Journal of Physical Education and Sport ® (JPES), Vol. 23 (issue 10), Art 316, pp. 2759 - 2768, October 2023
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Fundamental motor competencies in children aged 6 to 7 affected by ADHD

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Published online: October 31, 2023
(Accepted for publication : October 15, 2023)
DOI:10.7752/jpes.2023.10316

Abstract
In the past decade, there has been a considerable surge in interest within the professional and scientific communities regarding the study of children's motor competencies. This heightened attention is attributed to the pivotal role these competencies play in shaping an individual's lifelong physical activity trajectory. Of note, existing research consistently highlights delayed motor development and disruptions in motor learning processes among children diagnosed with attention deficit and hyperactivity disorder (ADHD). These challenges often manifest in reduced levels of physical activity and decreased participation in sports. This study aimed to analyse the level of basic motor competencies in 6–7-year-old children, drawing comparisons with a control group of children without ADHD. The data were collected from a cohort of 233 primary school children (45.49% girls) with an average age of 7.33 ± 0.45 years. The research sample comprised 103 children diagnosed with ADHD and a control group of 130 children without ADHD. The evaluation of motor competence involved the application of the MOBAK-1 test battery, encompassing assessment areas for both object movement and self-movement skills. Differences in motor competencies between the groups were rigorously assessed using an independent samples t-test. The outcomes revealed statistically significant differences favouring children without ADHD in both object movement and self-movement competence areas, as well as in the overall score of the MOBAK test, with medium and large effect sizes. While milder disproportions in motor competencies were observed among girls in the compared groups, a noteworthy finding was that 28% of girls with ADHD exhibited a need for educational motor support (scoring < 3 points per competence area) in object movement, and nearly 23% of boys showed a similar need in self-movement. The study underscores the importance of early diagnosis facilitated by contemporary diagnostic tools, such as the MOBAK-1 test battery. Such tools enable the reliable identification of differences in children's motor development within the context of physical education. The diagnostic identification of motor deficits in children serves as a crucial prerequisite for effective intervention, potentially mitigating the risk of later issues associated with physical inactivity.
Keywords: **physical education, MOBAK test, motor development, primary school children**

Introduction

The rationale for the development of motor competencies in childhood, as well as their position as a key factor in shaping an active lifestyle, is currently relatively well scientifically grounded (Lubans, Morgan, Cliff, Barnett, & Okely, 2010). Robinson et al. (2015) as well as Stodden et al. (2008) state that the development of adequate motor competencies is considered a decisive determinant of the regular and successful participation of an individual in lifelong physical activity and can have a protective effect against sedentary behaviour and unhealthy weight gain already in childhood.

Based on a systematic review, Bolger et al. (2020) report that contemporary children aged 6 to 10 years demonstrate below-average levels of fundamental motor skills compared to normative data from 1997 to 1998 (Ulrich, 2000). The development of fundamental motor skills is a necessary prerequisite for the formation of advanced and specific sports skills (Robinson, Wang, Colabianchi, Stodden, & Ulrich, 2020) and plays a crucial role in both the quality and quantity of an individual's lifelong motor activity (Brian et al., 2020). Likewise, Valero et al. (2021) stress the importance of fundamental motor skills in children's motor behaviour. As they note, object control skills in particular can be the key to achieving a higher level of motor activity.

Even though children with attention deficit and hyperactivity disorder (ADHD) can seemingly demonstrate a high level of physical activity, the frequent prevalence of motor deficits as well as an overall low level of motor competence is confirmed in them (Nigg, 2006).

ADHD is a neurodevelopmental disorder characterized by a persistent pattern of inattention, hyperactivity, and impulsivity that is pervasive across settings and leads to various degrees of functional impairment (American Psychiatric Association [APA], 2000; Biederman & Faraone, 2005). ADHD is one of the most commonly diagnosed neurodevelopmental disorders, with a prevalence ranging from 5% to 7% worldwide depending on the source of information for the diagnosis (Polanczyk, Willcutt, Salum, Kieling, & Rohde, 2014; Willcutt, 2012).

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Zametkin and Ernst (1999) state that motor hyperactivity is considered a key aspect of ADHD, which is manifested by an excess in movements and motor restlessness.

