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## Effects of Exercise Intervention on Gross Motor and Social Skills in Children with Autism: A Systematic Review

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### Abstract

With the increasing prevalence of autism diagnoses worldwide, there is a growing demand for interventions that support the holistic development of children with autism, particularly in gross motor function and social interaction. While exercise-based interventions have shown promise, existing research presents inconsistent findings. This study aims to systematically review the literature to clarify the potential effects of exercise interventions on the physiological health and social skills of children with autism. The ultimate goal is to derive universal conclusions and inform the development of tailored physical activity curricula that meet the unique needs of autistic children, providing a solid scientific foundation for inclusive physical education practices. A comprehensive literature review was conducted using subject-based searches across multiple databases, including PubMed, CNKI, Wikipedia, Web of Science, and Medline, covering publications from January 2006 to January 2024. After rigorous screening, sixteen randomized controlled trials (RCTs) focusing on exercise interventions for children with autism were selected for analysis. The systematic review revealed that exercise interventions significantly enhance gross motor skills and improve social interaction among children with autism. Additionally, these interventions contribute to improved executive functioning and are effective in reducing anxiety and feelings of low self-worth. Exercise interventions play a critical role in fostering the overall development of children with autism. They not only improve motor proficiency and social engagement but also boost self-confidence and alleviate psychological challenges. These findings underscore the importance of integrating structured physical activity programs into the education and therapy of children with autism to support their physical, emotional, and social well-being.

**Keywords:** *Children With Autism, Executive Functioning, Gross Motor Movements, Motor Intervention, Social Skills.*

### A. Introduction

Autism, a pervasive developmental disorder with neurobiological underpinnings, is centrally characterized by significant deficits in social interaction and communication, as well as repetitive, stereotyped patterns of behavior and interests (American Psychiatric Association, 2013). The scope of ASD is broad, encompassing a variety of subtypes such as Autism Spectrum Disorder (ASD), Asperger's Syndrome, and Rett's Syndrome, with ASD being regarded as the most severe form of the disorder. According to global statistics, the prevalence of ASD cannot be ignored, with approximately 1 in 100 children diagnosed with ASD (World Health Organization, 2022). Children with ASD not only face impairments in social interaction but also often suffer from co-occurring problems such as intellectual disability, difficulties in emotional regulation, impaired gross motor development, and executive functioning disorders, which collectively pose a significant barrier to their integration into the community (Lord et al., 2018).

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We are highly concerned about ASD not only because of its high prevalence and far-reaching impact on children's future development, but also because children with ASD, as a vulnerable group in society, deserve more attention and support for their rights and interests. To address the critical issue of ASD, the current mainstream solutions mainly include three major categories: medication, behavioral therapy, and educational intervention. In terms of medication, although there is no specific drug that can cure ASD, some medicines, such as antipsychotics and antidepressants, can alleviate the symptoms of anxiety, depression, and aggressive behaviors of children with ASD to a certain extent (King et al., 2009). However, the side effects of medication and the uncertainty of long-term effects limit its application. Behavioral therapies, such as Applied Behavior Analysis (ABA), aim to improve the social skills, language skills, and behavioral patterns of children with ASD through systematic training (Lovaas, 1987). The therapy focuses too much on superficial behavioral changes and ignores their intrinsic emotional, cognitive, and psychological needs. Children with autism may only mechanically complete a certain behavior to obtain a reward without understanding the meaning behind the behavior, and have poor transferability in the face of different scenarios. Educational interventions are too complex to be fully individualized. They cannot meet the unique needs of each autistic child, resulting in some autistic children making slow progress or failing to achieve the expected results during the intervention process. Although educational interventions will involve the development of social interaction skills, autistic children will still face difficulties in real-life social scenarios. Because educational environments are relatively more structured and predictable, and real-life social interactions are more complex, flexible, and uncertain, the social skills learned in educational interventions may not be successfully transferred to real-life situations for children with autism.

