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EFFECTS OF AN EXERCISE AND MINDFULNESS PROGRAMME ON SYMPTOMS OF ATTENTION DEFICIT HYPERACTIVITY DISORDER IN BOYS AGED 9-11 YEARS

UČINKI PROGRAMA TELESNE VADBE IN ČUJEČNOSTI NA SIMPTOME MOTNJE POZORNOSTI S HIPERAKTIVNOSTJO PRI DEČKIH OD 9 DO 11 LET

ABSTRACT

ADHD is the most common behavioral disorder in children. Some professional therapeutic treatment (PTT) of ADHD includes also physical exercise (PE) and mindfulness training (MT). In this study we have combined both. The sample included 20 subjects in the experimental (EG) and 19 in the control group (CG). All subjects were ADHD diagnosed boys, aged 10(±1) years. The intervention of the EG used PE and MT, while the CG intervention used unsystematic emotion education. The intervention took place twice a week for 60 minutes over the 3 months. The subjects' expression of ADHD symptoms was measured with the ASEBA CBCL/6-18 protocol (2023). Statistical analyses were calculated using IBM SPSS 25. Differences in the expression of ADHD symptoms between the groups were calculated using the Mann-Whitney rank test for independent samples. There were found no statistically significant differences (p=0.378). The short-term effect of the intervention was calculated using a two-factor ANOVA. On the symptom expression measures we found SSD (p<0.001) in both groups. There were significantly lower ADHD symptom expression in the EG. The same method was used to determine the long-term intervention effect. On both measures symptoms were a statistically significant (p<0.001) lower expressed in the EG. The magnitude of ADHD symptom expression was statistically significant (p<0.001) in both groups on both post-intervention measurements, but the symptom magnitude was significantly higher in the CG. Based on the findings, we suggest that such a systematic intervention could be used in modern PTT of children with ADHD.

Keywords: ADHD, intervention, exercise, mindfulness, boys

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IZVLEČEK

Motnja pozornosti s hiperaktivnostjo (ADHD) je najpogostejša vedenjska motnja pri otrocih. Strokovna terapevtska praksa za ADHD vključuje tudi telesno aktivnost (TA) in vadbo čuječnosti (Č). V tej študiji smo združili oboje. Vzorec je vključeval 20 preizkušancev v eksperimentalni skupini (ES) in 19 v kontrolni skupini (KS). Vsi preizkušanci so bili fantje z diagnozo ADHD, stari 10(±1) let. Intervencija v ES je vključevala TA in Č, medtem ko je intervencija v KS vključevala nesistematično izobraževanje o čustvih. Program je potekal dvakrat na teden po 60 minut v obdobju 3 mesecev. Izraženost simptomov ADHD smo merili z vprašalnikom ASEBA CBCL/6-18 (2023). Statistične analize smo izvedli s programom IBM SPSS 25. Razlike v izraženosti simptomov ADHD med skupinami smo izračunali z Mann-Whitney rang testom za neodvisne vzorce, kjer nismo ugotovili statistično značilnih razlik (SZR) (p = 0,378). Kratek časovni učinek intervencije smo izračunali z dvofaktorsko ANOVO. Pri merjenju izraženosti simptomov smo opazili SZR (p <0,001) v obeh skupinah. V ES je bilo izraženost simptomov ADHD bistveno manjša. Enak postopek smo uporabili za ugotavljanje dolgoročnega učinka intervencije. Pri obeh merjenjih so bili simptomi statistično pomembno nižje izraženi v ES (p <0,001). Velikost izraženosti simptomov ADHD je bila statistično pomembna (p <0,001) v obeh skupinah pri obeh merjenjih po intervenciji, vendar je bila izraženost simptomov bistveno višja v KS. Na podlagi ugotovitev ocenjujemo, da bi se lahko tak sistematičen program uporabil kot ena dodatnih sredstev celostne terapevtske obravnave za otroke z ADHD.

Ključne besede: ADHD, intervencija, vadba, čuječnost, fantje

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INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is the most common behavioural disorder in children today. According to Thomas et al. (2015), it is expressed in 7.2% of the child population. This disorder mainly affects activities (hyperactivity), behaviour (impulsivity) and the performance of executive tasks (inattention) (CHADD, 2023).

