FROM DIAGNOSIS TO INTERVENTION: A NEUROPEDAGOGICAL APPROACH USING THE DIAGNOSTIC-INTERVENTION PROGRAMME COMPREHENSIVE MOVEMENT INTERVENTION

Nikoletta Szászová, Alexandra Biščo Kastelová, Miroslava Bartoňová, László Varga

Department of Special Education, Comenius University, Bratislava, Slovakia
Institute of Educational Sciences and Psychology, University of Sopron, Sopron, Hungary
szaszova@fedu.uniba.sk, bisco.kastelova@fedu.uniba.sk
bartonova@ped.muni.cz, varga.laszlo@uni-sopron.hu

UDK: 612.7:[37.013:159.91]=111
Stručni rad
Primljen: 16. 4. 2025.
Prihvaćen: 2. 10. 2025.

Abstract

The study examines the effectiveness of the diagnostic-intervention programme Comprehensive Movement Intervention (CMI), which is based on the principles of neuropedagogy and focuses on correct motor development as the key factor in the successful functioning of pupils with developmental disorders. The research sample comprised ten first-level elementary school pupils with developmental learning disorders and impaired communication skills. The programme lasted for six months, with participants performing individual exercises at home under the supervision of a parent with regular check-ups every four to five weeks. The research methodology combined quantitative and qualitative approaches, and a single-group experiment was used to measure effectiveness. A pretest and posttest assessed 35 areas, each scored from 0 (impaired) to 1 (mastered). The results demonstrated statistically significant improvement: the average score increased from 15.70 to 28.40 ($p < 0.05$, paired t-test). The greatest improvement occurred in the areas of fine motor skills, balance and attention, and all participants showed improvement in at least one of the monitored areas (100% success rate, McNemar test, $p < 0.05$). The findings confirm that motor interventions can significantly affect the perceptual and executive functions of pupils with developmental disabilities. The study at the same time highlights the need for longitudinal studies on a larger sample and with a control group. The CMI programme appears to be a promising tool for supporting inclusive education. The study was conducted within the framework of the VEGA project No. 1/0196/23.

Keywords:
neuropedagogy, movement intervention, neurodevelopmental disorders, Comprehensive Movement Intervention

INTRODUCTION

Education is one of the important factors influencing the development of an individual. Since 2020, principle changes in education have been taking place in Slovakia that affect the raising and education of persons with special educational needs. The reforms are part of the Recovery and Resilience Plan of the Slovak Republic, with the key component being the Accessibility, Development and Quality of Inclusive Education. Measures such as a new definition of special educational needs, a Catalogue of Support Measures and the reform of the guidance and prevention system have been introduced. The document *Strategy for an Inclusive Approach in Education by 2030* (2021) sets the goals for increasing the accessibility and quality of education with an emphasis on equality. An important initiative is the transformation of the guidance system of the Ministry of Education of the Slovak Republic, which introduces a new structure of guidance services at five levels based on pupil needs. The changes were anchored in an amendment to the Education Act and regulations as well as new standards for the professional activities of counselling facilities, by which a uniform quality of services and support for the development of children and youth are ensured.

The coordinated activities of a school support team of experts significantly contribute to the effectiveness of inclusive education at school (Act No. 245/2008 Coll.). Support and diagnostics of pupils with developmental learning disabilities at school are provided by a school support team, and coordinated activities of the school support team experts thus significantly contribute to the effectiveness of inclusive education at school. Outside the school environment, support and diagnostics are provided by a Counselling and Prevention Centre. The Centre's basic activities are focused on diagnosing a pupil's current abilities in the areas of reading, writing and arithmetic. The level of perceptual, cognitive and motor functions, which are key for successfully mastering academic abilities, is also assessed (Kleknerová et al., 2023; Biščo Kastelová, 2024; Act No. 245/2008 Coll. as amended).

Pupils with developmental learning disabilities are a heterogeneous group that manifests in significant problems in school skills (reading, writing, counting), even if they are not based on reduced intellectual ability. These disorders can affect different aspects, such as phonemic awareness, word recognition, intellectual capacity, spelling, written communication and mathematical abilities. The professional public currently agrees that the most significant source of dyslexic

problems can be found in the area of impaired phonemic awareness. This brings with it not only problems with identifying sounds, but also problems with phonological manipulation, verbal memory, verbal learning, identifying words in a text and learning based on verbal stimuli (Habib, 2018; Ramus, 2003).

A diagnosis requires a comprehensive approach that includes psychological diagnostics (assessment of intellectual abilities and special abilities), pedagogical diagnostics (pupils' manifestations in the school environment), medical diagnostics (exclusion of organic causes), social diagnostics (environmental influence) and also special pedagogical diagnostics (confirmation of the diagnosis, setting up support measures and proposing correction). School documentation, which provides an overview of the pupil's school abilities, represents an important source for a diagnosis. If the differences between the results in the subjects are significant, the suspicion of confirming this diagnosis increases. The time course and detailed manifestation of these problems in different environments is equally important (Biščo Kastelová, 2024; Bartoňová, 2024). With special pedagogical diagnostics of developmental learning disorders, we apply two main approaches: static and dynamic (Bednářová, Šmardová, 2022). Static diagnostics focus on an accurate evaluation of the pupil's current state of development, skills and capabilities. This approach determines what the pupil currently masters but does not offer detailed instructions for an intervention, thus requiring a qualitative assessment of the context and interpretation of data. Standardised methods that use norms to determine what is considered average, above-average or below-average performance within the population are assigned to this category (Valenta, Morávková Krejčová, Hlebová et al., 2020).

Diagnostics should be seen as a dynamic rather than a static process that must take into account many factors. An inclusive view of pedagogical diagnostics puts demands on the diagnostic competencies of the teacher who uses dynamic diagnostics (Felcmanová & Habrová, 2015). It focuses on identifying effective methods and approaches that support the active development and full use of a pupil's potential. Its primary goal is to analyse the process of learning itself and to find ways to effectively stimulate this development. It emphasises the support of functional forms of learning, finding solutions and revealing practices that lead to positive changes in a child's thinking and development (Bednářová, Šmardová, 2022; Bartoňová, 2024). This approach does not focus only on solving a specific task but also supports overall cognitive processes and facilitates learning (Valenta, Morávková Krejčová, Hlebová et al., 2020).

Diagnostics of developmental learning disorders is essential for identifying and providing a suitable intervention.

