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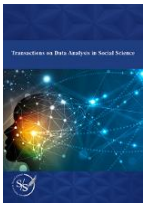

The Effect of Aerobic Training on Coordination, Social Adaptation, and Parental Concerns in Children with Autism Spectrum Disorder

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ABSTRACT

Background: Autism Spectrum Disorder (ASD) is characterized by impairments in social communication and the presence of restricted and repetitive behaviors, interests, or activities. Literature focuses on comparing physical activity and physical fitness in children with ASD, who are usually in a state of progress. **Objectives:** The aim of this study was to investigate the effect of aerobic training on coordination, social adaptation, and parental concerns in children with autism. Methods: This research employed a semi-experimental design with pre-test-post-test. Twenty-eight children aged 5 to 13 were divided into experimental and control groups from available samples. These children had previously been diagnosed with autism by a child psychiatrist and a medical team based on the diagnostic criteria of the latest edition of the Diagnostic and Statistical Manual of Mental Disorders and according to the Childhood Autism Rating Scale. Both groups underwent a pre-test, which included a wall-ball throwing test for assessing motor performance, and the Vineland and Pennsylvania questionnaires for social adaptation and parental concerns. After a twelve-session training period, a post-test was conducted. **Results:** The results indicated a significant effect of aerobic exercise on the coordination of children with autism ($p \leq 0.05$). However, no significant differences were observed in social adaptation and parental concerns ($p \geq 0.05$). According to the research findings, it can be concluded that aerobic exercise, contrary to social adaptations and parental concerns, can have a significant impact on the performance of children with autism.

1. INTRODUCTION

Autism, recognized as the most prevalent developmental disorder, is a neurodevelopmental condition characterized by deficits in communication skills, social interactions, and stereotypical behaviors [1]. Impairments in social development, language, and symbolic play that manifest before the age of 36 months are observed in children with autism spectrum disorder (ASD) [2]. The average prevalence of ASD in epidemiological studies is

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reported to be 5 cases per 10,000 individuals, with reported ranges varying from 2 to 20 cases per 10,000 individuals [2]. However, recent studies suggest a prevalence of 1 case per 100 births [3].

Motor problems and coordination deficits are also observed in individuals with ASD, and it appears that children and adolescents with ASD engage less in physical activities due to behavioral and social impairments, putting them at risk of inactivity and its associated negative consequences [4]. Given these circumstances, promoting movement and fostering desirable motor skills are essential to better control the living environment of individuals with ASD [5].

Educational, social, and professional opportunities for individuals with ASD have fundamentally changed with the movement towards their inclusion in society. Increasingly, skill training for individuals with ASD is used to enable them to experience more independent and effective lives [6]. Physical activity has been shown to improve many concerns reported by parents of children with ASD [7]. Recent meta-analysis indicates that the positive effects of physical activity in ASD have the greatest impact on motor coordination, motor skills, strength, endurance, and social performance [8]. Physical activity in children with ASD, by enhancing academic performance along with improving communication skills, cooperation, and self-control, has been reported to reduce stereotypical behaviors and improve overall quality of life according to parental reports [9].

In the general population of children in the United States, many youths with ASD do not engage in sufficient physical activity [10]. A recent report by the National Physical Activity Plan indicated that only 24% of individuals aged 6 to 17 in the United States participate in the recommended 60 minutes of physical activity per day [11]. Only 14% of youths in this age group who had ASD adhered to this recommendation because children and adolescents with ASD participate less in physical activities, both in structured planning such as physical education classes and in their leisure time, compared to their peers [12]. This difference may be partly due to fundamental differences in the motivation for physical activity and core ASD-related symptoms that challenge participation, especially in group activities [13]. Barriers to successful involvement in recreational physical activities for individuals with ASD also include limited resources and staff training [14]. Additionally, parents may lack information about available physical activity programs, and the challenges of facilitating experiences related to physical activities may complicate demands for other necessary intervention services [13].

