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Effects of a 12-Week Structured Physical Activity Intervention on Fine and Gross Motor Skills in Children with ADHD: A Quasi-Experimental Study

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Abstract

Background: Children with Attention-Deficit/Hyperactivity Disorder (ADHD) frequently experience motor deficits impacting functional performance. While physical activity offers cognitive benefits, evidence regarding its efficacy on standardized motor domains remains limited. This study evaluated a 12-week structured physical activity intervention on fine and gross motor skills in children with ADHD.

Methods: In this quasi-experimental study, 40 children (aged 7–10 years) with clinical ADHD (DSM-5) were assigned to an intervention group (n=20) or a control group (n=20). The intervention involved 12 weeks of structured physical activity (three 45-minute sessions/week; moderate-to-vigorous intensity) targeting coordination, balance, and precision. Motor performance was assessed at baseline and Week 13 using the Bruininks–Oseretsky Test of Motor Proficiency, Second Edition (BOT-2). Data were analyzed via ANCOVA, adjusting for baseline scores and medication status.

Results: All participants completed the trial (mean adherence: 92.8%). After adjusting for baseline and medication, the intervention group showed significant improvements over controls in fine motor standard scores (adjusted posttest mean=52.30, 95% CI [50.28, 54.32] vs. 44.05, 95% CI [42.02, 46.08]; adjusted difference=8.25, 95% CI [5.82, 10.68]; $F(1,37)=20.18$, $P<0.001$, $\eta^2p=0.35$) and gross motor standard scores (adjusted posttest mean=55.25, 95% CI [53.27, 57.23] vs. 46.10, 95% CI [44.12, 48.08]; adjusted difference=9.15, 95% CI [6.62, 11.68]; $F(1,37)=23.45$, $P<0.001$, $\eta^2p=0.39$). No adverse events occurred.

Conclusion: A 12-week structured physical activity intervention significantly improved fine and gross motor skills in children with ADHD. Integrating structured motor activities into pediatric care may provide meaningful benefits for this population.

Key Words: ADHD, Child Development, Exercise, Exercise Therapy, Motor Skills.

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1- INTRODUCTION

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders of childhood, characterized by persistent patterns of inattention, hyperactivity, and impulsivity that interfere with functioning and development (1,2). Global prevalence estimates suggest that approximately 5–7% of school-aged children meet diagnostic criteria for ADHD, making it a major public health and educational concern (3). Beyond the core behavioral symptoms, children with ADHD often experience a range of associated difficulties, including deficits in executive functioning, emotional regulation, academic achievement, and motor development (4,5). In recent years, growing attention has been directed toward understanding the broader developmental profile of children with ADHD, particularly their motor skill competence, which plays a crucial role in daily functioning, school participation, prowess, and psychosocial well-being.

Motor skill development is a fundamental component of childhood growth, encompassing both fine motor skills (e.g., handwriting, object manipulation, and precise hand movements) and gross motor skills (e.g., running, jumping, balance, and coordinated whole-body movements) (6,7). Competence in these domains supports academic performance, physical health, and social participation (8). However, a substantial body of research indicates that children with ADHD are at increased risk for motor coordination problems. Studies have consistently reported that between 30% and 50% of children with ADHD exhibit clinically significant motor impairments, often overlapping with Developmental Coordination Disorder (5,8,9). These impairments may manifest as poor balance, reduced manual dexterity, slower reaction times, and difficulties with motor planning and execution.

The presence of motor skill deficits in children with ADHD is not merely a secondary issue but has meaningful implications for their overall development. Poor motor competence can negatively affect classroom performance, particularly in tasks requiring sustained fine motor control such as writing, drawing, and manipulating learning materials (10,11). Similarly, gross motor difficulties can limit participation in physical education, sports, and playground activities, leading to reduced physical activity levels and fewer opportunities for social interaction with peers (10,12). Over time, these limitations may contribute to lower self-esteem, increased anxiety, and social isolation. Thus, addressing motor skill deficits is an essential component of comprehensive intervention strategies for children with ADHD.