THE IMPACT OF NEUROSCIENCE AND NEUROPEDAGOGY ON THE DIAGNOSIS OF DEVELOPMENTAL LEARNING DISORDERS

Contemporary research in the field of neuroscience has brought the knowledge that experience and intentional attention management can influence the functioning of the central nervous system, which raises the question of their importance for supporting the learning process and development, including in the category of students with developmental learning disabilities. Since the finding that learning processes and developmental processes are dynamic (Erwin, 1991 IN: Evrard, M., Bresciani Ludvik, M.J., 2016), substantiating these claims with research has been important. Current research results in the field of neuroscience is bringing new explanations about the functioning of the human brain and its ability to respond to experience, attention and the environment. Such discoveries enable individuals (not excepting individuals with developmental learning disabilities) to take greater responsibility for the development of their own abilities (Evrard, M., Bresciani Ludvik, M.J., 2016). Neuropedagogy is defining important areas of human learning, such as, e.g., the neural basis of reading, writing and memory processes. Neuropedagogy also focuses on answering questions through which we look for explanations for various neural mechanisms (behavioural, cognitive, emotional) and last but not least, neuropedagogy examines the lifelong development of an individual, especially during critical periods (early stages of development, school readiness, etc.) (Maršák, Janoušková, 2014). The neuropedagogical approach is therefore based on the fact that the human brain structure is the result of a long-term developmental process, is hierarchical and begins to develop already in the intrauterine phase of an individual's development (Kissné Zsámboki, Franady-Landerl, 2018).

It is this knowledge from neuroscience that is initiating discussions on the importance of using it to create educational opportunities that support learning and development of individuals and thus influence their school success. Based on this, it is possible to assume that special educators can use strategies that have a positive effect on the development of the central nervous system within their educational or intervention activities to support pupils' ability to do the following:

be aware of how and what they focus their attention on (attention regulation), regulate their emotions (emotional regulation), and be conscious of how they use their cognitive processes (cognitive regulation) (Bresciani Ludvik, M.J., Evrard, M., Goldin, F., 2016).

As part of current neuroscience knowledge, it is important to mention the importance of intentional movement for the development and support of brain activities. Research conducted in 2014 (Converse et al., 2014, In Bresciani Ludvik, M.J., Evrard, M., Goldin, F., 2016) pointed out that intentional movement can be a significant means of more intensive engagement and functioning of the brain, because the research participants who completed a 15-week course of tai chi – as a form of intentional movement – showed significant improvement in their attention compared to a control group. Running, brisk walking and other forms of exercise and movement also support learning, although the specifics within the functioning of the brain are not yet completely clear (Bresciani Ludvik, M.J., Evrard, M., Goldin, F., 2016). In their study, Willoughby and Hudson (2023) deal with the theory stating that the development of fine and broad motor skills in children is created by a sequence of targeted activities that ensure the interconnection and activation of individual executive functions. The presented theory speaks specifically about the important role that proper motor development plays in the formation of other functions, which are, however, immediately needed in the learning process.

Carrying out interventions for pupils with developmental disabilities is extremely important, since these pupils often face challenges in the areas of attention, motor skills and academic performance. Targeted programmes can help not only to moderate manifestations of a disorder but also to support overall development and involvement of pupils in the educational process. In this context, Jedličková and Sleziaková (2023) conducted a study that deal with the associations between writing disorders and graphomotor skills, as well as the development of graphomotor skills in pupils with dysgraphia and secondary attention deficit disorder. The study included qualitative research on a sample of three pupils diagnosed with a writing disorder who took part in the "Good Start Method" programme. The results showed that implementing this method helped not only in the development of the pupils' motor and graphomotor skills but also improvement in their attention.

In the special pedagogical diagnostics of pupils with developmental learning disorders, the assessment of their motor level plays an important role, also in

view of current knowledge from the field of neuroscience. The tests that special educators have at available for diagnostic activities cover key areas necessary for a comprehensive assessment of pupils' developmental capabilities. In the framework of the diagnostics for determining the level of motor skills in Slovakia, we start from diagnostic content standards (VUDPaP, 2023), which include tests such as the MABC-2 Motor Test, the Orientation Dynamic Test of Practice, the Laterality Test, Brunt-Lézineová, the Munich Functional Developmental Diagnosis, Bayley II/III, BOT-2 and Strassmeier. Motor skills, as one of the key areas during diagnosis and in the subsequent special pedagogical intervention, require the creation of new tools. Individual methods of diagnosis work with the individual only at the diagnostic level, and there is no follow-up intervention programme. Validation of the application of a neuropedagogical approach to interventions in the form of motor programmes is absent from Slovakia.

Compensation can be a relatively new diagnostic-intervention methodology originating from Hungary – Comprehensive Movement Intervention (CMI) – which serves as a diagnostic-intervention programme for persons with developmental disorders. It focuses in the diagnosis on the assessment of fine and broad motor skills, coordination of movements and basic elementary movements, etc. Comprehensive Movement Intervention (hereinafter referred to as CMI) was developed and verified in practice by the educator Kulcsár Mihályné. The CMI method is based on neuropedagogical approaches and knowledge from both theoretical and practical points of view.

Based on the theory of brain neuroplasticity (Schusterová, 2020; OECD, 2002; Dishman et al., 2012; Doidge, 2011; Ostatníková, 2017; Orel, Prochádzka et al., 2017), which points to the ability of the human brain to adapt its functions important for the learning process depending on physical activity, we point out the importance of movement as forming the basis of the CMI method (Bottyánová, 2021). Movement is important in the context of the formation of neurotransmitters and synapses (Teleanou et al., 2022), through which we can achieve better functioning of the nervous system.

We also apply the individual above-mentioned knowledge within a Comprehensive Movement Intervention programme. The programme consists of a diagnostic part and an intervention part. It needs be pointed out that in the diagnostic part the task of the specialist is not to make a diagnosis but to evaluate whether or not the child or pupil has mastered the given developmental areas. If the child shows deficits, this is an indication for a professional intervention in the form of

Comprehensive Movement Intervention.

During the testing, we assess 35 areas, which are divided into categories: visual perception, auditory perception, motor skills, speech skills, memory skills, thought operations and attention. It needs to be pointed out that some areas of testing cooperate and complement each other, and they cannot be completely separated from one another; therefore, they could also be classified into two circuit categories such as, for example, visual-motor coordination.

Movement exercises are compiled based on the results of the assessment of the individual and are implemented systematically in the home environment. A professional intervention in the form of frequent meetings with a certified CMI specialist is essential. What is important is that the exercise is automated, and the hierarchy of development of the individual's motor skills and other systems is maintained. The multi-stage intervention system consists of different motor exercises, and the assigning of new, higher-level motor exercises is possible only after the previous developmental stage has been fully mastered. According to Kulcsár (2014), the author of the programme, the intervention process can be ended in three ways: 1. successful completion – this means complete exhaustion of the programmes possibilities; the goal set at the beginning is achieved through the programme. 2. exhaustion of limits – successful completion of the intervention programme and adequate control of the motor exercises; however, despite completing the intervention programme, the individual failed to achieve the desired effect (for example, parental expectations). 3. stopping the intervention programme – the reasons for premature termination of the intervention process are mostly due to the child's aversion to the exercises, in which case the parents were unable to sufficiently motivate the child to cooperate.

The target group of the Comprehensive Movement Intervention is individuals with developmental disorders (learning disorders, attention disorders, impaired communication skills, a preschool age child who shows immaturity, individuals who show disorders in the motor system, sensorimotor system, etc.).

A very important fact is that the CMI programme does not claim that after completing it, the child or pupil will be "cured" of an already present diagnosis. Such claims are not appropriate here and are not relevant. Through the programme, we are able to eliminate developmental immaturity or deficits and achieve the child's individual potential, which is key to successfully mastering his or her academic skills.

