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Factors Influencing the Effect of Exercise on Intervention for Children with Autism Spectrum Disorders

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Abstract: Autism spectrum disorder is a neurodevelopmental disorder, and the core symptoms of children with autism spectrum disorder are social interaction and communication difficulties, and stereotyped behaviors. Exercise intervention, as a convenient and effective rehabilitation tool, has been shown to improve the core symptoms in children with autism spectrum disorders. This study systematically reviewed the factors influencing the effect of an exercise intervention on children with autism spectrum disorders in the last 10 years of related studies analyzing the effect of exercise intervention. There are a variety of exercise interventions in the literature, all of which can have a good effect on ASD, but there are problems such as incomplete exercise prescriptions, variable program selection, a wide age span of exercise intervention subjects, and subjective scale evaluation for effect evaluation. The analysis concluded that exercise intervention can improve social, communication, and stereotypical behaviors of children with ASD, and different intervention ages, different exercise programs, and different exercise intensities can affect the intervention effects. Exercise interventions should be delivered early, select a moderate-to-high intensity group exercise program, and be in an inclusive exercise environment. Future research can use brain and cognitive neuroscience to study the brain mechanisms of motor interventions and construct more objective evaluation criteria; improve motor prescriptions and explore the optimal age of intervention.

Keywords: Autism Spectrum Disorder, Physical Activity, Exercise Prescription, Influencing Factors

1. Introduction

Autism spectrum disorder (ASD), also known as autism or autism, is a neurodevelopmental disorder that occurs during early childhood development and is characterized by impairments in communication, social interaction, and stereotyped behaviors or abnormalities [1]. In recent years, the prevalence of children with autism has increased, and statistics from the Centers for disease control and prevention (CDC) in 2020 showed that there is 1 child with autism for every 54 children aged 8 years. "The 2019 China Autism Education and Rehabilitation Industry Development Report III" statistics show that there are more than 2 million children with autism aged 0-14 years old, and the number is growing at a rate of nearly 200,000 per year. Autism is ranked as the number one childhood mental illness by the World Health Organization and has become a global public health problem that seriously affects children's health. It is urgent to actively search for the causes and treatments of autism. The causes of autism are not fully understood and may be related to neurodevelopmental disorders, genetics, perinatal complications, and neuroendocrine disorders. Today's treatments for autism include medication and interventional therapies. Regular physical activity can improve skeletal muscle health, cognitive function, sleep, and reduce the risk of depression and obesity, but most children do not achieve the recommended physical activity levels, and children with ASD are less physically active than their normally developing peers. As a convenient and effective intervention for rehabilitation, physical activity interventions have been increasingly studied in recent years, and exercise interventions have been effective in the treatment of children on the autism spectrum, but the factors influencing the

effectiveness of exercise interventions for children with ASD, and the characteristics of developing exercise prescriptions for children with ASD and how to motivate individuals with ASD to adhere to and participate in physical activity, have not been specific recommendations. This study attempts to clarify the factors influencing the effect of exercise intervention by searching and sorting out relevant studies in recent years and to provide some reference and references for the development and formulation of exercise prescriptions for an exercise intervention in autism.

2. Effects of Motor Intervention on Children with Autism

Quantitative experimental studies and Meta-analysis and systematic evaluation evidence suggest that exercise interventions can influence ASD symptoms: by reducing stereotypic behaviors in children with autism [2-4]. Meta-analytic studies by Teh et al (2021) [5] showed that exercise interventions can improve stereotypic behaviors in individuals with ASD, and the more intense the exercise, the more significant the improvement. Meta [6-8] analysis studies by Chan, J. S et al. (2021) showed that physical activity had a moderate to strong effect on the improvement of social interaction in individuals with ASD, and group-based physical activity had a small to moderate effect on social functioning [9]. Huang et al. (2021) Meta-analysis showed that motor interventions can improve social and communication skills and motor skills in children with ASD.