Memarmoghaddam et al. (2016) have shown that executive problem solving performance develops in childhood and adolescence and is related to emotions, behaviour and interactions with the environment. Colomer et al. (2017) explained that ADHD is caused by a dysfunction of the prefrontal lobe of the brain and neurotransmitter transmission, so it seems logical that children with ADHD have difficulties in performing executive tasks (e.g. judging, planning, decision-making).

Ziereis and Jansen (2015) found that a common characteristic of children with ADHD is that they find it difficult to sit still for long periods of time and, without physical activity, focus their attention on what is happening in their surroundings (e.g. listening to explanations, instructions, rules, etc.). In doing so, they experience emotional frustration that influences their behaviour but which they cannot control. Therefore, they also have problems interacting with their environment. At school, this often has a negative impact on their academic performance and their relationships with teachers and peers. The authors also found that, in addition to difficulties in conative, cognitive and social development, children with ADHD also have difficulties in motor development. Compared to their peers, they have less developed muscle strength, balance and coordination, and speed/reactivity. Kim (2018) has also shown that these children (compared to their non-ADHD peers) have poorer muscle strength and balance. He further found that this has an impact on their inappropriate (including unstable) posture. Their poorer coordinated movement (coordination of the whole or parts of the body) in simple motor tasks also affects their poorer complex movement (agility) of the body in space. Therefore, he hypothesised that this is also the reason for the poorer motor and sporting performance than their peers without ADHD symptoms.

Nevertheless, some authors (CHADD, 2023) point out that people with ADHD can be extremely successful not only in sport but also in life if the disorder is recognised, addressed and treated by professionals. Otherwise, they often have problems in childhood and adolescence that have a negative impact on all areas of their life and functioning (family, peer, academic, etc.). If these problems are not recognised (and professionally addressed), they can face serious

problems in later life with their partner, family and other interpersonal relationships, as well as in their professional work. This can lead to various mental disorders (e.g. anxiety, depression), chemical (e.g. alcohol, drug abuse) and non-chemical addictions (e.g. high-risk gambling, obsession with sex), and delinquent and criminal behaviour. It is therefore important that ADHD symptoms are recognised, professionally managed and (if necessary) treated in childhood or early adolescence. This is the only way they can be resolved or adequately controlled (without too much difficulty) by the time the individual reaches adulthood.

The professional therapeutic practice and treatment of ADHD in children is complex and involves several approaches. For mild ADHD, cognitive behavioural therapy (CBT) and adjustments in the school environment are recommended. The main goal of CBT is for the child and parents to recognise, accept and manage the disorder appropriately. Professional collaboration with teachers and school psychological or social services is also very helpful in this respect. In more severe forms of ADHD (and when CBT is not effective), treatment with psychostimulants or medications such as short-acting methylphenidate, extended-release methylphenidate and atomoxetine is most commonly recommended (Pary et al., 2002; Drechsler et al., 2020). Anderluh (2014) stresses that pharmacological treatment of children should only form part of a comprehensive professional management and treatment. In this regard, Wolraich et al. (2019) found that combined treatment with CBT and medication is most effective in children with ADHD. Faraone and Buitelaar had already shown in 2010 that short-term severe ADHD is most effectively alleviated and controlled with medication; long-term severe ADHD is most effectively alleviated and controlled with a combination of CBT and medication. Van Doren et al. (2019) point out that modern professional therapeutic practice and treatment of children with ADHD should focus on short-term appropriate alleviation and long-term control of the disorder. The best results can be expected when all those involved (child, parents and family members, school and out-of-school environment, etc.) are actively involved.

Exercise is purposeful physical activity performed in an organised and planned way to improve physical performance and health. To maintain and improve health, experts primarily recommend exercise for aerobic endurance, strength and flexibility, but also relaxation; for the elderly, they recommend exercise for coordination and balance (WHO, 2022). For children with ADHD, exercise is increasingly being used as an additional means of alleviating the symptoms of ADHD. Den Heijer et al. (2017) found that for children with ADHD, exercise is a safe and effective means of reducing the disorders that occur in children with ADHD.

