

Efficacy of Sports Interventions for Children with Autism Spectrum Disorder and Promising Targets

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ABSTRACT

Sports interventions addressing physical and mental development in children with Autism Spectrum Disorder (ASD) are becoming increasingly prominent in recent years. This review examines whether sports intervention for children with ASD effectively promote growth and development in executive function and social cognition, and whether explicitly targeting those areas of development while devising interventions can optimize the impacts. Reviewing 13 existing studies, it is supported that sports intervention positively impacts executive function and social cognition among children with ASD, with individual interventions targeting more on executive function and collaborative interventions targeting more on social cognition. These conclusions may shed light on the relationship between sports intervention and its intended targets on children with ASD, while encouraging improvements in current interventions and designs of more target-oriented types of interventions.

Introduction

In recent years, sports interventions addressing physical and mental development in children with Autism Spectrum Disorder (ASD) are becoming increasingly prominent (Xue et al., 2019; Contreras-Osorio et al., 2021; Varigonda et al., 2021). As a major mental disorder that raises increasing public awareness, ASD is a neurodivergent developmental disability. People with ASD generally have differences in the brain; some are known (e.g., genetic variance), and others are not (Centers for Disease Control and Prevention, 2020). Nevertheless, regardless of the divergent causes, childhood-onset ASD is usually characterized by persistent deficits in social communication and social interaction, as well as restrictive or repetitive patterns in terms of behaviors, interests, and activities (American Psychiatric Association, 2013; Centers for Disease Control and Prevention, 2020).

Executive function and social cognition are two significant intentional targets of interventions designed for improvement against such disorders. Though children with ASD have varied intellectual abilities, most (70%) have associated deficits in general intellectual developmental aspects, and almost all have core deficits in social-interactive and social-communicative abilities (Mash & Wolfe, 2016). Executive function refers to the group of abilities of an individual to execute or perform tasks in high order (Lai et al., 2017). Conceptually, it includes the sub-functions of planning, cognitive flexibility, inhibition, attention-focusing, and working memory. Meanwhile, social cognition is a part of the high-order cognition in every human, or the ability to perceive and interpret themselves and their relationship with the social world. Generally, it includes the identification, interpretation (perception), and memory of social information and behaviors for making judgments and decisions (Fiske & Taylor, 1991; Aronson & Aronson, 2018).

Sports interventions use various types of sports (e.g., tennis, badminton, track-and-field, workout sessions) to support children with this disorder psychosocially (Chen et al., 2015; Xue et al., 2019). As a relatively novel type of intervention, sports interventions' first studies were conducted between 2004 and 2005 (de Boer et al., 2004; Myers & Johnson, 2007), with the first systematic review four years later (Petrus et al., 2008). These earliest studies primarily focus on general physical exercises' impact on children with ASD instead of

specific sports and tend to target behavioral improvement as a priority. In more recent studies, however, there is a higher tendency of divergence in both the means and the target of such interventions. For instance, Pan et al. (2017) researched table tennis' impact on general cognitive abilities among children with ASD, while Ziadat (2022) used online workout sessions to evaluate joint attention improvement among a similar group of children. In this review, while the types of sports used for intervention are not limited, including both racket/non-racket and individual/team sports, these interventions' impacts on executive function and social cognition are best focused on.

While studies and reviews have covered various developmental benefits of sports interventions for children with ASD (Contreras-Osorio et al., 2021; Morris et al., 2021), there is yet to be a systematic review demonstrating the specific benefits of executive function and social cognition to determine whether these are the most promising intervention targets. This review dedicates itself to exploring which types of sports intervention (e.g., racket/non-racket, individual/team) have the most significant positive impact on executive function and social cognition among children with ASD, and whether targeting these aspects of mental development while devising interventions may optimize these interventions' results.

Methods

A review of literature from Google Scholar, EI, and Scopus was conducted using the following key words: "Sports Intervention", "Physical Activity Intervention", "Sports Therapy", "Autism", "ASD", "Executive Function", "Social Cognition", "Children", and "Adolescents". Over 18,800 papers were identified in the first round of retrieval. By screening and excluding systematic reviews and meta-analyses, then studies that do not strictly regard ASD, sports intervention, executive function, and social cognition, 19 papers were included in the second round. After reading abstracts and evaluating the age of participants, 6 of the papers were further excluded, as they did not fit our age criteria for children or adolescents (3-16 years of age). Thirteen papers were included in the final review.

