Chettinad Health City Medical Journal
Volume 12, Issue 3 - 2023, Pg. No. 97-104
Peer Reviewed & Open Access Journal

Review Article

A Review of Literature on the Efficacy of Aerobic Exercises on Stereotypic Behaviour for Autism Spectrum Disorder

Rachael Lourdez Sonia D[1], Prasanna Mohan[2], R Sedhunivas[3], S Senthil Kumar[4]

[1]Masters of Physiotherapy, [2,3,4]Associate Professor, Garden City University, Bangalore, Karnataka.
DOI: https://doi.org/10.24321/2278.2044.202358

I N F O

Corresponding Author:
Rachael Lourdez Sonia D, Garden City University, Bangalore, Karnataka.
E-mail Id:
rachael98289525@gmail.com
Orcid Id:
https://orcid.org/0009-0001-1255-0160
How to cite this article:
Sonia DRL, Mohan P, Sedhunivas R, Kumar SS. A Review of Literature on the Efficacy of Aerobic Exercises on Stereotypic Behaviour for Autism Spectrum Disorder. Chettinad Health City Med J. 2023;12(3):97-104.

Date of Submission: 2023-02-24
Date of Acceptance: 2023-06-10

A B S T R A C T

Background: Autism Spectrum Disorder (ASD) is a heterogeneous neurobiological condition that features restricted, repetitive, and stereotypic behaviour, and impairments in social interaction and verbal and non-verbal communication. Autism is caused due to genetic and environmental factors. Autism is classified into five major types: Rett's disorder, Asperger's disorder, autistic disorder, childhood disintegrative disorder, and pervasive developmental disorder not otherwise specified. Stereotypic behaviour is involuntary; sensorial self-regulation activities are present in autistic children. Aerobic exercise (AE) is described as a type of exercise that elevates the heart rate and oxygen consumption of the body. It has been seen to cause improvement in an ASD child's physical development, cognitive development, and body composition.

Aim: This article aims to present a review of the relevant literature on the efficacy of aerobic exercises on stereotypic behaviour in ASD children.

Methods: This review is based on the PRISMA guidelines. The databases used for searching the articles were PubMed and Google Scholar. Inclusion criteria were taken care of while selecting the articles. The articles between the years 2011 and 2022 were selected.

Results: In this review, ten studies were selected according to the inclusion criteria and all these studies showed the effectiveness of aerobic exercise and a decrease in stereotypic behaviour in ASD children.

Conclusion: This literature review analysed the efficacy of AE on stereotypic behaviour in ASD children. This study concluded that physical activity, which included aerobic exercise, reduced the stereotypic behaviour of children affected by ASD.

Keywords: Autism Spectrum Disorder, Stereotypic Behaviour, Aerobic Exercise, Self-Stimulatory Behaviour, Physical Activity

Introduction

Autism Spectrum Disorder (ASD) is a neurobiological disorder that manifests as a variety of social interactions, verbal and non-verbal communication, limitations, and repetitive and stereotypic patterns of behavioural impairments.[1] ASD may also be described as a neurodevelopmental disorder that is predisposed by both hereditary and

environmental variables. Neurocognitive processes have a significant influence on the behaviour of people suffering from ASD.[2] With a male-to-female ratio of 3:1, the incidence of ASD is predicted to be 6 per 1000. The prevalence rate of ASD is five times higher in boys than in girls.[3] The aetiology of autism tends to be complicated and multifactorial, involving both genetic and environmental aspects.[4] Therefore, the genetic condition is comprised of tuberous sclerosis and fragile X syndrome. The three phases of the environmental factor are prenatal, perinatal, and postnatal. Prenatal risk factors include teratogen exposure, pesticide exposure, and congenital rubella syndrome. Obstetric diseases including preterm birth, hypoxia during birth, and irregular gestational periods are examples of perinatal risk factors. Postnatal risk factors include vitamin D insufficiency, heavy metal toxicity, leaky gut syndrome, autoimmune illness, viral infection, and oxidative stress.[3] The biological environment, which is composed of all chemical, bacterial, viral, and physical environmental effects and exposures that predominantly and directly affect a person's physiology, is one of the environmental risk factors for ASD. The biological environmental risk factors include maternal and paternal age, foetal environment, perinatal and postpartum events, medicines, smoking and alcohol use, nutrition (including short inter-pregnancy periods), immunisation and toxic exposure, psychological symptoms, and protective factors. Induced labour, no labour, breech presentation, foetal discomfort, gestational age less than 36 weeks, and caesarean delivery all increase the risk of autism.[5]