Current research documents delayed motor development and varying degrees of gross and fine motor deficits in both boys and girls with ADHD (Barkley, Edwards, Laneri, Fletcher, & Metevia, 2001; Fliers et al., 2009; Lelong et al., 2021). Based on clinical and epidemiological studies, it is estimated that 30% to 50% of children with ADHD demonstrate a severe impairment of motor development (Fliers et al., 2009). Barkley (1998) documents that 47% to 69% of children with ADHD suffer from gross motor coordination disorder.

Rosa Neto, Goulardins, Rigoli, Piek, and Oliveira (2015) explain that children with ADHD can demonstrate an average motor development delay of up to 23.4 months. Goulardins, Marques, Casella, Nascimento, and Oliveira (2013) report an almost one-year delay in motor age relative to chronological age in a population of children with ADHD. The often-occurring delay in motor development of children with ADHD is probably related to slower maturation of the cerebral cortex, especially its prefrontal parts responsible for attention, working memory, and motor control (Siedman et al., 2006; Shaw et al., 2007).

Deficits in motor abilities and skills of children with ADHD have led to formulating two lines of hypotheses that can explain the mentioned 'disruption' of motor functions. On the one hand, it is assumed that motor deficits belong to the basic symptomatology of ADHD; on the other hand, problems with motor functions are considered a manifestation of another secondary disorder—developmental coordination disorder (DCD), which has a high prevalence especially in children with ADHD. This disorder is manifested by a serious disruption in the process of motor learning, as well as in the practical implementation of motor skills (Kaiser, Schoemaker, Albaret, & Geuze, 2015). In agreement with the aforementioned, Fliers et al. (2009) state that it is not yet known whether certain motor deficits are part of the ADHD symptomatology or are conditioned by DCD. As reported by Fliers et al. (2009), as well as by Pitcher, Piek, and Hay (2003), the connection between ADHD and DCD has been scientifically detected for several decades, and the overlap between these diagnoses is estimated at 50%.

Despite the fact that previous research confirms serious impairment of fine and gross motor skills in children with ADHD, the detection of motor problems is not part of either the diagnosis or subsequently applied intervention programmes intended for the population of children with ADHD in primary education (Mokobane, Pillay, & Meyer, 2019).

As stated by Quitério et al. (2018), in children with a limited repertoire of motor skills or with deficits in motor development, the subsequent acquisition of more complex and context-specific motor skills can be problematic. Early identification of motor deficits and subsequent targeted intervention at school age is more economically effective in moderating the problems of an individual's motor development than the application of therapeutic approaches in adulthood. Diagnostic detection of a delay in children's motor development is the first step in preventing later problems related to the health aspects of physical activity (Lopes et al., 2020; Ružbarská, 2020).

Similarly, Herrmann (2018) states that the early detection of problems in the child's motor learning that takes place during physical education classes in school is crucial for the subsequent implementation of effective intervention. Boržíková, Chovanová, Majherová, and Kandráč (2020) state that the systematic stimulation of motor development and the intervention of motor competencies have a positive effect on the pace and quality of motor learning in younger school-age children.

Despite the scientific interest in investigating the peculiarities of the motor development of children with ADHD (Kroes et al., 2002), research findings identifying the level of motor competencies of children with ADHD are marked by considerable variability. This is primarily related to different methodological approaches and the diversity of applied diagnostic tools (Harvey & Reid, 2005).

Considering the above, the aim of this study is to identify and analyse the level of basic motor competencies in 6- to 7-year-old children with ADHD based on a comparison with a control group of children without ADHD. The reason for this comparison is also the fact that children with ADHD are mostly integrated (albeit with an individual educational plan) within the framework of joint primary education with peers without ADHD, physical education included.

Material & Methods

Participants

Primary education children from a total of 14 state, church, and private elementary schools in the region of eastern Slovakia were involved in the cross-sectional study. Children were recruited as a convenience sample. A total of 245 children, whose parents or legal representatives provided informed consent, participated in the study from the potential target group of 266 (92.11% response rate). A total of 233 children, with an average age of 7.33 years (SD = 0.45 years), completed all test items, and their data were included in the subsequent statistical analysis. A total of 103 children (girls: n = 50; 48.54%) with an average age of 7.56 years (SD = 0.46 years) formed a group of children with ADHD detected via institutionalized pedagogical–psychological diagnostics. The control group consisted of 130 children (girls: n = 56; 43.07%) without ADHD symptomatology with an average age of 7.21 years (SD = 0.25 years).

