

Effectiveness of structured exercises on motor skills, physical fitness and attention in children with ADHD compared to typically developing children-A pilot study

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ABSTRACT

Purpose: Children with ADHD exhibit decrements in fitness levels, motor skill ability and attention. The purpose was to evaluate the benefits of a structured, school-based exercise program on motor skill, physical fitness and attention in children with ADHD. **Method:** Ten 8–12 year old school boys with ADHD and ten typically developing (TD) were recruited. They underwent a six week structured exercise program which included aerobics, resistance exercises, motor skills and attention training. **Results:** Following the 6 week, school-based exercise program significant improvements in physical fitness, motor skills and attention were observed in ADHD children compared to the TD children. Additionally, the exercise sessions were acceptable and enjoyable to all children. **Conclusion:** It is proposed that an exercise program be incorporated in school physical education curriculum. Exercises should be considered, in addition to other forms of intervention, as an essential treatment for improving problems associated with ADHD in school children.

1. Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a neuro-behavioral condition observed globally in school children [1,2], with a prevalence of 5.3% to 20% worldwide [3,4], and 5.2% to 29.5% in India [5,6]. These children present with hyperactivity, a lack of attention and impulsivity [2,7,38], and in addition, there is some evidence, albeit scant, that these children exhibit deficits of gross and fine motor skills, as well as physical fitness [8].

Surprisingly, there is a paucity of studies that have examined a link between fitness, motor skills and attention in children with ADHD. Furthermore, given that children with ADHD have deficits in attention, motor skills and fitness [8], they are not routinely assessed, and more importantly, are not advised intervention programs that include training in motor skills and physical fitness [9–11].

Children with ADHD, if left untreated, are most likely to suffer impairments that persist into adulthood and have a negative impact on educational, occupational, and social outcomes [12]. A number of pharmacological interventions have been found to be effective in the short term, though minimum 20% of these children experience adverse

side effects [13]. Several studies have reported the beneficial effects of behavioural interventions, but they require extensive time commitments and effort by both clinicians and caregivers, resulting in low utilization rates [14,15]. In view of the chronic nature of ADHD and the limitations of currently available pharmaceutical and non-pharmaceutical treatments that primarily target attention deficits and hyperactive behaviour, there is a need for developing alternative approaches to manage behavioural, as well as fitness and motor skill deficits.

Children with ADHD are increasingly studying in regular schools that are inclusive; however, the support they receive is primarily focussed on psychological counselling and parent counselling. Surprisingly, in most cases, the stakeholders (children, parents and school administrators) know little or nothing of the benefits of exercises and the need to incorporate exercises in their routine care. Unfortunately these children are also not chosen for team sports/games as they considered being disruptive, which further leads to a reduction in their fitness levels.

Most schools have a physical education program in their curriculum, and thus are an ideal location to incorporate a structured exercise program in the management of children with ADHD. This would help these children improve not only fitness, but also attention and other

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behavioural parameters that are necessary for learning. Thus, the purpose of this pilot study was to evaluate the benefits of a structured, school-based exercise program in children with ADHD on motor skill, physical fitness and attention.

2. Materials and methods

2.1. Participants

Ten (10) school boys with ADHD and ten (10) typically developing boys between the ages of 8–12 were recruited for the study. The study was limited to boys as ADHD afflicts males more than females [16], and importantly, because males and females respond differently to exercise [17].

Participants represented a sample of convenience, and were recruited from schools in the Delhi / National Capital Region. Children who were not willing to participate, were currently participating in school sports, and or had a history of musculoskeletal, other neurological or cardiovascular disorders were excluded from the study. Informed consent and assent was taken from the parents and children respectively. As required by law, permission was also taken from the school principal (s).

2.2. Procedure

ADHD children selected for the study were diagnosed by a pediatrician and a school psychologist as per DSM V guidelines. All children were randomly measured at baseline (pre test) and following the intervention period (post test). Following initial assessment, a structured exercise program was administered to all children for 45 min per session, over a period of six (6) weeks for a total of eighteen (18) sessions. The 30 min of program included strengthening exercises for the upper limb, lower limb, and trunk, hopping, stepping exercises, ball throwing and rope jumping. Speed, repetition and number of sets were progressively increased every two weeks. Fine motor training was administered for five (5) minutes during each session and included stringing of beads in a straw, thread, and soft filament. Attention training that consisted of a 'spot the difference activity' was administered for ten (10) minutes during each session.

