Sport Sciences and Health Research

University of Tehran
Faculty of
Physical Education and Sport Science

The effect of training program on Autism Spectrum Quotient scores

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Article Info

Original Article

Article history:
Received: 18 March 2023
Revised: 10 June 2023
Accepted: 16 June 2023
Published online: 01 July 2023

Keywords:
autism
spectrum quotient
training.

Abstract

Background: Autism Spectrum Quotient (AQ) functions as an evaluative instrument designed to assess traits associated with autism. Variances exist within the brain of individuals on the autism spectrum. Moreover, certain exercises have the potential to impact specific regions of the brain.

Aim: This study aims to investigate how the program training of this study impact Autism—Spectrum Quotient.

Materials and Methods: Forty-two children aged 7-10 years with ASD were recruited to participate in this study. These children were randomly divided into two groups: the control group (N=10, 7.80±1.35 years) and the experimental group (N=32, age: 8.16±1.16 years). The experimental group underwent an 8-week training program. The Autism Spectrum Quotient (ASQ) questionnaire was used to assess the participants' scores in the pretest and posttest. This questionnaire consists of five subscales: social skills, attention switching, attention to details, communication, and imagination, as well as a total score.

Results: Based on the results, the program training had an impact on attention to detail (P=0.017) and social skills (P=0.057). However, there was no significant difference between the pretest and posttest scores for attention switching (P=0.096), communication (P=0.07), and imagination (P=0.161).

Conclusion: Based on the results, we can conclude that the program had a small but significant effect in terms of quantity. Due to the specific and unique structure of the brain, it takes time to achieve a substantial impact.

Cite this article: Nazary Sharif H, Salar S, Haegele JA. "The effect of training program on Autism Spectrum Quotient scores". *Sport Sciences and Health Research*. 2023, 15(2): 255-266. doi: https://doi.org/10.22059/SSHR.2024.328800.999.

EISSN: 2717-2422 | Web site: https://sshr.ut.ac.ir/ | Email: sshr@ut.ac.ir
 Publisher: University of Tehran, Faculty of Sport Sciences and Health

1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder which is characterized by deficits in social communication (e.g., deficits in nonverbal communication behaviors) and behavioral (e.g., stereotyped or repetitive behaviors) development [1]. In addition to the core social and behavioral characteristics, persons with ASD often present a range of co-morbidities, such as anxiety, developmental coordination disorder, and intellectual disability [2]. Although, traditionally, ASD has considered as a clinical condition which was totally distinct from general population, recent studies suggest that autistic traits are continuously distributed across the population [3, 4]. Enumerating the rate of ASDs is difficult, but the World Health Organization (2017) indicates that approximately 1 in 160 children worldwide is diagnosed with ASD [5].

Research supports physical activity as a mechanism to yield promising results with regard to cognitive benefits [6, 7], insofar that some researchers consider the impact of sport and physical activity on mental health and cognitive functioning critical [8, 9, 10]. Frequently, investigations have demonstrated that physical training can prevent cognitive decline and dementia [11, 12, 13, 14]. These effects are mainly attributed to better circulation as a result of exercise, which improves cerebrovascular health and determines benefits on metabolism of glucose and lipid, and oxygen supply to the brain [8, 15], can prevent cognitive decline [16].

Furthermore, studies have demonstrated that physical exercise can cause structural changes (e.g., increased gray matter volume in frontal and hippocampal regions), and following these changes, reductions in damage in gray matter are found [17]. All of these changes and effects are reflected on cognitive functioning [18], which is the determinant of behaviorally choices.

Furthermore, emotional states involving prefrontal areas and limbic structures affect cognitive functions [19]. Brain volumes, measures of white matter integrity or modulation in neurotrophins levels can be correlated to cognitive performance [17].

Looking at a more optimistic perspective, current evidence indicates that incorporating exercise and other physical activities into intervention programs for children with ASD can have a positive effect. Physical exercise has shown to be beneficial in addressing various issues related to symptoms such as motor deficits, obesity, difficulties in task execution, cognitive functioning, behavioral stereotypy, aggressive behaviors, and socioemotional well-being [20]. For instance, Chrystiane et al. showed that exercise can affect positively autism traits [20].