Children without serious health impairments were included in the study on a voluntary basis. All participants regularly attended two lessons of physical and sports education per week. Children with ADHD were fully integrated within standard primary education regarding the compulsory curriculum. The Ethics Committee of the University of Presov in Presov (Slovakia) approved the study. All procedures were conducted in agreement with the principles expressed in the Declaration of Helsinki.

Instrument

The MOBAK-1 test battery (Hermann, 2018) was applied to determine the level of basic motor competencies of the primary school children. This diagnostic tool was designed with the intention of evaluating the motor diagnostics of children in the context of primary education. Psychometric quality criteria for the MOBAK-1 have been confirmed several times in various validation studies via confirmatory factor analysis (Hermann, 2018; Carcamo-Oyarzun & Herrmann, 2020).

As part of the field measurement, standardized sports equipment was used in accordance with the protocol of the test battery. MOBAK-1 (for more details, see Herrmann, 2018) is structured into eight test items that cover two competence motor areas – *object movement* and *self-movement*. The competence area of *object movement* includes four motor tasks. *Throwing*:

The child throws six juggling balls from a 2.0 m distance at a target; *Catching*: The test leader drops a ball to the ground so that the ball bounces at least 1.30 m above the ground. The child catches the ball after the turning point; *Bouncing*: The child bounces a basketball along a marked corridor (5.0 x 1.0 m) until the finish line without losing the ball; *Dribbling*: The child dribbles a ball back through a marked corridor (5.0 x 1.0 m) without losing the ball. Similarly, the second competence area of *self-movement* includes four motor items. *Balancing*: The child balances across a see-sawing long bench without leaving it; *Rolling*: The child performs a forward roll fluently and is able to stand afterwards; *Jumping*: The child jumps fluently over four carpet tiles at a distance of 0.4 m each, between the tiles one-legged, beside the tiles with straddled legs; *Running*: The child runs sideways back and forth twice on a 3.0 m long ground mark.

Procedure

The testing was carried out during the standard scheduled physical and sports education lessons (45 min) in the gymnasiums of the respective participating schools. During the measurement, the children had appropriate sportswear and sports shoes, and basic health and hygiene requirements (e.g. drinking regime) were ensured.

The administration of the MOBAK-1 test protocol (Herrmann, 2018) was performed by a team of four trained test leaders. During the testing procedure, the participating school classes were divided into small groups consisting of four to six children.

These groups of children, led by one of the test leaders, gradually completed all the items of the MOBAK-1 test battery at the prepared test stations. Before completing each of the test items, the test leader explained the motor task to the children and provided a one-off demonstration. Practice attempts were not allowed. Children completed all test items in accordance with the MOBAK-1 protocol. The test subjects had six attempts in the *throwing* and *catching* test items, and the point scores in these items were as follows: 0 to 2 hits = 0 points, 3 to 4 hits = 1 point, and 5 to 6 hits = 2 points. For the other test items, each child had two attempts, and the point scores for the given items were as follows: both attempts failed = 0 points, one attempt passed = 1 point, and both attempts passed = 2 points (Herrmann, 2018).

Statistical Analysis

Observed data were processed using the IBM SPSS statistics package (Version 24.0; IBM, Armonk, NY, USA). The Shapiro-Wilk normality test was used to verify normal data distribution. Levene's test was also used to assess the equality of variances. The significance level established was 5% ($p < .05$). For description of a level of examined motor measures, mean, standard deviation, and a confidence interval (CI) of 95% were used. An independent samples *t*-test was applied to compare motor characteristics between the group of children with ADHD and the control group without ADHD. Effect size was evaluated using Cohen's *d*. Values of $d = 0.2$, $d = 0.5$, and $d = 0.8$ were interpreted as small, medium, and large effects, respectively (Cohen, 1988, 1992).