Results

Table 1 shows the list of the contents of the 13 papers.

Table 1. Type, design, sample, measure, and results of the 13 studies reviewed.

Intervention Type	Intervention	Study	Sample	Study Design	Age	Period	Outcome Measure	Results
Racket-based	Table-tennis	Pan et al., 2017	22, All Male	RCT	7-11	12 weeks	BOT-2, WCST	Improvements in motor skill proficiency and executive function, sustained for at least 12 weeks
	Badminton	Akin et al., 2017	3	Case Study	12-14	12weeks , 3 sessions/week, 60 min/week	BVRT, SCWT	Positive influence on the development of eye contact, long-time focus of objects and attention level development
Non-racket Based, Individual	Cycling	Ringenbach et al., 2015	10	RCT	8-16	20 min/session, 2 days between sessions	PPVT-4, Reaction Time, SCWT, Trail Making Test, TOL, Purdue Peg-board, Off-Task Behavior Assessment	Improvements in inhibition, cognitive planning and set-switching
	Cycling	Tse et al., 2021	62, 50M12F	RCT	8-12	2 weeks, 5 sessions/week, 60 min/session	TOL, CBTT, FDS, BDS, GNG	Significant improvement in all executive function components (planning, working memory, flexibility, inhibition)

	Exergaming	Anderson-Hanley et al., 2011	12	RCT	10-18	2 weeks	GARS-2, FDS, BDS, SCWT, Color Trails Test	Repetitive behaviors significantly decreased, while performance on Digits Backwards improved
	Online Workout Session	Ziadat, 2022	15, 10M5F	RCT	40%<10, 60%>10	5 months, 3 sessions/week, 30-37 min/session	JTAT	Enhancing joint attention skills
	Karate	Greco & de Ronzi, 2020	28	RCT	8-11	12 weeks, 2 sessions/week, 45 min/session	SSIS-RS, BRIEF	Greater socio-emotional competence (communication, cooperation, and engagement), better executive functioning ability (cognitive flexibility, inhibitory control and working memory), lower aggressiveness, sadness, anxiety and hyperactivity
	Mixed Martial Arts	Phung & Goldberg, 2019	26	RCT	8-11	13 weeks	WASI-II, ADOS-2	Improved executive function (emotion and behavior regulation, global executive composite)
	Kata Techniques	Movahedi et al., 2013	30, 26M4F	RCT	5-16	14 weeks	GARS-2	Significant improvement in social dysfunction in the exercise group; improvement retained over one month
Non-racket Based, Collaborative	Structured Physical Activity Program	Zhao & Chen, 2018	25	RCT	Mean 6	12 weeks, 24 sessions in total	SSIS, ABLLS-R	Overall improvement in social skills and social interaction; significant improvements appeared in communication, cooperation, social interaction, and self-control subdomains
	Mini-Basketball	Cai et al., 2020	29	RCT	3-6	12 weeks, 5 sessions/week, 40 min/session	CARS, DTI	Improves social cognition and white matter integrity
	Mini-Basketball	Wang et al., 2020	33	RCT	3-6	12 weeks, 5 sessions/week, 40 min/session	CHEXI, SRS-2, RBS-R	Better working memory and regulation; significantly improved core symptoms of ASD
	Mini-Basketball	Yang et al., 2021	30	RCT	3-6	12 weeks, 5 sessions/week, 40 min/session	SRS-2, rs-fMRI	Improves social cognition and executive control network connectivity

ASD: Status Quo

Before discussing the impact of various interventions on ASD, we took a closer inspection of this childhood disorder. Awareness of ASD has increased not only because of people's awareness of mental illnesses, but also its prevalence rate, which is approximately 1 out of 44 American children (Centers for Disease Control and Prevention, 2022). The number indirectly suggests the significance of developing and investigating adequate types of intervention targeting children with ASD.

Symptoms

ASD is characterized by persistent deficits in social communication and social interaction, as well as restrictive or repetitive patterns in terms of behaviors, interests, activities (American Psychiatric Association, 2013; Centers for Disease Control and Prevention, 2020). Physical symptoms include frequently flipping hands, lack of facial expressions, and lack of attention to the external environment and new stimuli (Centers for Disease Control and Prevention, 2020). Mental symptoms include loss of recognition of social cues (e.g., facial expressions, voice), emotional expressions, theory of mind (i.e., the understanding of another person's mind), and central coherence (i.e., the tendency to interpret stimuli globally; Mash & Wolfe, 2016).