Traditional treatment approaches for ADHD have primarily focused on pharmacological management and behavioral interventions (13,14,15). While stimulant medications are effective in reducing core ADHD symptoms for many children, they do not consistently improve motor coordination or physical competence. Behavioral therapies, although beneficial for self-regulation and classroom behavior, similarly have limited direct impact on motor skill development (13). As a result, there has been increasing interest in complementary and non-pharmacological interventions that can target both behavioral and motor outcomes simultaneously. Among these, physical activity-based interventions have emerged as a promising avenue.

Physical activity is widely recognized for its positive effects on physical health, cognitive functioning, and mental well-being in children (16). For those with ADHD, physical activity has been associated with improvements in attention,

executive function, mood regulation, and classroom behavior (16,17,18).

Neurobiological evidence suggests that exercise can influence neurotransmitter systems implicated in ADHD, including dopamine and norepinephrine, which play key roles in attention and motor control (16). Additionally, structured physical activity provides repeated opportunities for practicing motor skills in dynamic and motivating contexts, making it particularly suitable for addressing motor deficits in this population (18).

Recent research has begun to explore the effects of physical activity interventions on children with ADHD, with encouraging findings. Studies have reported improvements in attention, inhibitory control, working memory, and on-task behavior following aerobic exercise programs, martial arts training, yoga, and coordinated movement activities (19,20). However, despite this growing body of literature, relatively fewer studies have explicitly examined the impact of physical activity interventions on both fine and gross motor skills in children with ADHD. Most existing research has focused primarily on cognitive and behavioral outcomes, with motor development often treated as a secondary or unmeasured variable.

Therefore, the present study seeks to address these gaps by examining the effects of a structured physical activity intervention on fine and gross motor skills in children with ADHD. By focusing explicitly on motor outcomes, this research aims to contribute to a more comprehensive understanding of how physical activity can support the multidimensional development of children with ADHD. The study is grounded in a developmental and neurobehavioral framework, recognizing the interconnections among movement, cognition, and behavior.

2- MATERIALS AND METHODS

2-1. Study Design and Setting

This study employed a quasi-experimental pretest–posttest non-equivalent control group design to investigate the effects of a structured physical activity intervention on fine and gross motor skills in children with ADHD. The Institute Ethics Review Board approved the present study, and written informed consent was obtained from the parents/legal guardians of all participating children.

2-2. Participants

A total of 40 children (N = 40) aged 7–10 years with a formal diagnosis of ADHD according to DSM-5 criteria participated in the study. The diagnosis was established by licensed clinical psychologists through a comprehensive diagnostic interview process. To ensure diagnostic accuracy and clinical depth, the assessment incorporated standardized clinician-rated scales, specifically the Conners' Rating Scales, alongside structured reports from both parents and classroom teachers, focusing on the frequency and severity of inattentive, hyperactive, and impulsive symptoms. This multi-informant approach was utilized to confirm that the participants met the symptomatic threshold and severity levels required for a clinical ADHD diagnosis as specified by the DSM-5. Children were recruited from special education elementary schools.

Inclusion criteria were: (a) a confirmed ADHD diagnosis established by a licensed clinical psychologist through comprehensive diagnostic interviews and multi-informant reports (parents and teachers), (b) enrollment in a regular education classroom, and (c) the ability to participate in moderate physical activity. Exclusion criteria included comorbid neurological disorders, intellectual disability, or current participation in other

structured motor or physical training programs. To ensure the stability of motor performance, only participants with a consistent medication regimen (minimum 3 months of stable dosage) were included in the study.

Participants were assigned to either the intervention group (n = 20) or the control group (n = 20) based on existing classroom groupings. A priori power analysis was conducted using G*Power version 3.1 to determine the minimum required sample size for detecting a significant effect of the intervention on posttest outcomes while controlling for baseline scores in an analysis of covariance (ANCOVA). The analysis was based on a medium effect size (f = 0.25), an alpha level of 0.05, a desired statistical power of .80, two groups (intervention and control), and one covariate (pretest scores). The results indicated that a minimum total sample of 34 participants was required. To account for potential attrition and enhance the robustness of the findings, 40 participants were recruited, and all completed the study.

2-3. Measurement

Demographic and Clinical Data Collection: Demographic information, including age, sex, and medication status, was collected through structured interviews with parents and caregivers. To ensure the reliability of the clinical data, medication details, including type, dosage, and duration of use, were recorded. This information was essential to assess the baseline comparability of the groups and to control for potential confounding effects during statistical analysis.