Sports interventions may improve symptoms in children with ASD in several ways, i), participation in sports activities provides participants with opportunities to interact with other participants and teachers, e.g., in a community sports program, children with ASD have more opportunities to interact with other children, which may increase social interaction and promote improved communication and social interaction (George et al., 2011) [10]. (ii), physical activity can be fun for children with ASD and can increase self-confidence through physical activity (Stanishet al., 2015) [11]. (iii), physical activity can be an increase in oxytocin, a hormone that is thought to be associated with social interaction and cognition (Rassovsky et al., 2019) [12]. (iv), physical activity can improve brain development, and children with ASD have poor connectivity between developing brain regions; among them, there is evidence of insufficient connectivity in frontal and cerebellar cortex regions, which are associated with motor balance. Brain regions related to social interaction, such as the cerebellum, frontal lobe, and temporal lobe, are involved in the formation of the "social brain" network, and many studies have shown [13, 14] that these brain regions are the neural basis of social communication deficits in children with ASD. weeks of tai chi exercise intervention and found that tai chi exercise improved stereotypical behaviors in children with ASD, and its effects lasted for one month. The effect of tai chi exercise may be that tai chi exercise can have a physical and mental exercise effect, can reduce stress and stimulate the growth of hippocampal cells [15], and, in addition, may lead to reduced sympathetic nervous system activity and increased parasympathetic activation [16] (typically children with autism have dysregulated parasympathetic regulation compared to normal children) and improve brain morphology [17] (the cause of stereotypic behavior is thought to be changed in the structure of some areas of the brain), etc.

Yang 2021 [18] et al. conducted 12 weeks of mini-basketball training in 15 children with autism and found that it improved communication skills in children with autism, and evidence of motor and brain plasticity suggests [19] that physical exercise can lead to plastic changes in the functional connectivity of central neural networks. MRI images revealed significantly enhanced functional connectivity between the right cerebellum and the left inferior frontal gyrus in the experimental group [20]. The improved social cognitive abilities of school-aged children with ASD may be a result of children improving their social information processing by recognizing and imitating the teacher's behavior during mini-basketball training. In addition, the opportunity to establish social relationships with coaches and peers during mini-basketball training provides an opportunity to improve social skills.

Much of the literature has only assessed the immediate effects of exercise interventions, and a few studies have followed the effectiveness of the intervention over time; future studies need to conduct longitudinal follow-up studies to better understand the long-term benefits of exercise interventions for children with ASD.

Table 1. *Meta-analysis Literature on the Effectiveness of Exercise Intervention for Children with ASD.*

	Major Findings
Michelle et al (2011) [21]	Exercise interventions can improve social interaction
Healy et al. (2018) [6]	Exercise intervention has a moderate improvement effect on social interaction function
Howells et al. (2019) [9]	1. No improvement in communication with exercise intervention 2. exercise intervention had a small to moderate improvement effect on social interaction skills
Chan, J. Set al. (2021) [22]	Exercise intervention has a small to moderate effect on improving social interaction skills and communication
Teh, et al. (2021) [5]	Exercise intervention improves stereotypic behavior in children with ASD
Huang et al. (2020) [23]	Exercise intervention significantly improves social skills, communication skills, motor skills

3. Effect of Different Intervention Ages on Intervention Effects

The children with autism included in the analysis of this study were aged 3-15 years, with a mean age of 7.18 years. The intervention effects of the included literature show that motor interventions are effective for children with autism at different ages, and there are no relevant studies in the included literature on exactly which age interventions are most effective. Studies have shown that there are delays in motor development milestones in children with autism, that motor developmental deficits can have a significant impact on motor domains and other domains of development, that children's brain development matures by the age of 6 years, that 3-6 years is a critical period for the development of motor skills in children, and that a subgroup analysis of the Meta-analysis found that motor interventions were more effective for communication skills and social interaction in younger participants (Chan, J. S et al., 2021 [22]). It is suggested that the earlier the motor intervention, the better the effect of its intervention.