Effects on Cognition

Core deficits of ASD are centered around cognitive functions. Such cognitive deficits occur in branches of executive function and social cognition; some are exemplified as symptoms. In terms of executive function development, children with ASD deviate significantly from their peers. For instance, the comorbidity of severe Intellectual Disability among children with ASD is approximately 40%, while another 30% have mild or moderate Intellectual Disability (Fombonne, 2003, 2005). Other more specific aspects of executive function deficit include the lack of inhibitory mechanisms that prevent echolalia or self-stimulatory behaviors (Mash & Wolfe, 2016), as well as attention control that directs their focus to specific social stimuli in their surroundings.

Meanwhile, they also experience difficulties in social perception, understanding, and decision-making (sometimes regarded as the three components of social cognition; Stanford University, 2022). Regarding social perception and understanding, children with ASD typically lack monitoring of others' social activities, emotional reciprocity (the mechanism of being empathetic with others), sharing of their enjoyment, and use of expressive language (Frith, 2003; Mash & Wolfe, 2016).

This review will focus on both branches of deficits in cognitive ability. It will not only access each component independently, but also discuss them in the context of ASD intervention and attempt to validate their efficacy in correcting ASD-related deficits and promoting healthy growth and development.

Causes and Onset

ASD onset typically occurs in childhood; there are multiple causes of ASD, yet not every one of those is known (Mash & Wolfe, 2016; Centers for Disease Control and Prevention, 2020). The earliest symptoms may emerge within the first 12 months of age, while others may show up after 24 months of life or later. Usually, ASD begins before three years of age and lasts throughout one's life, though conditions may improve in later years (Society of Neuroscience, 2018). This informed our lower age limit for the current review.

State of ASD Research and Treatment

ASD diagnosis and treatment originated from psychiatrist Dr. Leo Kanner in 1943, when he observed 11 children with behaviors highly consistent with DSM-V's list of symptoms, such as lack of adequate eye contact, social awareness, and language (Kanner, 1943). Since then, psychoanalytic treatments were the first to emerge in the mid-twentieth century, as psychiatrists in that era believe that ASD is a withdrawal from reality as a defense from parental detachment (Bettelheim, 1967). These conclusions are unsupported by modern day intervention styles, since now psychiatrists view ASD as a biologically-based, neurodevelopmental disorder that prevents the children "entering reality" (Mash & Wolfe, 2016, p. 158).

The UCLA Young Autism Project in the 1960s, under the direction of Dr. Ivar Lovaas, marks one of the most significant contributions in the field of ASD-related intervention. Its development of the Applied Behavior Analysis (ABA) and Early Intensive Behavioral Intervention (EIBI) are now widely employed intervention styles that are proven to have long-lasting positive impact on learning and behavioral aspects of children with ASD (Gresham & MacMillan, 1997; Smith & Lovaas, 1997; Reichow & Wolery, 2009). Meanwhile, structured teaching models (e.g., TEACCH), developmental models (e.g., Early Start Denver Model), and relationship-focused approaches (e.g., DIR) have also developed in the early twenty-first century (Mesibov, Shea, & Schopler, 2005; Greenspan & Wieder, 2006; Dawson et al., 2010), though their impacts are considerably less than ABA or EIBI. Interestingly, most types of interventions are based on the same guidelines, such as early, intensive, structured, inclusion, ongoing (Mash & Wolfe, 2016), which implicates that modern psychiatrists' fundamental understanding of ASD is, in fact, coherent.

Researching treatment for ASD is essential since it is becoming an increasingly prominent illness across societies. While existing interventions are already effective solutions, possibilities exist among the un-

explored areas and types of intervention. This review is focused on sports interventions, an extension and predicted, plausible application of ABA (Smith & Lovaas, 1997). The rising trend of research in this type of intervention is supported by the increasing number of studies conducted in the past decade.

Sports Intervention's Effect on Executive Function Among Children with ASD

Executive function is the higher-level processing functions in human brains, especially the prefrontal cortex. It includes people's ability to detect, select, rehearse, and monitor information or sensory stimuli, as well as their ability to make decisions (i.e., higher-level responses) accordingly. It is usually categorized into branches of working memory, inhibitory control, and cognitive flexibility, though planning and attentional control is also considered its significant component (Society of Neuroscience, 2018). The majority of studies of sports intervention confirms the positive impact of sports (i.e., improvement and development) on executive function among children with ASD.