In previous studies, exercise intervention, as a non-pharmacological treatment, has demonstrated positive effects on children with ASD. Exercise intervention not only promotes the physical development of children with ASD and improves their physical fitness but also improves their emotional state and social skills by regulating brain function (Lang et al., 2010). By activating neurotransmitters such as dopamine and norepinephrine in the brain, exercise interventions help to alleviate anxiety and depression in children with ASD while enhancing their attention, executive functioning, and cognitive abilities. In addition, exercise interventions provide a platform for children with ASD to interact and cooperate with others, thus promoting the development of their social skills. Exercise intervention has many applications, from the home environment to schooling to professional rehabilitation training institutions (Pan, 2010). Mechanistically, exercise intervention can have a positive impact on children with ASD; on the one hand, it can directly affect the body to improve physical fitness and athletic ability; on the other hand, it can also regulate brain function, enhance executive dysfunction, and develop the mental health and social interaction ability of children with ASD (Sowa & Meulenbroek, 2012).

These experimental studies have shown that implementing adaptive physical education interventions for children with autism during the school years effectively enhances their motor skill levels, improves their general physical fitness, and helps develop their basic motor skills. However, two other key points must be focused on when implementing an adaptive physical education program in schools for the education of the intellectually disabled. Firstly, teachers need to have an in-depth understanding and familiarity with the characteristics of children with autism and establish a good partnership with them so that they can better monitor their motor skill learning and provide the necessary support. Second, motor intervention programs need to be designed to address the individual needs of each child with autism to ensure that they meet their unique developmental needs (Block et al., 2013).

Unlike other interventions, motor interventions are favored because of their advantages of low cost, easy implementation, and few side effects. Therefore, an in-depth exploration of the impact of motor interventions on the development of gross motor skills, social interaction skills, and executive dysfunction in children with autism not only has the potential to provide an innovative non-pharmacological treatment for children with autism but is also expected to enhance the quality of life of children with autism and promote their healthy physical and mental development (Bremer et al., 2016). Through this study, we hope to provide a theoretical basis for adaptive physical education intervention practice and provide insights into the future direction of adaptive physical education intervention, thus contributing to the comprehensive development of children with ASD.

## **B. Methods**

### **1. Search strategy**

The search used the China Knowledge Network (CNN) and Wikipedia databases. To obtain the complete Chinese literature on "sports intervention for children with autism," the search was mainly centered on the subject terms "sports intervention," "physical activity," and "physical activity" to explore the correlation between the two. To obtain the complete Chinese literature on "sports intervention for children with autism," this search was mainly centered on the subject terms "sports intervention," "physical activity," and "physical activity," which were combined with "children with autism" to explore the correlation between the two. First, "exercise intervention" and "children with autism" were the core keywords for a preliminary search to obtain the basic research literature in this field. Subsequently, the search was further refined to explore the specific effects of exercise intervention on children with autism. For "physical development," the combination of "exercise intervention," "children with autism," and "physical development" was used. For 'physical health,' a similar combination was used. In addition, special attention was paid to the performance of children with autism in terms of motor skills, so "basic motor skills" and "gross motor skills" were combined with "motor intervention" and "children with autism," respectively. "children with autism" was searched. To fully understand the effects of motor intervention on the social and cognitive functioning of children with autism, "social interaction" and "executive functioning" were searched with "motor intervention" and "children with autism" as keywords. The keywords "social interaction" and "executive function" were combined with "motor intervention" and "children with autism", respectively. This series of search strategies aims to reveal the critical role of motor intervention in treating children with autism in a comprehensive and in-depth manner. A total of 415 articles in Chinese, spanning 2006-2024 and ending on May 8, 2024, were retrieved.

English language searches were conducted in PubMed, Web of Science, and Medline databases, with the search being: ("Motor interventions" AND "Autism children " AND "Physical fitness") OR ("Motor interventions" AND "Autism children" AND "Physical and mental health") OR ("Motor interventions" AND "Autism children" AND "Basic motor skills" OR "Gross motor skills") OR ("Motor interventions" AND "Autism children" AND "Social awareness") OR ("Motor interventions" AND "Autism children" AND "Social awareness") ") OR ("Motor interventions" AND "Autism children" AND "Executive function") OR ("Motor interventions" AND "Autism children" AND "Executive function")

function"). Eventually, 1360 foreign language documents related to the topic were obtained, and the search ended on May 8, 2024.