Fine and Gross Motor Skills: Fine and gross motor skills were assessed using the Bruininks–Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) (21). To provide a comprehensive overview of motor proficiency, composite scores were utilized for analysis. The Fine Motor Composite (FMC) was calculated based on subtests measuring fine motor precision, fine motor integration, and manual dexterity. Similarly, the Gross Motor Composite (GMC) was derived from subtests assessing balance, bilateral coordination, running speed and agility, and strength. The internal consistency (Cronbach's α) for both the FMC and GMC composite scores was calculated using the pooled data from all participants at pretest, yielding a coefficient of α=0.94.

Physical Activity Intervention: The intervention consisted of a 12-week structured physical activity program, delivered three times per week for 45 minutes per session, during regular school hours in gymnasiums led by certified physical education instructors. To ensure intervention fidelity, all instructors followed a standardized curriculum manual, and sessions were monitored by the research team to ensure adherence to the protocol.

Each session followed a structured sequence: a 5–10-minute warm-up (light aerobic activity and dynamic stretching), a 25–30-minute core skill development phase, and a 5-minute cool-down (stretching and relaxation). The core phase targeted balance, coordination, agility, and strength through activities such as obstacle courses, ball-handling, and relay games, alongside fine motor stations (e.g., bead threading, pegboard manipulation, and tracing).

Exercise intensity was maintained at a moderate-to-vigorous level, as monitored through the children's perceived exertion and engagement levels, ensuring heart rate elevation appropriate for the target age group. To ensure progression, the complexity and difficulty of tasks were increased every two weeks by reducing object sizes, increasing the speed of movement requirements, and introducing more complex bilateral coordination sequences. Attendance and adherence were rigorously tracked; the study recorded an

average attendance rate of 92.8%, with any missed sessions being accounted for in the final analysis.

Control Condition: The control group engaged in standard, non-structured school physical education classes as part of their regular curriculum. These activities were led by school instructors and focused on general play and basic motor movements, without the specific structured curriculum, progressive difficulty, or fine-motor-targeted components implemented in the intervention group. Participants in the control group did not participate in any additional extracurricular sports or motor-related interventions during the 12-week study period.

2-4. Procedure

At baseline (Week 0), all participants completed pretest assessments of fine and gross motor skills using the BOT-2. Assessments were administered individually by trained evaluators who were blinded to group allocation. Following baseline testing, the intervention group participated in the physical activity program for 12 weeks, while the control group continued their usual school activities. Posttest assessments were conducted during Week 13 using the same procedures and instruments as at baseline. Attendance and adherence to the intervention were monitored throughout the study.

2-5. Data Analysis

All statistical analyses were conducted using IBM SPSS Statistics version 26. Data were first screened for accuracy, missing values, and outliers. Assumptions for ANCOVA were evaluated, including normality of residuals, linearity between the covariate (pretest scores) and dependent variables (posttest scores), homogeneity of regression slopes, and equality of error variances. Normality of residuals was assessed using the Shapiro–Wilk test and evaluation of skewness and kurtosis, all of which were within acceptable limits. Homogeneity of regression slopes was confirmed, as the interaction between pretest scores and group membership was non-significant, and equality of error variances was verified using Levene's test. Following the confirmation of these assumptions, ANCOVA was performed for each outcome (fine and gross motor skills). In these models, the posttest scores served as the dependent variable, the group (intervention vs. control) as the fixed factor, and both pretest scores and medication status were included as covariates to control for their potential influence on motor performance. Adjusted posttest means were reported, effect sizes were calculated using partial eta squared ($\eta^2 p$), and statistical significance was set at $p<0.05$.

2-6. Ethical Approval

The study was approved by the Ethics Review Board of the Sport Sciences Research Institute (Code: IR.SSRC.REC.1398.017). Additionally, written informed consent was obtained from the parents of all participating children.

3- RESULTS

3-1. Participant Characteristics

A total of 40 children with ADHD participated in the study, with 20 assigned to the intervention group and 20 to the control group. Detailed demographic, clinical, and pharmacological characteristics are presented in Table 1. To ensure the groups were comparable at baseline, standardized mean differences (SMD) were calculated for all primary variables. The results demonstrated that all baseline characteristics, including age, sex, ADHD severity (as measured by the Conners' Scale), ADHD presentation, and medication status, exhibited negligible to small SMDs (Cohen's $d<0.2$), indicating

clinical equivalence between the groups prior to the intervention.

