Original Article

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Effect of Aerobic Training on Anxiety, Activities of Daily Living and Visual Motor Skills Performance in Children with Autism: A Randomised Controlled Trial

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ABSTRACT

Introduction: The prevalence of Autism Spectrum Disorder (ASD) has significantly increased over the past 20 years. Characterised by impairments in communication skills and the presence of stereotypical behaviours, individuals with ASD often experience difficulties in performing Activities of Daily Living (ADLs), abnormalities in visual processing and anxiety disorders. Structured exercise programs can serve as an effective complementary therapy for individuals with ASD by reducing symptoms and maximising abilities.

Aim: To study the effect of aerobic exercise on anxiety, ADLs and visual motor skills performance in children with mild to moderate ASD.

Materials and Methods: This randomised controlled trial was conducted at the SGT Medical College Hospital and Research Institute in Gurugram, Haryana and Holy Heart Special School in Dwarka Mor, Delhi, India from January 2023 to May 2023. Thirty-eight children aged between 7 and 13 years with mild to moderate ASD who met the selection criteria were included and randomly assigned to two groups. Group A (n=19) received aerobic training, while Group B (n=19), the control group, received an ASD awareness lecture along with other students to help them understand this disorder, which may decrease anxiety and improve the performance of children with ASD. Data were collected at baseline and at the end of the 8th week of the study. The outcome measures used were the Screen for Child Anxiety Related Disorders (SCARED), the Functional Independence Measure (FIM) and the mirror drawing apparatus. Data were statistically analysed using the Shapiro-Wilk normality test and the Mann-Whitney test.

Results: Group A and Group B had respective median ages of 11 (8-13) years and 8 (7-12) years, with a similar gender distribution (F=1, M=18) in both groups. There was a significant reduction in the SCARED scores in Group A compared to Group B (p-value=0.004) after aerobic exercises. FIM scores were significantly higher in Group A than in Group B after the aerobic exercise intervention (p-value=0.009). Similarly, in Group A, the amount of time needed to draw the figure and the errors made with both the right and left hands decreased significantly for the mirror drawing score following aerobic exercises, indicating improvements in anxiety, ADLs and visual motor skills after the treatment.

Conclusion: The results indicated that incorporating aerobic activities for children with mild to moderate autism improves ADLs, visual motor abilities and reduces anxiety.

Keywords: Aerobic exercises, Autism awareness lecture, Autism spectrum disorder, Functional independence, Social anxiety

INTRODUCTION

One of the most severe chronic childhood disorders in terms of incidence, morbidity and social impact is ASD, which first appears in infancy [1]. The disorder was classified under the diagnosis of "Pervasive Developmental Disorders (PDD)" in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) text revision, but the DSM-V replaced the multicategorical diagnostic approach for autism with a single diagnosis based on several aspects [2]. In India, the prevalence of autism has been found to range from 0.5 to 1.1% [3,4]. Although the precise pathomechanics of ASD are unknown, several factors have been linked to the aetiology of disorders associated with autism [5].

Presumptive risk factors for ASD include certain genetic influences, perinatal problems, a family history of autism, older parental age at conception, intrauterine drug exposure, consanguinity and several others [6]. The two main areas of symptoms for this disorder are difficulties with social interaction or communication and restricted interests and repetitive behaviours [7].

As a result, children with ASD experience elevated levels of anxiety. Anxiety disorders adversely affect children's physical and social development, as well as their academic achievement. Quantitative studies based on parent questionnaire data indicate that children on the spectrum who have higher levels of anxiety have a lower quality of life than those with lower levels of anxiety [8]. Additionally, these children exhibit poor levels of independence and struggle with ADLs, such as personal hygiene, grooming, dressing and self-feeding, among other self-care tasks. Typically developing children at an early childhood age generally acquire these skills independently, although with varying degrees of maturity and skill across age groups. However, self-care is challenging for children with ASD, which negatively impacts their development in other areas [9].