In our paper, we present some partial results of the research, which was con-

ducted as part of a dissertation (Szászová, 2024) in the period from 2022 to 2024 and presents the use of the diagnostic-intervention methodology Comprehensive Movement Intervention (CMI) in Slovakia.

MATERIALS AND METHOD

A special educator should have acquired the competence to purposefully lead an intervention process with an individual according to his or her individual needs based on the processed diagnostics and subsequently proposed intervention. An important component in this process is to understand the associations between pupils' performance and their neuroscientific background. This is also confirmed by experts, such as Boon (2013), Thomas Ansari and Knowland (2019), Van Atteveldt et al. (2020) and Pávová (2023), who note that scientific knowledge from neuroscience can play an irreplaceable part in pedagogical practice.

In our research, we purposefully implement knowledge from neuropedagogy. The implementation consists in applying the CMI diagnostic and intervention tool, which is based on the theory stating that proper motor development is one of the key systems for the successful functioning of a pupil in the school environment. For this reason, we apply an intervention in the form of targeted movement exercises to pupils. We point out the fact that the CMI diagnostic and intervention programme, using the correct motor development of the individual, subsequently forms the basis for the successful functioning of a pupil with developmental disorders in the school environment. Proper motor development is very important from the viewpoint of the aetiology of many disorders. As many studies have said (Grzywniak, 2017; Ashlyn, 2020), delays and even deviations in motor development can form one group of causes of various developmental disorders. We consider the implementation of research to verify the effectiveness of the adapted diagnostic and the CMI intervention tool to be very important for Slovak pupils.

Methodology and Methods

The main aim of the research was to determine which areas are most impaired during testing in a selected group of participants. A partial aim was to determine in a selected group of pupils with developmental disabilities whether there was an overall improvement in the areas where they showed deficits after six months of

completing the CMI movement programme.

We were looking for an answer to the following research question: *In which areas will pupils with developmental learning disabilities experience the greatest improvement through the implementation of CMI with regard to impaired areas?*

We verified the effectiveness of the CMI statistically, and we set up the following hypotheses:

Hypothesis 1: We assume that after completing the CMI programme, the experimental group will in the posttest show a significant improvement in impaired areas compared to the status before completing the programme.

Hypothesis 2: We assume that after completing the CMI programme, each participant will show an individual significant improvement in the posttest compared to the status before completing the movement intervention.

We applied a mixed research design in the study, both a quantitative and qualitative methodology simultaneously (Bačíková, Janovská, 2018).

Table 1. Research methodology

Research method	Methodology	Characteristics and frequency of the method used
Experiment (one group technique)	Quantitative	verification of the effectiveness of the CMI programme
		** number uses: 2 times for each participant (pretest, posttest)* ** total number of uses 20 times*
	Qualitative	observation: monthly control meetings with research participants, monitoring their progress mainly in the movement sphere
		** number of uses: 5 times for each participant* ** total number of uses 50 times*
	Qualitative	assigning of relevant movement exercises based on the results of the assessment for each participant separately

When carrying out the research, we specifically applied the one group experiment technique. We compared 35 areas of testing before and after completing the intervention. We divided the testing areas into the following categories: visual perception, auditory perception, motor skills, speech/language skills, memory skills, cognitive operations, and attention. Individual areas of measurement in the Comprehensive Movement Intervention are scored with a value of 0 if the area is impaired, not mastered or deficient, and a score of 1 is awarded in the case of ade-

quate mastery of the given task/area. We chose this experimental method because it is the only research method that ensures the causal consequences of pedagogical action and is used to assess the effectiveness of the intervention (Gavora et al., 2010; Bačíková and Janovská, 2018). Severini and Kostrub (2018) describe an experiment in which the observed phenomenon is intentionally manipulated. The diagnostic component of the CMI program is not intended for the establishment of a medical diagnosis, but rather for the identification of weakened functions affecting learning. It is not a standardized method; the assessment is administered individually. Furthermore, the diagnostic process may only be conducted by a specialist who has successfully completed the theoretical and practical course associated with the CMI program. For the proper implementation of the neuropedagogical approach, it is essential to integrate the testing results with data obtained from the developmental history (anamnestic data). Simply possessing this information is insufficient; it is crucial to understand its meaning and context in relation to current neuroscientific knowledge. Therefore, working with the CMI program necessitates interdisciplinary thinking and the ability to adapt the intervention to the individual needs of each child. The results obtained from the testing were subsequently evaluated. The CMI diagnostic tool was administered to each participant twice, in the form of a pretest and a posttest.

STUDY DESIGN

To verify the efficacy of the motor intervention, a quasi-experimental design with a single group (i.e., a one-group pretest-posttest design) was utilised. Testing was conducted in two phases—before and after the completion of the motor intervention—focusing on assessing changes in selected functional domains among the participants.

The CMI diagnostic tool allows for a comprehensive assessment of several developmental domains. The following categories were monitored within the scope of this research:

Visual Perception: This category included tasks focused on directional and spatial orientation, graphic connection of dots, visuomotor skills, figure-ground differentiation, constancy of visual perception, and the identification and discrimination of images.

Auditory Perception: Assessed parameters included auditory differentiation, ear dominance and hearing, as well as auditory memory as part of the broader cognitive profile.
Motor Skills: Included tasks related to fine motor skills, drawing a human figure, spatial awareness, balance, dynamic praxis, body schema perception, cross-lateral movements, laterality, and fundamental movement skills (e.g., crawling, climbing, various forms of walking, jumping, head lift in a supine position).
Speech/Language Skills: Linguistic competencies were examined, including vocabulary, articulation, narrative abilities, and speech comprehension, alongside general knowledge.
Memory Skills: Assessed areas included visual-mechanical, visual long-term, auditory-mechanical, short-term, long-term auditory, and kinesthetic memory.
Cognitive Operations and Attention: This category considered causal thinking, logical reasoning, attention span, general knowledge, and the constancy of visual perception.
Social Maturity: This encompassed abilities to solve problematic situations, the level of social maturity, and work readiness.

The application of the CMI program within the pretest-posttest design allowed for the monitoring of the motor intervention's effect on the development of key learning domains. The results provided relevant data on potential changes within the individual functional categories and highlighted the significance of targeted motor stimulation in supporting the overall development of children.

RESEARCH PHASES

The research was structured into three distinct phases:

Phase One (September 2022 – August 2023)
This phase focused on the preparation of research instruments, participant selection, and the adaptation of the diagnostic tool to the Slovak context. This included:

- Preparation and piloting of the research instruments.
- Pilot verification of the diagnostic tool's comprehensibility with two experts.

- Direct work with individuals with developmental disorders, based on which some tasks were modified to better suit the needs of Slovak-speaking children.
- Selection of the research sample via a combination of convenience and purposive sampling (based on age and diagnosis; Gavora, 2010).

Phase Two (September 2023 – March 2024)

This phase involved the implementation of the research itself:

- Pretesting of participants using the diagnostic component of CMI.
- Design of individualised intervention plans.
- Home training via the CMI program (with continuous guidance and exercise updates every 4–5 weeks).
- Posttesting after six months of intervention.