Regarding pharmacological status, 42.5% of the participants were receiving medication, primarily stimulants such as Methylphenidate, at therapeutic dosages within the standard ranges established by clinical guidelines for pediatric ADHD treatment. To ensure the stability of motor performance, all participants had maintained a consistent medication regimen for at least three months prior to the study. All motor assessments were performed at a standardized time relative to medication administration to ensure consistent plasma concentrations. Furthermore, participants were required to maintain their prescribed dosage throughout the 12-week intervention period, and medication status was included as a covariate in the ANCOVA to control for its potential influence on motor outcomes.

Table-1. Baseline demographic, clinical, and pharmacological characteristics of participants by group.

Variable	Intervention	Control	SMD (Cohen's d)
Age (years), M±SDM	8.45 ± 1.02	8.30 ± 0.98	0.15 (Small)
Sex (Male), n(%)	14 (70%)	13 (65%)	0.10 (Negligible)
ADHD Severity (Conners' Scale), M±SDM	35.40 ± 5.20	34.80 ± 5.50	0.11 (Negligible)
ADHD Presentation, n(%)			
Combined	12 (60%)	11 (55%)	0.10 (Negligible)
Inattentive	5 (25%)	6 (30%)	0.10 (Negligible)
Hyperactive-Impulsive	3 (15%)	3 (15%)	0.00 (None)
On Medication, n(%)	9 (45%)	8 (40%)	0.10 (Negligible)
Not on Medication, n(%)	11 (55%)	12 (60%)	0.10 (Negligible)

3-2. Assumption Testing

Prior to conducting ANCOVA, assumptions were evaluated. Normality of posttest scores for fine and gross motor skills was examined using Shapiro–Wilk tests; all variables were non-significant ($p > 0.05$), indicating normal distributions. Skewness and kurtosis values were within ±2. Homogeneity of regression slopes was tested by examining the interaction between the covariate (pretest scores) and group, which was non-significant for both fine motor skills ($F(1,36) = 0.31$, $p = 0.58$) and gross motor skills ($F(1,36) = 0.42$, $p = 0.52$), confirming that ANCOVA assumptions were met. Levene's test indicated equality of error variances for fine motor skills ($F(1,38) = 0.42$, $p = 0.52$) and gross motor skills ($F(1,38) = 0.48$, $p = 0.49$).

3-3. Fine Motor Skills

Descriptive statistics for pretest and posttest fine motor skills are presented in Table 2 and Figure 1. An ANCOVA was conducted with posttest fine motor scores as the dependent variable, group as the fixed factor, and pretest scores as a covariate. The results indicated a significant effect of the intervention, $F(1,37)=20.18$, $p<0.001$, $\eta^2p = 0.35$, after adjusting for baseline scores. The adjusted posttest means were 52.30 (SE = 1.03; 95% CI [50.28, 54.32]) for the intervention group and 44.05 (SE = 1.03; 95% CI [42.02, 46.08]) for the control group. The adjusted between-group difference was 8.25 (95% CI [5.82, 10.68]), demonstrating a substantial improvement in fine motor skills attributable to the intervention.

Table-2. Fine motor skill scores by group.

Group	Pretest M±SD	Posttest M±SD	Adjusted Posttest M (SE)	95% CI of Adjusted M
Intervention	43.25 ± 6.10	52.40 ± 5.80	52.30 (1.03)	[50.28, 54.32]
Control	42.60 ± 5.95	44.10 ± 6.20	44.05 (1.03)	[42.02, 46.08]

Note: Adjusted difference between groups = 8.25; 95% CI for difference = [5.82, 10.68].

3-4. Gross Motor Skills

Descriptive statistics for gross motor skills are presented in Table 3 and Figure 1. An ANCOVA was conducted with posttest gross motor scores as the dependent variable, group as the fixed factor, and pretest scores as a covariate. The results revealed a significant intervention effect, $F(1,37)=23.45$, $p<0.001$, $\eta^2p=0.39$. The adjusted posttest means were 55.25 (SE = 1.00; 95% CI [53.27, 57.23]) for the intervention group and 46.10 (SE = 1.00; 95% CI [44.12, 48.08]) for the control group. The adjusted between-group difference was 9.15 (95% CI [6.62, 11.68]), indicating that the intervention substantially enhanced gross motor skills compared to the control condition.

