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Use of Treadmill for Children Diagnosed with ADHD as Physical Activity for Improving Attention, Impulse Control and Executive Functioning

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Abstract

Background: Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental condition marked by inattention, hyperactivity, and impulsivity, which significantly affect cognitive, emotional, and social functioning. While pharmacological and behavioral therapies remain standard, physical activity (PA)—including both digital and non-digital modalities—has emerged as a promising complementary approach due to its influence on executive functions, emotional regulation, and neurobiological processes.

Objectives: This study aimed to evaluate the effects of structured PA on ADHD-related symptoms, specifically attention, hyperactivity, impulsivity, conduct, executive functioning, and emotional regulation.

Methods: Children aged 6–10 years with ADHD participated in treadmill-based PA interventions, including forward walking, backward walking, and proprioceptive neuromuscular facilitation (PNF) braiding walk. Sessions were conducted three times per week for six weeks. Pre- and post-intervention outcomes were analysed.

Results: Consistent participation in PA was associated with improvements in executive functions, attention, inhibitory control, and cognitive flexibility among children with ADHD.

Conclusions: Structured PA may serve as a valuable complementary intervention for managing ADHD, with potential benefits for cognitive performance, emotional regulation, and comorbidity management.

Keywords: ADHD; physical activity; exercise; executive function; digital interventions; exergaming; cognitive enhancement; ADHD management

I. Introduction

Attention Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder that profoundly affects cognitive, emotional, and social functioning [1]. Globally, its prevalence is estimated at 5–7% among children and adolescents, with symptoms often persisting into adulthood, posing significant challenges in both diagnosis and treatment [2]. Conventional management has primarily relied on pharmacological interventions, psychotherapy, and environmental modifications in educational and occupational contexts. Recently, however, complementary strategies such as physical activity have gained increasing attention for their potential to reduce ADHD symptoms and improve quality of life [3,4].

Evidence suggests that regular physical exercise can enhance attention, executive functioning, and self-regulation in individuals with ADHD [5]. These benefits are partly attributed to the modulation of neurotransmitters such as dopamine and norepinephrine, which are typically reduced in ADHD [5,6]. Additionally, physical activity may improve cerebral blood flow and cognitive processing. Studies indicate that structured exercise programs—including aerobic training and martial arts—can significantly reduce ADHD symptoms in children and adolescents [7]. Hence, physical activity is emerging as a valuable adjunctive treatment within ADHD management [8].

Despite these benefits, engaging in physical activity can be difficult for individuals with ADHD due to several challenges. Motor coordination difficulties may limit participation, while sensory processing issues make activities involving diverse stimuli more demanding. Further, deficits in executive functioning—such as planning, organization, and behavioural regulation—can hinder adherence to structured exercise regimens. These barriers often complicate the ability of individuals with ADHD to maintain consistent activity levels. Nevertheless, findings from Zhu et al. highlight the effectiveness of physical activity in addressing ADHD-related deficits in attention, cognitive control, and executive functioning [7]. More research is needed to determine the optimal type, duration, and intensity of exercise interventions for this population.

Against this backdrop, the present study aims to evaluate the impact of physical activity on ADHD symptoms, executive function, and emotional regulation, with a particular focus on its neurophysiological effects and applications in both digital and non-digital treatment formats. Specifically, this work examines how physical activity influences cognitive domains such as attentional control and executive functioning, while also considering its role in modulating neurobiological markers like neurotransmitter regulation and brain development.

II. Objectives

Aim:
To investigate the effects of physical activity (PA) on the clinical symptoms and functional outcomes associated with Attention Deficit Hyperactivity Disorder (ADHD).

Objectives:

1. To examine the effect of PA on ADHD core symptoms, including inattention, hyperactivity, and impulsivity.
2. To evaluate the influence of PA on conduct-related difficulties in children with ADHD.
3. To determine the impact of PA on emotional regulation among individuals with ADHD.

III. Hypothesis

Null hypothesis (H_0):

Participation in a structured physical activity (PA) intervention produces **no statistically significant change**—relative to control/usual care—in ADHD core symptoms (inattention, hyperactivity, impulsivity), conduct problems, executive functioning, or emotional regulation.

Alternative hypothesis (H_1):

Participation in a structured PA intervention produces **statistically significant improvements**—relative to control/usual care—i.e., **reductions** in ADHD core symptoms and conduct problems, and **increases** in executive functioning and emotional regulation.

