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Physical Fitness Training Affects the Intestinal Flora of Children with Autism Spectrum Disorders

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Abstract: *With the emergence of physical fitness training (PFT), it is mainly used for adult fitness activities, while children with autism spectrum disorder (ASD) (a special group) are ignored. In this paper, we studied the influence of fitness training on the level of autism disorder and intestinal flora (IF) of autistic children through six weeks of fitness training intervention, so as to observe the changes in the level of autism and the diversity and richness of IF. From the results of PFT intervention, we know that the scores of ATEC, CARS, SRS and CBCL of ASD children were significantly reduced, the ace index, shannon index and chao index of the experimental group (EG) were significantly increased (P<0.01), and the simpson index was significantly decreased (P<0.01). In the data after intervention, the intestinal bacterial flora abundance level of EG was not significantly different from that of the control group (CG).*

Keywords: *Physical fitness training, Children with autism spectrum disorders, Intestinal Flora, Alpha diversity*

1. Introduction

For children with ASD, PFT can improve children's behavior, improve ASD perception, and improve the diversity of children's IF, and provide PFT for children with ASD according to their physical growth and development, so that each child with ASD can use PFT as part of their daily life, thus promote physical fitness and intestinal health in children with ASD.

Research on the effects of fitness training on the IF of children with ASD has yielded good results. In the study of children's fitness training, a comparative analysis of children's fitness training found that children who engaged in fitness training had better fitness data than children who did not engage in fitness training, indicating that fitness training has a positive and significant effect on improving children's physical fitness [1]. It has been mentioned in some studies that children should do a certain amount of exercise every day to maintain their exercise capacity and maintain a healthy weight, and it is also advocated that educators and families should always pay attention to children's daily physical activities and provide scientific physical education to children in order to promote the development of physical fitness in children [2]. In the study of IF in children with ASD, the association between IF and ASD originates from the fact that some children with ASD are accompanied by long-standing gastrointestinal disorders, and studies have reported that ASD faces many GI symptoms, such as constipation, diarrhea, and flatulence, and GI symptoms are closely related to mood and severity of autism symptoms.ASD faces GI symptoms along with changes in IF, such as Bacteroidetes/Firmicutes decrease and Lactobacillus and Desulfovibrio increase in ASD, and such flora changes are related to the severity of ASD [3-4]. In conclusion, more scientific, safe, and effective training is needed to make targeted training for children with ASD to lay a good foundation for subsequent physical health and promote the development of all physical qualities.

In this paper, we first introduced the concept of PFT and the characteristics of autism IF, as well as the mechanism of the effect of IF on autism, followed by the experimental analysis of the effect of PFT intervention on the IF of children with ASD, and finally, the results of PFT on the IF of children with ASD were analyzed by SDs in the degree of autism impairment, IF diversity before and after the intervention..

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2. Basic overview

2.1 Fitness training

The concept of physical fitness was originally proposed by a scholar who believed that there are two major aspects of physical fitness, one is "health fitness" which is closely related to people's daily life, and the other is "competitive fitness" which is related to competitive sports. Competitive fitness requires the coordination of all physical qualities to complete the competitions in which it is involved, while health fitness consists of basic physical qualities and physiological indicators [5]. Fitness is divided into two categories according to the subject: athletic fitness, which is evident in athletes, and health fitness in people's daily activities, which is very important for adults and athletic fitness, which can be considered as a sublimation of health fitness, and health fitness for children [6].

With the continuous development of society, people begin to pursue a higher quality and healthier life, so the body should be in good condition to adapt to life. PFT refers to the body's ability to adapt to various activities in daily life, and in the process of dealing with some emergencies or unexpected situations, the body can safely and effectively reduce and respond to the damage of the external environment on itself so as to achieve self-protection and have the physical movement ability [7]. Children with poor motor ability will show physical strain, lack of adaptation, fatigue and poor concentration in the process of PFT. PFT programs are designed to improve physical health, develop positive health-promoting skills, and develop good and regular exercise habits [8]. Therefore, PFT leads to a good motor ability and a healthy level of physical function.

The research on PFT for children in China points out that the physical fitness of young children in China is getting worse and worse, mainly in terms of overweight, high myopia, and poor motor skills, but the government has not pointed out clear regulations and policies on physical fitness education for young children, which is a major hidden problem for contemporary early childhood education [9]. The main purpose of PFT for young children is to allow children to use their bodies more flexibly through correct movement guidance, to exercise their will power, cognitive ability, to promote the perfection of all body functions, to show their proper motor ability, and to better adapt to the development of social life.