Aerobic exercises can improve social, communicative, and motor skills and reduce stereotypical and self-stimulatory behaviors in individuals with Autism [15]. Aerobic exercises involve controlled sensory stimuli in the form of self-directed and meaningful activities that emphasize basic needs for motivational behavior, with particular emphasis on biological requirements [4]. It has been shown that many children with autism lack sensory integration [16]. About half of children with autism have poor balance and coordination, and their vestibular and cerebellar systems are involved, leading to existing impairments in cognitive and motor functions [4]. Furthermore, these children have sensory and motor processing disorders and may have weak or intense reactions to environmental stimuli in the auditory, tactile, visual, and gustatory domains. Aerobic exercises seem to improve the better processing of sensory stimuli received by the child [4]. Shahrasfngharh and colleagues (2018) demonstrated the effects of aerobic exercises on motor skills and physical coordination in children with autism [4].

The results obtained from relevant research in this area, coupled with the need for the effectiveness of motor activity interventions on the performance and social adaptability of children with autism, highlight the necessity of further research in this field. Aerobic exercises, as a physical fitness program, are important both for meeting the exercise needs of these children and because they are practical for parents and instructors alike.

The program was found to be cost-effective in improving movement skills and body composition. This study aimed to determine the effect of aerobic exercises on the coordination, social adaptation, and parental concern of autistic children aged 5 to 13 in Tabriz.

2. METHODOLOGY

The present study employed a semi-experimental design with an applied objective, utilizing a pre-test-post-test pattern in two groups (experimental and control). The statistical population of the study consisted of all children aged 5 to 13 diagnosed with autism spectrum disorder in Tabriz in the year 1394. The sample for this study included 28 children with autism spectrum disorder, purposefully selected through convenient sampling from autism centers

in Tabriz. These children had previously received a diagnosis from a child psychiatrist, along with a medical team, based on the diagnostic criteria of the latest version of the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2000), and according to the Autism Behavior Checklist ranking.

It is worth mentioning that consent letters were obtained from the parents of the participants, assuring them of the confidentiality of the collected information.

None of the children had a history of participation in motor activities, including aerobic exercises. The aerobic exercise program included simple aerobic movements such as marching, easy steps, V-step, step touch, high knees, toe taps, V-step with toe tap, and backward heel. The experimental group attended individual aerobic exercise classes for eight weeks, with four sessions each week, lasting 45 minutes per session. During this period, the control and experimental groups engaged in regular school activities without any additional systematic and impactful sports activities.

Coordination involves the degree of muscle engagement and the timing of muscle contractions in the motor chain [17]. To assess coordination, the ball throw test towards the wall was utilized. This test measures the coordination of eye and hand movements. The test requires a tennis or baseball, a meter tape, and a chronometer. The procedure involves marking a specific distance of two meters from the wall, where the individual stands behind the line, facing the wall. The person then throws the ball towards the wall using one of their hands (in an underarm throw), and upon return, they must try to catch it with the other hand. The ball is then thrown back to the wall by the receiving hand, and the first hand that performed the initial throw should catch it. This test can be conducted within a specific time frame (e.g., 30 seconds) or as a count of continuous throws [18].

Social compatibility reflects the individual's interaction with others, satisfaction with their roles, and how they perform in these roles. It is likely influenced by personality, culture, and family expectations [19]. In this research, the Vineland Social Maturity Scale was employed to measure social compatibility. This scale, a developmental scale, assesses the individual's ability to meet their practical needs and assume responsibilities in life [20]. The scale's items can be categorized into eight classes, including general self-help, self-help in eating, self-help in dressing, self-control, employment, language communication, mobility, and socialization. Based on the scores obtained from this scale, social age and social maturity can be calculated [20]. The reliability coefficient, reported with a retest of 123 individuals for this scale, is 0.92[20]. The parents' concerns about their children were assessed using the Pennsylvania Worry Questionnaire, a 16-item questionnaire designed to measure intense, excessive, and uncontrollable worry in various situations and contexts. The Pennsylvania Worry Questionnaire is widely used in psychological studies related to anxiety and pervasive developmental disorders. It is employed in studies evaluating the effectiveness of treatments for pervasive developmental anxiety disorders, comparative studies on worry, laboratory experiments, and studies investigating the pathology of pervasive developmental anxiety disorders [21].