Bahrami et al. (2012) examined the impact of an exercise program called Kata techniques on children diagnosed with ASD. Their research determined that the program consistently reduced stereotypic behaviors in 42.54% of the participants who were assigned to the exercise group [21].

Smaller brain volumes and increased cerebrovacular disease can be in result of obesity, sedentary lifestyle, and lower physical activity [22]. Whereas ASDs is a neurodevelopmental disorder, obesity, sedentary lifestyle, and lower physical activity can intensify this disorder. Thus, it is not surprising that studies have demonstrated that children with ASDs tend not to engage in sufficient amounts of

physical activity, and spend most of their time in sedentary pursuits in comparison to typically developing (TD) children [23, 24, 25].

Engaging in an inactive lifestyle can affect brain function and health significantly [26]. For example, Oriel et al. (2011) stated that aerobic exercise prior to classroom activities may improve academic responding in young children with ASD. However, exercise had no significant effect on stereotypic behaviors [27].

There are some studies that provide conflicting results. For example, Kern et al. (1984) studied the effect of exercise on three children with ASD between 7 and 11 years of age, and found stereotypic behaviors to decrease significantly following vigorous jogging for 15 min [21]. However, in the same study, mild exercise was not effective [28].

Similarly, Liu et al. (2016) examined the effect of physical activity on stereotypic behaviors of children with ASD and found a noticeable reduction in stereotypic behavior for 2 hours after a 15 min moderate to vigorous exercise session [29]. In addition, Levinson and Reid's study (1993) demonstrated that although moderate exercise condition have little effect on the motor component of stereotypic behavior, the vigorous exercise condition resulted in a mean reduction of 17% [30].

Dong et al. reported that "Physical activity intervention had a moderate effect in improving attention problems in school-aged children with ADHD" [31].

Based on Zohaib et al., physical activity may improve social skills and help autistic children in their cultivating social skills [32]. Most of the studies approved the positive effect of physical activity on attention and social skills [33, 34, 35].

In order to quantify traits related to ASD, Autism-Spectrum Quotient (AQ) is widely employed in studies and clinical practice. For example, Ruzich et al. (2015) showed that in young adolescents, female siblings of individuals with autism spectrum condition scored higher AQ scores than control female [36]. Similarly, Egito et al. (2018) investigated factor analysis of the Brazilian Version of the Adult AQ and demonstrated that this version is an adequate instrument in order to evaluate signs compatible with the autism spectrum in adults [37].

At first, the AQ was used as a self-report measure for adults, and then a parent-report measure for adolescents (age: 12 to 15 years) and for children (age: 4 to 11 years) was developed. This assessment shows how many traits related to ASD that person demonstrates. Mostly, for adults with the average IQ, this questionnaire is self-report, otherwise, for children and individuals with lower IQ, it is parent report [38, 39]. The effect of physical activity on different cognitive variables among individuals with ASD is a subject which warrants further research. In addition, the gap of research examining exercise-based interventions on the AQ is substantial. Therefore, the purpose of this study is to investigate the effect of physical activity on AQ scores.

2. Materials and Methods

2. 1. Participation

Prior to any data collection, the educational system of disabled children of Tehran checked the project ethically. After approval, the approbation was given for entering schools and recruiting children with ASD in Tehran, Iran. The statistical population for this study was children with ASDs of Tehran, and the statistical sample

of the study was selected randomly. All of the subjects had files and record that included an ASD diagnosis. All the subjects attended to a school or institution for children with ASD.

From medical records, the state of cardiovascular, pulmonary, and musculoskeletal conditions of subjects were evaluated, and those with diseases, lack of orthopedic, cardiovascular, vestibular system, and somatic sensory system problems were excluded from the study. 32 Autistic children as experimental group (age: 8.16±1.16 years, height: 124.81±11.56 cm, weight: 33.02±7.72 kg, and BMI: 21.12±3.14 kg/m^2) and 10 Autistic children as control group (age: 7.80±1.35 years, height: 126.30±6.44 cm, weight: 34.80±4.61 kg, and BMI: 21.72±1.81 kg/m^2) were recruited to participate in this study.

Subjects were selected who demonstrated the ability to successfully engage in the training protocol with the research team and could be communicated with to perform exercises. Sometimes, research team members performed exercises alongside the children so that they could comprehend what the researcher was trying to convey. Severely autistic individuals were excluded because they were unable to perform any types of exercises at all. Therefore, all of the participants were high functioning Autism.