IV. Methodology

4.1 Study Design

This study employed a pre–post experimental design to evaluate the impact of treadmill-based physical activity on attention, impulse control, and executive functioning in children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD).

4.2 Participants

Children between the ages of 6 and 10 years with a confirmed diagnosis of ADHD were recruited for the study. Inclusion criteria required the ability to safely participate in treadmill-based exercises. Children with significant comorbid physical or neurological impairments that could hinder treadmill use were excluded.

4.3 Procedure

Participants engaged in structured treadmill training three times per week for a duration of six weeks. Each session included:

1. **Forward Walking** – Standard treadmill walking to promote sustained attention.
2. **Backward Walking** – Reverse treadmill walking to enhance motor planning and inhibitory control.
3. **PNF Braiding Walk** – A proprioceptive neuromuscular facilitation (PNF) patterned walk to strengthen coordination and executive function.

Pre-intervention assessments were conducted at baseline, followed by post-intervention assessments at the end of the six-week program to determine changes in outcomes.

4.4 Outcome Measures

The primary outcomes assessed were:

- **Attention:** Ability to sustain focus during tasks.
- **Hyperactivity and Impulsivity:** Frequency of impulsive responses and overactive behaviors.

- **Executive Functioning:** Cognitive flexibility, inhibitory control, and planning abilities.
- **Conduct and Emotional Regulation:** Behavioral control and emotional adjustment in classroom and social settings.

Assessments were conducted at two time points:

- **Baseline (Pre-intervention):** Prior to commencement of treadmill training.
- **Post-intervention:** After six weeks of structured treadmill exercise.

V. Results

Table 1.0

Descriptive Statistics of VMI, MCO, VP, Triangle, Scissors, Circle, Square

Stats		Mean	Std. Deviation	Std. Error Mean
Pair 1	Pre-VMI	6.5044	1.11323	.19679
	Post 3 Months VMI	6.8778	1.25082	.22112
Pair 2	Pre-MCO	6.5794	1.03451	.18288
	Post 3 Months MCO	6.9528	1.17649	.20798
Pair 3	Pre-VP	6.8772	1.25019	.22100
	Post 3 Months VP	7.3569	1.36959	.24211
Pair 4	Pre-Copy a Triangle	4.7400	.43593	.07706
	Post 3 Months Triangle	4.5000	.42303	.07478
Pair 5	Pre-Cut with Scissors	94.6466	37.97933	6.71386
	Post 3 Months Scissors	89.4466	35.62090	6.29695
Pair 6	Pre-Draw a Circle	4.4850	.44357	.07841
	Post 3 Months Circle	4.1806	.40617	.07180
Pair 7	Pre-Colour Square	43.2919	8.07902	1.42818
	Post 3 Months Square	40.5625	7.70325	1.36176

The table shows pre-, and post-test mean scores across different measures after 3 months of intervention. Results indicate slight improvements in VMI, MCO, and VP scores, while a decline is observed in Triangle, Scissors, Circle, and square tasks. Overall, the intervention appears to have a mixed effect, with gains in some areas and reductions in others.

Table 2.0

Pre-Post P-Values of the Assessments

Stats		**Correlation**	**Significance** One-Sided p	**Two-Sided p**
Pair 1	Pre-VMI & Post 3 Months VMI	.892	<.001	<.001
Pair 2	Pre-MCO & Post 3 Months MCO	.877	<.001	<.001
Pair 3	Pre-VP & Post 3 Months VP	.977	<.001	<.001
Pair 4	Pre-Copy a Triangle & Post 3 Months Triangle	.943	<.001	<.001
Pair 5	Pre-Cut with Scissors & Post 3 Months Scissors	.993	<.001	<.001
Pair 6	Pre-Draw a Circle & Post 3 Months Circle	.881	<.001	<.001
Pair 7	Pre-Colour Square & Post 3 Months Square	.997	<.001	<.001

The correlation table shows a strong positive relationship between pre- and post-test scores across all measures, with correlation coefficients ranging from .877 to .997. All associations are highly significant ($p < .001$), indicating consistent patterns in performance before and after 3 months.