Results

The independent samples *t*-test revealed statistically significant lower scores in children with ADHD compared to their peers without ADHD in most of the examined items of the MOBAK-1 test battery (Herrmann, 2018), while confirming a small to large effect size (*d*) ranging from 0.34 (balancing) to 1.03 (catching) (see Table 1).

The exceptions were the throwing ($t(231) = -0.98$, $p = .331$) and dribbling ($t(231) = 0.25$, $p = .803$) test items, in which the differences between the compared groups were not confirmed. From the point of view of the summative comparison of individual competence areas of the MOBAK-1 test battery, the results indicate statistically significant differences in favour of children without ADHD in both object movement and self-movement, as well as in the total score of the MOBAK test, with medium and large effect sizes (*d*) ranging from 0.78 up to 1.05 (see Table 2).

Table 1 Comparison of MOBAK-1 test items between children with and without ADHD

Items (Points 0–2)	Girls + Boys (with ADHD) N = 103			Girls + Boys N = 130			*t*-test	*p*	Cohen's *d*
	Mean	SD	95% CI	Mean	SD	95% CI			
Throwing	0.67	0.58	[0.56; 0.78]	0.59	0.62	[0.48; 0.70]	-0.98	.331	-0.13
Catching	1.04	0.59	[0.93; 1.16]	1.61	0.52	[1.52; 1.70]	7.79	< .001	1.03
Bouncing	0.75	0.48	[0.65; 0.84]	1.28	0.78	[1.15; 1.42]	6.19	< .001	0.82
Dribbling	0.85	0.59	[0.73; 0.96]	0.87	0.84	[0.72; 1.02]	0.25	.803	0.03
Balancing	1.10	0.69	[0.96; 1.23]	1.33	0.69	[1.21; 1.45]	2.57	.011	0.34
Rolling	1.00	0.79	[0.86; 1.16]	1.52	0.67	[1.41; 1.64]	5.45	< .001	0.72
Jumping	0.75	0.52	[0.65; 0.85]	1.12	0.70	[0.99; 1.24]	4.45	< .001	0.59
Running	0.91	0.57	[0.79; 1.01]	1.28	0.75	[1.15; 1.41]	4.20	< .001	0.56

Table 2 Comparison of competence areas and total MOBAK-1 test between children with and without ADHD

Competence areas	Girls + Boys (with ADHD) N = 103			Girls + Boys N = 130			*t*-test	*p*	Cohen's *d*
	Mean	SD	95% CI	Mean	SD	95% CI			
Object movement (Points 0–8)	3.26	1.08	[3.05; 3.47]	4.34	1.58	[4.06; 4.61]	5.91	< .001	0.78
Self-movement (Points 0–8)	3.73	1.30	[3.47; 3.98]	5.25	1.54	[4.98; 5.51]	7.99	< .001	1.05
Total MOBAK (Points 0–16)	7.17	1.91	[6.80; 7.55]	9.59	2.74	[9.12; 10.07]	7.16	< .001	1.00

The results of the comparison of motor measures in girls are shown in Tables 3 and 4. Girls with ADHD demonstrated statistically significantly lower scores than girls without ADHD in two items from the competence area of object movement: catching ($t(104) = 3.99$, $p < .001$) and bouncing ($t(104) = 3.54$, $p < .001$), with medium effect sizes. In the competence area of self-movement, girls with ADHD achieved significantly lower scores in rolling ($t(104) = 3.42$, $p < .001$) and jumping ($t(104) = 2.59$, $p = .011$), with medium effect sizes. In the overall assessment of motor competence areas, significantly higher scores of girls without ADHD compared to girls with ADHD were confirmed in both examined competence areas, as well as in the overall assessment, with medium to large effect sizes. An important finding is that the average score of girls with ADHD in object movement slightly exceeded the boundary value of 3 points, which indicates the need for so-called educational motor support as defined by Herrmann (2018).