2. 2. Instrument

AQ includes 50 items which assess preferences and habits [39]. Four-point Likert scale is the type of this questionnaire, with the answers of definitely agree, slightly agree, slightly disagree, and definitely disagree. All 50 items were divided into five subscales, including 10 items are for each: social skills, communication, imagination, attention to the details, and attention switching. The range of score is 0-150 in which lower scores illustrates lower autism traits and higher scores shows higher and more traits. This questionnaire is based on parents' feedback.

Hoekstra et al. (2008) studied the validity and reliability of the Autism-Spectrum Quotient (AQ). According to their study, the test-retest reliability, as assessed in 75 young adults recruited for the study, was found to be r= 0.78 for the total AQ score and r= 0.79 for the Social Interaction factor. The test–retest reliabilities for the lower order domains and the attention to detail factor were respectively: r= 0.71 (attention to detail), r= 0.69 (social skill), r= 0.68 (attention switching), r= 0.60 (communication), and r= 0.81 (imagination) [39].

The intervention was an 8-week (3 session per week) training program. Every session was 25 to 30 min, and divided to warm up, the program training, and cool down. Warm up and cool down were 5 to 7 min each, and 15 to 20 min (sometimes it took longer) were spent for the training program. The program focused on strengthening the core [40]. The trend of the program intensity gradually increased with the numbers of the week. The developmental of this program, which included a combination of Swiss ball training activities, was undertaking with the interest of the children. Furthermore, according to recent studies, vigorous exercises can be effective for reducing stereotypical behavior [30], and aerobic exercises were found to be effective for cognitive skills [27]. Since this program is a combination of vigorous and aerobic, and also seem to be interesting for children, it was selected for this study (Table 1).

Table 1. Program training

First and second week
Holding the abdomen in, in a supine position (3 sets and 20 reps in each set)
Holding the abdomen in, in a prone position (3 sets and 20 reps in each set)
Holding the abdomen in, in a squatting position (3 sets and 20 reps in each set)
Third week
Holding the abdomen in, with one leg in the abdomen in a supine position (3 sets and 20 reps in each set)
Holding the abdomen in, with one leg in the abdomen in a prone position (3 sets and 20 reps in each set)
Side lying bridge (for each side of the body, 6 reps, 10 sec pause)
Fourth week
Holding the abdomen in, in supine position with limbs up and keep hands and feet close together (3 sets and 20 reps in each set)
Squatting with raising one leg out of back (3 sets foe each leg and 20 reps in each set)
Trunk rotation while holding weights in each hand (3 sets each part of the body and 20 reps in each set)
Fifth week
Sitting on a Swiss ball and holding the abdomen in (3 sets, 10 sec)
Squatting while the Swiss ball is on the shoulder (3 sets and 15 reps for each set)
Bringing up the arm and legs simultaneously in the prone position (3 sets and 10 reps for each set)
Sixth week
Doing long in a 45 degrees inclined direction to the left or right (3 sets and 12 reps for each set)
Bridge (shoulders and hands on the ground and the bringing up on hip and foot (3 sets and 15 sec pause for each set)
Seventh week
Lying supine on the Swiss ball and rotating the trunk to the sides (3 sets and 15 reps for each set)
Doing the above exercise with holding weights in the hands (3 sets and 15 reps for each set)
Side lying bridge with bringing up the leg (6 repetitions for each side of the body and 10 sec pause)
Eighth week
Lying supine on the Swiss ball and holding the abdomen in and bringing one leg up (3 sets and 20 reps for each set)
Raising the opposite arm and leg while squatting (3 sets and 20 reps for each set)
Bridge so that the feet are placed on the Swiss ball and raise one foot (3 sets and 15 sec pause for each set)

2. 3. Procedure

After the parents' consent, AQ questionnaires were completed by parents as pre-test. Then, all of the children were exposed to the intervention (training program). After the period of the program training AQ questionnaire was filled by parents as posttest.