2.2 Intestinal Flora

(1) Characteristics of the IF of autism

A frequently observed phenomenon in studies of the IF of children with autism is a significant decrease in the ratio of Bacteroides to thick-walled bacteria, and this change in levels is due to a decrease in the content of Bacteroides and an increase in the content of thick-walled bacteria [10]. The opposite was reported in one study, where the number of thick-walled bacteria was reduced in autistic patients, but the statistical analysis was not significant. In addition to the variation in anaphylactic and thick-walled bacteria, significantly higher concentrations of Desulfovibrio, Sartorius, Lactobacillus, Clostridium, and Actinomyces were observed in patients with autism, and differences were observed in the ratio of anaphylactic to thick-walled bacteria. There was a correlation between the abundance of these flora and the degree of autism impairment. The metabolites of the autistic IF also differed significantly from those of healthy children, mainly in terms of high levels of short-chain fatty acids (SCFAs) and 5_hydroxytryptamine [11-12].

(2) Mechanism of action of IF in autism

Vibrio desulfuricans was detected in nearly half of the children with autism, while this sulfate-reducing bacterium is almost absent in normal subjects. Vibrio desulfuricans causes abnormalities in human sulfur metabolism, which is an important component of amino acids and plays an important role in maintaining metabolism, brain function, and the gastrointestinal barrier. Hydrogen sulfide, a metabolite of Clostridium perfringens, can directly cross the blood-brain barrier and affect brain development. Weyrongococcus converts acidic metabolites in the intestine can be converted to weak acidity, thus affecting the function of the gastrointestinal tract [13].

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3. Experimental study

3.1 Study subjects

In this experiment, 16 children with autism and 9 ordinary children were recruited as subjects, with autism as the EG and ordinary children as the healthy CG. A 6-week PFT intervention was conducted. The basic conditions of the subjects are shown in Figure 1. As can be seen from the data in the figure, there were no SDs in age (years), height (m), weight (kg), and BMI (kg/m2) between the two groups of children.

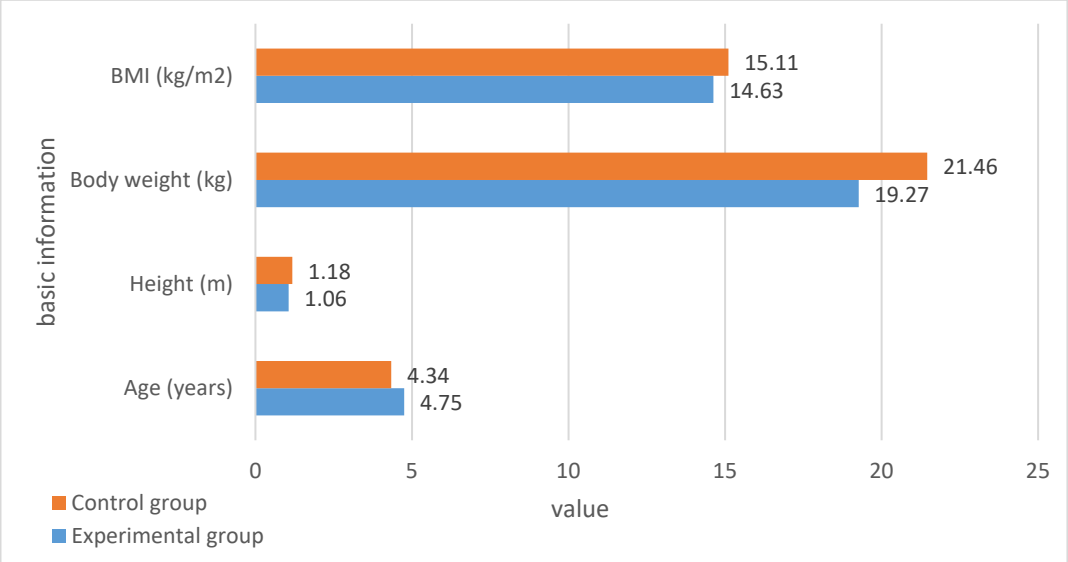

Figure 1: Basic information of the subjects

3.2 Research method

Because children with ASD are unable to stay focused on a single form of exercise for a long time, in order to achieve exercise intensity, this experiment adopts personalized PFT interventions to attract children with ASD to exercise continuously through changes in exercise forms so that they can achieve the corresponding exercise duration. Heart rate was monitored in real time during exercise.