2.3. Outcome measures

The following battery of reliable and valid tests were used to measure level of inattention, hyperactivity, motor skills, physical fitness and attention.

2.3.1. Vanderbilt teacher rating scale

Inattention and Hyperactivity levels of ADHD children were measured using the Vanderbilt teacher reported scale [18]. This scale is formulated in accordance with DSM 4 and children are scored between 0 and 9 on a categorical yes/no basis. A child scoring of more than six (6) is categorised as being inattentive and or hyperactive.

2.3.2. Motor skills

Gross motor locomotor skill was assessed by the single leg triple hop test [19], while object control skill was measured using the bilateral medicine ball throw test [20], and fine motor skill was assessed using the Nine hole peg test [21].

2.3.3. Physical fitness

The fitness of children was assessed using the following parameters: percentage body fat analysis [22]; hand grip strength [23,24]; muscle endurance, using the one minute sit up test [22]; leg explosive power using the standing vertical jump test [19]; flexibility using the sit and reach test [25]; aerobic capacity, using the 12-min walk test [26]; and anaerobic capacity, using the anaerobic step test [19].

Table 1

Inattention and Hyperactivity scores and type of ADHD children at baseline and following six weeks of a structured exercise program.

Participant ID codes	Inattention score (0–9)		Hyperactivity score (0–9)		Type:AD/HD/combined	
	Pre	Post	Pre	Post	Pre	Post
ADHD 01	9	8	4	7	AD	AD
ADHD 02	7	1	1	2	AD	NIL
ADHD 03	7	2	9	3	Combined	NIL
ADHD 04	9	7	9	5	Combined	AD
ADHD 05	8	7	2	2	AD	AD
ADHD 06	7	6	9	4	Combined	AD
ADHD 07	9	3	7	6	Combined	HD
ADHD 08	7	1	6	2	Combined	NIL
ADHD 09	8	2	6	1	Combined	NIL
ADHD 10	7	4	7	5	Combined	NIL

^a AD – Attention Disorder, HD – Hyperactivity Disorder, Combined –AD & HD.

2.3.4. Attention

Attention was measured by using trail making test (Test A and B) for children [27]. Test A has 15 numerical targets from 1 to 15, the child has to connect them in sequential order. Test B, has numerical and alphabetical targets where the child has to connect from 1 to 8 and include letters from A to G. As in the Test A, the patient must connect the dots in order while alternating letters and numbers, as in 1-A-2-B-3-C..., in the shortest time possible without lifting the pen from the paper.

3. Results

All outcome measures were analysed using a repeated measures ANOVA with one (1) between factor (Groups: ADHD vs TD children) and one (1) repeated factor (Time: Pre vs post). All comparisons were evaluated at $p < 0.05$ level of significance.

3.1. Demographics

Children with ADHD on average weighed 40.34 (± 3.99) kg, were 1.45 (± 0.11) meters tall and had an average BMI of 19.30 (± 1.54), while typically developing children (TD) on average weighed 31.16 (± 2.42) kg, were 1.40 (± 0.05) meters tall and had an average BMI of 15.99 (± 0.86).

As seen in Table 1, children with ADHD before intervention scored high on the Inattention scale and Hyperactivity scale (1–9) in Vanderbilt teacher rating scale. Following six weeks of structured exercises both scores reduced considerably, and 50% of the children could not be categorised as having ADHD symptoms.

3.2. Gross motor skills

3.2.1. Single leg triple hop

Both groups improved following structured exercises when children hopped on their right leg, as there was a significant main effect for time $F_{(1,20)} = 13.49$, $p < 0.05$. Main effect for group and the interaction effect failed to achieve significance. However, when children performed a single leg triple hop on their left leg, there was significant main effect for group $F_{(1,20)} = 7.87$, $p < 0.05$ and time $F_{(1,20)} = 8.93$, $p < 0.05$, but non-significant interaction.