## 2. Inclusion exclusion criteria

The inclusion and exclusion criteria for the study were established to ensure the relevance and quality of the selected literature. First, the research topic had to focus on the effects of adaptive physical education or sports interventions on children with autism, specifically in the domains of gross motor skills, executive functioning, and social interaction abilities. Second, the study participants were required to be children or adolescents diagnosed with autism, with an age range restricted to 3 to 12 years old. Third, the research design had to be a randomized controlled trial (RCT) involving exercise interventions. Finally, only studies published in Chinese or English were considered eligible for inclusion.

On the other hand, the exclusion criteria were applied to refine the literature selection further. These included studies for which the full text was not available, studies with duplicated content already represented in the existing body of literature, and studies that were dissertations, conference papers, or review articles. The screening and exclusion process of the literature included in the study is illustrated in Figure 1.

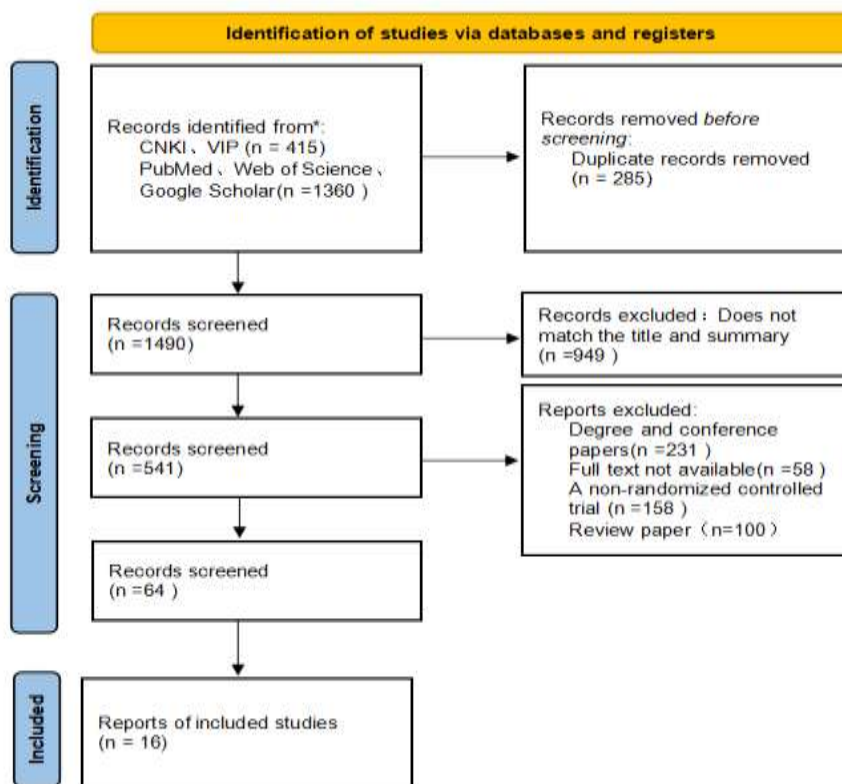


Figure 1. PRISMA Flow Diagram of Study Selection Process

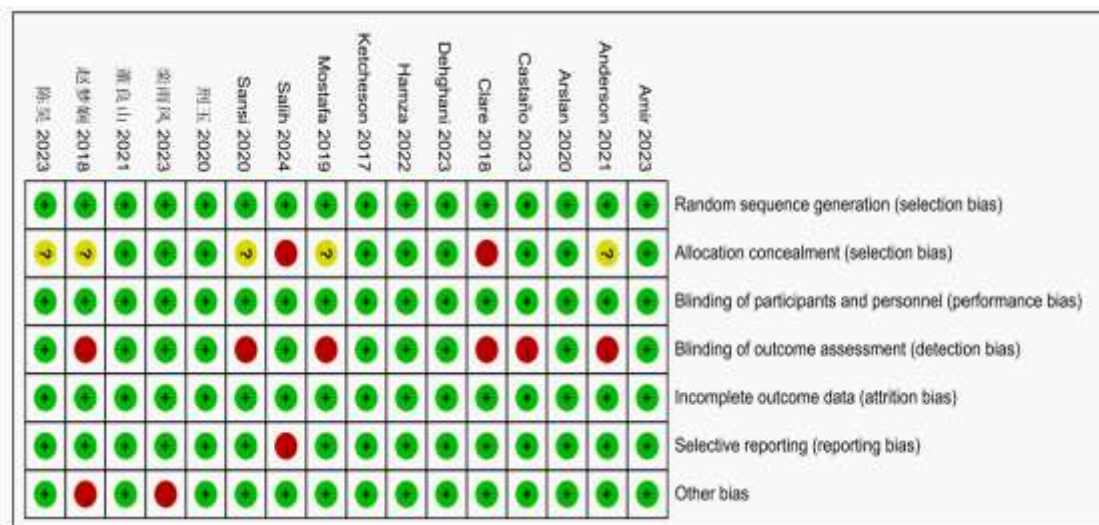
## 3. Risk Assessment Methodology

The quality of the 16 included papers was evaluated by using the Cochrane Risk of Bias Assessment Tool using the evaluation components in Figure 4.

realm	Evaluation content
<b>Selection bias</b> <b>Random Sequence Generation</b> <b>Assignment hiding</b> <b>Implementation bias (performance bias)</b> <b>Blinding of researchers and subjects</b>	<p>A detailed description of the methodology for generating random allocation sequences to assess component comparability is provided.</p> <p>A detailed description of the methods used to hide the random assignment sequences to determine the intervention score Whether the matching situation is predictable.</p> <p>The method of blinding the investigator and subjects to prevent them from knowing is described in detail. Interventions for subjects. Information is provided to determine whether blinding is adequate.</p>