3. RESULTS

In this section, demographic information such as age, number of children, and birth order is presented in Table 1. Table 2 shows the mean and standard deviation of the coordination test for each group across three stages, with Figure 1 illustrating changes in reaction skills in each group over the three stages. Table 3 presents the mean and standard deviation of social adjustment in each group across two stages, and Figure 2 depicts the changes in social adjustment over time. Table 4 shows the mean and standard deviation of parental worry in each group across two stages, with Figure 3 displaying the corresponding changes.

Table 1. Demographic characteristics of the participants

Variable	Group	Mean	Standard Deviation
Age	Experimental	7.7	3.3
	Control	6.0	1.5
Number of children	Experimental	1.7	0.7
	Control	1.3	0.5
Birth order	Experimental	1.5	0.7
	Control	1.3	0.5

Table 2. Mean and standard deviation of coordination test

Group (n)	Test Time	Mean	Standard Deviation	Standard Error of Mean
Experimental (14)	Pre-test	36.6	0.626	2.341
	Mid-test	50.7	0.863	3.228
	Post-test	57.8	1.239	4.636
Control (14)	Pre-test	21.5	0.187	0.699
	Mid-test	5.0	0.234	0.877
	Post-test	50.4	0.203	0.760

Table 3. Mean and standard deviation of social adjustment

Group (n)	Test Time	Mean	Standard Deviation	Standard Error of Mean
Experimental (14)	Pre-test	52.14	3.02	13.851
	Post-test	49.76	3.563	13.330
Control (14)	Pre-test	52.64	2.862	10.710
	Post-test	50.64	3.341	12.500

Table 4. Mean and standard deviation of parental worry

Group (n)	Test Time	Mean	Standard Deviation	Standard Error of Mean
Experimental (14)	Pre-test	52.14	3.02	13.851
	Post-test	49.76	3.563	13.330
Control (14)	Pre-test	52.64	2.862	10.710
	Post-test	50.64	3.341	12.500