The effect of exercise programmes on the expression of ADHD symptoms in children has been assessed in a small number of studies (Berwid and Halperin, 2012; Pontifex et al., 2013; Piepmeier et al., 2015; Den Heijer et al., 2017; Arumugam and Parasher, 2019; Chang, Jang, and Ho, 2022), but it is encouraging to see that positive effects have been reported. It is important to note here that they were conducted on small samples that were heterogeneous or without a control group, so their findings should be viewed with some reservation. Berwid and Halperin (2012) found that physical exercise in children with ADHD had a positive effect on the performance of executive tasks due to the stimulation of neurobiological processes. Pontifex et al. (2013) and Piepmeier et al. (2015) also found that a physical exercise programme in children with ADHD had a positive effect on the performance of executive tasks, as reflected in better attention, planning and working memory, and a higher number of correct solutions. Den Heijer et al. (2017), who studied the short- and long-term effects of aerobic endurance training on the incidence of ADHD symptoms in children with ADHD, found that short-term improvements in aerobic endurance were reversed in the long term. However, the short-term improvements in concentration, responsiveness, number of correct solutions to tasks and behaviour were maintained in the long term. Arumugam and Parasher (2019) studied the impact of aerobic endurance training on cognitive abilities and social skills in children with ADHD. They found similar findings - short-term improvement in aerobic endurance and short- and long-term improvement in cognitive abilities and social skills. Chang, Jang and Ho (2022) also found that both short-term and long-term exercise had positive effects on improving motor skills and executive functions and also reducing ADHD symptoms. Based on their research, these authors concluded that physical exercise may be one of the additional means of professional therapeutic treatment and management of children with ADHD.

Mindfulness has recently been increasingly used in professional practice for children with ADHD. In this context, it is defined as a self-monitoring tool for recognising, accepting and responding to ADHD symptoms. Kabat-Zinn (2003) suggests that mindfulness can be developed in a number of ways: relaxed breathing, meditation with observation of thoughts and emotions while at rest (e.g. sitting, lying down) or in movement (e.g. walking, specific movement tasks); or meditation for routine relaxation of muscles or body parts. A small number of studies have also examined the effect of mindfulness training on the incidence of ADHD symptoms in children with ADHD (Haydicky et al., 2015; Behbahani et al., 2018; Chung Chan et al., 2018; Lo et al., 2020). Due to implementation flaws, they have similar limitations to studies that have examined the impact of exercise programmes. Nevertheless, they have also

shown that mindfulness training can have a positive effect on reducing the frequency and intensity of ADHD symptoms. Haydicky et al. (2015) and Chung Chan et al. (2018) found that mindfulness training had a positive effect on the performance of executive tasks in children with ADHD; their attention, working memory and cognitive control improved. Behbahani et al. (2018), who studied the effect of mindfulness training on the frequency and intensity of ADHD symptoms in children with ADHD, found that parents rated their children's ADHD symptoms as less frequent and less intense after training. Parents also reported that their psychological distress was reduced. In a similar study, Chung Chan et al. (2018) found that children with ADHD improved their attention, working memory and behaviour control. Lo et al. (2020) found that for children with ADHD, mindfulness training improved their attention and reduced uncontrolled automatic responses, which were reflected in an inability to control bodily responses (i.e. tics) and behaviour, and marked impulsivity. On the basis of their research, these authors suggest that mindfulness training may be one of the complementary means of professional therapeutic management and treatment of children with ADHD.

We conducted a randomised controlled trial in boys aged 9 to 11 years diagnosed with ADHD to assess the effects of an exercise and mindfulness programme on the incidence of ADHD symptoms.

METHODS

Subjects

A randomised controlled trial involving 39 boys diagnosed with ADHD, with an average age of 10(±1) years, was conducted in the school year 2022/2023. 20 subjects were assigned to the experimental group and 19 to the control group. Inclusion criteria for the study were age ranging from 9 to 11 years and a diagnosis of ADHD without comorbidities (except for specific learning difficulties). The research was conducted in Ljubljana and Maribor. Pharmacological treatment and participation in other organized leisure activities (such as football, basketball and other sports activities) were not associated with ADHD treatment and therefore were not exclusion factors. All subjects participated voluntarily and with the consent of a parent/guardian. The study was approved by the Ethics Committee of the Faculty of Sport, University of Ljubljana (No. 033-14/2021-2) and by the Doctoral Studies Committee of the University of Ljubljana (Decision 2.11. of 7. 6. 2022).

Procedure

Randomisation using sealed envelopes was carried out by an independent person who did not subsequently take part in the study. After baseline measurements, which were taken one week before the start of the intervention, the subjects were randomly divided into experimental and control groups in a 1:1 ratio. The intervention programme of the experimental group was an exercise and mindfulness programme; the sham intervention of the control group was emotion education. Subjects were not informed and did not know which group they were participating in. The intervention programme of the experimental group was led by a Master of science in Kinesiology from the Faculty of Sport, University of Ljubljana, who is also a trainee in Systemic Family Psychotherapy from Sigmund Freud University in Ljubljana. The control group programme was run by the same person, which was intended to further mask the intervention programme to the subjects.

