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The Intervention Effect of Progressive Exercise Training on Children with Autism Spectrum Disorder

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Abstract: Background: Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by challenges in social interaction, communication, and restricted repetitive behaviors. Individuals with ASD often experience sensory sensitivities and motor coordination difficulties, impacting their daily functioning and overall well-being. Traditional physical education programs have been employed to address these challenges, but there is growing interest in exploring alternative interventions, such as progressive exercise training, to enhance the physical and cognitive abilities of children with ASD. Objective: To explore the effects of a progressive exercise intervention on children with ASD. Method: A total of 25 children with ASD participated in the study, with 11 in the intervention group and 14 in the control group. The intervention group received progressive exercise training for 10 weeks, three times a week, for 40 minutes each session, totaling 30 interventions. Results: Both the progressive exercise intervention group and the traditional physical education group showed significant improvements in sensory, social, motor, and self-care abilities in children with ASD. The progressive exercise intervention group showed faster progress in social interaction and self-care abilities, while the improvements in sensory and motor functions manifested later. In terms of total scores and social interaction dimension, the improvement in the progressive intervention group at each time point was significantly greater compared to the traditional physical education group. Conclusion: Progressive exercise training can significantly improve symptoms in various aspects of children with autism, and its effectiveness is superior to that of the traditional physical education group.

Keywords: Autism Spectrum Disorder, Exercise, Intervention, Progressive Exercise Training

1. Introduction

Autism Spectrum Disorder (ASD) is a globally recognized significant public health issue. Children with ASD not only suffer from continuous impairments in social communication and interaction across multiple contexts, and restricted, repetitive patterns of behaviors, interests, or activities [1], but also experience movement difficulties, poorer motor skills, and difficulties in motor coordination and balance, with over 50% of ASD children affected [2]. These limitations can restrict their physical activity choices [3, 4], leading them to prefer sedentary or low-activity behaviors, such as watching TV or using a computer [4, 5], which can result in a higher incidence of obesity and further physical and mental health problems, including diabetes, increased cardiovascular risk, and depression [6, 7].

Physical exercise is an effective intervention method for children with ASD and can promote their rehabilitation in multiple aspects. Exercise is a crucial factor influencing the health of individuals with developmental disorders, and its benefits for children with ASD have been studied [8]. Pan demonstrated that aquatic exercise, specifically swimming, intervention not only improves aquatic skills in ASD children but also enhances their social skills [9]. Hilton et al. also found that exercise can improve motor performance and executive functions in ASD children [10]. Additionally, research has shown that exercise helps improve balance and flexibility in ASD children while reducing stereotypical behaviors [11]. It has also been found that participation in exercise enables ASD children to engage in fun activities with peers and develop crucial interpersonal communication skills [12]. Other studies

that have used exercise as an intervention measure have reported positive effects on outcomes such as repetitive behaviors [13] and motor skills. The form of training also influences the intervention effect, with individual training effectively improving motor skills while group activities are more effective for promoting language and social abilities [14]. Overall, exercise is a beneficial approach to improving individuals' physical and mental functions as well as brain structure. Exercise training can be implemented in various flexible forms, targeting multiple aspects of development, and improving various symptoms of ASD. High-intensity exercise has better effects, and group activities can facilitate social interaction among ASD children, making exercise training an essential intervention method for ASD. In addition to addressing clinical symptoms, this study utilizes children's natural affinity for games and specifically targets the common motor difficulties among children with ASD by proposing progressive exercise training. Progression refers to starting from easy to challenging exercises, gradually transitioning from single warm-up movements to combinations of two actions, and eventually incorporating multiple movements. The effective combination of guidance, exercise, games, and interaction is emphasized. This approach integrates multiple functions and potentials of exercise training, ensuring the feasibility and effectiveness of the training.

2. Method

2.1. Subjects

Recruiting 30 ASD children aged 4-7 from a certain autism rehabilitation institution, with 5 children dropping out or incomplete testing data, 25 children were ultimately included. Among them, there were 17 boys and 8 girls, with an average age of 4.8±1.23. For the progressive physical education class, there were 11 participants including 5 boys and 6 girls, with an average age of 5±1.35. For the traditional physical education class, there were 14 participants including 12 boys and 2 girls, with an average age of 4.64±1.30. Using G*Power3.1 to calculate the total sample size required for repeated measures ANOVA is 24 people (statistical power=0.8, effect size=0.25), and the sample size has reached saturation. The ASD children participating in the sports intervention meet the following criteria: (1) diagnosed with ASD by child and adolescent psychiatry according to DSM-V (Diagnostic and Statistical Manual of Mental Disorders); (2) excluding severe physical illnesses, childhood schizophrenia, childhood disintegrative disorder, and epilepsy, etc.; (3) no history of ASD drug treatment.