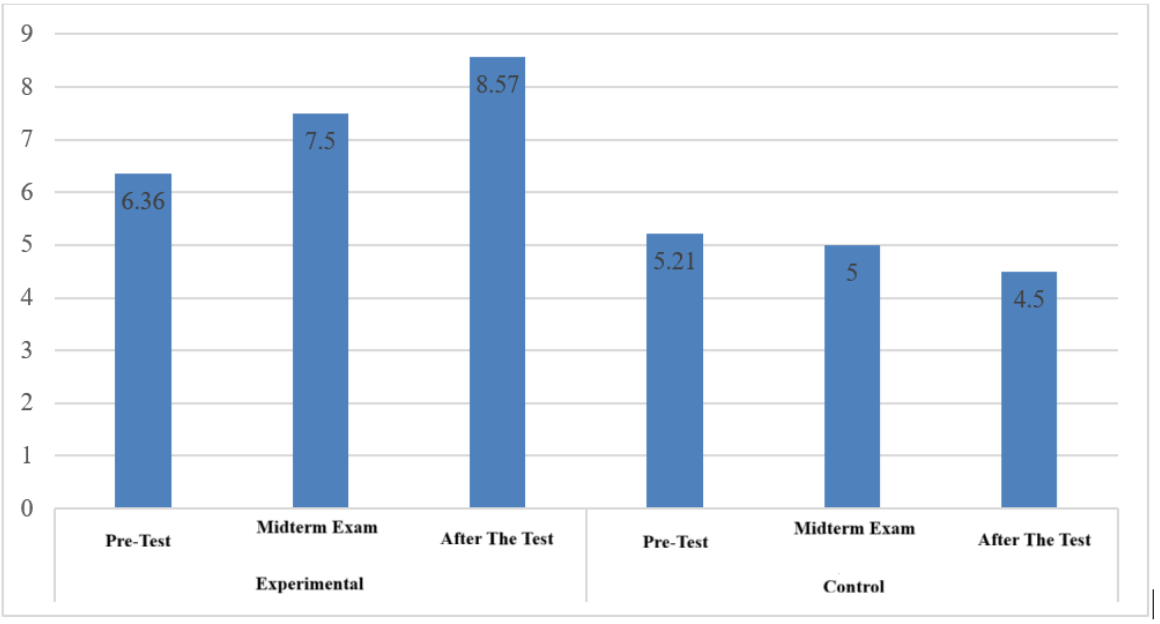

Fig. 1. Related to Changes in Coordination Test

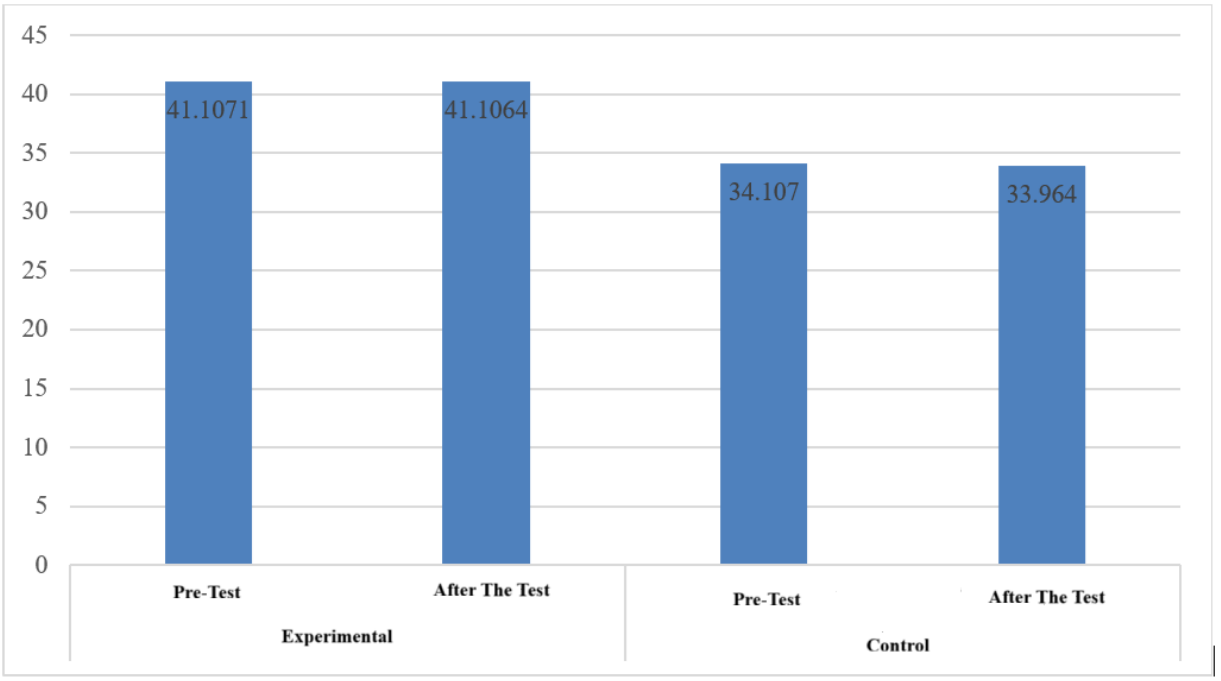

Fig. 2. Related to Changes in Social Adaptation Variable

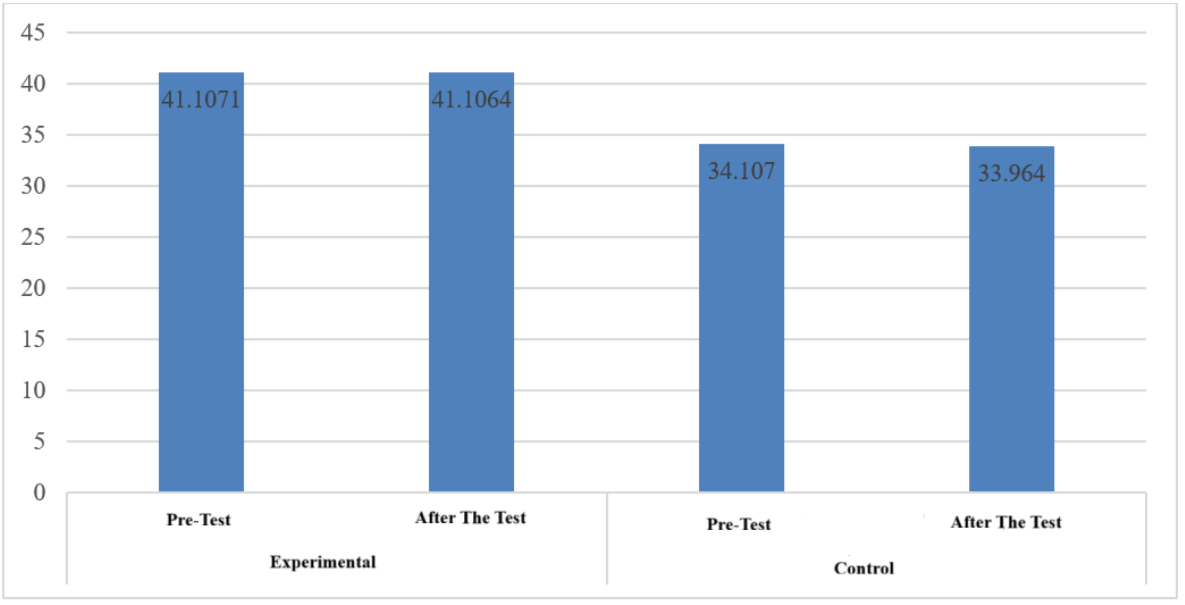

Fig. 3. Related to Changes in Parental Concern Variable

To examine the normality of the data distribution, the Kolmogorov–Smirnov test was applied ($P < 0.05$), and the results are presented in Table 5. To evaluate whether significant differences existed between the dependent variables in the pre-test data, repeated measures analysis of variance (ANOVA) and covariance (ANCOVA) were used. One of the assumptions of these tests is the equality of variances, which was verified using Levene's test. The equality

of variances assumption was confirmed at the 0.05 significance level for all study variables. Therefore, repeated measures ANOVA and ANCOVA were applied to test the research hypotheses.

As shown in Table 6, aerobic exercises significantly improved fine and gross coordination skills across all measured components.

Table 5. Kolmogorov–Smirnov test results for the measured variables in pre-test and post-test

Variable	Group	Stage	Z-value	Significance (P)
Coordination skill	Experimental	Pre-test	1.296	0.070
		Post-test	0.787	0.565
	Control	Pre-test	0.985	0.287
		Post-test	1.451	0.060