The intervention programme was tailored to boys aged 9 to 11 years. For both groups, the programme ran twice a week for three months; 24 training units were delivered over 12 weeks for both groups. Each training unit lasted 60 minutes. In the experimental group, each training unit was carried out in a planned and systematic way, following a carefully professionalised 12-week intervention programme. In the control group, however, the exercise units were carried out spontaneously and in an unscheduled manner. The exercise intervention programme for the experimental group included simple and complex movement tasks to develop coordination, agility, balance and responsiveness. The teacher's instructions were delivered in a planned and systematic way throughout, with encouragement for auditory and visual perception, allowing the subjects to develop their attention and focus on the tasks. This was integrated in a planned way with the mindfulness intervention programme. In line with the exercise programme, this included simple and complex tasks to develop focus on breath, sight and hearing, and to recognise, accept, understand and regulate emotional experience, which typically manifested as fear, anger and joy. The control group's programme was a spontaneous and unplanned emotion education session in which the subjects listened to, identified and discussed different aspects of emotional experience.

The short-term effect of the exercise and mindfulness programme on ADHD symptom severity in both groups was determined by calculating statistically significant differences between data collected from measurements taken 7 days before the start of the programme (baseline measurements) and 7 days after the end of the programme (endline measurements). The long-

term effect of the exercise and mindfulness programme on ADHD symptom severity was determined by calculating statistically significant differences between data collected at 7 days before the start of the programme (baseline measurements), 3 months after the start of the programme (three-month measurements) and 6 months after the end of the programme (six-month measurements). For both groups, all measurements were made using the ASEBA CBCL/6-18 (2023) assessment scale.

Tools

The Achenbach Assessment Scale for Children and Adolescents - ASEBA (Achenbach, 1991) (CBCL/6-18, TRF/6-18, YSR/11-18) is intended to assess a child's strong areas, adaptation skills, and identify behavioral, emotional and social problems. In our research, we used the assessment scale CBCL/6-18 (ASEBA, 2023), which was filled out by parents or guardians. Always by the same person following the same protocol four times (i.e. at baseline, endline, after 3 and 6 months). The listed scales enable the description of an individual's psychosocial characteristics based on DSM-5 diagnostic criteria (depression, anxiety, somatic problems, ADHD, oppositional-defiant disorder and conduct disorder) (ASEBA, 2023). For the purpose of research, we used a subscale based on the DSM-5 diagnostic criteria: ADHD (ASEBA, 2023). The ASEBA CBCL/6-18 (2023) assessment scale is intended for psychosocial diagnostic purposes and should therefore not be made public. That is why the data collection was participated by an experienced and highly educated psychologist. The degree of expression was scored on a scale where 0 meant that the problem was not expressed or the statement was not valid; 1 meant that the problem was partially expressed or the statement was partially valid; and 2 meant that the problem was fully expressed and the statement was always valid.