Children need to be able to accurately perceive visual information in order to complete ADLs. Visual perception, which is the ability of the human brain to receive, evaluate and assign meanings to specific visual inputs, is a fundamental yet necessary skill for carrying out daily tasks as well as for exploring and interacting with the outside world [10]. Furthermore, school-age children and adolescents with ASD have shown reduced sensitivity to novel visual stimuli, as reported by Keehn B and Joseph RM [11]. It is hypothesised that this sensitivity may be linked to anomalies in the dorsal visual processing stream.

Comparing typically developing children with children with ASD, the latter group exhibits lower levels of activity. Moreover, individuals with ASD represent a unique risk group due to their sedentary lifestyle, which raises the risk of obesity, diabetes and heart disease {World Health Organisation (WHO), 2002} [12]. Given that physical activity has been shown to be a successful strategy for preventing these issues in the general population, it is expected to be successful in the population with ASD as well [13]. Aerobic exercises have numerous benefits that set them apart from other forms of exercise. When it comes to games, sports and entertainment, aerobic activities can be the most appealing to children, which encourages them to engage in them with enthusiasm and desire [14]. Children with ASD benefit greatly from cycling's positive impacts on their cognitive planning and improved balance. It enhances their coordination and overall neurological involvement in tasks [15]. On the other hand, aquatic exercise has been demonstrated to help children with ASD maintain their target heart rate for longer durations and increase their overall cardiorespiratory endurance and stamina [16]. These physical activities help the children relax and lower their levels of self-stimulation. Jogging appears to be useful in improving their response time by reducing stereotyped behaviour. It also has a significant impact on academic performance and study habits [17].

Since aerobic exercise has been shown to lessen stereotyped behaviour in children with ASD, no research has looked at how aerobic exercise affects anxiety, ADLs, or visual motor abilities. The objective of this study was to ascertain the effects of aerobic exercise on anxiety, ADLs and visual motor skill performance in children with mild to moderate autism.

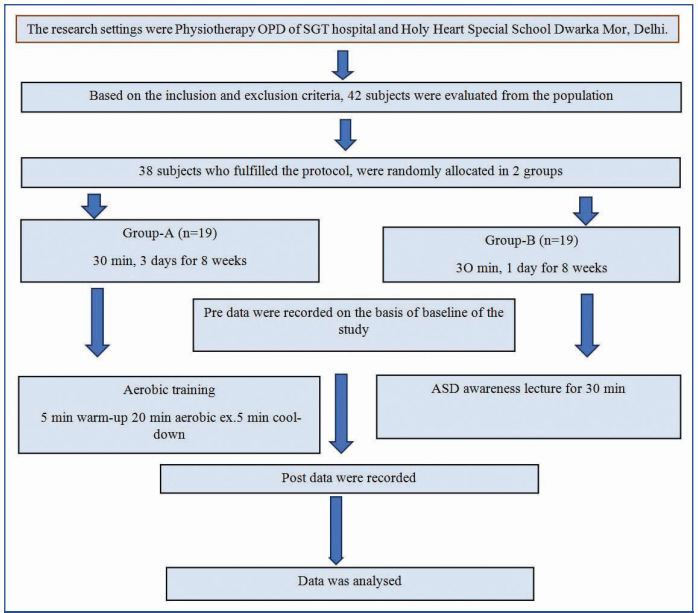
MATERIALS AND METHODS

This randomised controlled trial was conducted at SGT Medical College Hospital and Research Institute in Gurugram, Haryana and Holy Heart Special School in Dwarka Mor, Delhi, India between January 2023 and May 2023. Ethical clearance was obtained from the Departmental Ethics Committee, Faculty of Physiotherapy, SGT University, Gurugram, before recruiting participants (SGTU/FPHY/2022/421). The parents of the subjects were informed about the nature of the study and written consent was obtained from them.

Inclusion criteria: Children between the ages of 7 and 13 years, with mild to moderate ASD, who scored between 30 and 36 on the Childhood Autism Rating Scale (CARS) [18], children who scored more than 25 on the anxiety screening test SCARED [19] and children who could follow directions with assistance were included in this study.

Exclusion criteria: Cases of complex neurologic disorders such as epilepsy, phenylketonuria, fragile X syndrome, or tuberous sclerosis were excluded. Neurological conditions were identified by examining the medical records of these children. Additionally, children exhibiting behaviours that prevented them from participating in group activities or having other medical conditions that limited their ability to engage in physical activity were also excluded from the study.