Social adjustment	Experimental	Pre-test	0.746	0.634
		Post-test	0.734	0.654
	Control	Pre-test	0.889	0.408
		Post-test	0.858	0.453
Parental worry	Experimental	Pre-test	0.802	0.541
		Post-test	0.690	0.728
	Control	Pre-test	1.159	0.136
		Post-test	1.146	0.145

Table 6. Levene's test results for equality of variances in dependent variables

Variable	Group	Stage	Z-value	Significance (P)
Coordination skill	Experimental	Pre-test	1.296	0.070
		Post-test	0.787	0.565
	Control	Pre-test	0.985	0.287
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Parental worry	Experimental	Pre-test	0.802	0.541
		Post-test	0.690	0.728
	Control	Pre-test	1.159	0.136
		Post-test	1.146	0.145

The results of between-group and within-group comparisons indicated that aerobic exercise, unlike social adjustment and parental worry, could significantly impact the performance of children with autism.

Given the within-group significance (Table 7), post-hoc LSD tests were applied to determine the pairwise differences. Table 8 shows that in the experimental group, significant differences were observed across all stages, while in the control group, significant changes were only observed between pre-test and post-test.

These results indicate that aerobic training had a significant effect on coordination in children with autism, thus rejecting the null hypothesis and confirming the research hypothesis.