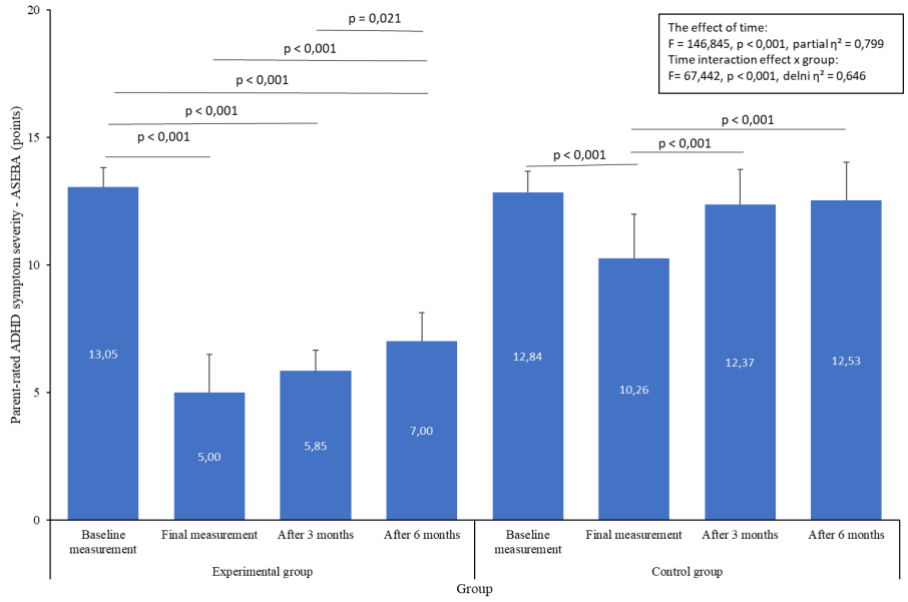
Statistical processing of data

The results were statistically analysed using IBM SPSS 25 (SPSS, Inc., Armonk, NY, USA). The mean and standard deviation of the variables were calculated. Normality of distribution was checked using the Shapiro-Wilk test for the whole sample and separately for the groups (experimental, control). Differences between the groups in age, baseline measurement scores and change at the end of the intervention (change (%) = final measurements - baseline measurements/initial measurements x 100%) were tested using the Mann-Whitney rank t-test for independent samples. As no statistically significant differences were found in the results between the experimental and control groups at baseline, further differences or the effect of the intervention on the expression of ADHD symptoms at repeated measurements (final

measurements, measurements at 3 months, measurements at 6 months) were determined using a two-factor analysis of variance for the repeated measurements. We calculated the effect of time and the effect of the interaction between time of measurements (baseline, endline, 3 months, 6 months) and group (experimental, control). In addition, we used the Bonferroni correction for repeated measures to determine the statistical significance of the differences between the measurements (baseline, endline, 3 months, 6 months) of the experimental and control groups. The magnitude of the effect of the independent variables on the dependent variables for repeated measurements was calculated using the partial eta-squared (η^2). The results were evaluated as statistically significant at the 5% significance level.

RESULTS

Figure 1: Finding statistically significant differences between experimental and control groups in the expression of ADHD symptoms in ASEBA-scored subjects as rated by parents - differences between experimental and control groups



Notes: ASEBA (scores) - expression of ADHD symptoms in children using the ASEBA CBCL/6-18 assessment scale (2023) as scored by parents, ANOVA - F value, p - statistical significance, η^2 - partial eta-squared. In the figure, the numbers in the columns show the expression of ADHD symptoms in the subjects with the mean scores according to the parent's scores on the ASEBA CBCL/6-18 (2023) assessment scale, and the vertical bars show the standard deviation of the parent's scores expressed as points on the same assessment scale.

Figure 1 shows the differences between the experimental and control groups in the expression of ADHD symptoms in subjects with ASEBA scores using the CBCL/6-18 (2023) assessment scale, which was used to obtain parent ratings. This was used to determine the short-term and

long-term effect of the physical exercise and mindfulness programme on the expression of ADHD symptoms in the subjects.

Figure 1 shows that the differences in the expression of ADHD symptoms with mean ASEBA scores between subjects in the experimental (M=13.05) and control (M=12.84) groups at baseline measurement were not statistically significant (p=0.378). This confirms that the groups were evenly matched at baseline, which was also a condition for the continuation of the study.

For the group of subjects studied, differences in ADHD symptom expression with mean ASEBA scores between baseline and endline measurements show statistically significantly lower ADHD symptom expression (-8.05 points, $p<0.001$). Differences in ADHD symptom expression with mean ASEBA scores between baseline and 3-month follow-up measurements also show statistically significantly lower ADHD symptom expression (-7.2 points, $p<0.001$). ADHD symptom expression with mean ASEBA scores between baseline and 3-month follow-up measurements also show statistically significant lower ADHD symptom expression (-7.2 points, $p<0.001$). Similarly, the differences between the baseline measurement and the measurement at 6 months show a similar pattern (-6.05 points, $p < 0.001$). This means that after the intervention, parents rated the subjects' expression of ADHD symptoms statistically significantly lower both in the short term (after 3 months from the start of the intervention) and in the long term (after 3 and 6 months from the end of the intervention), using the mean ASEBA scores. It should be noted, however, that the difference in parents' scores, expressed as the mean ASEBA score, was largest (-8.05 points) between the baseline (13.05 points) and endline (5.00 points) measurements, smaller (-7.2 points) between the baseline measurement and the three-month measurement (5.85 points), and smallest (-6.05 points) between the baseline measurement and the six-month measurement (7.00 points). The data (Figure 1) also show that parents rated the subjects' expression of ADHD symptoms as having a higher mean ASEBA score (7.00 points) at the 6-month follow-up measurement than at the final measurement (5.00 points). Statistical calculations here show a statistically significant increase in the expression of ADHD symptoms (+2.00 points, $p < 0.001$). The same is true for the measurement taken three months after the end of the intervention (+1.15 points, $p = 0.021$). Interestingly, the data in Figure 1 also show a statistically significant ($p<0.001$) lower expression of ADHD symptoms (baseline measurements - final measurements = -2.58 points) in the control group of subjects after the end of the intervention. However, three months after the end of the intervention (final measurements - measurements at three months = +2.11 points), we found a statistically significant ($p<0.001$) increase in the expression of ADHD symptoms. The same applies to the