<b>Measurement bias (detection bias)</b> <b>Blinded evaluation of study results</b>	<p>A detailed description of the methodology for blinding the evaluator of the study results to prevent them from knowing the Interventions for subjects. Information is provided to determine whether blinding is adequate.</p>
<b>Follow-up bias (attrition bias)</b> <b>The integrity of results data</b>	<p>Completeness of data reported for each of the primary outcome indicators, including loss to visit and dropout The. Whether loss of visits and withdrawals were explicitly reported, the number of people in each group (compared with the randomized group of (compared to the total), reasons for lost visits/withdrawals so that system evaluators can make relevant The processing.</p>
<b>Reporting bias</b> <b>Selective reporting of findings</b>	<p>Describes information system evaluators can use to judge the likelihood of selective reporting of study results, Sex, and related circumstances.</p>
<b>Other bias</b> <b>Other sources of bias</b>	<p>Does the information provided allow for an assessment of other bias-inducing factors in addition to the bias described above? Factors. If a problem or factor is mentioned in the protocol first, the Corresponding answers need to be given.</p>

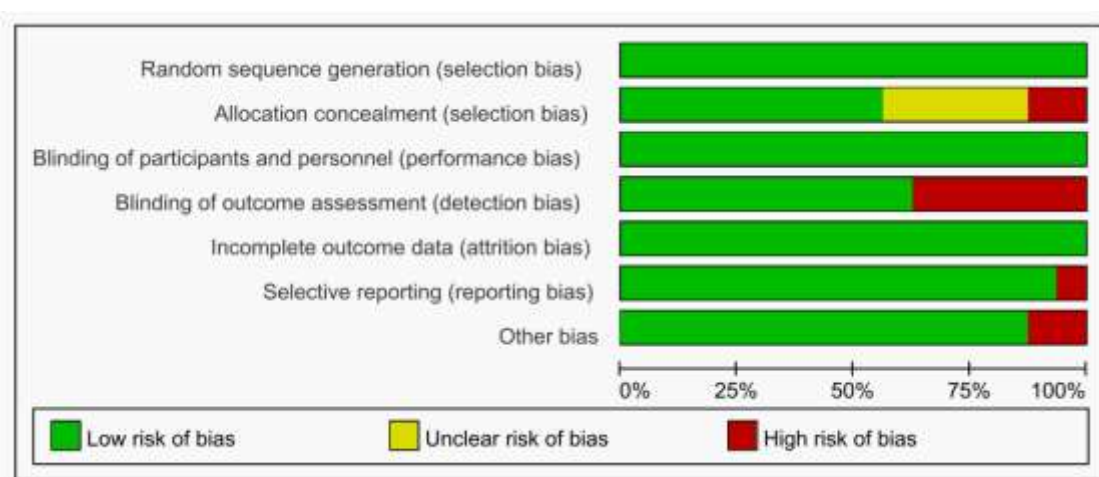
#### 4. Risk of Bias Assessment

In response to the quantitative methodological assessment of the included literature (see Figure 2), after careful analysis and evaluation, we found that nine papers presented a low degree of risk of bias, and these papers were superior in quality. Among these nine pieces of literature, six reached the high standard of 6. This scale is marked with "i" in Figure 2 to indicate that they meet the high-quality standard and "-" to indicate some deficiencies. To visualize the distribution of the indicators of the methodological assessment, Figure 3 provides a detailed classification and statistics of the entries in percentage statistics.