Five main types of ASDs are distinguished. These are childhood disintegrative disorder, pervasive developmental disorder, Asperger's syndrome, Rett's disorder, and autistic disorder.[6]

The neuropathology of autism is attributed to a variety of factors. According to some studies, the neurological and neuropsychiatric disruption in ASD may be due to a minor anomaly in the development of the cerebellum, limbic structure (hippocampus and amygdala), brainstem (olivary nuclei), and cerebral cortex (which includes megalencephaly and increased neuronal density).[7] Various current hypotheses explain the origin of ASD. Neuronal disruption, impaired migration, excitatory-inhibitory activity imbalance, dendritic formation, synaptogenesis, immunology, neuroinflammation, mirror neuron theory, and epigenetics contribute to neurodegenerative disorders.[8] The common signs of ASD include restricted, repetitive, and stereotypic behaviour patterns, impairments in social skills and communication deficits, and also in a disturbance in sensory-motor stimuli.[9]

Stereotypic behaviour, also known as Self-Stimulatory Behaviour (SSB) or repetitive and restrictive behaviour, is commonly seen in autistic children.[10] Toe walking, hand-arm flapping, body swaying or spinning, finger flicking, jumping impulsively, swinging forward and backwards, spinning toys, sniffing, and sudden and delayed echolalia are characteristics of stereotypic behaviours.[11] These are involuntary, sensorial self-regulation movements that limit an individual's interaction with the environment.[12]

Aerobic Exercise (AE) activity that involves the use of oxygen by the body's metabolic system is called aerobic exercise.[13] During aerobic exercises, the body generates energy by utilising the oxygen in the air surrounding it, and this process influences the enhancement of cognitive function. The persistent use of AE training consistently increases the hippocampus's growth, which is responsible for regulating emotions, motivations, memory, and overall learning capabilities, and improving the quality of life. Aerobic physical activity develops social skills, regulates emotions, and increases attention span.[14] Exercise places the circulatory system under stress, modifying brain physiology and potentially enhancing the cognitive effects of the exercise's cognitive components. Rapid neurochemical modifications brought on by vigorous aerobic exercise may also help the brain get ready for future or ongoing active learning. According to motor skill instruction, aerobic exercise causes a higher amount of skill repair than either acquiring skills or exercising alone.[15]

The literature review on aerobic activities for children with autism spectrum disorders exhibiting stereotypic behaviour is limited. The efficacy of aerobic exercise in reducing stereotypic behaviour in autistic children is the focus of this study.

Need of the Study

ASD is a neurobiological disorder that impacts the Quality of Life (QoL) by impairing social and communication skills as well as limited, repetitive, and stereotypic behaviour.[2] It is caused due to pathological changes in the brain's neural mechanisms, physiological, genetic, and metabolic changes along with infections and other illnesses. Stereotypic behaviours include nodding, shaking arms, jumping, rotating body weight, manipulating objects, avoiding eye contact, and interrupting learning.[16]

So, the purpose of this review of the literature is to analyse the articles to establish whether aerobic exercise reduces stereotypic behaviour in children with ASD.

Objective of the Study

To conduct a review of the literature on the efficacy of aerobic exercises on stereotypic behaviour for autism spectrum disorder.

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202358

Materials and Methods

Study Design

This review of literature is based on the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) guidelines.

