to improve daily functioning of children and adults with DCD.\nAIM: This study explored differences and similarities in gaze behaviour during walking between typically developing young adults and those with DCD.\nMETHODS AND PROCEDURES: Ten young adults with DCD (age: 22.13 ± 0.64. The visual-spatial function can be assessed using the BVRT test. It is a test that can be used in the diagnosis of DCD, because children with such disorders show some impairment of visual-motor control and visual information processing, which may manifest itself, for example, as difficulty in walking upstairs [36]there is currently a paucity of research supporting these claims. We investigated the visuomotor control strategies underpinning stair negotiation in children with (N = 18, age = 10.50 ± 2.04 years. Disorder in functioning at school can also be assessed using the MFF J. Kagan test. It defines the cognitive style of impulsiveness-reflexivity, which can largely reflect difficult functioning at school [37]. Like other questionnaires, the TSN test (version for older and younger children) can be used in the study of cognitive functions related to learning to read and write, as well as to assess the automation of recalling lexical information.

The verification of the mini-golf diagnostic tool, which was developed for this study, confirms its use for the motor assessment of children. The applied research tool, in a pleasant way for the examined person, provides information on selected aspects of the child's motor development, using the conditions of play. It is an inexpensive and friendly way to catch children who have movement problems. Finding difficulties early allows early intervention, which in turn can prevent negative consequences in the future.

However, the presented research needs to be continued to propose a detailed screening model for DCD.

CONCLUSIONS

1. Difficulties discovered in parametric tests are confirmed by difficulties detected using minigolf.
2. There is a correlation between the results of the mini-golf game and the results in the ABC, BOT-2 tests.
3. There is a correlation between the psychometric performance of visual-spatial functions and the perception of attention and the performance of mini-golf.
4. Thanks to the game of mini-golf — GoDiag.me 1.0. — on a specially prepared field, you can examine, among others: the number of strokes to place the ball in the hole, the average speed of the ball, the average impact force, the force of hitting the ball with the dominant and non-dominant upper limb, thanks to which it is possible to assess the child's coordination skills.
5. The examined parameters can help in the motor characterization of the child, and thus serve for early motor assessment for developmental disorders, including Developmental Coordination Disorder.

6. Screening for developmental co-ordination disorders should be included in early school-age children. For this purpose, you can use the conditions of the game of mini-golf.

SOURCE OF FINANCING

GRANT entitled "Development of a model of screening diagnostic tests for Developmental Coordination Disorder based on selected parameters of mini-golf game".

OPERATIONAL PROGRAMME

Intelligent Development priority axis 2 Support for the environment and business potential for R&D&I activity measure 2.3 Pro-innovative services for Sub-measure 2.3.2 Innovation vouchers for SMEs.