Table-3. Gross motor skill scores by group.

Group	Pretest M±SD	Posttest M±SD	Adjusted Posttest M (SE)	95% CI of Adjusted M
Intervention	45.10 ± 6.85	55.35 ± 6.10	55.25 (1.00)	[53.27, 57.23]
Control	44.75 ± 7.00	46.20 ± 7.30	46.10 (1.00)	[44.12, 48.08]

Note: Adjusted difference between groups = 9.15; 95% CI for difference = [6.62, 11.68].

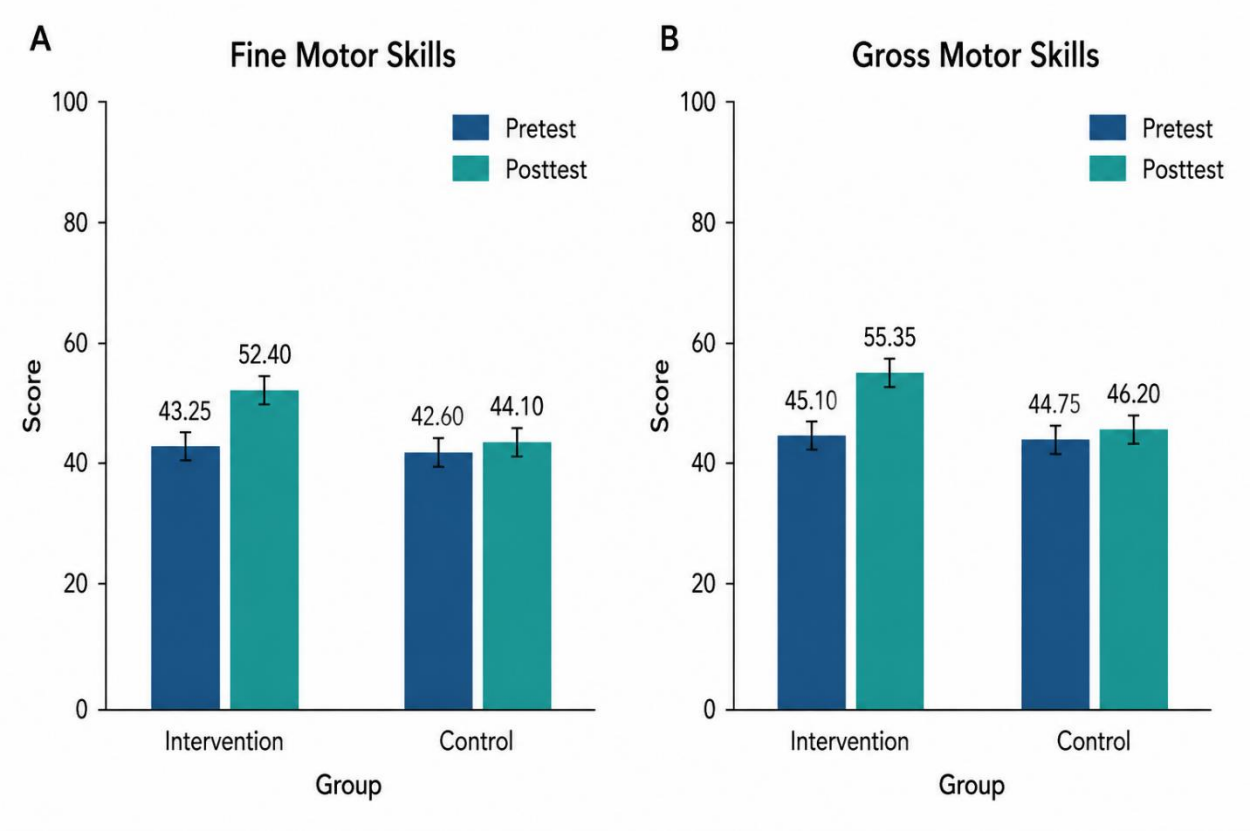


Figure-1: Comparison of fine and gross motor skill scores by group.

4- DISCUSSION

The present study investigated the effects of a 12-week structured physical activity intervention on fine and gross motor skills in children with ADHD. The findings indicate that children who participated in the intervention demonstrated improvements in both fine and gross motor skills compared to a control group that continued regular activities. These results support the growing evidence that targeted physical activity may play a critical role in addressing motor deficits in children with ADHD.