**Figure 2.** Risk of Bias Assessment of Selected Studies Using the Cochrane Risk of Bias Tool

The methodological quality of the selected literature was evaluated systematically to ensure the reliability and validity of the included studies. As illustrated in Figure 2, the evaluation criteria were organized into specific categories, with a checkmark ("✓") indicating that the criterion was met and a dash ("—") signifying that it was not met. This schematic overview provides a visual summary of how each study aligned with the quality indicators used in this review. Furthermore, Figure 3 offers a consolidated schematic representation of the methodological quality assessment across all included studies, highlighting common strengths and weaknesses in study design, implementation, and reporting. These visual aids serve to enhance transparency and facilitate a deeper understanding of the methodological rigor applied throughout the literature selection process.



**Figure 3.** Summary of Risk of Bias Across All Included Studies

To further interpret the methodological rigor of the included studies, Figure 3 presents the percentage of each criterion met in the methodological quality assessment. This figure offers a quantitative overview, highlighting which aspects of methodological quality were most frequently addressed across the literature and which were commonly overlooked.

Complementing this, Figure 4 illustrates the distribution of methodological quality components in the included studies, showcasing the relative portion of criteria fulfilled. Together, these figures provide a comprehensive insight into the overall quality profile of the selected research, helping to identify patterns of strength and areas needing improvement in future studies concerning adaptive physical education or sports interventions for children with autism.

**C. Results and Discussion**

**1. Key findings of the included studies (large table)**

After the screening and exclusion process, 16 research papers were included in the study. The included papers were mainly from the International Journal of Developmental Disabilities, Autism and Developmental Disorders, and Autism Magazine journals. Sixteen randomized controlled trials were conducted with 514 participants. The included literature studies are summarized in Table 1 below.

**Table 1.** Summary of Intervention Programs Targeting Motor and Social Skills in Children with Autism Spectrum Disorder (ASD)

Author	Participant (In A Clinical Trial, Etc.)	Diagnostic	Intervention Programs	Interference Frequency	Post-Intervention Measurement Of Benefits
<b>Dong Liangshan et al. (2021)</b>	18 patients aged 5-12 years	Clinical diagnosis of autism, meeting diagnostic criteria for autism diagnostic interviews	Structured Movement Intervention Program	12 weeks, 3 times per week, 60 minutes each time	The experimental group's basic motor skills improved significantly, and their social interaction ability waited for a significant improvement.
<b>Criminal Justice Error! Reference source not found. (2020)</b>	24 patients 18 boys, six girls	Diagnosis based on ADI-R and C-PEP scale diagnostic criteria	Significant Muscle Motor Skill Acquisition	12 weeks, 3 times per week, 60 minutes each time	Exercise intervention can effectively improve the considerable muscle motor skills of autistic children in the experimental group.
<b>Mengxian Zhao et al. (2018)</b>	41 patients aged 5-8 years	ASD (n=33), Asperger's syndrome (n=7)	Structured physical activity program	24 sessions of 60 minutes each over 12 weeks	A unique structured physical activity program positively impacted the social interaction and communication skills of children with autism.