2.2. Research Tool

The Autism Behavior Checklist (ABC) is a tool used to assess the behavioral characteristics of individuals with ASD. It consists of 57 items that cover five domains: sensory skills, social interaction, physical movement, language abilities, and self-care skills. A total score of 31 or higher is considered the screening cut-off point for ASD, while a total score of 53 or higher is used as the diagnostic cut-off point (reference values). Higher scores indicate more pronounced symptoms of autism. In this study, the Cronbach's α coefficient for this scale was 0.82.

2.3. Research Design

Progressive Physical Education Class, Traditional Physical Education Class, Sports Intervention for 10 weeks, 3 sessions per week, 40 minutes per session, totaling 30 interventions.

The Autism Behavior Checklist (ABC) was used for baseline assessment (T1) before the intervention, with a post-assessment (T2) conducted after the 5th week of intervention, and a follow-up assessment (T3) conducted after the intervention.

Progressive Physical Education Class Intervention: Divided into three stages. The first stage focuses on basic skill exercises such as walking, running, jumping, and crawling. The second stage involves interactive sports games like relay races and three-legged races. The third stage involves group scenario games like "Eagle Catches Chicks" and "Cops and Robbers."

The intervention utilized a staged group training approach, incorporating games throughout the process. It included the following components: (1) Training of basic motor skills, including jumping, crawling, rolling, and balancing on a beam; (2) Interactive games involving two participants; (3) Group scenario-based sports games. The games gradually increase in difficulty and physical activity. To ensure children's shared attention and imitative ability, multiple individuals demonstrate the same movement. Initially, the coach demonstrates, followed by parents or volunteers, to break the children's stereotypes and promote generalization and transfer of observation. During training, parents or volunteers use gestures to guide children's attention, and exaggerated hand gestures accompany demonstrations, such as saying, "I'm starting" and "I'm finished," ensuring observation of the initiation and key aspects of the movements. Children take turns in line, with multiple observations and imitations. If 80% of the children successfully imitate the movement, they move on to the next new activity. The specific design is as follows: Stage 1: Basic motor skills such as walking, running, jumping, and crawling. This stage prepares for subsequent activities, enhances basic motor skills, and trains observational and sensory integration abilities as the foundation for future interactions and group games. Stage 2: Interactive sports games for two participants, such as three-legged races, ball-passing runs, and relay races. This stage enhances interaction and emotional communication between two individuals. Stage 3: Group scenario-based sports games, such as "Eagle Catches Chicks," "Moving House," "Cops and Robbers," and "Sticking the Pancake." This stage combines role-playing scenarios and sports. It incorporates elements of scenario creation, role-playing, and imagination into physical activities to improve empathy skills. Through learning and understanding game rules, multiple individuals engage in sports interaction, enhancing social skills and cognitive functions. Intervention personnel: To ensure training effectiveness, in addition to coaches and parents, volunteers also participate in

demonstrations or provide one-on-two assistance to subjects (such as directing attention and preventing wandering). Prior to the training, parents, coaches, and volunteers receive systematic training, including guidelines for demonstrations and assistance.

Traditional Physical Education Class Intervention: Activities include running, playing basketball, throwing sandbags, and shooting baskets. There was no systematic design, mainly emphasizing free physical activities.

Data Collection Method: Behavioral data were collected using the Autism Behavior Checklist at T1/T2/T3. The checklist was completed by parents and teachers for the ASD children in the intervention group. Additionally, 4 students specializing in sports rehabilitation assisted in the training process.

2.4. Data Analysis

A mixed-design analysis of variance (ANOVA) was conducted, which involves a repeated measures approach. The analysis considered two factors: the between-group factor (with two levels: the traditional physical education group and the progressive exercise intervention group) and the within-group factor (with three levels: baseline, 5th week, and 10th week). Within-group effects were examined using repeated measures ANOVA to assess the effect of time on the scores (baseline, 5th week, and 10th week) and to determine if there was an interaction effect between time and group. Between-group effects were examined to evaluate differences in scores between the two groups at baseline, 5th week, and 10th week. Interaction effects were analyzed to investigate if there were differential effects over time between the two intervention methods (traditional physical education vs. progressive exercise intervention). If a significant interaction effect was observed, post-hoc analyses such as simple effects analysis or pairwise comparisons (using correction methods such as Tukey or Bonferroni) were conducted to further examine group differences at different time points. Effect sizes were computed to assess the practical significance of the intervention effects.

3. Results

3.1. The Change in Symptoms of Children with ASD

The descriptive statistical results of the overall scores and scores on various subscales for the pretest and posttest of the two groups of participants with ASD are shown in Table 1. An independent samples t-test was conducted to examine if the two groups were homogeneous at the pre-intervention stage, and the results revealed no significant differences in autism symptoms between the intervention group and the control group.