Phase Three (January – April 2024)

This phase was dedicated to the analysis and interpretation of the acquired data (Szászová, 2024).

DATA ANALYSIS PROCEDURE

At the beginning of the research, the pretest was administered according to the CMI program methodology. Based on the pretest results, an individual exercise regimen was created for each participant, focusing on areas with identified deficits, with exercises derived from neuropedagogical principles. Participants received instruction on the exercises, and parents were trained as co-therapists. Home training was performed with a minimum frequency of five times per week. Control meetings were held at regular intervals (every 4–5 weeks). During these meetings, the CMI methodology was used to assess whether the participant had automated the given exercises or if continued training was required. Based on this evaluation, supplementary exercises were subsequently assigned, or the original ones were maintained. The posttest was administered after the six-month intervention period. The level of improvement was determined using a simple mathematical calculation, specifically the percentage of improvement compared to the pretest.

Furthermore, McNemar's test—which is designed for comparing dichotomous variables in smaller research samples—was used to analyze changes in the se-

lected functional areas of the participants before and after the motor exercises. This test enabled the identification of statistically significant differences in shifts, making it particularly suitable for evaluating the effectiveness of interventions in longitudinal research.

Although the entire CMI program is characterised as a long-term intervention (the recommended duration is 12–16 months), due to the time constraints of the research, the measurement was conducted after the initial six months of the intervention.

Characteristics of the research sample

We set the criteria for selecting the research sample based on the analysis of statistical reports from school counselling and prevention facilities (both public and private) according to the number of registered clients and the type of health disadvantage in the 2022/2023 school year. The first largest group comprised pupils with impaired communication skills (ICS) and in second place are pupils with developmental learning disabilities (DLD). According to DSM-V, these diagnoses belong to the group of neurodevelopmental disorders, and according to ICD-11 to mental, neurodevelopmental and behavioural disorders (APA, 2013; WHO, 2019). In Table 2, we summarise the research sample.

Table 2. Characteristics of the research sample

Participant	Sex	Age	Diagnosis	Developmental deviations in motor skills in early childhood	Occurrence of developmental disorders in the family
P1	boy	11	ICS+DLD	no	no
P2	boy	9	ICS	yes	yes
P3	boy	8	ICS	yes	no
P4	boy	7	ICS	yes	no
P5	girl	10	DLD	yes	no
P6	girl	10	DLD	yes	no
P7	boy	9	ICS	yes	yes
P8	boy	10	ICS	yes	no
P9	girl	9	DLD	yes	no
P10	boy	11	DLD	yes	no

Legend: DLD – developmental learning disorders, ICS – impaired communication skills

All participants (n = 10) attended the first level of primary school. Based on anamnestic interviews before the diagnostic-intervention process, we determined that developmental deviations in early childhood were present in 9 participants (n = 9), and a positive family history in the form of the presence of developmental disorders in the family was identified in 2 participants (n=2). The participants were included in the intervention process on the basis of the identified impairments (criterion for selecting participants). After the pupils' deficits were identified, an individual intervention plan was created for each participant in the form of movement exercises, according to the methodology of the CMI intervention programme. The participants then did the exercises in their home environment under the supervision of a parent (who was trained in the programme as a co-therapist). Participants took part in follow-up sessions with a certified professional every 4 to 5 weeks, where they were then assigned additional follow-up exercises based on their individual pace of developmental.

Ethical aspects

In carrying out the study, we started from and were guided by the European Charter for Researchers (2006), through which basic principles and ethical principles were observed. Ethical rules, such as anonymity, informed consent in accordance with Act No. 18/2018 Coll. *on the Protection of Personal Data*, prevention of harm and misleading the participant, were respected to the maximum extent (Ritomský, 2015; Kasacova, 2019, Kaposi, Szoke, 2022).

RESULTS

In the study, we monitored in which areas the participants showed the greatest improvement through the CMI intervention in relation to impaired areas. The following graphs interpret the overall values of positively scored areas. Graph no. 1 shows the pretest values (before the CMI programme), and Graph no. 2 then presents the results of the research after completing the CMI intervention. It shows the absolute improvements after six months of the CMI with respect to the individual areas tested.

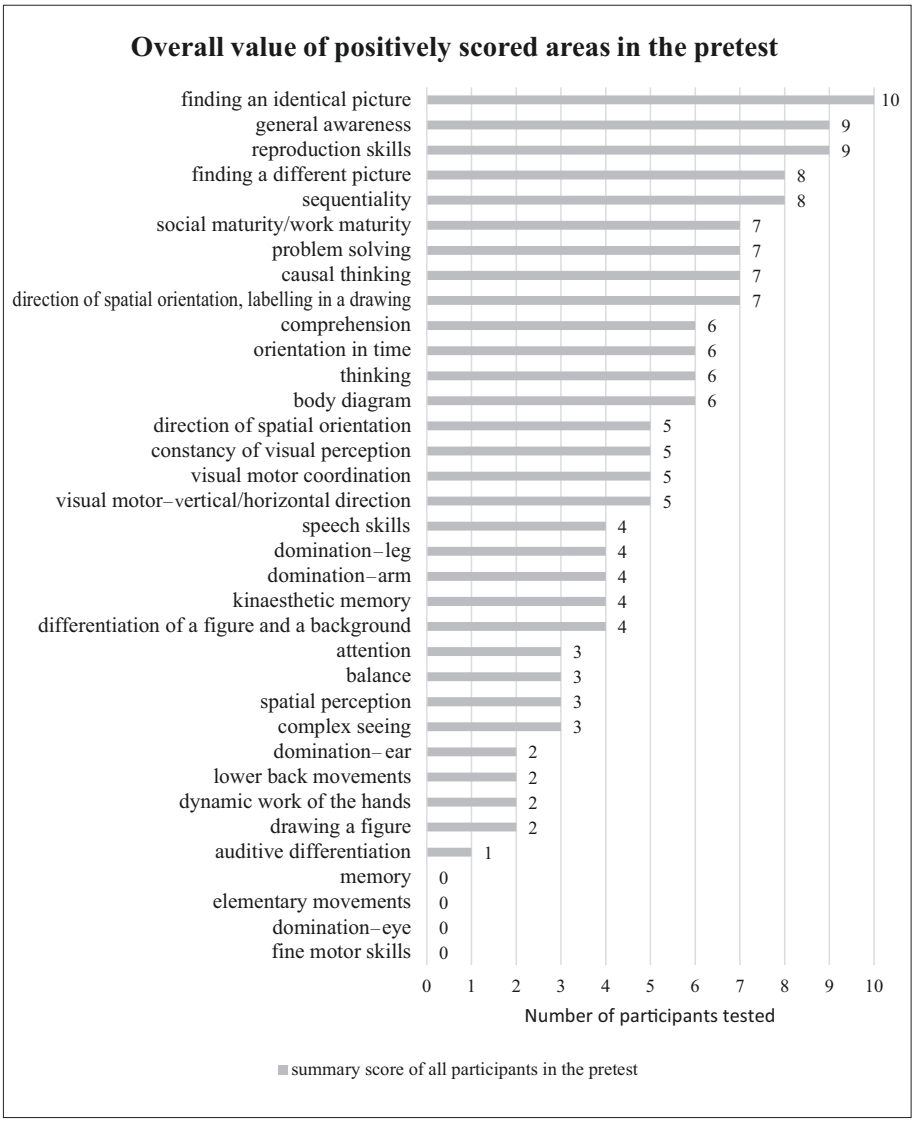

Figure 1. Overall value of positively scored areas in the pretest (Source: Szászová, 2024).