Like girls, boys with ADHD achieved statistically significantly lower scores than the control group of boys without ADHD in almost all motor test items (see Table 5). The exceptions were two items from the competence area of object movement, namely throwing ($t(125) = -0.42$, $p = .675$) and dribbling ($t(125) = -0.65$, $p = .515$), in which both compared groups performed similarly. Within the summative assessment of competence areas and the total score of the MOBAK test, boys with ADHD demonstrated a significantly lower level than their peers without ADHD, with medium (object movement: $d = 0.79$) to large (self-movement: $d = 1.28$; total MOBAK test: $d = 1.26$) effect sizes (see Table 6). The results of the independent comparisons of girls and boys indicate that the disproportions between the compared groups of girls (ADHD/without ADHD) are milder compared to boys.

From a diagnostic point of view, it was worthwhile to have a closer look at the percentage of children who, based on their performance in the individual competence areas of the MOBAK-1 test, did not reach the boundary value of 3 points, and thus demonstrated the need for so-called educational motor support (Herrmann, 2018). As shown in Figure 1, from the total set of children with ADHD, almost 22% showed motor deficits in the competence area of object movement and almost 20% in self-movement. On the other hand, in the group of children without ADHD, the percentage of children with motor deficits was almost 15% for object movement and almost 7% for self-movement.

Table 3 Comparison of MOBAK-1 test between girls with and without ADHD

Items (Points 0–2)	Girls (with ADHD) N = 50			Girls N = 56			*t*-test	*p*	Cohen's *d*
	Mean	SD	95% CI	Mean	SD	95% CI			
Throwing	0.70	0.58	[0.54; 0.87]	0.59	0.59	[0.43; 0.75]	-0.97	.336	-0.19
Catching	1.10	0.68	[0.91; 1.29]	1.57	0.53	[1.43; 1.72]	3.99	< .001	0.78
Bouncing	0.66	0.52	[0.51; 0.81]	1.13	0.79	[0.91; 1.34]	3.54	< .001	0.69
Dribbling	0.70	0.54	[0.55; 0.86]	0.84	0.84	[0.61; 1.07]	0.99	.323	0.19
Balancing	1.22	0.68	[1.03; 1.41]	1.45	0.69	[1.26; 1.63]	1.71	.091	0.33
Rolling	0.96	0.86	[0.72; 1.20]	1.48	0.71	[1.29; 1.67]	3.42	< .001	0.67
Jumping	0.78	0.51	[0.64; 0.92]	1.11	0.76	[0.90; 1.31]	2.59	.011	0.50
Running	1.04	0.49	[0.90; 1.18]	1.19	0.79	[0.98; 1.41]	1.19	.233	0.23

Table 4 Comparison of competence areas and total MOBAK-1 test between girls with and without ADHD

Competence areas	Girls (with ADHD) N = 50			Girls N = 56			*t*-test	*p*	Cohen's *d*
	Mean	SD	95% CI	Mean	SD	95% CI			
Object movement (Points 0–8)	3.10	1.15	[2.77; 3.43]	4.11	1.53	[3.70; 4.52]	3.79	< .001	0.74
Self-movement (Points 0–8)	3.98	1.27	[3.62; 4.34]	5.23	1.67	[4.78; 5.68]	4.30	< .001	0.84
Total MOBAK (Points 0–16)	7.50	2.12	[6.90; 8.10]	9.36	2.84	[8.60; 10.12]	3.78	< .001	0.74

Table 5 Comparison of MOBAK-1 test items between boys with and without ADHD

Items (Points 0–2)	Boys (with ADHD) N = 53			Boys N = 74			*t*-test	*p*	Cohen's *d*
	Mean	SD	95% CI	Mean	SD	95% CI			
Throwing	0.64	0.59	[0.48; 0.80]	0.59	0.64	[0.45; 0.74]	-0.42	.675	-0.08
Catching	0.98	0.50	[0.84; 1.12]	1.64	0.51	[1.52; 1.75]	7.17	< .001	1.29
Bouncing	0.83	0.43	[0.71; 0.95]	1.41	0.74	[1.23; 1.58]	5.09	< .001	0.92
Dribbling	0.98	0.60	[0.81; 1.15]	0.89	0.85	[0.69; 1.09]	-0.65	.515	-0.12
Balancing	0.98	0.69	[0.79; 1.17]	1.24	0.68	[1.09; 1.40]	2.13	.035	0.38
Rolling	1.04	0.73	[0.84; 1.24]	1.55	0.64	[1.40; 1.70]	4.20	< .001	0.76
Jumping	0.72	0.53	[0.57; 0.86]	1.12	0.66	[0.97; 1.27]	3.68	< .001	0.66
Running	0.77	0.61	[0.61; 0.94]	1.34	0.71	[1.17; 1.50]	4.69	< .001	0.84