Sample size: To calculate the sample size, G Power software was utilised. Based on the effect size of 1.41 from a previous study, an α of 0.05 and a power of 95%, with a 25% dropout rate, the sample size was determined to be 38 [20]. A total of 42 subjects were screened for ASD and after applying the inclusion/exclusion criteria, 38 subjects were recruited for the study [Table/Fig-1]. Computerised random assignment was used to randomly assign children to either Group A or Group B with a 1:1 allocation ratio using random allocation software version 2.0. It was a single-blinded study in which the investigators were blinded; that is, the person who administered the intervention was different from the person who allocated the participants into groups. Participants were not blinded to the interventions.



[Table/Fig-1]: Consort flow chart of the study design.

Outcome Measures

The dependent variables were the SCARED screening tool to measure anxiety levels, the FIM to assess ADLs and the mirror drawing apparatus to evaluate visual motor skills. The independent variables included an ASD awareness lecture for the control group and aerobic exercises for the study group.

1. **SCARED:** This self-report questionnaire assesses children's symptoms of anxiety disorders related to the DSM-IV, based on reports from parents and children. The SCARED-P and SCARED-C scales consist of 41 items divided into five subscales: generalised anxiety symptoms (nine items), separation anxiety symptoms (eight items), social anxiety symptoms (seven items), panic or somatic symptoms (thirteen items) and school avoidance (four items). The SCARED scale demonstrated good internal consistency (α=0.74 to 0.93) and test-retest reliability (intraclass correlation coefficients=0.70 to 0.90) for the total score and each of the five factors. There was also moderate parent-child agreement (r-value=0.20 to 0.47, p-value <0.001 for all correlations) and discriminative validity (both between anxiety disorders and within anxiety disorders) [19]. A total score of ≥25 may indicate the presence of an anxiety disorder.
2. **FIM:** The FIM assesses and monitors the level of support a person may need to perform daily tasks. The FIM assessment instrument comprises 18 measures categorised into motor and cognitive domains. Each item is scored on a 7-point ordinal scale, ranging from a score of 1 to a score of 7. A higher score indicates greater independence in performing the tasks associated with that item. The range of FIM scores is from 18 to 126, with a maximum value of 126 indicating complete independence and a value of 18 indicating total dependency. The total FIM Intraclass Correlation Coefficient (ICC) was 0.96; for the motor domain, it was 0.96 and for the cognitive domain, it was 0.91 [21].
3. **Mirror drawing apparatus score:** The mirror drawing tool, invented by Starch in 1910 [22], is now available in an electronic format. The apparatus consists of a desk with a five-pointed star pattern. A mirror is positioned vertically at a specific location on the desk to reflect the star pattern to participants. The star design is traced using a metal pointer connected to an electrical counting device. When the subject places the stylus at the beginning of the grooved path of the star, the digital timer immediately begins recording time in seconds and decimal parts. Additionally, any errors made during the task are automatically recorded by a digital error counter. Both the digital timer and the error counter can be reset [23].

Intervention

Group A, the intervention group (n=19), underwent eight weeks of aerobic exercises for 30 minutes each session, three times a week. Group B, the control group (n=19), received informative lectures regarding ASD for 30 minutes. In this study, both the intervention and control groups participated in ongoing rehabilitation training. Based on this, the intervention group received additional aerobic exercise intervention, while the control group was prohibited from participating in any exercise program outside of the recommended rehabilitation instructions [24].

These sessions were conducted at the physiotherapy Outpatient Department (OPD) of SGT Hospital and Holy Heart Special School in Dwarka Mor, Delhi, India, under the supervision of a physiotherapist with over 10 years of experience working with children with autism. An exercise diary was maintained to document information regarding the total number of sessions, the reasons for any absenteeism, the incidence of any adverse events and the number of repetitions. Therapy adherence was monitored to ensure it was delivered as planned.

The Group B received informative lectures regarding ASD along with other students for 30 minutes once a week. These informative lectures were delivered to address the lack of information among non ASD students, enabling them to better support their ASD peers. Having peers with whom students with ASD feel comfortable is beneficial in reducing stress and enhancing skill acquisition [25]. Participants were also instructed to maintain their usual routines without engaging in any additional structured physical exercise programs during the research period.