Inclusion Criteria

- Articles that included ASD with stereotypic behaviour
- Articles published only in English
- Articles containing full-text
- Articles including both genders
- Age group between newborn and 20 years
- Articles published from 2011 to 2022

Exclusion Criteria

- Articles published in languages other than English
- Articles published before 2010
- Articles have not included other than aerobic exercises
- Articles not related to keywords
- Articles with participants' ages above 20 years

Methodology

This review was based on the PRISMA guidelines, and the articles were searched in PubMed and Google Scholar using the keywords "autism spectrum disorder, stereotypic behaviour, aerobic exercise, physical activity, and self-stimulatory behaviour". Replicated articles were removed by screening the titles. Only English language articles were chosen so that we could obtain relevant analyses, suitable interpretations, data analysis, and accurate information to be stated in this review. Articles published between the years 2011 and 2022 were considered. Full-text articles were chosen so that comprehensive information could be gathered from articles. Articles with unrelated keywords, articles published in languages other than English, and articles published before 2010 were excluded according to the exclusion criteria. Ten articles were selected on the basis of the inclusion and exclusion criteria. Figure 1 shows how the articles were selected.

Table 1 provides an overview of the selected articles.

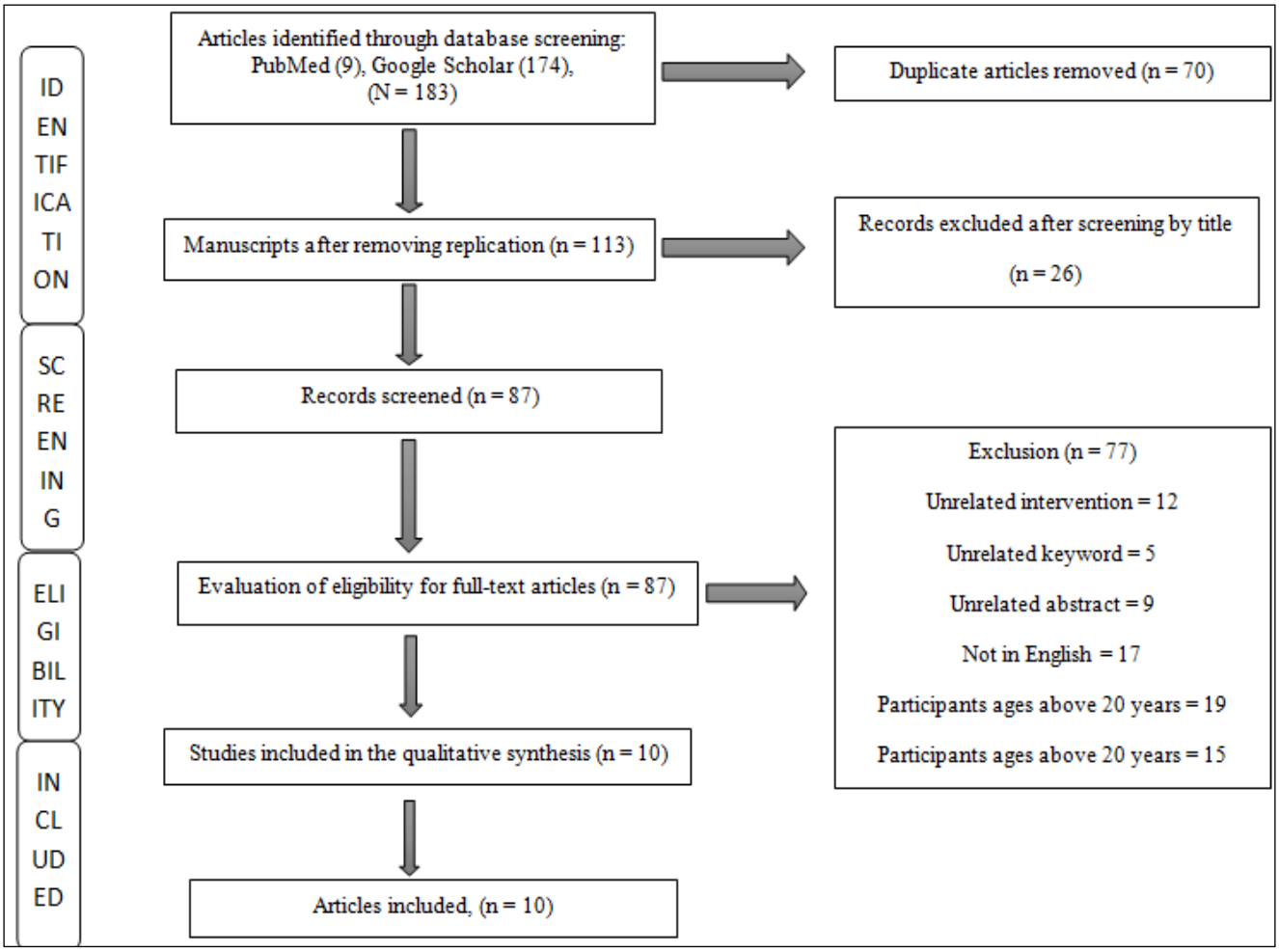

Figure 1.Flowchart of the Selection of Articles

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202358

Table 1.Details of Selected Articles

S. No.	Authors	Year	Type	Conclusion
1.	Oriel et al.[12]	2011	Within-subject crossover study	This study employed a within-subject crossover design strategy, with a treatment group participating in aerobic exercise and a control group from four classes of students aged 7 to 11 years. Two classrooms were chosen as the treatment group, while the other two classrooms served as the control group. This study was conducted for three weeks. It showed that it was possible to improve academic performance in ASD children by providing them with exercise before participating in classroom activities. This article discussed the importance of aerobic exercise in young children with Autism Spectrum Disorders (ASD). The 15 minutes of aerobic exercise, a method that was affordable and simple to apply, provided a way to improve academic performance.