Table 6 Comparison of competence areas and total MOBAK-1 test between boys with and without ADHD

Competence areas	Boys (with ADHD) N = 53			Boys N = 74			*t*-test	*p*	Cohen's *d*
	Mean	SD	95% CI	Mean	SD	95% CI			
Object movement (Points 0–8)	3.42	0.99	[3.14; 3.69]	4.51	1.61	[4.14; 4.89]	4.41	< .001	0.79
Self-movement (Points 0–8)	3.49	1.30	[3.13; 3.85]	5.26	1.44	[4.92; 5.59]	7.09	< .001	1.28
Total MOBAK (Points 0–16)	6.87	1.64	[6.42; 7.32]	9.77	2.67	[9.15; 10.39]	7.02	< .001	1.26

An educational need for motor support in the object movement competence area was demonstrated by almost 20% of girls and 11% of boys without ADHD. In contrast, 28% of girls and more than 15% of boys with ADHD showed motor deficits. In the competence area of self-movement, 16% of girls and almost 23% of boys with ADHD dis not even score 3 points. In the children without ADHD, approximately 5% of girls and more than 8% of boys showed motor deficits. These findings point to the higher prevalence of motor deficits in the ADHD children compared to the control group without ADHD, which was more pronounced in the self-movement component (see Figure 2). Regarding the difficulty of the individual test items of the MOBAK-1 test battery, the results indicate that the most challenging test items for both children with and without ADHD were throwing in the competence area of object movement and jumping in the competence area of self-movement. In contrast, the least challenging MOBAK test items were catching and rolling or balancing.

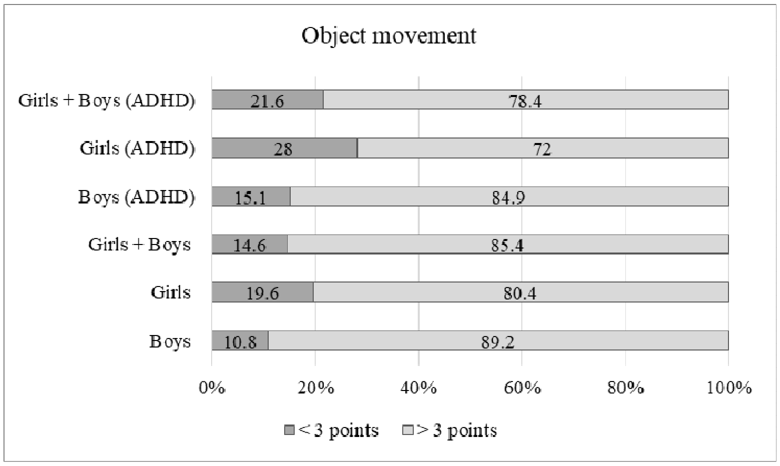

Figure 1 Distribution of sample by need for educational motor support (< 3 points/Object movement)

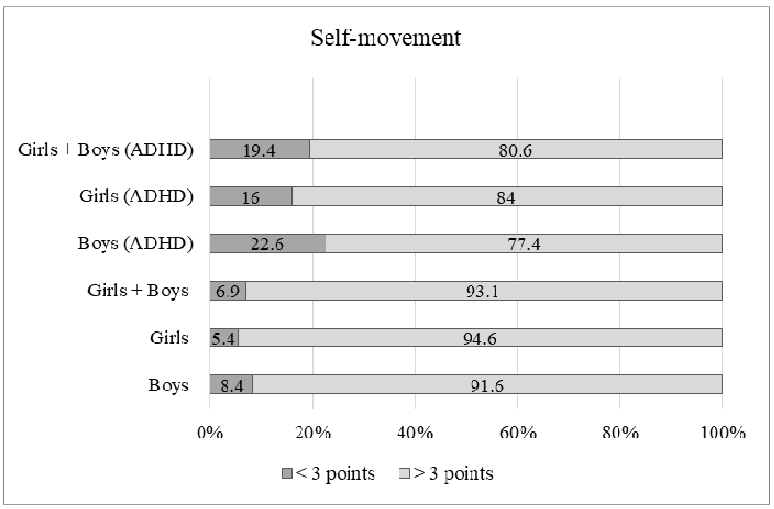

Figure 2 Distribution of sample by need for educational motor support (< 3 points/Self-movement)