4. Effects of Different Exercise Programs on Intervention Effects

In terms of exercise type selection, the literature included in the analysis included aerobic exercise (jogging, etc.), movement skill practice-based exercises, physical games, ball games, traditional martial arts programs, animal-assisted classes, structured exercises incorporating multiple sports, and exercises such as swimming, hydrotherapy, and yoga that were not included in the analysis. National and international studies have examined a variety of exercise interventions for children with ASD, and no studies have been found in the literature on which exercise programs are most effective in intervening with specific symptoms in children with ASD.

4.1. Effect of Individual Exercise and Group Exercise Programs on Intervention Effects

Group-based sports programs promote children's physical and mental development (Rinehart et al. 2018 [24]), group-based physical activity increases opportunities for social interaction and promotes social communication, and a Meta-analysis comparing individual-based and group-based sports interventions found that individual-based sports interventions improved social skills and reduced undesirable social behaviors. Paradoxically, group sports did not show corresponding expectations, and the authors suggested that it was the individual-based intervention that provided one-to-one contact opportunities that allowed participants to feel valued and cared for, whereas group sports participants were exposed to events that were unpredictable. Stanish [11] et al. (2015) reported that many individuals with autism did not find team sports enjoyable, possibly because compared to group 1-to-1 interventions receive more attention and care from the therapist compared to interventions. While another Meta-analysis provided evidence that a group-based exercise program would improve social skills in children with ASD (Howells et al., 2019 [9]) and suggests group exercise programs as a focus for future research. The intervention setting of the exercise intervention (whether it was a group intervention or not) was not a key factor in the success of the intervention, as found in a recent Meta-analysis (Chan, J. S et al. 2021) [22] study, and further research is needed to elucidate this in the future.

Twelve of the studies included in the literature analyzed in this study used group-based exercise programs and 10 studies used individual-based exercise programs, and in terms of intervention effects, both group and individual exercise programs were effective on symptoms in children with ASD. Group-based physical activity has both advantages and disadvantages for children with ASD, but children with ASD eventually have to integrate into society, and performing group-based sports helps children with ASD gradually integrate into group life.

4.2. Effect of the Inclusion of Normal Children in Group Exercise Membership on Intervention Effects

Group sport-based sports interventions need to consider the participants' inclusiveness of children with ASD and children with ASD's emotions toward group sports. According to contact theory [25], both the frequency and quality of social interactions are essential for increasing mutual understanding and acceptance, and participation of children with ASD and normal children in a variety of sports activities together in an inclusive environment has a positive impact on the peer attitudes of both, motivating children with ASD to participate in sports and facilitating communication and interaction between children with ASD and normal children. Sansi 2021 [26] conducted a study of 45 children with ASD aged 6-11 years and 11 normal children who were exposed to an inclusive physical activity intervention for 12 weeks, two days a week, one hour a day, children with ASD had improved motor and social interaction skills, and normal children had improved motor skills and positively influenced their attitudes towards children with ASD.

The literature included in this paper did not examine the effect of the inclusion of normal children in group sports on the effect of the intervention. Considering that the ultimate goal of the intervention is normal life for people with autism, the inclusion of normal children in group sports contributes to mutual understanding and acceptance, and it is recommended that children with ASD and normal children participate in physical activities together in an inclusive setting.

5. Effect of Different Exercise Intensity on Intervention Effects

The literature included in this paper did not compare the effects of different exercise intensities on intervention effects. The meta-analysis found that exercise intensity was a very important factor in the effects of exercise interventions (Chan, J. S et al., 2021 [22], Teh et al., 2021 [5]). It has been shown that exercise intensity has a significant moderating effect on

intervention effects, with higher exercise intensity having a greater effect on intervention effects, and that high-intensity exercise interventions can improve executive abilities in children with autism. There was a non-linear relationship between exercise intensity and social-emotional improvement, with a smaller effect of low-intensity exercise interventions, and given the generally low physical activity level of children with ASD, sustained high-intensity exercise interventions may cause discomfort to participants and affect subsequent exercise participation (Chan et al., 2019 [27]). Six studies included in the literature analyzed here described moderate-intensity exercise and all showed an effect of the intervention. Taken together, it is recommended that children with ASD engage in physical activity at a moderate-to-vigorous intensity.

