

# Children with Attention Deficit Hyperactivity Disorder

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Children with attention deficit hyperactivity disorder are characterized by inattention, hyperactivity, impulsivity, difficulty in controlling behavior, or such comprehensive symptoms, while children with ASD have apparent deficits in social communication skills and repetitive stereotyped behavior patterns. Despite significant differences in the core symptoms between children with ADHD and ASD, clinical studies have supported the similarity of the behavioral disorders, and the findings suggest that the two types of children not only have highly shared heritability, but also represent the performance of the same endophenotype and can be classified into the same diagnostic entity.

ADHD

ASD

exercise intervention

children

## 1. Exercise Intervention Has a Significant Effect on Gross Motor Skills of ADHD/ASD Children

Meta-analysis studies have shown that exercise intervention can improve the gross motor skills in children with ADHD/ASD, which is consistent with the findings of Ruggeri et al. <sup>[1][2]</sup>. The underlying mechanism by which exercise intervention induces improvements in gross motor skills may be related to neuroanatomy <sup>[3][4]</sup>. On one hand, exercise intervention can cause a series of biological reactions in the muscles and organs, promoting neurogenerative, neuroadaptive, and neuroprotective processes to favorably affect the structural development and functional neurocognitive development of the brain primarily through the regulation of the brain's neural circuitry, mediation of executive function, and lasting impact on the developmental trajectory of gross motor skills in children with ADHD/ASD <sup>[5][6]</sup>. On the other hand, exercise intervention may help the prefrontal cortex of the brain to formulate and improve perception–motor related skill tasks, while the prefrontal cortex of the brain can get away to focus on cognitive and adaptive functions, allowing for the gradual automation of gross motor skills <sup>[7]</sup>.

Among the gross motor skill interventions, six types <sup>[8][9][10][11][12][13][14][15][16][17]</sup> of exercise interventions could improve the locomotor skills of ADHD/ASD children, and only two types <sup>[8][13][14]</sup> could improve the object control skills for both types of children. Of these, the FMS intervention <sup>[13][14]</sup> and the table tennis exercise <sup>[8]</sup> had the potential to improve both the locomotor skills and object control skills in both types of children, but the enhancing effect of the FMS intervention was better. Further analysis found that the FMS intervention could not only provide a goal-oriented, structured, and progressive guidance strategy, positively change the functional connection of the brain's neural network and have an impact on the brain's neurogenesis, adaptation, and protection <sup>[5][18]</sup>, but in particular, it created the best stimulating environment in the learning situation and helped children with ADHD/ASD

to create a positive self-perception and experience [13]. In addition, six types [9][10][11][15][16][17][19][20] of exercise interventions could improve the stability skills in children with ADHD/ASD, but aquatic therapy had the best improvement effect. Aquatic therapy mainly applies the principles of hydrodynamics to provide multiple sensory stimulations through water temperature, weight reduction, and vestibular input to promote gross motor skill execution [21].

## 2. Exercise Intervention Has a Significant Effect on Fine Motor Skills of ADHD/ASD Children

The findings that exercise intervention improves the fine motor skills in children with ADHD/ASD are not consistent with the results of Zhang et al. [22]. These differences may be due to the sample size, the form and intensity of the intervention, the tactile sensitivity, and the overall lack of social imitation being different [23]. It has been shown that exercise intervention may not only promote the brain to make connections in visual feedback and motor commands, but also form connectivity with both the visual network and the dorsomedial motor region, and most likely through visual imitation to improve the hand–eye coordination ability and upper limb motor skills in children with ADHD/ASD. It may also promote central nervous system plasticity and increase neurotransmitter secretion, increasing the level of brain arousal, and thereby improving executive function and enhancing the fine manual control of both types of children [24][25].

Among the studies included in the meta-analysis, only four studies [9][10][15][17] focused on the effect of exercise intervention on the fine motor skills of children with ADHD/ASD. The table tennis exercise and horse-riding program were important interventions to improve their fine motor skills, but the specific exercise patterns differed. The successful performance of table tennis exercises mainly depends on visual perception and executive function, that is, accurately predicting the spatial trajectory and arrival time of the table tennis ball, and immediately making the selection and execution of the ball response. Table tennis exercise is based on the principle of constraint-induced exercise therapy, which guides children with ADHD/ASD to perform repetitive exercises, conceal motor potential through different strategies and tasks, and promote hand–eye coordination, fine manual control, and executive function of both types of children [10][15]. Through active vision and somatosensory control, the horse-riding program coordinated the connection between vision and the limbs and performed the movements of the limbs correctly. ADHD/ASD children are required to grasp the handle of the horse-riding machine during the horse-riding program, and alter the posture and speed of their upper limbs from time to time according to the visual information and trunk movement, improving hand–eye coordination and fine manual control [9][17]. Currently, the fine motor skills of most children with ADHD/ASD show structural defects and are lower than the level of children of the same age [26][27]. Therefore, it is hoped that more appropriate exercise interventions can be used to improve the fine motor skills of both types of children.

## 3. Effects of Moderator Variables in Exercise Intervention on FMS in ADHD/ASD Children

The results show that although both open-skill and closed-skill can improve FMS in children with ADHD/ASD, the improvement effect of closed-skill was better. The motor environment is considered to be the main sign that distinguishes open-skill from closed-skill. Closed-skill (running, cycling, swimming, etc.) are performed in a relatively consistent, controllable, and self-regulating environment; open-skill (table tennis, football, basketball, etc.) refer to responding in an environment that is dynamic, unpredictable, and influenced by external factors. In general, open-skill interventions tend to be more complex [28][29]. The analysis of this study demonstrates that children with ADHD/ASD have defects in complex tasks, adaptive behavior, and motor development, and that performance on the FMS is significantly poorer than that of children of the same age. Therefore, simple, regular, and predictable closed-skill are more suitable for the development of FMS of both types of children [30][31].

In addition to the form of intervention, the FMS of ADHD/ASD children was also affected by the time, frequency, and duration of the intervention, which is consistent with previous meta-analysis studies [32]. This study found that an exercise intervention of 60 min each time, twice a week, for at least 12 weeks was the most beneficial for improving the FMS in children with ADHD/ASD. In terms of intervention time, each 60-min improvement effect was the best. For example, tai chi training [33] and the FMS intervention [3] implemented a 60-min structured intervention program to effectively improve the children's movements and skills. With regard to the frequency of intervention, exercise intervention once or twice a week may improve FMS in children with ADHD/ASD, and the improvement effect was better twice a week, which is consistent with the aquatic therapy of Pan [34]. Exercise intervention three times or more per week had no significant effect on improving the FMS of the two types of children, indicating that intensive exercise intervention may not be suitable for the development of both types of children, probably because the development of FMS of both types of children lags behind that of normal children, and the frequency of intervention should be consistent with their actual developmental abilities [12][16]. In terms of intervention duration, the improvement effect is better for 12 weeks or more. Long-term exercise intervention may increase the brain growth factors in children with ADHD/ASD, promote brain activity, improve cognitive ability, and enhance the practice effect of the FMS [5]. Lourenço et al. pointed out that exercise intervention lasting at least 12 weeks may stimulate the long-term attention and FMS proficiency of the two types of children to a greater extent [35][36]. In conclusion, to maximize the benefits of exercise interventions, the potential effect of moderator variables should be considered.

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