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Effect of 6-Week Structured Exercise Program on Attention Span, Behavior and Motor Skills Performance in Children with ADHD; A Randomized Control Trial Study

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ABSTRACT

Purpose: Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by a persistent pattern of impulsivity, inattention and hyperactivity with onset in early childhood and a high rate of persistence into adulthood. Children with ADHD are known to struggle with motor coordination and find it challenging to complete several motor activities at once or in a sequential order. Aim of the study is to assess the effect of structured exercise program on attention span, behavior and motor skills in children with ADHD.

Methods: 30 diagnosed subjects of ADHD were randomly allocated in Experimental and Control Group by chit method. The experimental group was given 18 sessions of a structured exercise program which included strengthening exercise, aerobic exercise, fine motor training and attentiveness training in the form of group therapy (thrice a week for 6 weeks) for 45 minutes while the control group received the best practice usual care protocol which included medication and behavioural therapy. Outcome measure were trial making test, 9-peg hole test, single leg triple hop test and repetitive behaviour scale.

Results: with in group analysis repeated measure ANOVA was used and independent t-test was used to compare the groups. For all statistical tests, a p-value of ≤0.05 was taken as a significant difference

Conclusion: This study primarily highlights the potential benefits of structured exercise program in improving attention span and motor skills in children with ADHD, while behavioral outcomes may require more targeted strategies highlighting the complexity of behavioral management in children with ADHD.

KEYWORDS: Attention deficit hyperactivity disorder, Trial making test, Nine hole peg test, Single leg triple hop test, Repetitive behavior scale

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INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by inappropriate hyperactivity, impulsivity and inattention with onset in early childhood and a high rate of persistence into adulthood [1]. The prevalence ranges from 5.3% to 20% globally, while in India, it ranges from 5.2% to 29.5% [2]. Boys are diagnosed with this illness twice as often as girls [3]. In Tamilnadu, the prevalence of ADHD was found to be 8.8%. The subtypes of ADHD were classified as 43.3% for inattentive type and hyperactive type, and 13.2% for combined type of ADHD [4]. The DSM-5 (The Diagnostic and Statistical Manual of Mental Disorders) has classified patients into three groups based on how severe their symptoms of hyperactivity, inattention, or both are inattentive subtype, hyperactive-impulsive subtype, and combination hyperactive-impulsive and inattentive subtype [3]. Evidence showed that the caudate nucleus of the corpus striatum has anatomical asymmetries in

children with ADHD [5]. Another suggested theory is linked to disturbed catecholamine neurotransmission, which states that people with ADHD have lower levels of the neurotransmitters dopamine and NE in the brain regions connected to executive functions and attention, which lowers cognitive function [6].

Patients with ADHD have trouble paying attention, controlling impulsive behaviours, and in most cases are overly active [7]. It is linked to lower executive function (EF) performance and motor deficits [6]. These processes include cognitive flexibilty, impulsivity, response inhibition and selective attention [8]. Previous research has shown that children with this disorder have high-risk and critical psychological problems such as aggression, antisocial behaviors, self-harm, and substance abuse [9]. Additionally, these children face many problems at school, such as not doing their homework, being easily distracted in class, dropping out of school, and being rejected by their classmates. Moreover, children with ADHD are known to have difficulties with motor coordination and have difficulties performing multiple motor tasks in a sequence or at the same time [7]. Deficient behavioral inhibition (BI) processes are considered a core feature of ADHD. Moreover, self-perceptions of patients with ADHD are low with regards to their feelings on behavior, ability to get along with others and to succeed in school. Over time they become more doubtful about their ability to cope with academic and social issues during adolescence which leads to anxiety, depression, low general mood state and lower self esteem as compared to other children of the same age [9]. Furthermore, 2 distinct types of attentional problems have been connected to ADHD. Sustained attention deficiency, or the inability to do so over an extended period of time and selective attention deficiency which refers to the inability to focus attention on important components of a task while ignoring unimportant information [10]. Children with ADHD have poor fine motor coordination, and a few studies have also revealed motor skill issues with the control of large motions including synkinesis, running, climbing, hopping on one leg, and tasks requiring the stabilization of the trunk [11]. Physical activity (PA) increases the availability of dopamine and NE in synaptic clefts of neurons of the CNS. There is evidence that PA results in changes in the cerebral structure that are expected to be important for cognitive performance [12]. The purpose of this study was to assess the effectiveness of a structured exercise program on attention span, behaviour, and motor skills in children diagnosed with ADHD.