The aerobic exercise program was divided into two phases, each lasting four weeks. In the first phase (0-4 weeks), the child began with a five-minute warm-up session that included arm circles, jumping jacks, marching in place, standing forward bends and high heels. After the warm-up period, children were engaged in 20 minutes of aerobic exercises, which included walking, static cycling, jumping, running in place and side shuffles. The session concluded with a five-minute cool-down period that included shoulder stretches, lower back rotational stretches, seated toe touches and child's pose.

In the second phase (5-8 weeks), sessions also began with a five-minute warm-up, which included neck bending, neck rotation, hip rotation and hopping in place. The aerobic exercises during this phase included 20 minutes of trampoline jumping, static cycling and engaging aerobic workouts. The child then underwent a five-minute cool-down period that involved lunge stretches, knee-to-chest stretches, overhead shoulder stretches, wrist rolls and standing quad stretches.

Exercise intensity was assessed using a Polar H10 watch with heart rate sensors, targeting 65% to 85% of the age-calculated maximum heart rate. Each workout also included 2-3 minute water breaks or rest periods [26,27]. A full description of the aerobic exercise program, including the dosage, can be viewed in [Table/Fig-2,3].

1st phase (0-4 weeks)	2nd phase (5-8 weeks)	Dosage
Warm-up phase (5 min)	Warm-up phase (5 min)	
1. Arm circle	1. Neck bending	5 Rep×2 sets
2. Jumping jacks	2. Neck rotation	
3. Marching in place	3. Hip rotation	
4. Standing forward bend	4. Hopping in place	
5. High heels		
Aerobic intervention (20 min)	Aerobic intervention (20 min)	
1. Walking	1. Trampoline jumping	3 min
2. Static cycling	2. Static cycling	3 min
3. Running in place	3. Entertaining aerobic workouts	4 min
4. Side shuffles		5 min
5. Jumping		5 min
Cool down phase (5 min)	Cool down phase (5 min)	
1. Shoulder stretches	1. Lunge stretch	5 Reps×2 sets
2. Lower back rotational stretches	2. Knee to chest	
3. Seated toe touches	3. Overhead shoulder stretches	
4. Child's pose	4. Wrist rolls	
	5. Standing quad stretches	

[Table/Fig-2]: Aerobic exercises.

[Table/Fig-3]: Aerobic intervention a) Walking; b) Static cycling; c) Running in place; d) Side shuffles; e) Jumping; f) Trampoline jumping; g) Entertaining aerobic workouts.

STATISTICAL ANALYSIS

The data analysis was conducted using IBM Statistical Package for the Social Sciences (SPSS) version 20.0. A non parametric test was performed because the test scores did not show a normal distribution, as indicated by the results of the Shapiro-Wilk normality test. The Mann-Whitney Test was used to compare demographic data, CARS scores for autism severity and outcome variables (SCARED, FIMS and mirror drawing score) between the groups. Gender differences across the groups were compared using the Chi-square test. Additionally, the SCARED, FIM and mirror drawing scores after the completion of aerobic training were compared between the groups using the Mann-Whitney Test. A group analysis was conducted using the Wilcoxon Signed-Rank Test. For this study, statistical significance was defined as p-value <0.05. ANCOVA (analysis of covariance) was used for variables that revealed substantial baseline differences between the two groups.

RESULTS

The eight weeks of training sessions were completed by all 38 participants enrolled in this study. The participants were aged between 7-13 years, with a median age of 11 years in Group A and 8 years in Group B, showing no statistically significant difference (p-value=0.112). Furthermore, the gender distribution indicated that 18 (94.74%) of the participants were male and 1 (5.26%) was female, making the majority of participants in this study male in both groups. No statistically significant differences in height and weight were found between Group A and Group B (p-value=0.872, p-value=0.737). At baseline, the scale for autism severity, CARS, also did not show a significant difference (p-value=0.329) [Table/Fig-4].

The score on the SCARED screening tool was found to be significantly lower (p-value=0.004) in Group A than in Group B after aerobic exercise training. There was a discernible difference between Groups A and B (p-value=0.009) for the FIM score postintervention.