Figure 1. shows the tested areas in the form of the pretest, i.e., prior to the start of the Comprehensive Movement Intervention (CMI). Based on these results, we can state that the participants showed the greatest impairments in the areas of memory of elementary movements, laterality of the eye and fine motor skills. These results were not surprising, since individuals with developmental disorders often have impairments in the area of fine motor skills of the hands. Impairments in elementary movements point to the fact that the participants have not correctly mastered some basic movement patterns (e.g., crawling, climbing, etc.), which form the developmental basis for the proper development of not only motor skills, but also, for example, visual perception, spatial orientation or attention (Szászová, 2024).

Figure 2 shows the areas tested after six months of performing the CMI programme. The individual scores indicate absolute improvement in relation to the areas tested.

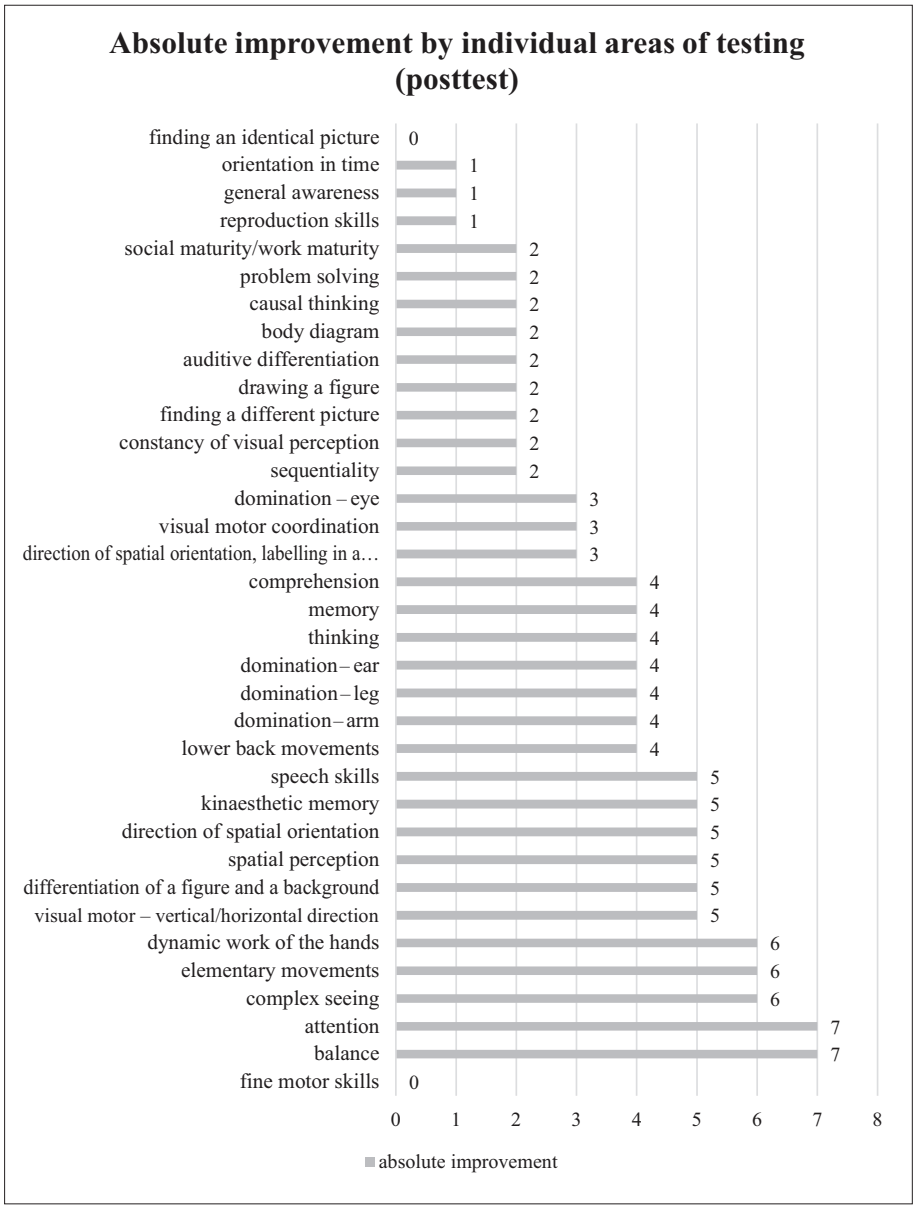

Figure 2. Absolute value improvement after completing six months of the CMI intervention in the individual tested areas (Source: Szászová, 2024).

The results show that the greatest improvement after a six months of the intensive CMI intervention were observed in the areas of *fine motor skills, balance and attention*. It should also be pointed out that from these areas only fine motor skills appeared among the most impaired areas in the ***pretest***. This means that the greatest improvement in relation to the impaired areas occurred in fine motor skills. From the viewpoint of the intervention effect, what is important for us is that positive changes occurred in areas such as *balance* and *attention*, which although not deficient in every participant, showed improvement after completing the CMI intervention in all participants who had deficits in balance and attention. The mentioned improvements are related. Positive progress occurred in the *area of balance*, as we purposely stimulated the vestibular system of our participants through movement exercises. The vestibular system forms the basis of a person's sensory system. A person's central nervous system gives priority to motor activity (particularly in the first years of a person's life), when these movements are automated; this means that the person can move or act without thinking about it (Wiliams, Schellenberger, 1996 in Bottyánová, 2021). These areas are closely associated with attention, since if they function correctly, the child does not have to make an extreme effort to focus his attention on a specific activity. The results thus indicate that we cannot separate individual sensory or sensorimotor or even perceptual-motor systems from each other and deal with individual deficits of some functions in isolation. The individual needs to be perceived comprehensively and with a holistic approach to develop his or her potential.

Hypothesis testing (statistics, statistical hypothesis testing)

Hypothesis No. 1: We assume that after completing the CMI programme, the experimental group will show a significant improvement in the impaired areas in the posttest compared to the state before completing the programme.

In the comparative analysis, our aim was to determine whether a statistically significant change occurred in the participants overall after completing the six-month CMI programme. In this regard, we summed the values 0 and 1 from the original 35 testing areas, which gave us a score on a scale from 0 to 35. This means that the higher the score, the better the results. In this case, it is a continuous variable, i.e., comparing the values from the pretest and posttest. For a statisti-

cal evaluation of the data, we chose a paired t-test and worked with a significance level of 5% (alpha=0.05).