2.	Mays et al.[17]	2013	Review study	This study aimed to determine whether antecedent aerobic exercise (jogging) might decrease stereotypic behaviour. Two severely autistic elementary-aged students were the participants in this study. The stereotypic behaviour was reduced during instructional sessions. They conducted the interventions between Alison and Boyd and they compared the percentage of stereotypic behaviour. They had seen a minimal decline in Boyd's stereotypic conduct and a moderate decline in Allison's stereotypic behaviour. According to the result of the intervention, following their jogging sessions, both individuals spent less time behaving stereotypically than they were at baseline, indicating that aerobic exercises were effective. They concluded that simple interventions like vigorous jogging can reduce stereotypic behaviour immediately following the workout, at least for a short time.
3.	Neely et al.[18]	2014	Experimental study	In this study, the impacts of antecedent physical activity carried out during instruction sessions for children with ASD were examined. Due to the participants' fatigue from the exercise, two theories have been put forward to explain the impacts of antecedent exercise on stereotypy. Following antecedent physical activity that persisted until the behavioural markers of satiation occurred, there were higher levels of academic engagement and lower levels of stereotypy during the instructional sessions.
4.	Young and Furgal[19]	2016	Short review	This study was conducted with individual ASD children. The child performed antecedent exercises like jogging or running, trampoline exercises, and water-based exercises. According to this study, such exercises seem to have a positive effect on reducing undesirable behaviours and encouraging desired action in children with ASD. Aerobic exercise was found to increase academic performance for these children. They reported that aerobic exercise was correlated to a short-term decline in self-stimulation by stereotypic behaviour.