References

1. Dannemiller L, Mueller M, Leitner A, et al. Physical Therapy Management of Children With Developmental Coordination Disorder: An Evidence-Based Clinical Practice Guideline From the Academy of Pediatric Physical Therapy of the American Physical Therapy Association. Pediatr Phys Ther. 2020; 32(4): 278–313, doi: 10.1097/PEP.0000000000000753, indexed in Pubmed: 32991554.
2. Biotteau M, Albaret JM, Chaix Y. Developmental coordination disorder. Handbook of Clinical Neurology. 2020: 3–20, doi: 10.1016/b978-0-444-64148-9.00001-6.
3. American Psychiatric Association, American Psychiatric Association, editors. Diagnostic and statistical manual of mental disorders: DSM-5. 5th ed. D. American Psychiatric Association, Washington 2013: 947.
4. Duffy J, McLaulin JB. Psychiatry Specialty Board Review For The DSM-IV. Routledge 2013: 131.
5. Ahonen T, Kooistra L, Viholainen H, Cantell M. Developmental motor disorders: A neuropsychological perspective. Developmental Motor Learning Disability: A Neuropsychological Approach. 2004 : 265–290.
6. Kirby A, Sugden DA. Children with developmental coordination disorders. J R Soc Med. 2007; 100(4): 182–186, doi: 10.1177/014107680710011414, indexed in Pubmed: 17404341.
7. Crespo-Eguílaz N, Magallón S, Narbona J. Procedural skills and neurobehavioral freedom. Front Hum Neurosci. 2014; 8: 449, doi: 10.3389/fnhum.2014.00449, indexed in Pubmed: 24999324.
8. Lingam R, Jongmans MJ, Ellis M, et al. Mental health difficulties in children with developmental coordination disorder. Pediatrics. 2012; 129(4): e882–e891, doi: 10.1542/peds.2011-1556, indexed in Pubmed: 22451706.
9. Developmental Coordination Disorder: Background, Pathophysiology, Etiology. https://emedicine.medscape.com/article/915251-overview (15 January 2022).
10. Lee K, Jung T, Lee DoK, et al. A comparison of using the DSM-5 and MABC-2 for estimating the developmental coordination disorder prevalence in Korean children. Res Dev Disabil. 2019; 94: 103459, doi: 10.1016/j.ridd.2019.103459, indexed in Pubmed: 31476726.
11. Blank R, Barnett AL, Cairney J, et al. International clinical practice recommendations on the definition, diagnosis, assessment, intervention, and psychosocial aspects of developmental coordination disorder. Dev Med Child Neurol. 2019; 61(3): 242–285, doi: 10.1111/dmcn.14132, indexed in Pubmed: 30671947.
12. Bonney E, Aertssen W, Smits-Engelsman B. Psychometric properties of field-based anaerobic capacity tests in children with Developmental Coordination Disorder. Disabil Rehabil. 2019; 41(15): 1803–1814, doi: 10.1080/09638288.2018.1446189, indexed in Pubmed: 29509037.
13. van der Linde BW, van Netten JJ, Otten BE, et al. Psychometric properties of the DCDDaily-Q: a new parental questionnaire on children's performance in activities of daily living. Res Dev Disabil. 2014; 35(7): 1711–1719, doi: 10.1016/j.ridd.2014.03.008, indexed in Pubmed: 24685097.
14. Braaksma P, Stuive I, Boomsma H, et al. We12BFit!-Improving lifestyle physical activity in children aged 7-12 years with developmental coordination disorder: protocol of a multicentre single-arm mixed-method study. BMJ Open. 2018; 8(6): e020367, doi: 10.1136/bmjopen-2017-020367, indexed in Pubmed: 29950462.
15. Cermak SA, Stein Duker LI, Williams ME, et al. Feasibility of a sensory-adapted dental environment for children with autism. Am J Occup Ther. 2015; 69(3): 6903220020p1–690322002010, doi: 10.5014/ajot.2015.013714, indexed in Pubmed: 25871593.
16. Smits-Engelsman B, Vinçon S, Blank R, et al. Evaluating the evidence for motor-based interventions in developmental coordination disorder: A systematic review and meta-analysis. Res Dev Disabil. 2018; 74: 72–102, doi: 10.1016/j.ridd.2018.01.002, indexed in Pubmed: 29413431.
17. Li YC, Wu SK, Cairney J, et al. Motor coordination and health-related physical fitness of children with developmental coordination disorder: a three-year follow-up study. Res Dev Disabil. 2011; 32(6): 2993–3002, doi: 10.1016/j.ridd.2011.04.009, indexed in Pubmed: 21632207.
18. Dunford C. Goal-orientated group intervention for children with developmental coordination disorder. Phys Occup Ther Pediatr. 2011; 31(3): 288–300, doi: 10.3109/01942638.2011.565864, indexed in Pubmed: 21488710.
19. Farmer M, Echenne B, Drouin R, et al. Insights in Developmental Coordination Disorder. Curr Pediatr Rev. 2017; 13(2): 111–119, doi: 10.2174/1573396313666170726113550, indexed in Pubmed: 28745216.
20. Zwicker JG, Missiuna C, Harris SR, et al. Developmental coordination disorder: a review and update. Eur J Paediatr Neurol. 2012; 16(6): 573–581, doi: 10.1016/j.ejpn.2012.05.005, indexed in Pubmed: 22705270.
21. Hunt J, Zwicker JG, Godecke E, et al. Awareness and knowledge of developmental coordination disorder: A survey of caregivers, teachers, allied health professionals and medical professionals in Australia. Child Care Health Dev. 2021; 47(2): 174–183, doi: 10.1111/cch.12824, indexed in Pubmed: 33140459.
22. Smith M, Banwell HA, Ward E, et al. Determining the clinical knowledge and practice of Australian podiatrists on children with developmental coordination disorder: a cross-sectional survey. J Foot Ankle Res. 2019; 12: 42, doi: 10.1186/s13047-019-0353-y, indexed in Pubmed: 31423153.