Author	Participant (In A Clinical Trial, Etc.)	Diagnostic	Intervention Programs	Interference Frequency	Post-Intervention Measurement Of Benefits
<b>Castañero</b> Error! Reference source not found. <b>et al. (2023)</b>	20 patients aged 4-7 years	ASD	Structured Physical Activity Program	8 weeks, 3 times per week, 60 minutes each time	The experimental group showed significant improvement in gross motor skills. A structured physical activity program improves gross motor skills in children with autism spectrum disorders.
<b>Sansi</b> Error! Reference source not found. <b>et al. (2020)</b>	45 cases 6-11 years old	Students with ASD who do not have a secondary condition such as vision or hearing loss	Inclusive sports activities	12 weeks, 2 times per week, 60 minutes each time	Inclusive physical activity improves the motor and social skills of students with ASD.
<b>Clare et al. (2018)</b>	64 cases 6-12 years old	Asperger's syndrome, autism, or a developmental disorder that is a specific reference	Essential coordination and linkage of forces	48 weeks, 2 times per week, 40 minutes each time	Improved metabolic health reduced the impact of autism and increased physical activity.
<b>Anderson</b> Error! Reference source not found. <b>et al. (2021)</b>	62 cases of 50 male and 12 female patients	Mild to moderate ASD	Bicycle Skills Acquisition	2 weeks, 5 times per week, 60 minutes each time	Four executive function components (planning, working memory, flexibility, and inhibition) were assessed, and there were significant improvements in all four elements.
<b>Arslan et al. (2020)</b>	14 patients with a mean age of $10.07 \pm 0.25$ years	Atypical autism spectrum disorders	Structured Circuit Exercise Program	12 weeks, 3 times per week, 60 minutes each time	The autism sports intervention group showed significant improvements in running speed, agility, balance, standing long jump, visual and auditory responses, grip strength, and flexibility.
<b>Hamza et al. (2020)</b>	22 patients aged 6-7 years	Meets Diagnostic Statistical Manual of Mental Disorders (DSM-V)	Technical water sports or game-based water sports	8 weeks, 2 times per week, 50 minutes each time	Aquatic activities positively impact motor and social skills, effectively improving gross motor skills in children with autism and

Author	Participant (In A Clinical Trial, Etc.)	Diagnostic	Intervention Programs	Interference Frequency	Post-Intervention Measurement Of Benefits
		diagnostic criteria for autism			promoting social-emotional well-being.
<b>Hatipoğlu</b> Error! Reference source not found. etc. (2024)	34 patients aged 3-6 years	autism spectrum disorder	MIP Movement Intervention Program	12 weeks, 2 times per week, 60 minutes each time	The 12-week MIP program improved motor, social, and preschool skills and lowered Autism Spectrum Disorder Index levels in children with autism.
<b>Chen Hao et al. (2024)</b>	30 patients aged 3-6 years	Diagnosis of ASD according to DSM-V	Tailored activity level moderate intensity sports games	8 weeks, 6 times per week, 30 minutes each time	Participation in physical game training significantly improves executive function information processing and enhances functional brain efficiency in children with ASD.
<b>Mostafa Sarabzadeh et al. (2019)</b>	18 patients aged 6-12 years	ASD	Taijiquan Training	6 weeks, 3 times per week, 60 minutes each time	Tai chi training is an effective system for improving ASD balance, motor coordination, and concentration.
<b>Ketcheson et al. (2019)</b>	60 patients aged 6-10 years	ASD meeting ADOS-2 diagnostic criteria	Structured physical activity for specific motor skills	8 weeks, 3 times per week, 35 minutes each time	Interventions can improve motor and executive functioning in children with autism.
<b>Luan Yufeng et al. (2023)</b>	16 patients aged 7-10 years	ASD	Light Equipment Rhythmic Exercise	8 weeks, 3 times a week. 60 minutes each time	The experimental group's social participation data before and after the experiment were significantly different, as were social tendency, cognition, communication, and self-regulation.
<b>Haghighi et al. (2023)</b>	16 patients aged 6-10 years	ASD	Comprehensive physical training	8 weeks, 3 times per week, 60 minutes each time	The CPT program significantly affected various social skill indicators and physical attributes such as grip strength, upper and lower body strength, flexibility, and balance.
<b>Homayounnia et al. (2024)</b>	30 patients aged 9-11 years	ASD	sensorimotor integration exercises	12 weeks, 3 times per week, 45 minutes each time	Sensory-motor integration exercises can be an appropriate intervention to promote and improve social skills

Author	Participant (In A Clinical Trial, Etc.)	Diagnostic	Intervention Programs	Interference Frequency	Post-Intervention Measurement Of Benefits
					and motor performance in children on the autism spectrum.