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202358

5.	Olin et al.[20]	2017	Experimental study	This study, which involved seven autistic children under the age of 13 years, was chosen for the review. Baseline behaviour measurements and pre-exercise and post-exercise measurements were taken in this study. Participants self-selected an elliptical cycle, or treadmill ergometer for their initial workout. For the experimental conditions, four specific aerobic exercises were done continuously for 10 or 20 minutes at either a low or high intensity. The reduction of self-stimulatory behaviour in autistic children was observed after giving them shorter and less intense exercise. They concluded that low-to-moderate intensity exercises significantly reduce the stereotypic behaviour whereas high-intensity aerobic exercises may increase such behaviour.
6.	Ferreira et al.[21]	2018	Cross-sectional study	According to this study, physical exercise helps people with ASD experience decreased comorbidities as well as fewer clinical features. The programme for Children with ASD (PEP-AUT) regimen is to (1) investigate the multi-factor relationships between the metabolic profile, amount of physical activity, level of fitness, and health-related quality of life in children with ASD; (2) to evaluate how a 40-week exercise programme affected all these factors in ASD children. Modifications in the symptom profile and amount of physical activity in children were the primary outcomes. The anthropometric and metabolic profile, aerobic capacity, handgrip strength, socioeconomic status, and health-related quality of life were the secondary outcomes.
7.	Keerthna and Manikumar[22]	2018	Quasi-experimental study	They conducted this study using a quasi-experimental design with 30 children diagnosed with ASD in the age group of 6 to 12 years children with mild to moderate severities. Group A was provided with task-oriented aerobic exercise and Group B with sensory integration therapy for 20 minutes each. It was concluded that Group A (TOAE) showed a significant improvement in the reduction of self-stimulatory behaviour than Group B (SIT), which meant that the task-oriented aerobic exercise group showed better results than the sensory integration therapy group.
8.	Adeogun et al.[23]	2018	Experimental study	This study was conducted among 64 children diagnosed with ASD between the ages of 2 and 20 years. Aerobic exercises that improve autistic children's bilateral coordination, reaction time, and static balance were performed by them for eight weeks. It was suggested that manipulative exercises, aerobic dancing, throwing tiny balls, and catching bean bags should be incorporated into the physical education programme for the students of special schools. It was seen that frequent aerobic exercise benefits children with ASDs in terms of static balance, flexibility, bilateral coordination, response time, and BMI, but has no impact on their muscle strength.

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202358

9.	Strofylla et al.[24]	2021	Experimental study	This study showed that an aerobic exercise programme can enhance participants' motor skills, body composition, and cognitive capacities. The Movement Assessment Battery for Children (2nd ed.) and the Cognitive Assessment System were used to assess cognitive performance. The authors concluded that a 6-month aerobic training programme was beneficial in improving the cognitive capacity to plan and balance, along with visual-motor coordination in ASD children. Also, they observed that aerobic exercises significantly altered body composition.
10.	Cole[25]	2021	Systematic review	In this study, ten articles were reviewed that showed the effectiveness of aerobic exercises on stereotypic behaviour in ASD. The authors concluded that six studies showed a direct positive correlation between aerobic exercise and children with autism through decreased stereotypic behaviour. The other three studies provided the data that assisted in selecting the appropriate fitness tests to better understand the functioning of ASD children's cardiorespiratory system. They conducted a comprehensive analysis of primary and secondary studies involving newborns and adolescents aged eighteen years and above. These comprised articles published between 2015 and 2020 as well as a single 2008 article.

Discussion

There were ten studies included in this review: one systematic review, one quasi-experimental study, one cross-sectional study, one short review, one within-crossover study, one review, and four experimental studies. These experiments investigated the impact of aerobic exercises on children affected by ASD and concluded that these exercises were useful in reducing the stereotypic behaviour of autistic children.

A systematic review by Cole[25] comprised ten studies that investigated how aerobic exercise impacted the stereotyped behaviours of ASD children. This study concluded that six research studies directly linked more aerobic activity to decreased stereotypic behaviour in ASD children and the other three studies stated that they were utilised to decide the necessary fitness tests for the specific population and to know more about how the cardiorespiratory system functions in children with ASD. Thirty participants from both genders, aged 6 to 12 years, were divided into two categories for a quasi-experimental study[22] reviewed in the current article. Task-Oriented Aerobic Exercise (TOAE) was used in Group A (experimental group), whereas Sensory Integration Therapy (SIT) was used in Group B (control group) over six weeks. It was concluded that Group A showed a higher reduction in self-stimulatory behaviour than Group B. According to a short overview,[19] aerobic exercises have been correlated with a momentary decline in self-stimulation through stereotypic behaviour and an improvement in academic performance in autistic children.