Table 3. Statistical evaluation of the data – paired t-test (Source: Szászová, 2024)

Test	N	M	SD	t	df	p
Pretest	10	15.70	5.23	-10.483	9	**<0.001**
Posttest		28.40	3.86			

Legend: N – number of participants, M – mean value, SD – standard deviation, t – test statistic of paired t-test, df – number of degrees of freedom, p – p-value

The table shows that the test yielded a p-value of less than 0.05, which means that the difference between the pretest and posttest is ***statistically significant.*** The raw score of the participants in the pretest was 15.70. In the posttest, the score increased to 28.40, which is a significant rise. The p-value of the paired t-test confirmed a statistically significant difference. This means that within the posttest there was a significant improvement when applying the six-month CMI movement intervention.

The results ***confirm hypothesis no. 1***, that after completing the six-month CMI movement intervention, a significant improvement occurred in the experimental group in the posttest in the impaired areas compared to the status before completing the CMI programme.

Hypothesis 2: We assume that after completing the CMI movement intervention, each participant will show individual significant improvement in the posttest, compared to the status before completing the movement intervention.

Based on the implementation of the CMI intervention for each participant, we assessed the effectiveness of the CMI programme using the McNemar test. With the McNemar test, we worked with a significance level of 5% (*alpha=0.05*). If the results in the test were in the form of a p-value less than 0.05, the difference between the groups before and after testing was statistically significant.

Table 4. Summary interpretation of statistical significance of data – pretest and posttest of the CMI programme (Source: Szászová, 2024)

Participant	N	Pretest	Posttest	p-value (McNemar test)
P1	35	21	31	**0.002**
P2		12	29	**<0.001**
P3		13	29	**<0.001**
P4		7	27	**<0.001**
P5		15	24	**0.012**
P6		20	33	**<0.001**
P7		9	20	**0.001**
P8		19	31	**<0.001**
P9		20	31	**0.001**
P10		12	29	**0.021**

Legend: N=total number of testing areas, pretest, posttest=achieved values, p-value=statistical indicator

Table 4 shows statistically significant values. The McNemar p-value shows a value less than 0.05 for each participant. Therefore, based on the results of the McNemar test, it can be concluded that each participant experienced significant improvement after completing six months of Comprehensive Movement Intervention. ***Hypothesis 2 was confirmed.***

DISCUSSION

Through a pretest, we identified the most frequently impaired areas in pupils with developmental disorders (developmental learning disorders, impaired communication skills). On the basis of this, we set up an individual exercise programme for each participant focused on the impaired areas in the form of motor exercises. The pretest showed that the following areas were most impaired in the research participants – *memory, elementary movements, dominance and fine motor skills*. These areas were evaluated at a level of zero for all participants. In the posttest, we focused on whether improvements occurred in these areas, or whether the movement intervention had a significant impact on other areas at the same time. The posttest showed that significant improvements occurred in the areas of *fine motor skills, balance and attention*. This was thus a total improvement of 70%, because even though balance and attention were not recorded as the most

impaired in the pretest, the improvement after completing the six-month CMI intervention was much more significant than in the areas (elementary movements, memory dominance) that were assessed as the most deficient.

We must note, however, that immediately after the areas with the best improvement (*attention, balance, fine motor skills*) with a value of 60%, improvement was also seen in elementary movements, which were identified as deficient areas in the first testing. If we compare the obtained data, we can state that the individual areas correlate, and it can be said that the greatest improvements occur in the areas of *fine motor skills, balance and attention* (Szászová, 2024).

The results of research and professional publications confirm that movement is an essential and important part of the intervention within the comprehensive care of individuals with developmental disorders (Goddard Blythe, 2016, Kulcsár, 2020, Stephen Sarlós, 2022). Our research on the use of CMI movement intervention in pupils with developmental disorders also confirmed this. The areas in which participants progressed during the movement intervention (after six months of exposure) are *attention, fine motor skills and balance*. Our study results are consistent with research conducted in the United States (Ashlyn, 2020), which noted that after completing a movement intervention the research sample improved *attention* and *motor skills*. Our results are also confirmed by Polish research (Grzywniak, 2017). After an intervention there, it was found that the motor programme was effective mainly in the areas of *concentration of attention* and *motor skills*, specifically motor coordination, which is a person's balance, is also mentioned. According to our research, stimulation and targeted working on individual sensory or sensorimotor systems has an effect and its justification in pedagogical sciences. The vestibular system, together with other systems (proprioceptive) form the basis of a pupil's successful functioning in the school environment. Our participants showed deficits specifically in these areas, which subsequently formed the basis of functional attention, or eye-hand coordination, eye movement control and motor planning. Individuals with developmental disorders often have problems with these systems, which are areas that form the basis for the learning process.

Experts (Goddard Blythe, 2016; Király, Szakály, 2011; Kulcsár, 2014 in Bottyánová, 2021) are of the opinion that the effectiveness of intervention programmes lies in their systematicity and intensity, in a regular time sequence. Our research also confirm these statements, since through systematic exercise we recorded significant improvements in impaired areas in our participants. Regular in-

terventions in the form of exercises of individual motor skills improve executive functions and also have an effect on the learning process itself (Dishman et. al., 2012). It is important to state that for the intervention programme to be as successful as possible regular home exercise requires significant internal motivation and perseverance on the part of the parent. An essential factor, among others, is the trust of the parent towards the expert. These facts confirm that, in addition to the correct intervention, the overall attitude of the parent, family or child towards the intervention process is also key.

CONCLUSION / SUMMARY

The aim of this study was to determine the overall effectiveness of the Comprehensive Movement Intervention (CMI) programme in an experimental group of Slovak pupils. The results point to the effectiveness of the programme, since the improvement in each participant showed notable significance (which is also confirmed by statistical data). We further state that the theory of brain neuroplasticity, on which the CMI programme is based, has its place and justification in special pedagogy. We implemented movement elements into the intervention in such a way as to utilise the potential of the brain and achieve its greatest possible progress in the participants. We can conclude that the theory of brain neuroplasticity, which states that some brain functions can change based on physical activity, remains valid (Rakús, 2009; Egyed, 2011;Varga, 2016; Schusterová, 2020). Our results suggest that individuals with developmental disorders have difficulties in the motor sphere (elementary movements) regardless of whether they are developmental learning disorders or impaired communication skills (Szászová, 2024). From our point of view, a comprehensive holistic approach is an appropriate method that offers a wide range of usability to the special educator. Comprehensive movement intervention – CMI appears to us to be one of the appropriate and adequate forms of assistance, though we are aware of the need for further, primarily longitudinal, research in this area. Completion of the six-month intervention showed positive changes in the area of perceptual and motor abilities in our participants, but areas where the participants show deficits remained. The results also indicate that the assessment of motor areas within special educational diagnostics has an important role, since motor areas also have an indirect impact

on other functions participating in the learning process.

We see the limitations of our research in the number of participants, which prevents the generalization of the results to a broader population of children with specific developmental disorders in Slovakia.