23. Karkling M, Paul A, Zwicker JG. Occupational therapists' awareness of guidelines for assessment and diagnosis of developmental coordination disorder: Mesure selon laquelle les ergothérapeutes connaissent les lignes directrices relatives à l'évaluation et au diagnostic du trouble du développement de la coordination. Can J Occup Ther. 2017; 84(3): 148–157, doi: 10.1177/0008417417700915, indexed in Pubmed: 28730904.
24. Novak C, Lingam R, Coad J, et al. ‚Providing more scaffolding': parenting a child with developmental co-ordination disorder, a hidden disability. Child Care Health Dev. 2012; 38(6): 829–835, doi: 10.1111/j.1365-2214.2011.01302.x, indexed in Pubmed: 21848938.
25. Camden C, Wilson B, Kirby A, et al. Best practice principles for management of children with developmental coordination disorder (DCD): results of a scoping review. Child Care Health Dev. 2015; 41(1): 147–159, doi: 10.1111/cch.12128, indexed in Pubmed: 24387638.
26. Sit CHP, Yu JJ, Wong SHS, et al. A school-based physical activity intervention for children with developmental coordination disorder: A randomized controlled trial. Res Dev Disabil. 2019; 89: 1–9, doi: 10.1016/j.ridd.2019.03.004, indexed in Pubmed: 30875607.
27. Hession CE, Law Smith MJ, Watterson D, et al. The Impact of Equine Therapy and an Audio-Visual Approach Emphasizing Rhythm and Beat Perception in Children with Developmental Coordination Disorder. J Altern Complement Med. 2019; 25(5): 535–541, doi: 10.1089/acm.2017.0242, indexed in Pubmed: 30789282.
28. Yam TT, Wong MS, Fong SS. Effect of Kinesio taping on electromyographic activity of leg muscles during gait in children with developmental coordination disorder: A randomized controlled trial. Medicine (Baltimore). 2019; 98(6): e14423, doi: 10.1097/MD.0000000000014423, indexed in Pubmed: 30732198.
29. Mentiplay BF, FitzGerald TL, Clark RA, et al. Do video game interventions improve motor outcomes in children with developmental coordination disorder? A systematic review using the ICF framework. BMC Pediatr. 2019; 19(1): 22, doi: 10.1186/s12887-018-1381-7, indexed in Pubmed: 30651097.
30. Howie EK, Campbell AC, Abbott RA, et al. Understanding why an active video game intervention did not improve motor skill and physical activity in children with developmental coordination disorder: A quantity or quality issue? Res Dev Disabil. 2017; 60: 1–12, doi: 10.1016/j.ridd.2016.10.013, indexed in Pubmed: 27863326.
31. Straker L, Howie E, Smith A, et al. A crossover randomised and controlled trial of the impact of active video games on motor coordination and perceptions of physical ability in children at risk of Developmental Coordination Disorder. Hum Mov Sci. 2015; 42: 146–160, doi: 10.1016/j.humov.2015.04.011, indexed in Pubmed: 26037276.
32. Miles CAL, Wood G, Vine SJ, et al. Quiet eye training facilitates visuomotor coordination in children with developmental coordination disorder. Res Dev Disabil. 2015; 40: 31–41, doi: 10.1016/j.ridd.2015.01.005, indexed in Pubmed: 25721344.
33. Bieber E, Smits-Engelsman BCM, Sgandurra G, et al. A new protocol for assessing action observation and imitation abilities in children with Developmental Coordination Disorder: A feasibility and reliability study. Hum Mov Sci. 2021; 75: 102717, doi: 10.1016/j.humov.2020.102717, indexed in Pubmed: 33360601.
34. Nowotnik A. Funkcjonowanie uwagi a poziom umiejętności czytania u dzieci w wieku wczesnoszkolnym. Edukacja. 2013; 121(1): 37–53.
35. Warlop G, Vansteenkiste P, Lenoir M, et al. Gaze behaviour during walking in young adults with developmental coordination disorder. Hum Mov Sci. 2020; 71: 102616, doi: 10.1016/j.humov.2020.102616, indexed in Pubmed: 32452432.
36. Parr JVV, Foster RJ, Wood G, et al. Children With Developmental Coordination Disorder Show Altered Visuomotor Control During Stair Negotiation Associated With Heightened State Anxiety. Front Hum Neurosci. 2020; 14: 589502, doi: 10.3389/fnhum.2020.589502, indexed in Pubmed: 33328936.
37. Borkowska A. Impulsywność poznawcza w zespole ADHD. Psychologia Rozwojowa. 2005;10(3). http://cejsh.icm.edu.pl/cejsh/element/bwmeta1.element.ojs-issn-2084-3879-year-2005-volume-10-issue-3-article-2957 (15 January 2022).