Characteristics	Group A Median (IQR)	Group B Median (IQR)	z value	p-value
Age (years)	11 (8-13)	8 (7-12)	-1.59	0.112
Gender, n (%)	F=1 (5.26)	F=1 (5.26)		
	M=18 (94.74)	M=18 (94.74)		
Height (meter)	1.10 (0.92-1.27)	1.19 (0.94-1.27)	-0.161	0.872
Weight (kg)	28 (17-41)	32 (17-37)	-0.336	0.737
CARS	33 (31-35)	34 (32-34)	-0.976	0.329

[Table/Fig-4]: Demographic characteristics of the group A and group B.

Similarly, for the mirror drawing task, the time required to draw the picture and the errors made while drawing with both the right and left hands decreased significantly (p-value=0.003 for time and p-value=0.047 for errors, respectively) after aerobic exercise training in Group A. Within-group analysis revealed a significant decrease in the scores of SCARED, FIM and mirror drawing in Group A [Table/Fig-5].

Variables		Parameter	Group A Median (IQR)	Group B Median (IQR)	p-value
SCARED		Preintervention	44 (42-50)	47 (45-52)	0.086
		Postintervention	42 (41-46)	51 (44-53)	0.004*
		p-value	<0.001**	0.623	
FIM		Preintervention	96 (87-98)	92 (78-111)	0.624
		Postintervention	111 (98-114)	98 (78-111)	0.009**
		p-value	<0.001**	0.102	
Mirror drawing score	Time rt	Preintervention	155 (145-170)	154 (135-170)	0.501
		Postintervention	133 (120-146)	158 (139-170)	0.003**
		p-value	<0.001**	0.06	
	Error rt	Preintervention	62 (60-78)	65 (52-70)	0.297
		Postintervention	56 (45-63)	63 (55-70)	0.047*
		p-value	<0.001**	0.54	
	Time it	Preintervention	175 (159-180)	162 (132-178)	0.225
		Postintervention	156 (140-172)	174 (145-180)	0.041*
		p-value	<0.001**	0.038	
	Error it	Preintervention	78 (72-85)	71 (65-77)	0.027
		Postintervention	61 (60-67)	69 (56-79)	0.009**
		p-value	<0.001**	0.569	

[Table/Fig-5]: Comparison of median values of SCARED, FIM and mirror drawing scores within and between groups.
Within group analysis was done by Wilcoxon signed-rank test
Between groups analysis was done by Mann-Whitney test

DISCUSSION

The main purpose of this study was to determine the impact of aerobic training on anxiety, ADLs and visual-motor activity in children with ASD. Aerobic training showed a significantly greater reduction in the SCARED score, FIM score and mirror drawing score in Group A. Children with ASD may be significantly affected by anxiety. It impacts their capacity to engage in pleasurable activities, socialise with peers and perform well in school. Anxiety affects the abilities necessary for learning and success in the classroom, contributing to the academic underachievement often observed in children on the autism spectrum. Cognitive Behavioural Therapy (CBT) is a popular treatment method for anxiety; however, some children may struggle to communicate their emotions or recognise stressful situations, which means they may not benefit from CBT. Given this obstacle, these children often have limited treatment options. Exercise has anxiety-reducing benefits comparable to those of CBT or medication.

Therefore, exercise could be a potential therapy for anxiety in children with ASD. In the present study, a significant improvement in the SCARED score was found in Group A after the intervention (p-value <0.001). These results imply that children with ASD benefit immediately from the anxiolytic effects of exercise. Numerous prior studies have demonstrated the beneficial effects of aerobic exercise on anxiety reduction [28,29] and the findings of the current study support these results, as there was a reduction in anxiety after the implementation of the aerobic exercise program. The improved SCARED scores in both the current and previous studies after aerobic exercises may be related to decreased levels of anxiety-inducing hormones such as cortisol and glucocorticoids, as well as enhanced synthesis of neurotransmitters and opioids (β-endorphins) and nor adrenaline [30,31]. Additionally, exercise may lead to psychological adaptations, including lowered anxiety and improved self-efficacy, sensitivity brought on by prolonged exposure to the physical symptoms of worry and a component of distraction [32,33].