2. 4. Statistic

Shapiro-Wilk test was used to assess the assumption of normality. This assumption was satisfied concerning with all variables except the total number. Thus, two-tailed paired sample t tests were used to compare pre- and post-test for normal data (social skill, attention switching, attention to the details, communication, imagination), and Wilcoxon test, which is a none-parametric test, used to compare pre and post-test of total score. Also, Mann-Whitney U was employed to compare two groups in total score. The assumption of normality related to total score was not satisfied in both groups. All of the statistical analysis had been done on SPSS 16.0, and $P \leq 0.05$ considered as significance level for comparison of scores.

3. Results

3. 1. Normality test

Shapiro-Wilk test was showed that all of the variables were normally distributed.

3. 2. Comparison tests

Paired sample t-test illustrated that there was significant difference between pre and posttest in social skills and attention to the details (Table 2) between experimental group and control group.

According to the results of Wilcoxon test (Table 3), there was a significant difference between the pre and post-test of the experimental group; however, in the control group, there was no significant difference. Also, Mann-Whitney test (Table 4) showed there was no significant difference between two groups in pretest, but in posttest the difference was significant.

Table 2: Paired sample t-test for ASQ

Variable		Mean	SD	t	sig
Experimental group					
Social skills	Pretest	13.34	4.81	1.97	0.057*
	Posttest	13.18	4.70		
Attention switching	Pretest	16.21	3.29	1.71	0.096
	Posttest	15.90	3.24		
Attention to the details	Pretest	13.25	4.38	2.52	0.017*
	Posttest	13.03	4.16		
Communication	Pretest	15.18	4.53	1.86	0.07
	Posttest	14.90	4.54		
Imagination	Pretest	16.50	4.60	1.438	0.161
	Posttest	16.43	4.63		
Control group					
Social skills	Pretest	16.10	3.41	0.890	0.423
	Posttest	15.7	2.71		
Attention switching	Pretest	16.40	2.50	-1.037	0.327
	Posttest	17.2	2.48		
Attention to the details	Pretest	14.70	2.58	-0.208	0.840
	Posttest	14.80	2.89		
Communication	Pretest	16.40	3.74	0.514	0.619
	Posttest	16.20	3.70		
Imagination	Pretest	18.0	2.74	1.078	0.309
	Posttest	17.60	2.66		

* $P \leq 0.05$

Table 3. Wilcoxon test for total score

Group		Mean	SD	sig
Experimental	Pretest	74.50	12.17	0.001*
	Posttest	73.46	11.83	
Control	Pretest	81.60	8.23	0.587
	Posttest	81.50	7.18	

* $P \leq 0.05$

Table 4. Mann-Whitney U for total score

Variable		Z	sig
Total	Pretest	-1.73	0.084
	Posttest	-2.04	0.041*

* $P \leq 0.05$

4. Discussion

This study showed that although the reduction of AQ score after the program training was significant, it was small in number a quantity. If an exercise training program can be consistently implemented for a long period of time, AQ scores maybe decrease noticeably. The exercise program had specific effects on attention to the detail and social skills. However, there was no significant difference between the pre- and post-test in attention switching, communication and imagination. Also, statistical analysis showed the significance difference between two groups in posttest. The congruity between two groups was assessed in pretest that was proved.

The hypothesis regarding neurotransmitters proposes that the impact of physical exercise on stereotypical behaviors might occur because of the influence it has on neurotransmitters. Studies in neurobiology investigating the potential triggers of stereotypic behaviors in people with autism encompass abnormalities within the serotonin, dopamine, and GABA neurotransmitter systems [41, 42].

More precisely, it has been demonstrated that the malfunctioning of these neurotransmitter systems in the basal ganglia is responsible for inducing stereotypic behaviors in individuals with autism [43].

Research on exercise has demonstrated that engaging in physical activity has the capacity to bring about beneficial alterations in the production and breakdown of monoamines [44]. In a study, Ma (2008) consolidated research findings on the advantageous effects of moderate exercise on the physiological processes associated with brain well-being and revealed that exercise promotes the augmentation of norepinephrine, serotonin, and GABA [45]. Additionally, Petzinger et al. (2015) observed that regular treadmill exercise has the potential to enhance dopamine neurotransmission [46].

Physical activities and exercises program can be effective in reducing AQ scores of children with ASDs, which may suggest that training programs, like the one in this study, can help improve brain function. The results of this study support previous findings [47, 48, 49, 50]. Brain oxygenation and brain network are two crucial elements to improve brain function. They can be provided by exercise and physical activity [50]. The cognitive function of these areas is impaired in autism [51, 52, 53]. Exercises and physical activity improve cognitive function [47, 54], and the AQ score is correlated with brain function and social attention [55]. The results of the present study are consistent with Movahedi et al. (2013) that showed long term Kata techniques training can improve social dysfunction of children with ASD [56].