3.2. Changes in Dimensional Scores for Children with ASD in the Intervention and Control Groups Pre and Post Intervention

A repeated measures analysis of variance (ANOVA) was conducted to examine the differences in the ABC Scale dimensions and total scores between the intervention group and the control group at T1 and T3. The results showed significant improvements in both groups of children, except for the main effect and interaction effect of language dimension (Ps > 0.05), as shown in Table 2.

Specific improvements were observed in the following aspects:

(1) Total scores: There was a significant main effect of measurement time ($P < 0.001$), a significant main effect of group ($P < 0.05$), and a significant interaction effect between group and measurement time ($P < 0.05$).

(2) Sensory dimension: There was a significant main effect of measurement time ($P = 0.021$), a non-significant main effect of group ($P = 0.615$), and a non-significant interaction effect between group and measurement time ($P = 0.303$).

(3) Social interaction dimension: There was a significant main effect of measurement time ($P < 0.001$), a significant main effect of group ($P < 0.001$), and a significant interaction effect between group and measurement time ($P < 0.001$).

(4) Motor dimension: There was a significant main effect of measurement time ($P = 0.008$), a non-significant main effect of group ($P = 0.299$), and a non-significant interaction effect between group and measurement time ($P = 0.557$).

(5) Self-care dimension: There was a significant main effect of measurement time ($P < 0.001$), a non-significant main effect of group ($P = 0.428$), and a non-significant interaction effect between group and measurement time ($P = 0.965$).

Further post-hoc analysis of the significant main effects revealed that the overall symptoms, social interaction, and self-care abilities of children in the intervention group showed significant improvements during the early to middle period (T1-T2), with T2 and T3 scores significantly lower than T1 (Ps < 0.05). There were no significant differences between T2 and T3 (Ps > 0.05), indicating a relatively stable period in the middle to later stages (T2-T3), with the intervention effects maintained during the follow-up period (T3-T4). Sensory abilities showed a trend of improvement at T2 and T3 ($P = 0.076$, $P = 0.079$). These results suggest that the improvement trends in different dimensions are inconsistent. Simple effect analysis revealed that in terms of total scores and social interaction dimension, the improvement in the progressive exercise intervention group at each time point was significantly greater than the traditional physical education group ($P < 0.05$).

According to the findings, there were significant improvements in various dimensions of the ABC Scale, indicating the effectiveness of progressive exercise intervention for children with ASD. The intervention group showed greater improvements compared to the control group, particularly in social interaction and self-care abilities.

Table 1. *Descriptive Statistical Results (M±SD) of Variable Scores for Pretest and Posttest in Two Training Groups.*

	intervention group		control group	
	T1	**T3**	**T1**	**T3**
sensory skills	11.91±5.48	6.63±4.83	13.50±4.31	9.00±6.51
social interaction	19.45±8.31	10.27±6.01	14.43±6.10	14.86±6.91
physical movement	5.91±2.31	3.72±2.42	5.71±2.68	4.64±2.38
language abilities	15.82±7.22	13.91±7.19	13.14±8.57	12.79±5.73
self-care skills	13.36±4.03	11.27±4.86	13.71±4.28	10.36±4.43
total score	66.45±14.11	39.82±12.79	60.50±11.64	47.64±6.52

Table 2. *Changes in Dimensional Scores for Children with ASD in the Intervention and Control Groups Pre and Post Intervention.*

	intervention group			control group		
	T1	**T2**	**T3**	**T1**	**T2**	**T3**
sensory skills	11.91±5.48	8.45±6.32	6.63±4.83	13.50±4.31	9.92±7.64	9.00±6.51
social interaction	19.45±8.31	12.82±5.44	10.27±6.01	14.43±6.10	13.28±8.10	14.86±6.91
physical movement	5.91±2.31	3.0±1.76	3.72±2.42	5.71±2.68	5.21±3.72	4.64±2.38
language abilities	15.82±7.22	8.45±5.43	13.91±7.19	13.14±8.57	13.79±7.74	12.79±5.73
self-care skills	13.36±4.03	11.36±4.27	11.27±4.86	13.71±4.28	10.57±5.67	10.36±4.43
total score	66.45±14.11	44.09±7.98	39.82±12.79	60.50±11.64	52.79±15.30	47.64±6.52

4. Discussion

The intervention effect of exercise training on symptoms of ASD children was compared between the intervention group and the control group at baseline (T1), and no significant differences were found in the symptoms dimensions between the two groups, indicating comparability. However, gradual exercise training was found to be beneficial for improving overall symptoms of ASD children, as well as enhancing sensory, social communication, motor skills, and self-care abilities.

In comparison to similar studies, our findings align with previous research that long-term exercise intervention can significantly improve social interaction difficulties in individuals with ASD [15-18]. While some previous studies have focused on specific types of exercise interventions such as horseback riding, swimming, and karate, which are targeted towards high-functioning individuals with ASD [19-21], our study utilized a random convenience sample of participants and found improvements in a broader range of individuals, suggesting a wider applicability of exercise interventions for ASD children.