6. Effect of Exercise Duration and Frequencies on the Intervention Effects

Currently, no effect of duration of exercise and frequency of exercise movement on intervention effects was found in the literature, and Meta-analysis of the literature (Chan, J. S et al. (2021) [22]), regression analysis showed that the duration of the intervention, total duration of the intervention, and the proportion of participants of both sexes did not have a significant effect on intervention effects. The literature included in this paper had an intervention duration of 10-16 weeks and an exercise intervention frequency of 2-6 times per week with a mean of 3.6 times per week for 30-120 min (including warm-up and relaxation time), with the majority of studies exercising for 30-60 min. The American College of Sports Medicine recommends moderate-intensity aerobic exercise for adults for more than 30 min per session, 5 days per week [28], and on balance, physical activity for children with ASD is recommended for more than 30 min per session, 2-3 times per week.

7. Factors Influencing Physical Activity Participation in Children with ASD

7.1. Motor Skills and Self-confidence in Children with ASD

In a survey of ASDs [29], it was found that physical athletic ability, competitive ability in different types of sports activities, and self-confidence were important factors motivating their participation in sports. Low levels of physical activity, as well as low self-confidence, can lead to greater vulnerability to injury in sports activities. Children with ASD will be more inclined not to participate in such physical activities if they do not reach the physical fitness level of the sport they want to participate in. Children with ASD are more likely to participate in sports that are familiar and in which they have mastered motor skills.

Factors such as social impairment and physical appearance may cause children with ASD to lack self-confidence, and lack of confidence in physical activities can lead to a more fragile perception and participation in unwanted physical activities can cause stress and anxiety.

7.2. Motivation of ASD Children to Participate in Physical Activity

Gaining enjoyment and pleasure from physical activity and perceiving the meaning of physical activity are the main motivations for children with ASD to participate in physical activity. Being more interested in the physical activity they participate in and feeling better with the peers they participate with are motivations for participating in physical activity. Physical activities that promote physical health and have specific goals and objectives are perceived as meaningful by children with ASD; children with ASD reject physical education classes when they perceive them as meaningless. Jachyra 2021 [30] et al. studied how society and culture influence physical activity participation and concluded that when physical activities bring meaningfulness, a sense of identity, and generate feelings of pleasure, participants are more willing to participate in physical activity, and that children with ASD's participation in physical activity are also influenced by the social relationships, values, and their own experiences in their environment, and that individualized strategies and approaches need to be tailored to promote their participation in physical activity.

7.3. Predictability of Physical Activity Engaged in by Children with ASD

Children with ASD will be more willing to participate when they are more familiar with the sport they are going to participate in and how to do it. Familiarity with the environment and type of activity, as well as knowing how to prepare, how to play sports, and playing sports with people they trust, increases feelings of security about playing sports. The unpredictability of participating in physical activity increases the element of insecurity and can influence children with ASD to actively participate in physical activity.

8. Conclusion

Exercise interventions can improve social, communicative, and stereotypic behaviors in children with ASD, and early interventions are more effective, and exercise prescriptions should be developed by choosing physical activity at moderate-to-high exercise intensities and in an inclusive physical environment. A review of the literature reveals that there are a variety of exercise interventions that are effective for all age levels of intervention through their respective exercise prescriptions. However, there are still problems such as incomplete exercise prescriptions, inconsistent program selection, and subjective scale evaluation for effect evaluation. Therefore, in the future ASD exercise intervention program, brain and cognitive neuroscience can conduct more in-depth research on the brain mechanism of exercise intervention and construct more objective evaluation criteria; improve the

exercise prescription and build an exercise intervention mechanism with the joint participation of "family-school-community". We hope to bring better rehabilitation means for ASD patients.

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