3.2.2. Seated medicine ball throw

Both groups improved following exercises, there was a significant main effect for group, $F_{(1,20)} = 5.30$, $p < 0.05$; significant main effect for time, $F_{(1,20)} = 19.66$, $p < 0.05$, as well as a significant group \times time interaction, $F_{(1,20)} = 1.11$, $p < 0.05$. Tukey's post hoc analysis revealed greater improvements in the ADHD group compared to the TD group.

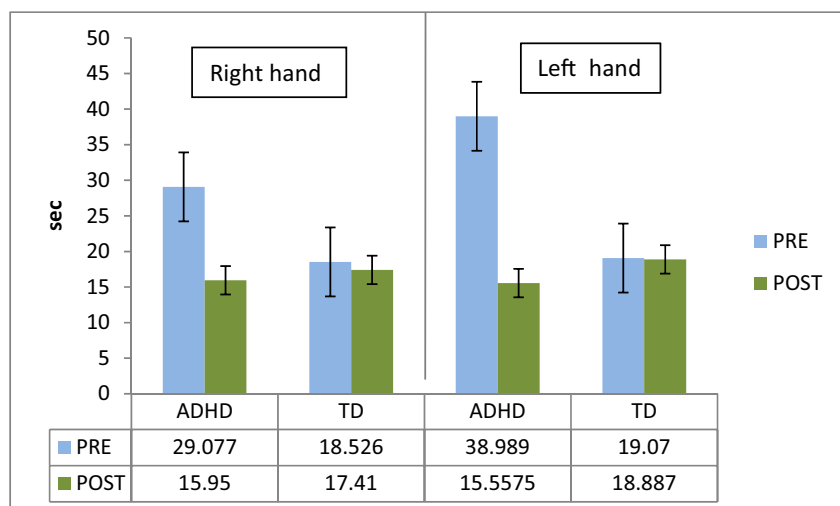


Fig. 1. Fine motor skill: Showing means (\pm SD) of time taken to perform a Fine Motor Skill (nine-hole peg test) by ADHD and TD children following six weeks of structured exercises. The blue colour represents pre test mean (before 6 weeks of intervention) for ADHD & TD. Green colour represents post test mean (after 6 weeks of intervention) for ADHD & TD. Fine motor skills improved in all children but the mean difference between the pre and post test values of ADHD & TD showed greater difference in children with ADHD, hence ADHD children improved better than TD. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

*Main effect for time, $p \leq 0.05$, *Main effect for group, $p \leq 0.05$, **Interaction group \times time, $p \leq 0.05$.

TD – Typically Developing, ADHD – Attention Deficit Hyperactivity Disorder.

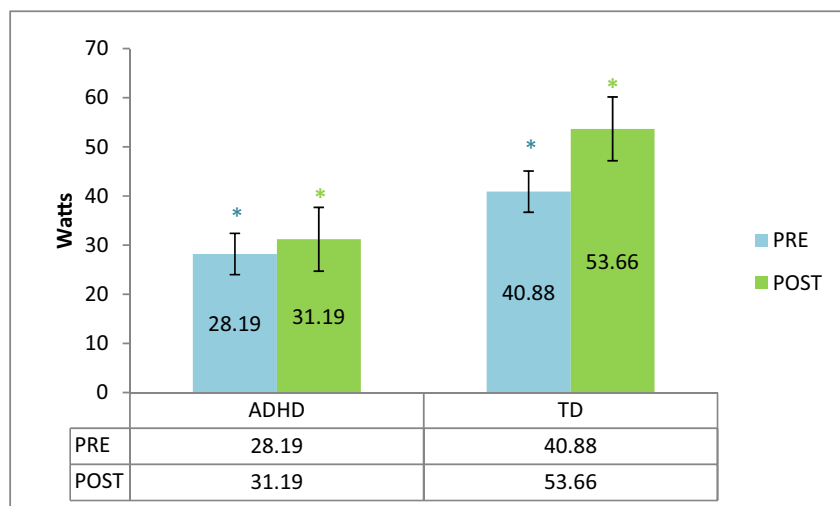


Fig. 2. Anaerobic capacity: Showing means (\pm SD) of Anaerobic Capacity (power expended) in ADHD and TD children following six weeks of structured exercises. The blue colour represents pre test mean (before 6 weeks of intervention) for ADHD & TD. Green colour represents post test mean (after 6 weeks of intervention) for ADHD & TD. Anaerobic capacity improved in all children but the mean difference between the pre and post test values of ADHD & TD showed greater difference in children with ADHD, hence ADHD children improved better than TD. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Note: *Main effect for time, $p < 0.05$, *Main effect for Group, $p < 0.05$, **Interaction group \times time, $p < 0.05$. TD – Typically Developing, ADHD – Attention Deficit Hyperactivity Disorder.