In a cross-sectional study, the subjects were evaluated in two phases.[21] Phase 1 was a 12-week cross-sectional research that evaluated participants' manifestations, metabolic activity, level of physical activity, level of physical fitness, socioeconomic status, and health-related quality of participation. Phase 2 was a 48-week therapy experiment that included a 40-week fitness intervention. It was conducted in a facility designed exclusively for children with ASD. Another research showed that the stereotypic behaviour of children with ASDs was reduced with Antecedent Aerobic Exercise.[17] This study compared the behaviour of two children and concluded that an intervention like jogging may reduce stereotypic behaviour for at least a short period after aerobic exercise. A within-subject crossover study was conducted between the treatment group and the control group.[12] Aerobic exercises were performed by the treatment group for 3 weeks. The result of this study was the improvement in the academic performance of children with ASD when aerobic exercises were given before classroom activities.

According to the neurotransmitter theory, physical activity impacts stereotyped behaviours and could be related to the effects of neurotransmitters. Dysfunctions in the serotonergic, dopaminergic, and GABA neurotransmitter systems are among the potential reasons for stereotypic behaviours in people with autism. Aerobic exercise has an

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202358

impact on neurotransmitters which leads to a decrease in stereotypic behaviours due to fatigue.[26] When a functional analysis found a pattern of stereotypy that was persistent across circumstances, the stereotypic behaviour was interpreted as being reinforced by aerobic exercises.[17] Regular aerobic exercise has been shown in several studies to be an effective method of reducing stereotypy and self-stimulation in children with ASD.

Conclusion

The efficacy of aerobic exercises on stereotypic behaviour in ASD children and the improvement in their academic performance by reducing such behaviour was evaluated in this review. This study concluded that physical activity, which included aerobic exercises, reduced the stereotypic behaviour of the children affected by ASD.