MATERIALS AND METHODS

It was an Experimental study design conducted from August 2023 to July 2024 in college of physiotherapy Pt BDS PGIMS Rohtak. The ethical clearance was taken from the Institutional Biomedical Research Committee of Pt B.D Sharma UHS, Rohtak vide letter no. BREC/23/TH-Physiotherapy/12 dated 20.07.2023. Children diagnosed with ADHD were recruited from the outpatient department of Psychiatry, Pt. B.D. Sharma UHS, Rohtak. A total of 30 participants were enrolled in the study. Inclusion criteria included children between the age group 8 to 15 years who were diagnosed using DSM-5 scale and children that have never been treated for ADHD or children that have dropped out from conventional treatment program for atleast 6 months. The children who had previous history of medical or systemic problems such as hypertension, hypotension or diabetes mellitus, any musculoskeletal deformities such as scoliosis, kyphosis or pes cavus, Neurological problems (sensory or motor deficit), Orthopedic disorders (past history of trauma before application of study atleast 2 months), Rheumatic fever or profound intellectual disability as ruled by history and clinical diagnosis were excluded from the study.

A signed written informed consent was obtained from the participants as well as their parents in language that the individuals understand well. Using random chit sampling method, participants were allocated to either experimental group (group A) or control group (group B). Group A was given 18 sessions (each session will be of 45 minutes, conducted thrice a week for 6 weeks) of a structured exercise program whereas group B followed best practice usual care protocol for 6 weeks. Participants of both the groups were assessed at baseline, 3rd week and at 6th week for all the parameters.

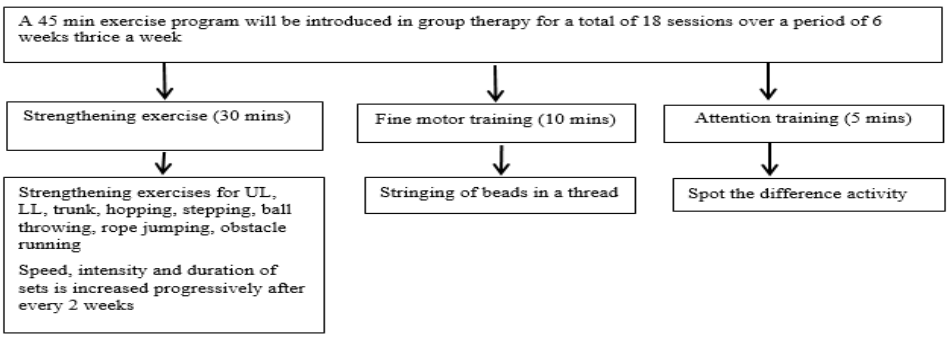

FIG.1.1. Exercise Program Includes [3]

FIG.1.2. Exercise performed by Subjects of experimental group

Control group followed the best practice usual care protocol which included medication, behaviour therapy, school programming and function [12].

Outcome Measures: Trial making test was used to measure attention span [2]. Single leg triple hop test (SLTHT) was used for assessing the gross motor function [13]. Nine-hole peg test was used for assessing the fine motor function [14]. Repetitive behaviour scale was used to assess the behaviour of participants [15].

Statistical Analysis: Statistical analysis was performed by using SPSS software version 26.0. Categorical variables were expressed as frequency and percentages. Continuous variables werepresented as mean ± SD. For

Between group analysis, independent t-test was used to assess the difference between the experimental group and control group. For all statistical tests, a p-value of ≤0.05 was taken as a significant difference.

RESULTS

The mean age of participants was 10.26 ± 1.980 years and 10.93 ± 1.869 years in EG and CG respectively. There was no statistically significant difference was found at baseline in between both groups (p=**0.351**). Table 1.1. Shows post hoc pairwise comparison using the Bonferroni correction of all variables at the baseline assessment, 3rd week and 6th week assessment in both the groups.

Table 1.1. Comparison of demographic variables of groups at baseline

Variable	Experimental group				Control group			
	Mean ± SD		Mean differences	P value	Mean ± SD		Mean differences	P value
Attention span by Trial making test (TMT-A)	Baseline 62.26 ± 11.63	3 weeks 51.73 ± 11.35	10.533	0.00**	Baseline 63.60 ± 11.61	3 weeks 61.40 ± 11.33	2.200	0.00**
	3 weeks 51.73 ± 11.35	6 weeks 46.33 ± 10.81	5.400	0.00**	3 weeks 61.40 ± 11.33	6 weeks 59.60 ± 10.97	1.800	0.01*
	Baseline 62.26 ±	6 weeks 46.33 ±	15.933	0.00**	Baseline 63.60 ±	6 weeks 59.60 ±	4.000	0.00**