ADLs include personal hygiene, clothing and tooth brushing. The ability to live freely and self-sufficiently in everyday contexts is influenced by the acquisition of certain skills. Children with autism can live longer and become less dependent on others if they are able to complete ADLs independently [34]. Problems with fine and gross motor skills are seen in children with ASD to varying degrees. Previous studies [35,36] indicated that, compared to children without ASD, children with ASD are less inclined to engage in certain movements. An essential aspect of teaching children with ASD is including exercise regimens that assist in developing fundamental motor skills. Aerobic exercises showed a significantly greater improvement in the FIM score (p-value=0.009) of Group A in the present study, which suggests that physical activity has a positive impact on Body Mass Index (BMI), dynamic balance, muscle strength, motor coordination and academic achievement [37]. These findings align with previously published research indicating that aerobic fitness and motor skills are related to each other and leads to a better memory and/or attention [38]. Aerobic exercise is any kind of cardiovascular training that emphasises raising heart rate and breathing. Numerous stereotyped behaviours, such as involuntary repetitive motions, lower muscle tone than peers and disruptive and unpredictable sleep patterns, have been observed among children on the autism spectrum. Aerobic-based activities help reduce these stereotyped behaviours and, in turn, enhance the child's cardiovascular capacity, attention span and sleep patterns, thereby improving their ability to perform ADLs.

Visual Motor Integration (VMI) refers to the ability of the hands and eyes to cooperate in smooth, effective patterns. It requires both hand-eye coordination and visual perception. The ability to convert visual perception into motor functioning is necessary for visual-motor skills, which include motor control, motor accuracy, motor coordination and psychomotor speed [39]. Individualised patterns of visual and motor impairments in students with ASD may affect how well they perform in the classroom on visual, motor and visual-motor activities [40,41]. Oliver CE, discovered that after providing occupational therapy intervention, children's writing readiness skills significantly improved [42]. Findings suggested that aerobic exercises led to a significant improvement in mirror drawing scores, meaning that the time and error in completing the task decreased significantly (p-value <0.05). Children with autism were given movement imaging activities by Kardaani MA and Ebrahimpur M, who found that motion visualisation is a simple, approachable technique that enhances visual-motor perception abilities [43].

Recent research has demonstrated that exercise, particularly aerobic activity, can improve cognitive skills and increase the overall size of the brain. The hippocampus, a brain region involved in emotion regulation, memory, motivation and general learning capacities, has been found to expand more rapidly in response to persistent aerobic exercise training [44]. Increase in hippocampal function through aerobic exercise may have a significant positive impact on the quality of life for many autistic children who struggle with short-term memory.

Within-group analysis revealed the effectiveness of six weeks of aerobic exercises on anxiety, ADLs and visual motor skills in Group A. Since children on the autism spectrum are known to spend a disproportionately small amount of time on moderate-to-vigorous activities compared to typically developing children, it is crucial to take this into account when constructing an activity schedule for this unique group of children. Aerobic exercise has the added benefit of being enjoyable, which is advantageous for those on the autism spectrum. Additionally, it encourages the body to continue pumping oxygen to the muscles and keeps the heart working.

Limitation(s)

The study included individuals with specific characteristics (such as age), which may have limited the generalisability of the findings. Diversity in participant demographics would enhance the study's external validity. The study may not have explored the long-term consequences of aerobic exercises. To determine if the reported benefits are long-lasting or if they gradually diminish over time, it would be necessary to evaluate the results over a longer time frame. Finally, a thought-provoking area for future research would be how to incorporate sensory activities into aerobic training.

CONCLUSION(S)

Findings of this study suggest that the inclusion of aerobic exercises significantly improves anxiety, visual motor skills and ADLs performance in children with mild to moderate autism. Thus, clinicians and rehabilitation professionals may consider incorporating aerobic exercises as part of a multifaceted treatment program for these children. These observations indicate that conducting longitudinal research to track participants would be a valuable way to learn more about the durability and long-term benefits of aerobic exercises on anxiety, ADLs and visual motor skills. Additionally, examining discrepancies between the findings for males and females could provide more precise outcomes.

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