Source of Funding: None

Conflict of Interest: None

References

1. Srinivasan SM, Pescatello LS, Bhat AN. Current perspectives on physical activity and exercise recommendations for children and adolescents with autism spectrum disorders. Phys Ther. 2014 Jun;94(6):875-89. [PubMed] [Google Scholar]
2. Demetriou EA, Lampit A, Quintana DS, Naismith SL, Song YJ, Pye JE, Hickie I, Guastella AJ. Autism spectrum disorders: a meta-analysis of executive function. Mol Psychiatry. 2018 May;23(5):1198-204. [PubMed] [Google Scholar]
3. Watts TJ. The pathogenesis of autism. Clin Med Pathol. 2008;1:99-103. [PubMed] [Google Scholar]
4. Lord C, Elsabbagh M, Baird G, Veenstra-Vanderweele J. Autism spectrum disorder. Lancet. 2018 Aug 11;392(10146):508-20. [PubMed] [Google Scholar]
5. Bölte S, Girdler S, Marschik PB. The contribution of environmental exposure to the etiology of autism spectrum disorder. Cell Mol Life Sci. 2019;76(7):1275-97. [PubMed] [Google Scholar]
6. Daud SN, Maria M, Shahbodin F, Ahmad I. Assistive technology for autism spectrum disorder: a review of literature. Proceedings of the International MEDLIT Conference; 2018 Mar. p. 1-7. [Google Scholar]
7. Schmitz C, Rezaie P. The neuropathology of autism: where do we stand? Neuropathol Appl Neurobiol. 2008 Feb;34(1):4-11. [PubMed] [Google Scholar]
8. Yenkoyan K, Grigoryan A, Fereshetyan K, Yepremyan D. Advances in understanding the pathophysiology of autism spectrum disorders. Behav Brain Res. 2017 Jul 28;331:92-101. [PubMed] [Google Scholar]
9. Johnson CP, Myers SM; American Academy of Pediatrics Council on Children with Disabilities. Identification and evaluation of children with autism spectrum disorders. Pediatrics. 2007 Nov;120(5):1183-215. [PubMed] [Google Scholar]
10. Lang R, Koegel LK, Ashbaugh K, Regester A, Ence W, Smith W. Physical exercise and individuals with autism spectrum disorders: a systematic review. Res Autism Spectr Disord. 2010 Oct 1;4(4):565-76. [Google Scholar]
11. Hattier MA, Matson JL, Macmillan K, Williams L. Stereotyped behaviors in children with autism spectrum disorders and atypical development as measured by the BPI-01. Dev Neurorehabil. 2013 Oct;16(5):291-300. [PubMed] [Google Scholar]
12. Oriel KN, George CL, Peckus R, Semon A. The effects of aerobic exercise on academic engagement in young children with an autism spectrum disorder. Pediatr Phys Ther. 2011;23(2):187-93. [PubMed] [Google Scholar]
13. Patel H, Alkhawam H, Madanieh R, Shah N, Kosmas CE, Vittorio TJ. Aerobic vs anaerobic exercise training effects on the cardiovascular system. World J Cardiol. 2017 Feb 26;9(2):134. [PubMed] [Google Scholar]
14. Dhaliwal KK, Orso CE, Richard C, Haqq AM, Zwaigenbaum L. Risk factors for unhealthy weight gain and obesity among children with an autism spectrum disorder. Int J Mol Sci. 2019 Jul 4;20(13):3285. [PubMed] [Google Scholar]
15. Best JR. Effects of physical activity on children's executive function: contributions of experimental research on aerobic exercise. Dev Rev. 2010;30(4):331-51. [PubMed] [Google Scholar]
16. Ferreira JP, Ghiarone T, Cabral Júnior CR, Furtado GE, Carvalho HM, Rodrigues AM, Toscano CV. Effects of physical exercise on the stereotyped behavior of children with autism spectrum disorders. Medicina (Kaunas). 2019 Oct;55(10):685. [PubMed] [Google Scholar]
17. Mays MN. Using antecedent aerobic exercise to decrease stereotypic and self-stimulatory behavior in children with autism [dissertation]. Georgia State University; 2013. [Google Scholar]
18. Neely L, Rispoli M, Gerow S, Ninci J. Effects of antecedent exercise on academic engagement and stereotypy during instruction. Behav Modif. 2015 Jan;39(1):98-116. [PubMed] [Google Scholar]
19. Young S, Furgal K. Exercise effects in individuals with autism spectrum disorder: a short review. Autism Open Access. 2016;6(3):1-2. [Google Scholar]
20. Oline SS, McFadden BA, Golem DL, Pellegrino JK, Walker AJ, Sanders DJ, Arent SM. The effects of exercise dose on stereotypical behavior in children with autism. Med Sci Sports Exerc. 2017 May 1;49(5):983-90. [PubMed] [Google Scholar]
21. Ferreira JP, Toscano CV, Rodrigues AM, Furtado GE, Barros MG, Wanderley RS, Carvalho HM. Effects of a Physical Exercise Program (PEP-Aut) on autistic

children's stereotyped behavior, metabolic and physical activity profiles, physical fitness, and health-related quality of life: a study protocol. Front Public Health. 2018 Mar 2;6:47. [PubMed] [Google Scholar]
22. Keerthna S, Manikumar M. Effectiveness of task-oriented aerobic exercise to evaluate the severity of autism in autism subjects with self-stimulatory behaviour. Int J Creat Res Thought. 2018;6(2):36-55.
23. Adesokan A, Ogunfeyitimi EO, Obafemi KE, Adesokan TT. Effect of physical exercise on weight reduction of students. ASEAN J Phys Educ Sport Sci. 2023;2(2):117-22. [Google Scholar]
24. Strofylla G, Charitou S, Asonitou K, Koutsouki D. Efficacy of 6-month adapted aerobic program on motor proficiency, BMI and cognitive abilities of students with autism spectrum disorder: three case reports. Open J Soc Sci. 2021 Sep;9(9):153-66. [Google Scholar]
25. Cole DK. The effect of aerobic exercise on children with autism spectrum disorder: a systematic literature review [dissertation]. University of Central Florida; 2021. [Google Scholar]
26. Tarr CW, Rineer-Hershey A, Larwin K. The effects of physical exercise on stereotypic behaviors in autism: small-n meta-analyses. Focus Autism Other Dev Disabil. 2020 Mar;35(1):26-35. [Google Scholar]

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202358