Planning

Planning refers to the ability to organize and structure task completion processes, which involve identifying the materials used and creating the order of potential tasks (Society of Neuroscience, 2018). Children with ASD are inclined to have a deficit in planning due to the lack of central coherence, which may make them focus exceptionally on local stimuli without realizing the global context (Mash & Wolfe, 2016).

The Tower of London test is a prominent indicator of change in planning abilities. Both cycling therapies employed this test and demonstrated an increase in the raw score with a medium effect size (Ringenbach et al., 2015; Tse et al., 2021).

Working Memory

Working memory is a short-term declarative memory that has only limited capacities of information storage (Society of Neuroscience, 2018). For children with ASD, the greatest component they lack is verbal working memory, or the temporary storage of verbal components such as letters, numbers, names (Bellani et al., 2011).

Forward Digit Span (FDS) and Backward Digit Span (BDS) are widely used tests assessing participants' verbal working memory in studies included in this review. Both the cycling therapy by Tse et al. (2021) and exergaming intervention by Anderson-Hanley et al. (2011) indicated an improvement of verbal working memory with small effect sizes in BDS, though no similar improvement is observed for the FDS.

A badminton intervention by Akin et al. (2017) demonstrated a numerical yet not statistically significant improvement in visual working memory. Such memory ability is almost kept constant even in the retention test eight weeks after.

Cycling therapy, especially structured bicycle training instead of static cycling, as well demonstrated improvement in visual working memory through the Corsi Block Tapping Task (Tse et al., 2021).

Inhibitory Control

Inhibitory control is the ability to limit influences from unwanted thoughts and behaviors, i.e., the ability to inhibit pre-existing, natural, habitual, or dominant behaviors and select more appropriate behaviors towards one's goals (Anderson & Weaver, 2009; Li et al., 2021). In the case of ASD, the patient's symptoms of repetitive

or routine behaviors, which exemplifies their lack of inhibition of such self-stimulation, demonstrate their disparity in this branch of executive function.

The Stroop Test is a measure widely used across various studies to demonstrate improvement in inhibition. For instance, in the badminton intervention, numerical improvements were found in scoring for this during the post-test compared to the pre-test (Akin et al., 2017). Meanwhile, its employment in the two cycling therapies and exergaming intervention proved inhibitory control improvement (Anderson-Hanley et al., 2011; Ringenbach et al., 2015; Tse et al., 2021), though Off-task Behavior Assessment Ringenbach et al.'s study shows no decrease in the rate of stereotypical, repetitive behaviors afterward.

Repetitive behaviors of children with ASD were decreased in the exergaming intervention under the assessment of Gilliam Autism Rating Scale, second edition (Anderson-Hanley et al., 2011). Pan et al. (2017) also devoted parts of their table-tennis intervention to inhibitory control training of children with ASD, though no measures were taken.

Interestingly, in both martial-arts-related interventions - the karate intervention by Greco & Ronzi (2020) and mixed martial arts intervention by Phung and Goldberg (2019) - problematic behaviors are also reduced under measurement of the Behavior Rating Inventory of Executive Function.

In one of the mini-basketball intervention studies, lower scores in the Childhood Executive Functioning Inventory (which implies better performance) in inhibition and regulation were found (Wang et al., 2020). There was also a decrease in the rate of repetitive movements.

Attentional Control

Attentional control refers to an individual's control over what to focus on and what to ignore. Children with ASD have a common disparity in joint attention, or the attention towards objects of mutual interest. This is supported by their inability of using protodeclarative gestures and vocalizations to direct the visual attention of other people to objects of shared interests, as well as overselective and impaired shifting of attention to sensory input (Mash & Wolfe, 2016, p. 165-168).

Bourdon Visual Attention Test (post-test) examining the badminton intervention demonstrated an immediate numerical yet not statistically significant increase in visual attention among all three participants after 12 weeks of training sessions (Akin et al., 2017). Though there is a numerical drop of scoring for all three participants after eight weeks during the retention test, each participant's scoring is still higher than the pre-test. Such results demonstrated the long-lasting effect about attentional control of badminton training on children with ASD, and implicated the importance of continuous, long-term physical activity. Meanwhile, online workout sessions were also demonstrated to have a positive impact on joint attention (Ziadat, 2022).