### 4.2. Systematic evaluation

The effect of exercise intervention on physical health development in children with autism. It is well known that motor interventions for children with autism through specially designed physical activities can provide a solid foundation for improving motor skills and recovering physical functioning. This type of intervention is usually individualized, fun, rhythmic, and targeted. It shows significant positive effects on children with autism by improving their physical functioning, mastering basic motor skills, promoting the healthy growth of muscle tissues, and developing multiple aspects of physical fitness, such as speed, agility, coordination, and endurance. **Error! Reference source not found.** For example, Xingyu et al. (2020) found that a 12-week ample muscle motor skill training was implemented for a group of children with autism. Through this training, the researchers sought to explore and validate the effectiveness of enhancing basic motor skills in autistic children through ample muscle motor training. The study results showed that the children who participated in the training made significant progress in their considerable motor skills, demonstrating that motor interventions effectively improved them in children with autism.

In addition, Mostafa Sarabzadeh et al. (2019) found that 18 children with autism between the ages of 6 and 12 were randomized, with one group participating in a tai chi program for 6 weeks. Following the tai chi training, significant improvements in motor skills, body balance, and ball skills were observed in autistic children. However, this training did not produce a substantial effect on improving the dexterity of the hands of the children with autism. Castaño et al. (2023) implemented a structured physical activity program with a group of children with autism and used the TGMD-3 scale before and after the intervention to assess gross motor skills. The study results indicated that the children who participated in the program showed significant improvement in gross motor skills, and their physical fitness and motor abilities also improved significantly.

#### *Effects of exercise intervention on social interaction skills of children with autism.*

According to a recent study released by the Centers for Disease Control and Prevention (CDC) in 2020, the prevalence of autism has risen by about 10% from the previous rate. This data has attracted widespread attention because, with the increase in the prevalence of autism, the social adaptability and psychological condition of the autistic community has also gradually become a problem that society needs to pay attention to and solve. **Error! Reference source not found.**

Researchers Dong Liangfang et al. (2021) conducted a study in which they selected 18 children with autism and randomized them into an experimental group (n=8) and a control group (n=10). Both the experimental and control groups underwent a 10-week exercise intervention. Before the beginning and after the end of the experiment, the researchers assessed the subjects' social interaction skills using the Playground Observation of Peer Engagement Scale (POPE). The results of the study showed that the children with autism in

the experimental group significantly reduced the time spent in isolation to a significant level during the exercise intervention. In addition, there was a substantial increase in their joint participation time, and the time spent in isolation, proximity, parallelism, and spectatorship was reduced to varying degrees. This result suggests that the exercise intervention had a positive impact on the improvement of social interaction skills of autistic children in the experimental group.

Another study by Mengxian Zhao (2018) found that she set 25 children with autism as the experimental group and another 25 children with autism as the control group and conducted a 12-week structured sports training intervention for the experimental group. To assess the effect of sports intervention on the social interaction skills of children with autism, the researchers used the Assessment of Basic Speech and Learning Skills-Revised (ABLLS-R) and the Social Skills Improvement System Rating Scale (SSIS-RS). The study results showed that the experimental group showed an overall improvement in social interaction and communication skills and a significant change in the overall level of social interaction skills compared to the control group. There was a substantial improvement in children's performance in the experimental group in specific social skills such as eye contact, group participation, and establishing communication sessions with teachers and participants.

*The effect of motor intervention on the executive abilities of children with autism.*

Individuals with autism, a disorder that exhibits marked differences in neurophysiology, are often accompanied by executive dysfunction. This dysfunction can adversely affect the daily life, learning, and social interaction skills of individuals with autism. Chen Hao et al. (2024) studied 26 children with autism who were randomly assigned to experimental and control groups of 13 children each. The experimental group received an 8-week intervention that lasted 30 minutes six times per week. The intervention program for the experimental group was carefully designed according to the individual characteristics of each child with autism, and the activity intensity of the sports program was controlled at an appropriate moderate level. In contrast, the control group did not receive any sports intervention. The study results showed that as children with autism learn new and more complex motor skills, their brains constantly integrate old and latest information. This process helps to enhance the executive functions of children with autism.

Anderson et al. (2023) also conducted a study of 62 children with autism randomly assigned to a learning-to-ride-a-bicycle group, a stationary bicycle group, and a control group (20 children in each group). The researchers assessed four key components of executive function: planning, working memory, flexibility, and inhibition. The study results showed that all children with autism in the learning-to-ride-a-bike group showed significant improvements in executive function.