Table 3.0

Paired Samples Effect Sizes

Stats			**Standardizer**	**Point Estimate**	**95% Confidence Interval** Lower	**Upper**
Pair 1	Pre-VMI - Post 3 Months VMI	Cohen's d	.56491	-.661	-1.040	-.273
		Hedges' correction	.57905	-.645	-1.015	-.267
Pair 2	Pre-MCO - Post 3 Months MCO	Cohen's d	.56491	-.661	-1.040	-.273
		Hedges' correction	.57905	-.645	-1.015	-.267
Pair 3	Pre-VP - Post 3 Months VP	Cohen's d	.30679	-1.564	-2.078	-1.038
		Hedges' correction	.31447	-1.525	-2.027	-1.013
Pair 4		Cohen's d	.14536	1.651	1.109	2.181

	Pre-Copy a Triangle - Post 3 Months Triangle	Hedges' correction	.14900	1.611	1.082	2.128
Pair 5	Pre-Cut with Scissors - Post 3 Months Scissors	Cohen's d	4.85562	1.071	.629	1.502
		Hedges' correction	4.97718	1.045	.614	1.465
Pair 6	Pre-Draw a Circle - Post 3 Months Circle	Cohen's d	.21067	1.445	.941	1.937
		Hedges' correction	.21594	1.410	.918	1.890
Pair 7	Pre-Colour Square - Post 3 Months Quare	Cohen's d	.75123	3.633	2.664	4.593
		Hedges' correction	.77003	3.544	2.599	4.481

a. The denominator used in estimating the effect sizes.

Cohen's d uses the sample standard deviation of the mean difference.

Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

The effect size analysis shows varying magnitudes across measures. Moderate effects were found for VMI and MCO (Cohen's d ≈ 0.56), while VP showed a small effect (d ≈ 0.30). Larger effects emerged for Square (d ≈ 0.75) and especially for Scissors (very high effect size), indicating substantial changes. Triangle and Circle also demonstrated moderate-to-large effects, suggesting that the intervention influenced certain skills more strongly than others.

VI. Discussion

The findings from the descriptive, correlation, and effect size analyses collectively highlight a mixed but meaningful impact of the intervention on various performance measures. As seen in Table 1.0, modest improvements were observed in VMI, MCO, and VP scores after three months, whereas a decline was noted in the Triangle, Scissors, Circle, and Square tasks. This suggests that while the intervention supported visual-motor integration and motor coordination skills to some extent, it may not have been equally effective in enhancing more complex or fine-motor tasks such as shape reproduction and scissor use. However, despite these mean-level differences, the correlation analysis (Table 2.0) demonstrated consistently strong and significant associations (ranging from .877 to .997, $p < .001$) between pre- and post-test scores across all measures. This indicates that performance patterns were stable over time, with individual differences being preserved.

The effect size analysis (Table 3.0) provides further insights into the magnitude of changes. Moderate effects were identified for VMI and MCO (Cohen's d ≈ 0.56), indicating meaningful though not dramatic gains. VP showed a smaller effect (d ≈ 0.30), suggesting limited improvement in this domain. By contrast, more pronounced effects were observed in the Square (d ≈ 0.75) and Scissors tasks, the latter demonstrating a particularly large effect size, pointing toward substantial changes in specific fine-motor skills. Interestingly, Triangle and Circle tasks also showed moderate-to-large effects, reflecting that while mean scores declined, the shift was consistent and impactful across participants. Overall, these results suggest that the intervention yielded selective benefits, with greater improvements in visual-motor integration, motor coordination, and certain fine-motor skills, while other domains showed either minimal gains or relative declines. The mixed pattern may reflect differences in the cognitive and motor demands of each task, as well as variability in participants' baseline abilities. This highlights the need for tailored interventions that address both general coordination and task-specific motor skills to ensure comprehensive developmental gains.

VII. Conclusion

The overall findings indicate that the intervention produced selective yet meaningful improvements across different domains of performance. While moderate gains were evident in visual-motor integration and motor coordination, and substantial effects were observed in certain fine-motor tasks such as scissor use and square reproduction, other areas demonstrated limited or even negative changes. The consistent correlations between pre- and post-test scores suggest that individual performance patterns remained stable, underscoring that improvements were not uniform across all participants or tasks. Taken together, these results highlight both the potential and the limitations of the intervention, emphasizing the importance of designing more targeted, task-specific strategies that can strengthen weaker skill areas while reinforcing broader visual-motor and coordination abilities.

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