Cognitive Flexibility

Cognitive flexibility is defined as an individual's ability to shift or switch between different mindsets, mental tasks, or concepts (Archambeau & Gevers, 2018). Among children with ASD, the greatest difficulty lies in their tendency to behave in routine manners or stick to routines, as it signifies how they may not switch between mindsets.

The table-tennis intervention demonstrated an improvement in cognitive flexibility among experimental group which underwent the intervention (Pan et al., 2017). The use of Wisconsin Card Sorting Test in this study enabled researchers to examine whether participants can make correct choices under constantly shifting rules; total correct answers increased proportionately, while the number of preservative responses and preservative errors (i.e., the responses and errors that stick to the same rule) reduced after intervention. However, it is not known whether this improvement is strictly due to physical activities induced by table-tennis, or the executive function training specifically modified and employed in the intervention (e.g., children learned to hit

only orange balls when orange and white balls are served to them at random, such that they inhibit their actions of hitting white balls). Nevertheless, the medium of table-tennis has been shown to be beneficial in triggering cognitive flexibility growth.

Set-switching abilities of children with ASD also improved during Assisted Cycling Therapy; the experimental group given the therapy scored higher in the Trail Making Test, while the control group did not have such difference (Ringebach et al., 2015).

Sports Intervention's Effect on Social Cognition among Children with ASD

Social cognition broadly refers to the cognitive process that includes other individuals (i.e., the cognition of social interactions; Blakemore et al., 2004). Similar to other cognitive processes, it includes an individual's perception, understanding, and explicit behavior that serves as output of the previous two processes. In this review, the social understanding and social communication skills of children with ASD are discussed respectively. These segments of social cognition may be the most widely known deficits among children with ASD.

Social Understanding

Social understanding is the ability to detect social stimuli and conclude another person's internal feelings and antecedents or consequences of emotions (Mash & Wolfe, 2016). One of its branches that this review examines is social interactive skills, the recognition of social cues (e.g., emotional reciprocity) and the tendency to relate to others in terms of enjoyment, interest, and attention (Brown et al., 2014). This review combines the perception and understanding process of social interaction (e.g., emotion) because they are closely related and tests addressing the first process may address the second simultaneously (e.g., participants may not demonstrate their perception of emotions if they cannot understand them).

Joint Attention of children with ASD, being considered a prominent deficit in social understanding, demonstrated an improvement after long-term online workout sessions (Ziadat, 2022).

Via the Social Skills Improvement System Rating Scale, the karate intervention concluded a positive impact on emotional understanding and empathetic abilities of children with ASD, though the scale is greatly based on participants' parent's perception of their children (Greco & Ronzi, 2020). Using the same scale, an effect on cooperation, responsibility, and empathy is also found in the structured physical activity program (Zhao & Chen, 2018). The kata techniques intervention, using Gilliam Autism Rating Scale, Second Edition, also reported a reduction of overall social dysfunction severity, which lasts unchanged even after one month (Movahedi et al., 2013). As an inference, the karate and kata technique interventions' use of verbal cues and attentional cueing, as well as the structured physical activity program's cooperative, inclusive environment, may have contributed to such results.

Social Communication Skills

In general terms, social communication skills include both verbal and non-verbal components, from speeches to nonverbal gestures. In this segment of social cognition, children with ASD are usually characterized by impairment of language abilities, such as pronoun reversal (i.e., repeating pronouns as heard without changing to suit situations), pragmatics (i.e., using or interpreting language appropriately according to social or communicative contexts), as well as protodeclarative gestures.

The karate intervention, apart from evaluating the social interactive skills, also reported an improvement in social communication skills (e.g., taking turns during conversations) of children with ASD (Greco &

Ronzi, 2020). In contrast, participants who underwent the mixed martial arts intervention demonstrated weaker predicted emotional regulation abilities (Phung & Goldberg, 2019), which implies the lack of evidence for the efficacy of using mixed martial arts intervention to promote social-emotional growth.

Meanwhile, using both the Social Skills Improvement System Rating Scale and the Assessment of Basic Language and Learning Skills-Revised, the structured physical activities program concluded an increase in scores for communication and verbal language skills (Zhao & Chen, 2018).

Notably, all three mini-basketball interventions demonstrated significantly lower post-test (i.e., Social Responsive Scale-second edition) social cognition and communication t-scores compared to baseline, which implies a positive impact of the intervention on social cognition and communication (Cai et al., 2020; Wang et al., 2020; Yang et al., 2021).