The lack of social skills is a core impairment in ASD. This study suggests that exercise training can improve the social communication and self-care abilities of ASD children. In terms of social communication, the intervention group showed significantly greater improvement compared to the control group, indicating a significant enhancement in social interaction ability with exercise training. This result is consistent with previous research that long-term exercise intervention can significantly improve social interaction difficulties in individuals with ASD [21-23].

This study created an inclusive and friendly training environment for ASD children, promoting their social behaviors in a pleasant gaming atmosphere. Additionally, the training was conducted in a group format, and cooperative games also stimulated the social needs of the children. Participation in the games required following rules and cooperation with two or more players, which also enhanced their social skills.

In terms of self-care, the improvement in the intervention group was significantly greater than the control group. Most ASD children have difficulties in self-care, with low abilities to perform daily activities like dressing and personal hygiene. Although this study did not directly train self-care abilities, the comparison with the control group suggests that exercise training significantly improves individual self-care abilities.

Since self-care abilities are closely related to coordination and flexibility of movements, exercise training indirectly promotes self-care abilities by improving movement abilities. Therefore, exercise training has multifaceted intervention functions. Exercise training also helps improve sensory and motor functions in ASD children. The improvement in sensory perception in ASD children suggests that progressive exercise training can improve their sensory perception, including visual, auditory, and vestibular perception.

The most direct changes from exercise training come from the body itself. Exercise helps strengthen muscle strength and enhance control abilities. The exercise games in this study, such as crawling, jumping, rolling, and walking on balance beams, provided comprehensive training for the children's movement abilities, contributing to the improvement of their sensory and motor abilities.

However, exercise training had the weakest effect on improving language abilities in ASD children. In terms of language skills, no significant progress was observed in both the intervention and control groups before and after the training, and there were no significant changes in different time periods within the intervention group. This may be attributed to the delayed integration of language elements in this exercise training, which primarily focused on training children's motor skills.

To ensure the children's attention to gestures, language assistance was minimized during the initial stage of training, and the training primarily relied on gesture guidance to enhance the children's ability for independent observation. It was only when situational group games gradually increased

in later stages that language elements were appropriately incorporated to facilitate the children's understanding of role-playing rules.

The results of this study indicate that there are differences in the progress trends of different dimensions, and from the perspective of intervention process, the progress of socialization and self-care abilities can be roughly divided into three stages. The early and middle stages (T1-T2) are the leap stage, and the progress of children may be due to the improvement of joint attention. During the first three training sessions, the children were in the adaptation stage. When they adapted to the group environment and improved their joint attention, there was a significant improvement in socialization. The rapid progress may be related to the improvement of attention in children with ASD. The middle and later stages (T2-T3) are the stabilization period, during which ASD children have adapted to the group environment and corresponding games, reached a relatively stable state, and entered a high plateau period of progress. To achieve greater progress, longer practice or adding new elements that interest children may be necessary to break through this high plateau.

The effectiveness of this study is attributed to the design of the program. The motor training program in this study improved the overall symptoms of ASD children and produced significant effects. This may be due to several factors: (1) group intervention created social situations for children, which stimulated their social needs and improved their willingness to socialize; (2) the intervention was in the form of exercise, which helped children overcome movement disorders and improve their motor abilities; (3) incorporating game elements into the exercise. The interesting nature of the games attracted the children's interest and made them willing to continue participating in the exercises, and cooperative games increased their social opportunities; (4) motor training used gesture guidance to direct children to follow gaze, which habitually shifted attention from objects to people; (5) multiple demonstrations by different subjects. Multiple demonstrations reduced the difficulty of learning and demonstrated by different people also helped children generalize the behavior.

5. Conclusions

In conclusion, the findings from this study suggest that progressive exercise intervention has a positive impact on children with ASD. The intervention group, who received progressive exercise training for a period of 10 weeks, three times a week, for 40 minutes per session, showed significant improvements in sensory, social, motor, and self-care abilities. The progress in social interaction and self-care abilities was faster in the intervention group, while improvements in sensory and motor functions were observed later. Furthermore, the intervention group showed significantly greater improvement in total scores and social interaction dimension compared to the traditional physical education group at each time point. Therefore, progressive exercise training is an effective intervention for improving symptoms in various aspects of children with autism, surpassing the effectiveness of traditional physical education. These findings provide important insights for further research and intervention strategies for children with ASD.

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Abbreviations

ASD: Autism Spectrum Disorder

ABC: Autism Behavior Checklist

DSM-V: Diagnostic and Statistical Manual of Mental Disorders

ANOVA: A Mixed-Design Analysis of Variance

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Conflicts of Interest

The authors declare no conflicts of interest.

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