Executive functioning plays a vital role in the cognitive, emotional, and behavioral development of children with autism. It significantly influences how they learn to regulate behavior, maintain focus, and engage in flexible thinking. Enhancing executive functioning enables children with autism to better comprehend the consequences of their actions, follow multi-step instructions, and retain essential information (Doebel, 2020; Shaheen, 2014). Early development of executive functions is particularly crucial, as research suggests that timely intervention can lead to notable improvements in academic performance, daily functioning, and adaptive behaviors in later life.

This systematic review confirms that exercise interventions play a vital and beneficial role in the development of children and adolescents, particularly those diagnosed with autism. Among various non-pharmacological treatments, exercise intervention is considered one of the most effective strategies for addressing the social, emotional, and cognitive challenges faced by individuals with Autism Spectrum Disorder (ASD). Such interventions not only foster interpersonal communication and responsiveness to environmental cues but also enhance emotional regulation, reduce instability, and increase attention span (Shaheen, 2014).

Designing appropriate exercise programs tailored to the needs of individuals with autism has demonstrated significant improvements in physical fitness, including cardiovascular health, muscular strength, motor coordination, and overall endurance. These physiological benefits are also associated with reduced autism-related symptoms and the prevention of secondary conditions such as obesity and sedentary-related disorders.

The review also reveals that when exercise interventions are delivered through engaging and individualized formats, children with autism exhibit increased motivation and active participation. Structured physical activities can foster teamwork, boost self-esteem, and reduce anxiety, ultimately enhancing social interaction skills. Notably, increased classroom engagement, including improved eye contact and emotional involvement, was observed as a positive outcome of such interventions. From a neurological perspective, deficits in executive functioning among children with autism are linked to delayed maturation in the frontal cortex and reduced activity in cerebellar and prefrontal regions. Exercise stimulates neural activation between the cerebellum and dorsolateral prefrontal cortex, supporting both motor performance and executive function development (Diamond & Lee, 2011).

To optimize the delivery and effectiveness of adaptive physical education, awareness must be raised among parents about the benefits of such programs. Institutional support is also essential, particularly in reforming curricula, enhancing teaching methods, and upgrading sports facilities and resources. The lack of trained professionals remains a significant barrier in many educational settings. Therefore, targeted professional development programs for adaptive physical education teachers are crucial. Educators should adopt student-centered approaches, incorporate learners' interests, and collaborate closely with parents to provide individualized instruction aligned with each child's developmental profile.

Despite its contributions, this study has several limitations. First, the number of included articles, while involving 514 participants across multiple countries, may not adequately represent the full diversity and scale of the global autism population, limiting generalizability. Second, the exclusive focus on randomized controlled trials may have excluded relevant findings from observational or qualitative studies that offer valuable insights into the nuanced impacts of exercise interventions. Third, although objectivity was prioritized in the literature screening and data analysis processes, potential subjectivity in methodological judgments could influence the results. Finally, while this review successfully identified the positive impacts of exercise on physical health and social interaction, it did not delve deeply into the underlying neurobiological mechanisms or long-term outcomes. Future studies should address these gaps to strengthen the evidence base and improve intervention design.

## **D. Conclusion**

This systematic review provides an in-depth examination of the various benefits that children with autism, ages 3-12 years old, derive from participating in a sports intervention that involves a range of adaptive sports programs, such as tai chi, technical aquatic programs, cycling skill acquisition, large-muscle motor skill learning, and structured physical education classes. These sports programs are carefully designed to provide a safe and productive sports experience for children with autism based on their specific needs. Through participation in these exercise interventions, we have found that children with autism have achieved significant gains and improvements in physical health, social skills, and executive functioning. These exercise interventions had a tremendous positive impact on reducing anxiety, increasing self-confidence, helping children with autism overcome low self-esteem, and improving their attention span. These findings provide an essential perspective that exercise interventions can effectively promote the overall development of children with autism. Through the studies in this systematic review, we have not only revealed the positive benefits of participation in sports interventions for children with autism but also provided some critical guiding directions for future research and practice. We look forward to providing more effective support and assistance to children with autism through more in-depth study and practice shortly, so that they can better integrate into society and realize their values.

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