The findings of this study showed that the intervention group exhibited gains in fine motor skills, including manual dexterity, fine motor integration, and precision. This finding aligns with previous studies (19,20,22), indicating that structured movement activities, particularly those incorporating hand–eye coordination, object manipulation, and task-specific skill training, can enhance fine motor competence in children with neurodevelopmental disorders. Improvements in fine motor skills are particularly important for children with ADHD because deficits in this domain have been linked to academic challenges, such as handwriting difficulties, slower task completion, and reduced classroom participation (8,23,24). While the present study did not directly measure these functional outcomes, the observed gains in motor proficiency suggest that such interventions could potentially support academic and daily living tasks.

Similarly, gross motor skills, including balance, bilateral coordination, agility, and locomotor abilities, improved significantly in the intervention group. These findings are consistent with prior research (25,26,27), demonstrating that aerobic and coordinated movement programs enhance gross motor performance in children with ADHD. Improvements in gross motor skills may also facilitate greater participation in physical activities and sports, thereby potentially promoting physical fitness, social engagement, and psychosocial well-being (28,29). The integration of dynamic exercises, obstacle courses, and agility drills in the intervention likely provided repetitive, structured opportunities for skill acquisition, motor planning, and neuromuscular coordination.

The observed improvements in motor skills may be explained by several possible mechanisms. First, physical activity has been shown to modulate neurotransmitter systems, including dopamine and norepinephrine, which are implicated in attention, motor control, and executive functioning in ADHD (18,30). It is plausible that such modulation contributed to the observed motor improvements. Second, repetitive, structured practice of motor tasks is thought to strengthen neural pathways associated with motor execution and sensorimotor integration, potentially facilitating skill acquisition (31). Finally, the social and motivational components of group-based physical activity may increase engagement, adherence, and effort, which could further amplify motor skill gains (32).

These findings have important practical implications for clinicians, educators, and parents. Incorporating structured physical activity programs into school curricula or clinical interventions may provide a low-cost, accessible strategy for supporting motor development in children with ADHD. Such programs could complement traditional behavioral or pharmacological treatments, addressing domains that are often overlooked, such as fine and gross motor competence. Additionally, improving motor skills may have potential downstream benefits for academic achievement, physical activity participation, self-esteem, and peer relationships, contributing to holistic child development.

4-1. Limitations

Several limitations should be acknowledged. First, the sample size was relatively small, which may limit generalizability. Future studies with larger, more diverse samples are needed to confirm these findings. Second, the study utilized a quasi-experimental design without long-term follow-up; thus, the durability of the intervention effects over time remains unknown. Third, although the intervention was structured and standardized, individual differences in motivation, baseline motor ability, and

ADHD symptom severity may have influenced outcomes. Fourth, a significant limitation is that the study did not explicitly screen for comorbid Developmental Coordination Disorder. Given the high prevalence of co-occurrence between ADHD and DCD, the observed motor deficits may be influenced by comorbid motor impairments rather than being solely attributed to ADHD. Future research should implement standardized screening tools for DCD to isolate the specific effects of physical activity on ADHD-related motor symptoms. Finally, the study did not assess broader functional outcomes, such as academic performance or social participation, which are important for understanding real-world benefits. Future research should explore the long-term sustainability of motor skill improvements and investigate whether gains translate into enhanced daily functioning and academic performance. Comparative studies examining different types, intensities, and durations of physical activity interventions could help identify optimal program characteristics for children with ADHD. Additionally, integrating objective neurophysiological measures, such as motor cortex activation or sensorimotor connectivity, could provide further insight into the underlying neurobiological mechanisms of change.

5- CONCLUSION

In conclusion, the findings of this study suggest that a 12-week structured physical activity intervention may significantly enhance both fine and gross motor skills in children with ADHD. The intervention represents a feasible and engaging strategy for addressing motor deficits in this population, with potential benefits that could extend to academic, social, and physical domains. These findings highlight the importance of considering motor skill development within comprehensive treatment approaches for children with ADHD and underscore the value of structured physical activity as a promising intervention.

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8- CONFLICT OF INTEREST STATEMENT

There was no conflict of interest.

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