measurements taken six months after the end of the intervention (final measurements - measurements at six months = +2.27 points, $p<0.001$).

The effect size of intervention time was statistically significant ($p<0.001$, partial $\eta^2=0.799$). The same was true for the effect size of intervention time and subject group ($p<0.001$, partial $\eta^2=0.646$).

Table 1. Detection of statistically significant differences between experimental and control groups in the extent of parent-rated ADHD symptom expression using ASEBA scores

ASEBA (points)		**N**	**M**	**SD**	**S.N.M.**	**Z**	**p**
Final measurements - Baseline measurements (%)	Experimental group	20	-61,68	11,24	2,51	-5,357	0,000*
	Control group	19	-19,85	13,77	3,16		
Measurements after 3 months - Baseline measurements (%)	Experimental group	20	-55,02	6,90	1,54	-5,361	0,000*
	Control group	19	-3,50	11,18	2,56		
Measurements after 6 months - Baseline measurements (%)	Experimental group	20	-46,25	8,68	1,94	-5,317	0,000*
	Control group	19	-2,12	13,24	3,04		

Notes. ASEBA (scores) - expression of ADHD symptoms in children with ASEBA CBCL/6-18 (2023) according to parents' scores, M - mean of ASEBA scores, SD - standard deviation, S.N.M. - standard error of the mean, Z - test statistic, p - statistical significance.

Table 1 shows the comparison between the two groups of the change in parents' ratings of children's behavioural, emotional and social problems at the end of the intervention, 3 months and 6 months after the end of the intervention. Subjects who implemented exercise combined with mindfulness had statistically significantly greater improvements in parent ratings of children's behavioural, emotional and social problems at the end of the exercise intervention (+41.83%, $p < 0.001$), at 3 months post-intervention (+51.52%, $p < 0.001$), and at 6 months post-intervention (+33.01%, $p < 0.001$), compared to the control group.

DISCUSSION

This study was conducted in boys aged 9-12 years diagnosed with ADHD, examining the short-term and long-term effects of a systematic and planned intervention programme of physical exercise and mindfulness on the expression of parent-rated ADHD symptoms. For this reason, the data obtained cannot be directly compared with similar studies. Overall, the intervention programme of physical exercise and mindfulness had a positive effect. Similar to researchers before us who have studied the effect of exercise (Berwid and Halperin, 2012; Pontifex et al., 2013; Piepmeier et al., 2015; Den Heijer et al., 2017; Arumugam and Parasher, 2019) and those

who have studied the effect of mindfulness (Haydicky et al., 2015; Behbahani et al., 2018; Chung Chan et al, 2018; Lo et al., 2020), we found a reduction in the expression of ADHD symptoms in the subjects after the intervention. From this perspective, we confirmed that an intervention programme of physical exercise and mindfulness can be one of the complementary means of professional therapeutic management and treatment of children with ADHD.