3.2.3. Nine-hole peg test

As seen in Fig. 1, children improved their fine motor skills in both hands following structured exercises. Significant main effects for group and time were qualified by a significant group \times time interaction for the right hand $F_{(1,20)} = 86.16, p < 0.05$; and for the left hand $F_{(1,20)} = 18.35, p < 0.05$. Tukey's post hoc revealed significant improvements following exercises in both groups; however, the improvements were greater in ADHD children compared to TD children.

3.3. Physical fitness

3.3.1. Body composition

he percentage of body fat decreased in both groups following six (6) weeks of the structured exercise program. The analysis of percentage body fat revealed a main effect for group, $F_{(1,20)} = 7.3, p < 0.05$; a main effect for time, $F_{(1,20)} = 43.52, p < 0.05$; however, the interaction failed to achieve significance.

3.3.2. Muscle strength

Grip strength in both hands improved (Right – Group, $F_{(1,20)} = 53.9, p < 0.05$; time, $F_{(1,20)} = 31.6, p < 0.05$; Left – Group, $F_{(1,20)} = 23.9, p < 0.05$; time, $F_{(1,20)} = 28.4, p < 0.05$) following the structured exercise program, however, the improvements were greater in the ADHD group as there was a significant group \times time interaction in both hands Right –

$F_{(1,20)} = 4.67, p < 0.05$; Left – $F_{(1,20)} = 8.67, p < 0.05$. Tukey's HSD Post hoc analysis revealed a greater increase in grip strength (right and left) in ADHD children than TD children post six weeks of a structured school based exercise program.

3.3.3. Leg explosive power

Explosive power significantly improved in both groups following structured exercises, with greater improvements in children with ADHD. There was a main effect for group, $F_{(1,20)} = 32.24, p < 0.05$; a main effect for time, $F_{(1,20)} = 17.77, p < 0.05$; and a group \times time interaction, $F_{(1,20)} = 4.9, p < 0.05$. Tukey's post hoc analysis revealed greater improvements in the ADHD group compared to the TD group.

3.3.4. Anaerobic capacity

Anaerobic capacity improved significantly in both groups following structured exercises, with greater improvements in children with ADHD (Fig. 2). There was a main effect for group, $F_{(1,20)} = 15.29, p < 0.05$; a main effect for time, $F_{(1,20)} = 32.13, p < 0.05$; group \times time interaction, $F_{(1,20)} = 10.28, p < 0.05$. Tukey's post hoc analysis revealed significantly greater improvements in the ADHD group post structured exercises than in the TD group.