Table 7. Repeated measures ANOVA results for within-group changes in coordination test

Source of variation	Sum of squares	df	Mean square	F	Significance (P)	Eta squared
Effect of measurement stages	21.4	1	10.7	11.5*	0.0001	0.4
Group × measurement stages	43.4	12	21.7	23.4*	0.0001	0.7
Within-group error	33.3	15	0.9			

Table 8. Pairwise comparisons (LSD) for within-group changes in coordination test

Group	Stage 1	Stage 2	Difference	Standard Error	Significance (P)
Experimental	Pre-test	Mid-test	-1.4*	0.3	0.0001
	Pre-test	Post-test	-3.8*	0.6	0.0001
	Mid-test	Post-test	-2.1*	0.3	0.0001
Control	Pre-test	Mid-test	0.2	0.2	0.4
	Pre-test	Post-test	-0.7	0.2	0.2
	Mid-test	Post-test	0.5	0.2	0.7

4. CONCLUSION

This research demonstrated that aerobic exercise training significantly influences the coordination skills of autistic children, contrary to social concerns and parental worries. Due to the lack of a similar research background, a direct comparison could not be made; however, a study conducted by Yanik and colleagues, focusing on aerobic exercise, vestibular stimulation, and neurodevelopmental therapy in children aged 7 to 10 with Down syndrome, found no significant differences in the outcomes of these interventions. Notably, the aerobic exercise group showed a significant improvement in sensory integration and fine motor skills related subtests [22].

The findings of this study suggest that aerobic exercise training has a meaningful impact on the coordination of autistic children. The explanation for this result lies in the fact that physical exercises contribute to better force distribution, timing between movements, enhanced learning, and consequently, the development and refinement of relevant motor programs. The improvement in coordination can also be attributed to the reliance on proprioceptive information from deep receptors, as rhythmic exercises facilitate the transmission of sensory signals to higher neural centers [23].

According to social learning theory, the acquisition of social skills occurs through a child's interactions with the environment. Therefore, children with autism can experience social skills by actively observing activities in the environment, interacting with peers, classmates, and establishing positive interactions with their surroundings. In this regard, creating a sports environment accompanied by music and rhythmic movements provides the opportunity for autistic children to be seen alongside their peers, fostering dynamic and positive interactions. Aerobic exercises, by creating a lively and dynamic environment, allow children to establish relationships with their surroundings, and participating in these group physical activities enhances imitation skills in these children, significantly aiding their social adaptation [24]. Therefore, the non-alignment of the present research results with previous studies may be due to the specific conditions of the participants, the duration of training sessions, and the nature of the exercises involved.

Autism spectrum disorders have severe effects on family life, and one of the parents' biggest concerns about their child's future is the lack of understanding from others about the child's condition. The most stressful factor experienced by parents of autism is the limited societal acceptance of autistic behaviors and the failure to receive social support. Artistic, sports, and scientific educational approaches enhance the self-awareness of mothers, helping them recognize the strengths and weaknesses and change their attitudes and beliefs successfully. It seems that parents, by observing that their children receive support from specialists and trainers in classes such as sports, can successfully cope with their stresses and problems. Therefore, the non-alignment of the present research results with previous studies may be due to the specific conditions of the participants, parental perspectives, and the educational environment.

5. GENERAL CONCLUSION OF THIS STUDY

Given the above results, it can be concluded that empowering autistic children in all behavioral and motor areas through simple and dynamic physical activities such as aerobics is possible. Such activities can significantly impact the lives of these children to a great extent, improving the quality of their future lives.

6. RESEARCH RECOMMENDATIONS

Considering the limited number of participants in this study due to constraints in selecting participants and the high cost of such research, it was not possible to conduct this research with a larger group. Therefore, it is recommended to expand this study on a larger number of children. Furthermore, providing accurate motion assessment tools and other measurement instruments can enable the investigation of the effects of physical exercises and any other type of exercise on each of the fundamental functions and other behavioral functions of children in a more detailed manner.

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Transparency Statement

The data supporting this study are available upon reasonable request to the corresponding author, subject to ethical and confidentiality considerations.

Declaration of Interest

The authors declare that they have no competing interests.

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