As it was mentioned, one of the mechanisms that make exercise an effective element in brain function is oxygenation. Frequently, studies showed that moderate exercises improve brain oxygenation [57, 58, 59]. Changes in tissue (brain) oxygenation are associated with brain activity [60], and this oxygenation strongly depends on the training intensity. Low to moderate intensity exercise can increase cerebral oxygenation; however, during maximal exercises, cerebra oxygenation will be decreased [57].

Thomas and Stephane (2008) reported that prefrontal cortex oxygenation is increased in the first minutes of exhaustive exercise but is reduced significantly from the workload corresponding to the second ventilator threshold up to exhaustion [61].

However, Endo et al. (2013) showed different results. According to their study, it is likely that, for 15 min ergometer exercise at moderate intensity to improve cognitive function through increased neural oxygenation in the prefrontal cortex [62].

Conflicting results can be related to the exercise intensity. In maximal exercise, cerebral deoxygenation occurs across prefrontal, premotor, and motor cortices [63]. Moreover, some studies shows that this deoxygenation in maximal exercises is greater in prefrontal than premotor and motor region [63]. Since the training program of this study is low to moderate intensity, one of the reasons of significant effects can be due to brain oxygenation.

Another reason why exercises can improve brain function, which leads to improved AQ, is brain network. AQ provides a principled approach to predicting core function and deficits associated with specific brain system [64].

Zielinski et al. (2012) demonstrated that specific abnormalities in brain network structure are present in ASD. They reported that the extent and distribution of the salience network, involved in social-emotional regulation of environmental stimuli, is restricted in ASD. In contrast, there is an increased distribution of posterior elements [65].

The salience network is a part of the brain that consists of the dorsal anterior cingulate cortex (dACC) and bilateral insula [66]. These regions of the brain contribute to communication, social behavior, and self-awareness through the integration of sensory, emotional, and cognitive information [67].

Voss et al. (2010) studied the effect of exercise on brain network. It was not significant after 6 months, but there was a significant increase in functional connectivity between aspects of the frontal, posterior, and temporal cortices within the Default Mode Network and a Frontal Executive Network, two brain networks central to brain dysfunction [65].

Although the changes in AQ in the present study were significant, it is not noticeable in number. This may be related to the time of the program training. Time has been noted as an important factor for an exercise program to be effective on brain. McFadden et al. (2013) showed that intrinsic activity in the default mode network significantly was reduced after 6 months exercise. The training program was a supervised treadmill-walking program, and the intensity increased from 60% to 75%, which is considered moderate exercise [69].

Brain network is correlated with physical and mental fitness [70]. According to Weng et al. (2017), moderate intensity exercises enhances the brain's attention reorienting functions through the integration of the dorsal and ventral attention networks [71]. Individuals with ASD have weaker functional connectivity in dorsal attention network [72]. Attentional processes are modulated by the suppression and engagement of default mode network and dorsal attention network [73].

Based on the results of the present study, the training program affects attention to details significantly. Regarding the results of the previous studies, the effects of physical activities on default mode network and dorsal attention network can be the reason why our program was effective in enhancing attention to detail.

Although the effects of exercises on brain frequently have been studied, it is not clear that how exercises and physical activities can be effective on brain function, and what are its effects on regions of brain

distinctively. But it is clear that the intensity of the exercises is one of the most important key elements to affect the brain function. AQ shows brain function in some specific areas. To understand more clearly how physical activity can affect brain function, it is strongly needed to study brain activities in specific areas in different exercise intensity.

5. Conclusions

However, the statistical results of the present study show that the program training affect social skills and attention to the details, other elements such as imagination, attention switching and communication were on the edge of significance. Obviously, it takes time much longer for program training to be effective on brain. The changes in scores statistically are significant, but they were small. Brain needs time more than body to accept and adapt to changes.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors contributed to analysis of the results and to the writing of the manuscript.

Ethical considerations

The authors have completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc. This article has the ethical code by the code of IR.SSRC.REC.1399.082.

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

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