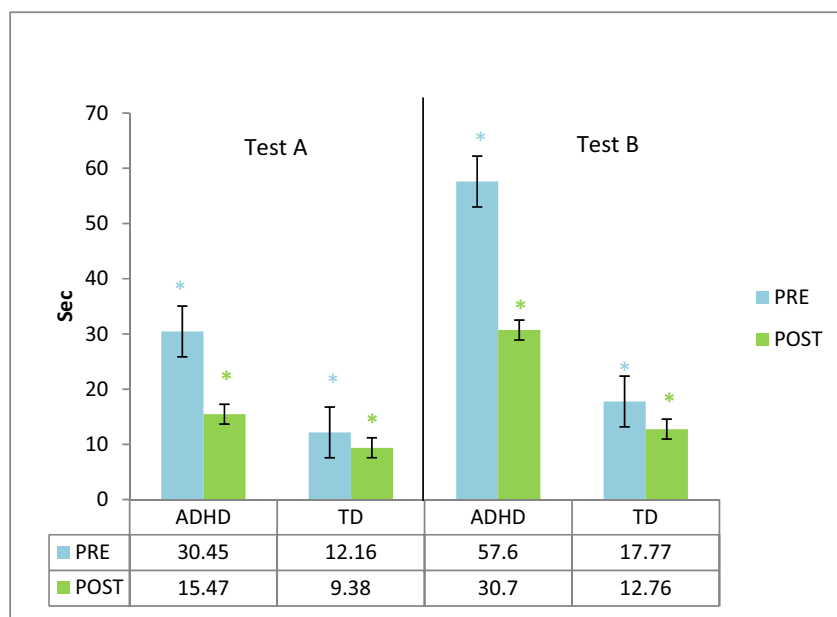


Fig. 3. Attention: Showing means (\pm SD) of time taken to perform an Attention task (Trail Making Test A & B) by ADHD and TD children following six weeks of structured exercises. The blue colour represents pre test mean (before 6 weeks of intervention) for ADHD & TD. Green colour represents post test mean (after 6 weeks of intervention) for ADHD & TD. Attention improved in all children but the mean difference between the pre and post test values of ADHD & TD showed greater difference in children with ADHD, hence ADHD children improved better than TD. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Note: *Main effect for time, $p \leq 0.05$, *Main effect for Group, $p \leq 0.05$, **Interaction group \times time, $p \leq 0.05$. TD – Typically Developing, ADHD – Attention Deficit Hyperactivity Disorder.

3.4. Attention

Attention improved in all children following structured exercises (Fig. 3). There was a main effect for group ($A - F_{(1,20)} = 68.51, p < 0.05$; $B - F_{(1,20)} = 189.03, p < 0.05$); time ($A - F_{(1,20)} = 226.18, p < 0.05$; $B - F_{(1,20)} = 111.99, p < 0.05$), and a significant group \times time interaction in both groups ($A - F_{(1,20)} = 106.72, p < 0.05$; $B - F_{(1,20)} = 52.67, p < 0.05$). Tukey's HSD post hoc analysis revealed greater improvements in attention (Form A and B) in ADHD children than TD children post six weeks of a structured school based exercise program.

4. Discussion

Overall, the results of this study found strong evidence in support of benefits following a six week, structured, school-based exercise program in children with ADHD. It is noteworthy that significant improvements were reported by teachers on the inattention and hyperactivity scale in ADHD children following exercises. Taylor et al. [28], reported similar improvements in classroom performance in children with ADHD following a mixed exercise and activity program. Thus, structured exercises should be considered as an essential treatment for reducing disruptive behaviour in the classroom.

Structured exercises prescribed in this study, were safe, feasible and an effective method of improving fitness in children with ADHD. These findings are consistent with previous studies reporting that generalized exercises, such as rope jump training etc. significantly improved balance, cardiovascular endurance, muscular strength, body composition, and flexibility in children with ADHD [24,29]. However, the referenced studies were not school based, and did not report dosage and/or progression parameters [30].

Research has suggested a need for improving fine and gross motor skills in order for children with ADHD to gain functional independence in school as well as in their home environment [31,32]. In this study, gross as well as fine-motor skills improved, where the results are similar to previous studies. Short-term and long-term improvements in motor skills have also been reported following moderate intensity exercise programs [33,34]. Accordingly, it is suggested that gross and fine-motor exercises be incorporated in training programs for ADHD children.

The benefits of general exercises improving attention deficits in children with ADHD are well documented [35–37], and similar results were found in our study. It has been suggested that physical exercises

increase levels of dopamine, norepinephrine, and serotonin, which typically are reduced in children with ADHD, and thus, an increase helps improve focus and attention [34]. Additionally, there is an increased allocation of attentional resources following an exercise induced positive functioning of the dorsolateral posterior frontal cortex [35].

Preliminary evidence suggests that children, particularly ADHD children, benefitted from a school-based, structured exercise program which can be incorporated within physical education curriculum. As with all pilot studies, and small sample sizes, these results should be interpreted and generalized with caution. Future studies should include a larger sample size, a sampling of children across age groups, gender and a greater number of schools.

Declaration of Competing Interest

None.

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