Discussion

This paper explored the types of sports intervention that have the most significant positive impact on executive function and social cognition among children with ASD. Meanwhile, it also studied whether these interventions' results would be optimized if these aspects of mental development are targeted explicitly while devising interventions.

Close analysis and review of 13 pre-existing studies that researched various sports interventions ranging from racket-based, individual non-racket-based, and collaborative non-racket-based interventions, supported that sports intervention is effective in promoting the executive function and social cognition of children with ASD. In specific, individual interventions, whether racket or non-racket, demonstrate more significant promotion of executive function than collaborative interventions. Meanwhile, collaborative interventions show more substantial support for developing social cognitive abilities than individual interventions.

Indeed, there are exceptions. On the one hand, karate, an individual non-racket-based intervention, promotes social understanding and communication skills (Greco & de Ronzi, 2020). On the other hand, one mini-basketball study shows efficacy in promoting inhibitory control, which is a branch of executive function (Wang et al., 2020). However, the existence of such exceptions does not hinder the general conclusion that individual interventions emphasize more improvement of executive function, while collaborative interventions are more helpful in triggering social cognition growth.

Among the 13 studies included, only the table-tennis intervention employed an explicit modification of its content such that it targets branches of executive function explicitly (Pan et al., 2017), and a few other studies have used social communicative techniques (e.g., verbal and attentional cues) as slight adjustments (Movahedi et al., 2013; Greco and Ronzi, 2020). Even so, evidence in those studies supports the hypothesis that the modifications have an extra positive impact (i.e., optimization) on the efficacy of the intervention. In other words, if an intervention can target aspects of mental development specifically in its design, it will better promote the mental development of children with ASD compared to interventions directly borrowed from mainstream courses without adjustments.

These conclusions shed light on an emerging type of intervention targeting children with ASD, which combines mental development with physical fitness and well-being. In real-world contexts, these recommendations may offer children with ASD alternative interventions to pursue growth and development apart from conventional Applied Behavioral Analysis or TEACCH models, if other types of interventions have limited efficacy.

Limitations

One limitation of the present review is the lack of biological analysis of ASD. This review did not examine what ASD looks like in the brain or how the brain is affected during sports interventions, and thus cannot support the efficacy of sports interventions on a solid biological basis but rather a cognitive one. This review only covers interventions with children and it is important to acknowledge that many adults are also disturbed by ASD. Those adults may require other types of adulthood interventions different from what were included in this review. In addition, though this review focused primarily on sports interventions, its intention is not to discount other potential types of treatments that may as well promote executive function and social cognition development among children.

Future Directions

This review demonstrated how sports intervention can be helpful in promoting the growth of executive function and social cognition among children with ASD. More studies may need to focus on the means of delivery of those interventions, to devise more effective interventions and appropriately apply those interventions in the future.

In specific, future studies may focus on developing a model that identifies intervention targets for individual children with ASD; and determining particular modifications that may apply to existing sports training programs to best target the intended areas of development. The first focus deals with choosing the best intervention type that suits individual children's needs. This review supports that individual interventions better promote executive function, while collaborative interventions better promote social cognition. However, whether a child needs an enhancement in executive function or social cognition should be determined prior to implement either individual or collaborative intervention. The second focus deals with the problem of modifying ordinary sports training programs into ASD-specific interventions. Most papers in this review essentially borrow ordinary sports training programs without extra modification or addition of executive-function-or-social-cognition-related modules; yet the few papers that demonstrate explicit modifications show more significant results. Therefore, it's essential to determine what to modify and how to modify it when borrowing a pre-existing ordinary sports training session into an intervention specifically for children with ASD.

Conclusion

This paper explored the types of sports intervention that most significantly impact executive function and social cognition among children with ASD, and the means that can optimize those interventions' results via a review of 13 studies. It is supported that individual interventions may better impact executive function, while collaborative interventions may better impact social cognition. It is also found that modification of interventions that more precisely target those areas of development gives more significant positive impacts than simple borrowing of ordinary sports training sessions. Using the conclusions this review provided, it is possible to improve the current intervention programs or design more target-oriented interventions to address these children's psychopathological development more effectively. This review laid the foundation for enhancing the interactive consistency between sports interventions and their intentional targets on individual children. Critical evaluation of past approaches to treating ASD is important for future improvement.

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