The number of participants in our research was influenced by several objective and organizational factors related to the course of the intervention itself. Some participants were excluded due to insufficient continuity in home-based exercises, which closely correlated with varying levels of motivation, persistence, and personal commitment of the parents, who acted as co-therapists in the home setting. These aspects were monitored and continuously assessed during the study.

It should also be noted that the research was conducted by a single researcher without the support of a broader research team. From a methodological perspective, however, the program requires intensive and individualized attention for each participant in order to ensure that all intervention principles are adhered to and that a systematic approach is maintained in the research process. Given the limited personnel capacity, it would not have been possible to guarantee the qualitative integrity of the intervention according to the program's standards with a much larger sample size.

For these reasons, we recommend that similar research in the future be conducted with the support of a professional team, thus creating the opportunity to expand the sample size while maintaining methodological accuracy and systematic implementation. This approach would also allow for the acquisition of statistically robust and more broadly applicable results.

Another significant limitation is the absence of a control group, which would have allowed for a comparison of the effects of the movement intervention with natural development or alternative approaches. The inclusion of a control group would have substantially increased the methodological robustness and validity of the findings. Therefore, it is imperative to include this element in future research.

A further limiting factor is the time frame of the study – the program was assessed after 6 months, although the standard duration of the intervention within the given framework is 12 to 16 months. It is therefore possible to assume that the full completion of the program could have led to more significant or different outcomes that are not captured at this stage.

For the aforementioned reasons, the results of this study should be interpreted with a certain degree of caution. Despite these limitations, however, the study provides important insights into the practical implementation of a movement in-

tervention for children with neurodevelopmental disorders in the context of Slovakia, where such research remains insufficiently developed. The presented findings thus serve as a foundational framework for further scientific research with a broader methodological scope.

This contribution is part of the output of VEGA project no. 1/0196/23 *Approaches, interventions and attitudes of teachers towards pupils with specific learning disabilities and specific behavioural disorders (ADHD) in Slovak primary schools.*

Data Availability Statement

Data supporting this study are available from (https://opac.crzp.sk/?fn=ResultFormChildO2ELOL&seo=CRZP-Zoznam-záznamov) or are available upon request from the academic library of Comenius University in Bratislava, as part of Nikoletta Szászová's dissertation.

References

American Psychiatric Association (APA). (2013). Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-5). American Psychiatric Publishing.

Ashlyn, J., & Milligan, C. (2020). The effects of integration therapy on retained primitive reflexes. The Effects of Integration Therapy.

Bačíková, M., & Janovská, A. (2018). Základy metodológie pedagogicko-psychologického výskumu. Sprievodca pre študentov učiteľstva. Šafárik Press.

Bartoňová, M. (2024). Přístupy a intervence u jedinců se specifickými poruchami učení. IRIS.

Bednářová, J., & Šmardová, V. (2022). Diagnostika dítěte předškolního věku, 2. díl. Co by díte mělo umět ve věku od 3 do 6 let. Edika.

Biščo Kastelová, A. (2024). Diagnostika v špeciálnopedagogickom poradenstve (2. vydanie). IRIS.

Boon, H. (2013). Neuroscience for old pedagogy. Joint AARE Conference, Adelaide 2013. https://doi.org/10.13140/2.1.5030.5923

Bottyánová, N. (2021). Hodnotenie neuromotorickej zrelosti ako základu pre učenie [Master's thesis, Univerzita Komenského v Bratislave, Pedagogická fakulta].

Bresciani Ludvik, M. J., Evrard, M., & Goldin, F. (2016). Strategies that intentionally change the brain. In M. J. Bresciani Ludvik (Ed.), The neuroscience of learning and development: Enhancing creativity, compassion, critical thinking, and peace in higher education (p. 365). Routledge, Taylor & Francis Group.

Dishman, R., Berthoud, H. R., Heymsfield, S. B., O'Doherty, J., Sherwood, A., & Wadden, T. A. (2012). Neurobiology of exercise. Obesity a Research Journal. https://doi.org/10.1038/oby.2006.46 (Note: The year in the DOI is 2006, but 2012 was provided in the text. I used 2012 as the publication year.)

Doidge, N. (2011). Váš mozek se dokáže změnit. Computer Press, a.s.

Egyed, K. (2011). Az agyi plaszticitás és a rugalmas fejlődés. In I. Balázs (Ed.), Biztos kezdet Kötetek I., A génektől a társadalomig: a koragyermekkori fejlődés színterei (pp. 166–204). http://www.bddsz.hu/sites/default/files/Danis%20et%20al_Biztos%20Kezdet%20K%C3%B6tet%20I_bel%C3%ADvek.pdf

Európska charta výskumných pracovníkov. (2006). Kodex správania pre nábor výskumných pracovníkov. Office for Official Publications of the European Communities.

Evrard, M., & Bresciani Ludvik, M. J. (2016). Unpacking neuroplasticity and neurogenesis. In M. J. Bresciani Ludvik (Ed.), The neuroscience of learning and development: Enhancing creativity, compassion, critical thinking, and peace in higher education (p. 365). Routledge, Taylor & Francis Group.

Felcmanová, L., & Habrová, Z. (2015). Katalog podpůrných opatření. Univerzita Paleckého.

Gavora, P., et al. (2010). Elektronická učebnica pedagogického výskumu. Univerzita Komenského. http://www.e-metodologia.fedu.uniba.sk/

Goddard Blythe, S. (2010). Dieťa v rovnováhe (3. vyd.). Inštitút psychoterapie a socioterapie. (Note: The provided text lists both 2016 and 2010. I used 2010 as the date for the 3rd edition.)

Grzywniak, C. (2017). Integration exercise programme for children with learning difficulties who have preserved vestigal primitive reflexes. ACTA Neuropsychologia, 15(3), 241–256. https://doi.org/10.5604/01.3001.0010.5491

Habib, M. (2018). Dyslexie de développement. EMC - Psychatrie/Pédopsychiatrie, 1–12. https://www.neurodyspaca.org/IMG/pdf/37-81436.pdf

Jedličková, P., & Klimentová, A. (2021). Development of attention and executive functions in pupils with ADHD. In L. Gómez-Chova, A. López Martínez, & I. Candel Torres (Eds.), INTED 2021: 15th International Technology, Education and Development Conference (pp. 2265–2270). IATED Academy.

Jedličková, P., & Sleziaková, A. (2023). Development of graphomotorics and correction of graphomotor difficulties in primary school pupils. Slavonic Pedagogical Studies Journal, 12(1), 40–47.

Kaposi, J., & Szoke-Milinte, E. (2022). Kutatási módszerek pedagógusjelölteknek. Pázmány Péter Katolikus Egyetem.

Kasacová, B. (2016). Etické aspekty pedagogického výskumu. In A. Budniak & M. Mnich (Eds.), "Podejścia metodologiczne w pedagogice. Koncepcje – badania - wyniki" (pp. 103–114). Wydawnictwo Uniwersytetu Śląskiego.