Discussion

This study focused on the analysis of the level of basic motor competencies in 6- to 7-year-old children with ADHD based on a comparison with a control group of children without ADHD. The empirical data documented a significantly lower level of motor competencies in children with ADHD compared to their peers without ADHD, regardless of gender. These findings correspond with several previous studies. Barkley et al. (2001) state that children with ADHD demonstrate an overall lower level of gross motor coordination and graphomotor skills. Similarly, Verret, Gardiner, and Béliveau (2010) document a significantly lower level of locomotor skills in children with ADHD, while their level of flexibility and aerobic endurance is at a similar level to their peers without ADHD.

Shen, Lee, and Chen (2012) point to a low level of balance and kinaesthetic differentiation motor abilities, as well as deficits in motor learning. In addition, children with ADHD often demonstrate significantly lower performance in motor tasks requiring hand-eye coordination, as well as visual-motor integration. Goulardins et al. (2013) and Palácio, Oliveira, Arneiro, and Cassella (2016) also state that the biggest difference in motor competencies between children with ADHD and without ADHD is found in the level of balancing skills, but this was not confirmed in the girls of this study, since balancing was at a comparable level in girls with ADHD and without ADHD.

Rosa Neto et al. (2015) confirm lower levels of spatial and temporal orientation in children with ADHD. Spatial orientation includes the processes of localization, visual–spatial memory, distance estimation, and orientation speed. Low levels of time orientation in children with ADHD may be explained by poor performance in executive functions (Klimkeit, Mattingley, Sheppard, Lee, & Bradshaw, 2005). Similarly, frequent occurrence of laterality anomalies is confirmed in children with ADHD (Reid & Norvilitis, 2000). It is assumed that the mentioned spatial and temporal parameters are important factors that determine the level of most of the examined motor measures of the MOBAK test and can to some extent explain the lower performance of children with ADHD compared to children without ADHD.

Tseng, Henderson, Chow, and Yao (2004) report that attention and impulsivity are predictors of the level of motor skills and motor learning of children with ADHD with a 55.9% share of their variability. As reported by Fliers et al. (2009), inattention apparently negatively determines the motor skills and motor learning of children with ADHD. Based on the assessment and observation of parents and teachers, fine and gross motor problems are attributed to a deficit in attention and not to hyperactivity or impulsivity in up to one third of children with ADHD. It is obvious that the mentioned aspects of ADHD symptomatology had a negative effect on the performance of the children in this study in individual motor skills.

Goulardins et al. (2013) emphasize that stimulation of motor development can largely positively determine self-control, self-discipline, and self-evaluation in the population of children with ADHD.

The results of this study also indicate that almost 22% of children with ADHD show motor deficits (< 3 points per competence area) in object movement and almost 20% of children in self-movement. In relation to this, Geuze (2005) states that up to 47% of children with ADHD are below the 25th percentile based on the Test of Gross Motor Development (TGMD-2) application (Ulrich, 2000). This is a clinically borderline value that indicates serious motor deficits and the necessity for a special motor intervention.

Kim, Mutyala, Agiovlasitis, and Fernhall (2011) state that children with ADHD participate to a lesser extent in physical activity with very high intensity, and the degree of their involvement in organized forms of sports activities is also lower compared to the population without ADHD.