	11.63	10.81			11.61	10.97		
Attention span by Trial making test (TMT-B)	Baseline 121.60 ± 25.90	3 weeks 100.47 ± 14.01	21.133	0.00**	Baseline 118.00 ± 16.25	3 weeks 115.47 ± 17.18	2.533	0.58^{NS}
	3 weeks 100.47 ± 14.01	6 weeks 84.60 ± 7.97	15.867	0.00**	3 weeks 115.47 ± 17.18	6 weeks 106.73 ± 18.10	8.733	0.00**
	Baseline 121.60 ± 25.90	6 weeks 84.60 ± 7.97	37.000	0.00**	Baseline 118.00 ± 16.25	6 weeks 106.73 ± 18.10	11.267	0.00**
9HPTR (hole peg test Right hand)	Baseline 30.13 ± 5.65	3 weeks 28.13 ± 4.86	2.00	0.00**	Baseline 32.40 ± 4.11	3 weeks 32.00 ± 4.03	0.400	1.000^{NS}
	3 weeks 28.13 ± 4.86	6 weeks 25.60 ± 3.92	-2.00	0.00**	3 weeks 32.00 ± 4.03	6 weeks 30.86 ± 4.27	1.133	0.01**
	Baseline 30.13 ± 5.65	6 weeks 25.60 ± 3.92	4.53	0.00**	Baseline 32.40 ± 4.11	6 weekss 30.86 ± 4.27	1.533 -	0.93^{NS}
9HPTL (hole peg test Left hand)	Baseline 30.13 ± 5.80	3 weeks 28.06 ± 4.80	2.067	0.01*	Baseline 32.40 ± 4.04	3 weeks 31.53 ± 4.10	0.867	0.01*
	3 weeks 28.06 ± 4.80	6 weeks 25.33 ± 3.81	2.733	0.00**	3 weeks 31.53 ± 4.10	6 weeks 30.40 ± 4.27	1.133	0.07^{NS}
	Baseline 30.13 ± 5.80	6 weeks 25.33 ± 3.81	4.800	0.00**	Baseline 32.40 ± 4.04	6 weeks 30.40 ± 4.27	-2.000	0.01*
Single leg Tripple hope test (SLTHT)	Baseline 12.73 ± 2.15	3 weeks 11.80 ± 1.85	0.933	0.00**	Baseline 13.80 ± 1.37	3 weeks 13.13 ± 1.27	0.667	0.03**
	3 weeks 11.80 ± 1.85	6 weeks 10.60 ± 1.79	1.200	0.00**	3 weeks 13.13 ± 1.27	6 weeks 12.76 ±1.22	0.567	0.01*
	Baseline 12.73 ± 2.15	6 weeks 10.60 ± 1.79	-2.133	0.00**	Baseline 13.80 ± 1.37	6 weeks 12.76 ±1.22	1.233	0.00**
Repetitive behaviour test (RBS)	Baseline 36.53 ± 5.55	3 weeks 34.66 ± 5.35	1.867	0.00**	Baseline 36.73 ± 3.75	3 weeks 36.00 ± 3.31	0.733	0.107^{NS}
	3 weeks 34.66 ± 5.35	6 weeks 32.66 ± 4.90	2.000	0.00**	3 weeks 36.00 ± 3.31	6 weeks 35.60 ± 3.20	0.400	0.698^{NS}
	Baseline 36.53 ± 5.55	6 weeks 32.66 ± 4.90	3.867	0.00**	Baseline 36.73 ± 3.75	6 weeks 35.60 ± 3.20	1.133	0.145^{NS}
*The mean difference was significant when value of p was ≤ 0.05. NS- Non Significant (p > 0.05)								

Within group analysis of TMT-A, TMT-B,9HPTR, 9HPTL, SLTHT and RBS reflected that there was highly statistically significant difference in pain intensity at 3 weeks (p=0.00) and 6 weeks (p=0.00) in the experimental group. However TMT-A, TMT-B,9HPTR, 9HPTL, SLTHT show significant difference at week 6 (p=0.100) for control group although

RBS did not show any statistically significant difference (p=0.145) in control group.

Table 1.2. represents the between group analysis of all the variables by using unpaired t-test at baseline, at 2 week and at 6 weeks in both the groups.