Király, T., & Szakály, ZS. (2011). Mozgásfejlődés és a motorikus képességek fejlsztése gyerekkorban. Dialóg Campus Kiadó. https://unieszterhazy.hu/public/uploads/mozgasfejlodes_5538f4c1056cc.pdf

Kissné Zsámboki, R., & Farnady-Landerl, V. (2018). Neuropedagógiai innovációs lehetőségek a neveléstudományi kutatásokban az EMOTIV EPOC+ mobil EEG készülék alkalmazásával. Képzés és gyakorlat, 16(3), 21–37.

Kleknerová, K., Viščorová, E., Krupová, E., & Borák, M. (2023). Odborné činnosti poskytované deťom/žiakom s vývinovými poruchami učenia. Minis-

terstvo školstva, vedy, výskumu a športu Slovenskej republiky. https://www.minedu.sk/data/att/330/27173.ff1431.pdf

Kulcsár, M. (2014). A tanulás öröm is lehet, Delacato módszere alapján. Magánkiadás.

Kulcsár, M. (2020). Kulcsár Mihályné által kidolgozott komplex mozgásfejlesztő tevékenység elméleti háttere és hatékonysága a gyakorlatban. Széchenyi István Egyetem.

Maršák, J., & Janoušková, S. (2014). Neuropedagogika – neurověda a pedagogika ve společném úsilí. Pedagogika, 64(1), 99–116.

OECD. (2008). Understanding the Brain: the Birth of a Learning Science New insights on learning through cognitive and brain science. https://www.oecd.org/site/educeri21st/40554190.pdf

Orel, M., & Procházka, R., et al. (2017). Vyšetrení a výzkum mozku: pro psychology, pedagogy a další nelekářske obory. Grada.

Ostatníková, D., et al. (2017). Základy lekárskej fyziológie. Univerzita Komenského v Bratislave – vydavateľstvo UK.

Pávová, A. (2020). Význam poznatkov z neurovedy pre vzdelávanie. Pedagogické rozhľady, 29(4), 28–32.

Rakús, A. (2009). Neuroplasticita. Neurológia pre prax, 10(2), 77–79. http://www.neurologiapreprax.sk/index.php?page=pdf_view&pdf_id=3740&magazine_id=3

Ramus, F. (2003). Theories of developmental dyslexia: Insights from a multiple case study of dyslexic adults. Brain, 126(4), 841–865. https://doi.org/10.1093/brain/awg076

Ritomský, A. (2015). Metodologické a metodické otázky kvantitatívneho výskumu. IRIS.

Schusterová, I. (2020). Kognitívna stimulácia u detí – prínos psychológa. In Dieťa v ohrození:"...aby pomoc deťom prišla včas!" (pp. 72–77). VUDPaP.

Stephens-Sarlós, E. (2022). A Stephen-Sarlós program, Továbblépés megrekedt egészségi, tanulási, viselkedési és komunikációs problémákból. AduPrint Kiadó és Nyomda Kft.

Szászová, N. (2024). Implementácia neuropedagogického prístupu do pohybového intervenčného programu u žiakov s vybranými vývinovými poruchami [Master's thesis, Univerzita Komenského v Bratislave, Pedagogická fakulta].

Teleanu, R. I., Niculescu, A. G., Roza, E., Vladâcenco, O., Grumezescu, A. M., & Teleanu, D. M. (2022). Neurotransmitters—Key factors in neurological and

neurodegenerative disorders of the central nervous system. International Journal of Molecular Sciences, 23(11), 5954. https://doi.org/10.3390/ijms23115954

Thomas, M. S. C., Ansari, D., & Knowland, V. C. P. (2019). Educational neuroscience: Progress and prospects. Journal of Child Psychology and Psychiatry, 60(4), 477–492.

Valenta, J., Morávková Krejčová, B., Hlebová, B., et al. (2024). Znevýhodněný žák. Grada.

Van Atteveldt, N., Peters, S., De Smedt, B., & Dumontheil, I. (2020). Towards greater collaboration in educational neuroscience: Perspectives from the 2018 Earli-SIG22 Conference. Mind, Brain, and Education, 14(2), 124–129. https://doi.org/10.1111/mbe.12250

Varga, L. (2016). Új tudomány születőben: kisgyermekkori neuropedagógia. Soproni Egyetemen Benedek Elek Pedagógiai Kar. [Conference paper]. varga_laszlo_uj_tudomany_szuletoben_konf_tanulm_u.pdf (wordpress.com)

VUDPaP. (2023). Diagnostické obsahové štandardy. https://vudpap.sk/wp-content/uploads/2023/02/Diagnosticke-obsahove-standardy.pdf (Note: I used 2023 as the year based on the URL path.)

Willboughby, M., T., et al. (2023). Rediscovering reliable components analysis: An application to executive function skills in early childhood. Psychological Assessment, 35(1), 32–41. https://doi.org/10.1037/pas0001179

World Health Organization International (WHO). (2019). Statistical Classification of Diseases and Related Health Problems (11th ed.). https://icd.who.int/browse11/l-m/en

Zákon č. 245/2008 Z. z. Zákon o výchove a vzdelávaní (školský zákon) a o zmene a doplnení niektorých zákonov.

Od dijagnoze do intervencije: neuropedagoški pristup utemeljen na dijagnostičko-intervencijskom programu Comprehensive Movement Intervention

Sažetak

Rad se bavi učinkovitošću dijagnostičko-intervencijskog programa Comprehensive Movement Intervention (CMI), koji se zasniva na načelima neuropedagogije i naglasak stavlja na ispravni motorički razvoj kao ključni čimbenik za uspješno funkcioniranje učenika s poteškoćama u razvoju. Istraživanje je provedeno na uzorku od deset osnovnoškolskih učenika prvog razreda s poteškoćama u razvoju i smanjenim komunikacijskim vještinama. Provedba programa trajala je šest mjeseci, a sudionici su individualne vježbe izvodili kod kuće pod roditeljskim nadzorom, uz redovne preglede svakih četiri do pet tjedana. U istraživačkoj metodologiji kvantitativni pristup kombiniran je s kvalitativnim, a učinkovitost je mjerena eksperimentom na jednoj grupi. Pred- i posttestom ocjenjivalo se 35 područja, svako na skali od 0 (smanjeno) do 1 (svladano). Rezultati su pokazali strateški značajno poboljšanje: prosječna se ocjena povećala s 15,70 na 28,40 ($p < 0,05$, t-test za zavisne uzorke). Najveće je poboljšanje zabilježeno na području fine motorike, ravnoteže i pozornosti, a svi su sudionici pokazali napredak u bar jednom od promatranih područja (100% uspješnost, McNemarov test, $p < 0.05$). Nalazi potvrđuju da motoričke intervencije mogu znatno utjecati na percepcijske i kognitivne funkcije učenika s poteškoćama u razvoju. U radu se istodobno ističe potreba za longitudinalnim istraživanjem na većem uzorku i s kontrolnom skupinom. Po svemu sudeći, program CMI ima potencijal kao alat u poticanju inkluzivnog obrazovanja. Studija je provedena u sklopu projekta VEGA br. 1/0196/23.

Ključne riječi:
neuropedagogija, motorička intervencija, neurorazvojni poremećaji, Comprehensive Movement Intervention