Almost 20% of girls and 11% of boys without ADHD in this study showed motor deficits (< 3 points per competence area) in object movement. Even though this is a lower proportion of children compared to children with ADHD, the aforementioned findings indicate that even this part of the school population does not achieve motor competence that would correspond to the healthy motor development of younger schoolchildren and enable them to participate successfully in a broad context of physical activity. Based on a cross-sectional international study, Wälti et al. (2022) report that more than 25% of children aged 8 to 10 years showed a need for educational motor support in the area of object movement and more than 20% of children in self-movement. Brian, Getchell, True, De Meester, and Stodden (2020), Robinson et al. (2015), and Stodden et al. (2008) emphasize that the development of motor skills plays a crucial role in both the quality and quantity of an individual's lifelong physical activity. In this context, Quitério et al. (2018) state that the MOBAK test enables to identify children with deficits in individual motor competencies in the setting of physical education and conceptually formulate individualized feedback. It makes it possible to implement intervention strategies in a more targeted manner, especially for children who show a motor delay or another type of insufficient level of motor skills.

Regarding the difficulty of the test items in the MOBAK test, it turns out that for children with ADHD, but also without ADHD, the most difficult test items are throwing and jumping, which corresponds to the findings of several previous studies (Carcamo-Oyarzun & Herrmann, 2020; Herrmann, Heim, & Seelig, 2019; Quitério et al., 2018).

The level of competencies in object movement in children without ADHD is comparable to findings from several similar studies. Children without ADHD from this study outperformed Chilean children (mean = 3.71; Carcamo-Oyarzun & Herrmann, 2020) and German children (mean = 4.03; Herrmann, Heim, & Seelig, 2019) and fell slightly behind Swiss children (mean = 4.67; Herrmann, Gerlach, & Seelig, 2015) and Portuguese children (mean = 4.90; Quitério et al., 2018). In the self-movement component, children without ADHD achieved a slightly higher level than Chilean children (mean = 4.72; Carcamo-Oyarzun & Herrmann, 2020), German children (mean = 4.48; Herrmann, Heim, & Seelig, 2019), and Portuguese children (mean = 4.70; Quitério et al., 2018). On the other hand, their scores were slightly behind the performance of Swiss children (mean = 5.48; Herrmann, Gerlach, & Seelig, 2015).

Several limitations of this study should be mentioned. First, due to the cross-sectional design, no causality can be defined from the research data. Another limitation is the lack of a more detailed analysis of the sociodemographic and socioeconomic contexts, as well as the somatic factors of the studied subjects. Considering the symptomatology of ADHD, it would be appropriate to include the diagnosis and analysis of fine motor skills in future research objectives to analyse longitudinal changes in the motor competencies of this population as well as the connections between motor measures and their academic performance or behavioural aspects of personality.

Conclusions

This study verifies and at the same time expands the previous research in motor development in the population of children with ADHD. A significant disproportion in the level of a significant part of the examined motor measures in children with ADHD compared to their peers without ADHD is confirmed. Milder differences are detected between the compared groups of girls. However, the research results indicate a certain degree of motor insufficiency even in children without ADHD, especially in object movement.

The development of basic motor competencies should be a key educational strategy of physical education in primary education. The use of modern diagnostic approaches, such as the MOBAK-1 test battery, makes it possible to reliably identify differences in the motor development of children in the setting of physical education.

Early diagnostics of motor competencies in primary school children would make it possible to implement more effective stimulation and ensure their developmental stability, especially in children with serious motor deficits, delayed motor development, or excessive body weight, in this sensitive developmental period. It is precisely this part of the school population that, due to the inadequate development of motor abilities and skills, is at risk of the vicious cycle of obesity and sedentary behaviour already seen in childhood.

With regard to the results of this study, the following recommendations applicable to educational practice are formulated: a) to balance the formation of children's fine and gross (locomotor and manipulative) motor skills (not only those children with ADHD); b) to increase the overall involvement of students with motor deficits in extracurricular physical activities; c) in accordance with the idea of an active school, to implement a higher proportion of diverse physical activities (e.g. during recess, in school subjects other than physical education, active commute to school, etc.) in primary education; and d) to improve the competence of primary education teachers regarding the planning and implementation of individualized intervention motor programmes.

Conflicts of interest

The authors declare no conflict of interest.

Acknowledgement

The paper was supported by the scientific project No. 1/0162/22 – *'Learners' motor competences in the context of primary education: Determinants and possibilities of stimulation'*, which was funded by the Scientific Grant Agency of the Ministry of Education, Science, Research and Sports of the Slovak Republic and the Slovak Academy of Sciences.

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