Short-term effects of the intervention programme

The short-term effects of the intervention programme on the expression of parent-rated ADHD symptoms in the subjects were assessed by means of a difference-in-differences analysis between baseline and endline measurements, which was conducted three months after the start of the study in the experimental group, in which the exercise and mindfulness intervention programme was implemented in a planned and systematic way. The analysis showed a statistically significant reduction in the expression of ADHD symptoms. We found that the expression of ADHD symptoms in the subjects was relatively much lower after three months of the programme than before the start of the programme. Interestingly, we found similar results in the control group of subjects, where the emotion education programme was implemented in an unsystematic and unplanned way. The apparent implementation of the programme in the control group was intended to mask the actual implementation of the intervention programme in the experimental group. If we had not implemented the programme in the control group, this would have been quickly revealed in the conversations between the experimental group, as they were peers and socialised in various school and extracurricular activities. The short-term lower expression of ADHD symptoms in the control group at the final measurement (compared to baseline) is thus partly attributed to the placebo (neither parents/guardians nor children knew which group they were in) and partly to the emotion education, where subjects listened to, identified and discussed different aspects of emotional experience. Although we found statistically significantly lower ADHD symptom expression in both groups at the final measurement, the difference in the magnitude of symptom expression between the two groups was statistically significant. We have shown that a planned and systematic exercise and mindfulness programme in the experimental group resulted in a much lower incidence of ADHD symptoms than in the control group. Thus, it can be argued that physical training in coordination, agility, balance and responsiveness, but also mindfulness training to focus on breath, vision and hearing, and to recognise, accept, understand and regulate emotions, had a positive effect, leading to a lower incidence of ADHD symptoms. As we did not determine the effect size or proportion of the effect of exercise and mindfulness training in isolation, we

cannot say which of the two interventions had a greater effect on reducing ADHD symptoms in the subjects. However, we can conclude that the designed physical exercise and mindfulness programme improved attention, self-regulation and calming in the subjects in the experimental group, thereby reducing the severity of ADHD symptoms. Our findings in the positive short-term effects of the programme seem to be in line with researchers who have established the effect of physical exercise programmes in children with ADHD (Den Heijer et al.,2017; Arumugam and Parasher, 2019); as well as mindfulness programmes (Haydicky et al., 2015; Behbahani et al., 2018; Chung Chan et al., 2018; Lo et al., 2020). In our study, we believe that a systematic and planned combination of physical exercise and mindfulness training with simple and complex tasks captured all the core symptoms of ADHD and therefore had a relatively strong and positive effect on them.

Long-term effects of the intervention programme

The long-term effect of the exercise and mindfulness programme in the experimental and control groups was measured at 3 and 6 months after the programme. In the experimental group, both at three and six months after the programme, we found a statistically significant lower expression of ADHD symptoms in the subjects in that group, as assessed by their parents. In the control group, however, the parent-rated ADHD symptom severity was not statistically significant at both 3 and 6 months. Given that the subjects in the experimental group showed the lowest expression of ADHD symptoms at the final measurement and then increased each time at the measurements taken three and six months after the end of the intervention, it can be argued that the effect of the intervention was diminishing over time. It is important to note here that both exercise and mindfulness practice are recognised means of improving mental health and quality of life, but that they only have the desired effect when practised appropriately - several times a week. The fact that both good physical performance and mindfulness decline without adequate exercise has been repeatedly demonstrated. When analysing the magnitude of ADHD symptom expression, we came up with interesting findings, as the difference in magnitude of expression between the experimental and the control group was not greatest on the final measurements (after 3 months of the programme), but on the measurements after 3 months of the intervention. At the 6-month follow-up, the difference was statistically significant, but had already decreased significantly. The decline in results is attributed to the diminishing impact of the physical activity and mindfulness programme. As expected, the effect of the programme diminishes with distance from the end of the programme, but nevertheless, compared to before the programme, it still has an effect and an impact on the magnitude of

ADHD symptom expression. It is important to note that six months after the end of the programme, the expression of ADHD symptoms in the experimental group was still significantly lower than before the programme. Moreover, at the beginning of the study, all subjects were classified as symptomatic, but subsequently the subjects in the experimental group achieved normative scores on all follow-up measures after the physical activity and mindfulness programme. This means that the control group remained symptomatic throughout the school year, while the experimental group reduced the severity of these symptoms to normative values. Achenbach and Rescorla (2003) stated that children whose ADHD symptom expression reaches normative values with the CBCL/6-18 (2023) assessment scale scores do not need ongoing professional help. However, children whose scores place them in the clinical treatment range usually have high symptom severity and require ongoing professional help to monitor their mental health. Even when considering the findings of the long-term effects of our intervention programme, we stress that they cannot be directly compared with the findings of previous research. However, we can argue in accordance with them that both physical exercise (Berwid and Halperin, 2012; Pontifex et al., 2013; Piepmeier et al., 2015; Den Heijer et al., 2017; Arumugam and Parasher, 2019; Chang, Jang, and Ho, 2022) and mindfulness training (Haydicky et al., 2015; Behbahani et al., 2018; Chung Chan et al., 2018; Lo et al., 2020); or better still their combination, serves as an additional means of modern - comprehensive professional therapeutic treatment and management of children with ADHD.