Variable		Group A (Mean±SD)	Group B (Mean±SD)	t value	p value
Attention span by Trial making test A (TMT-A)	**Baseline**	62.26 ± 11.63	63.60 ± 11.61	-0.314	0.756^{NS}
	3 weeks	51.73 ± 11.35	61.40 ± 11.33	-2.333	0.027*
	6 weeks	46.33 ± 10.81	59.60 ± 10.97	-3.335	0.002**
Attention span by Trial making test (TMT-B)	**Baseline**	121.60 ± 25.90	118.00 ± 16.25	0.456	0.652^{NS}
	3 weeks	100.47 ± 14.01	115.47 ± 17.18	-2.620	0.014*
	6 weeks	84.60 ± 7.97	106.74 ± 18.10	-4.333	0.00**
9Hole Peg Test (R)	**Baseline**	30.13 ± 5.65	32.40 ± 4.11	-1.255	0.220^{NS}
	3 weeks	28.13 ± 4.86	32.00 ± 4.03	-2.368	0.025**
	6 weeks	25.60 ± 3.92	30.86 ± 4.27	-3.515	0.020**
9Hole Peg Test (L)	**Baseline**	30.13 ± 5.80	32.40 ± 4.04	-1.240	0.225^{NS}
	3 weeks	28.06 ± 4.80	31.53 ± 4.10	-2.125	0.043*
	6 weeks	25.33 ± 3.81	30.40 ± 4.27	-3.427	0.002**
Single leg triple hop test (SLTHT)	**Baseline**	12.73 ± 2.15	13.80 ± 1.37	-1.617	0.117^{NS}
	3 weeks	11.80 ± 1.89	13.13 ± 1.27	-2.291	0.030*
	6 weeks	10.60 ± 1.79	12.56 ± 1.22	-3.507	0.002**
Repetitive behaviour scale	**Baseline**	36.53 ± 5.55	36.73 ± 3.75	-0.116	0.909^{NS}
	3 weeks	34.66 ± 5.35	36.00 ± 3.11	-0.820	0.419^{NS}
	6 weeks	32.66 ± 4.90	35.60 ± 3.20	-1.938	0.063^{NS}
*The mean difference was significant when value of p was ≤ 0.05. NS- Non Significant (p > 0.05)					

DISCUSSION

Significant improvement in attention span with exercise program over a period of 6 weeks can be attributed to the fact that physical exercise enhances the release of neurotransmitters like dopamine and NE which play a crucial role in attention and executive functioning [16]. For children with ADHD, who often have lower levels of these neurotransmitters, increased activity can lead to improved focus and attention. Regular physical activity promotes neuroplasticity, the brain's ability to adapt and reorganize itself. Physical exercise can enhance cognitive function in children with ADHD. Exercise, particularly aerobic and motor-based activities, has been shown to stimulate neural growth and improve the functioning of areas of the brain associated with attention and executive function, such as the prefrontal cortex [17,18].

The structured exercise program likely provided a foundation for improving fine and gross motor coordination, which in turn could have contributed to the observed improvements. Repetitive practice of motor tasks during exercise, including tasks that required hand-eye coordination, balance, and agility, may have contributed to enhancing children's motor control [19,20]. Generalized exercises, such as rope jump training etc. significantly improved balance, cardiovascular endurance, muscular strength, body composition, and flexibility in children with ADHD[21,22].Physical activity might be an effective supplement to medication to reduce behavioral impairments that interfere with learning and academic progress and to directly benefit cognitive performance by ADHD children [8,7]. Despite the improvements in attention span and motor skills, no significant changes were observed in behaviour. Behavioural improvements in children with ADHD can be subtle and may require a more intensive program to achieve detectable results. [16,23]. Another consideration is that the exercise program used in this study may have been more effective in targeting cognitive and motor aspects of ADHD rather than directly addressing behaviour. ADHD related behaviours, such as impulsivity and hyperactivity, may require more comprehensive interventions, including behavioural therapy, in conjunction with physical activity [24,25].

CONCLUSION

In this study, although the core symptoms of ADHD have improved with both structured exercise program and adhering to best practices for routine treatment, this study primarily highlights the potential benefits of structured exercise programs in improving attention span and motor skills in children with ADHD, while behavioral outcomes may require more targeted strategies highlighting the complexity of

behavioral management in children with ADHD. These findings contribute to the growing body of evidence supporting the integration of physical activity into therapeutic approaches for managing ADHD. To sum up, it can be concluded that children with ADHD have been shown to benefit from physical activity in terms of their attention, cognitive, and social skills. Therefore, it is possible to view exercises as an additional form of therapy required to help people with ADHD control their symptoms.

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CONFLICT OF INTEREST

There is no conflict of interest.

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