CONCLUSION

The findings suggest that exercise can play an important role in managing the symptoms of ADHD, improving the overall well-being of children with the disorder. A number of studies have shown that regular physical exercise can have a positive impact on reducing ADHD symptoms, including increased attention, reduced hyperactivity and impulsivity, and improved cognitive function. We hypothesise that physical exercise may increase levels of neurotransmitters such as dopamine, which is associated with attention in executive tasks. It is essential that exercise intervention is planned and systematic, and that it is performed consistently. The duration of intervention programs with physical activity, in which positive effects were reported, was different (1 to 34 months) (Donnelly et al. (2016). In our case, when the program lasted twice a week for three months, we found an improvement in the subjects' ability to maintain attention and concentration.

We also hypothesise that physical exercise can help to release children's hyperactivity and mental tension, thereby reducing their impulsivity. We conclude that regular physical exercise can help balance energy levels and improve self-control of emotions and behaviour. This is probably because exercise increases blood flow to the brain, which in turn provides the cells with an abundant supply of oxygen and energy. This is thought to improve cognitive function, which is important for remembering, learning and performing executive tasks. It may also affect the development of brain structures related to these functions in children. Exercise is also known to release endorphins, which are natural 'happiness hormones' and are credited with reducing mental stress and anxiety. Therefore, with regular exercise, we can also expect to experience improved mood and general well-being. We recommend that children with ADHD get at least 60 minutes of physical exercise a day, which is in line with WHO recommendations (2022). Further benefits can be expected when exercise is planned and systematic, and led by trained professionals who also take into account children's individual interests and motivations, which can further influence their well-being and satisfaction.

Mindfulness training in children with ADHD is reported by some research to be an important additional means of managing ADHD symptoms. Findings suggest it can help improve the longer-term maintenance of adequate concentration, attention and focus when performing executive tasks. We conclude that in children, deliberately and systematically focusing attention on the present moment may help to reduce ADHD symptoms and redirect their attention to the performance of current tasks. In line with our findings, however, similarly to exercise, we stress that a positive effect can only be expected with consistent exercise - at least twice a week for at least three months. We hypothesise that it is during this period that children increase their ability to control and act on disturbing thoughts and feelings that trigger uncontrolled impulsive behaviour. It is also important to reduce the critical response of the environment (e.g. parents, teachers, peers), which can trigger further frustration in children with ADHD symptoms. Therefore, we believe that mindfulness training can be a good tool to reduce psychological distress and anxiety. Children with ADHD most often experience this precisely because they do not recognise and manage their ADHD symptoms. We conclude that through consistent mindfulness training, they can also develop greater mental, physical and emotional control, which has the effect of reducing the occurrence of anger, fear and aggression. In our case, this was achieved through simple and complex mindfulness tasks focusing on breath, sight and hearing, which clearly had an impact on recognising, accepting, understanding and regulating their emotional experience. However, we assume that similar results can be achieved through

meditation, breathing exercises and other means. Similarly to physical exercise, mindfulness training for children with ADHD emphasises that the desired - positive - effects of reducing the expression of symptoms can only be expected with planned and systematic training, led by trained professionals who also take into account the children's individual interests and motivation, and can thus further influence their relaxation, well-being and satisfaction.

The program contributed to a lower expression of ADHD symptoms, but this does not mean that they are no longer diagnosed with ADHD.

Based on our findings, we believe that physical exercise and mindfulness training can be one of the complementary means of modern - professional therapeutic treatment of children with ADHD.

Shortcomings and limitations

The biggest drawback of the survey was the relatively small sample of male subjects, aged 9-11 years. We believe that future research in children diagnosed with ADHD would benefit from a larger sample including both sexes. We therefore suggest that a future study with three experimental groups and one control group be carried out. One experimental group should implement the exercise programme, the other the mindfulness programme, and the third the exercise and mindfulness programme. It would probably be more appropriate to use specifically designed scales for the ADHD assessments in future research to measure the expression of ADHD symptoms in children. While there are three main types of ADHD (predominantly inattentive presentation, predominantly hyperactive/impulsive presentation and combined presentation), with our research we were unable to identify differences between them with the rating scale CBCL/6-18 (ASEBA, 2023). However, this was not possible due to the small sample size. It should be also taken into account that despite the fact that our research found that the intervention program had a positive effect on the lower expression of ADHD symptoms, this does not mean that the change was clinically significant for the participants (and they no longer have symptoms or a diagnosis of ADHD).

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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