In this study, the EG was given 6 weeks of targeted PFT with 2 sessions of 1 hour each week, while the CG did not undergo PFT, and simple physical activities were the main focus in kindergarten. The data of the EG and the CG were compared and analyzed to analyze the effect of PFT on children's physical fitness. Children with ASD were assessed with the Autism Treatment Evaluation Form (ATEC), the Child Assessment Scale for Autism (CARS), the Social Communication Scale (SRS), and the Child Behavior Checklist (CBCL), and stool samples from the healthy CG and the EG before and after the experiment were collected for 16sDNA sequencing to analyze the diversity and community abundance of the IF.

3.3 Mathematical statistics

In this paper, we need to use significant difference (SD) analysis to test the results of the effect of PFT intervention on the IF of children with ASD, generally by calculating the t-value or Z-value, and the p-value size to reflect whether there is a SD in structure.

$$t = \frac{\overline{X} - \mu}{\frac{S}{\sqrt{n}}} (df = n - 1) \quad (1)$$

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$$Z = \frac{\overline{X} - \mu}{\frac{\sigma}{\sqrt{n}}} \quad (2)$$

Where S denotes the estimate of the overall standard deviation, df is the degree of freedom, μ is the overall mean, σ is the overall standard deviation, and n is the sample size.

4. Analysis of the results of the effect of PFT intervention on the IF of children with ASD

4.1 The effect of PFT on the degree of severe impairment in children with ASD

Table 1: Index scores of the degree of autism impairment before and after the intervention

Degree of autism impairment		Pre-intervention	Post-intervention	P-value
CARS		36.84	33.57	P<0.01
ATEC)	ATEC-Total Score	61.21	54.93	P<0.01
	ATEC-Voice/Language Communication	12.55	11.34	P<0.05
	ATEC-Social Skills	18.73	15.62	P>0.05
	ATEC-Sensory/Cognitive Awareness	20.45	17.36	P<0.01
	ATEC-Health/Physical Behavior	16.18	14.72	P>0.05
SRS		91.85	83.64	P<0.05
CBCL		42.77	36.05	P<0.01

As shown in Table 1, the CARS and ATEC scores of children with ASD decreased significantly (P<0.01) through the 6-week PFT intervention, from 36.84 to 33.57 for CARS and from 61.21 to 54.93 for ATEC, with lower scores on both scales indicating better ability and lower autism impairment. Although the ATEC "social competence" and "health/physical/behavioral" subscales did not reach significance (p>0.05), they showed a decreasing trend; meanwhile, the Social Responsiveness Scale (SRS) and the Child Behavior Checklist (CBCL) scores both decreased and showed a SD before and after the intervention. The lower scores on the SRS and CBCL scales represented a better degree of improvement, so the combined results of the ATEC subscale with the SRS and CBCL reflect that the social and behavioral problems of children with ASD were improved by the 6-week PFT intervention.

The effect of PFT on the social and behavioral aspects of children on the autism spectrum may be due to the enhancement of their physical fitness and motor skills through exercise, which allows them to have the energy and stamina to deal with challenges in group activities, thus increasing their self-confidence and motivation to interact with others. Also the guidance and interaction of the trainer with the subjects during the PFT may be a factor in improving their social skills. The large number of physical activities and movement sequences during exercise can play a compensatory role for stereotyped behaviors, and PFT improves self-stimulation in children with ASD.

4.2 Changes in IF abundance before and after PFT intervention

From Table 2 and Figure 2, it can be, seen that the ace, chao, and shannon of the Alpha diversity of the IF of the subjects were significantly increased (P<0.01) and the simpson index was significantly decreased (P<0.01) after 6 weeks, indicating that the abundance of the IF of the subjects was significantly improved by the 6-week PFT intervention. This indicates that regular PFT can increase the beneficial IF and suppress the unfavorable flora, demonstrating that exercise has a positive health effect on the intestinal tract.

Table 2: Alpha diversity

	Pre-intervention	Post-intervention	P-value
ace	124.35	368.74	P<0.01
shannon	3.62	5.43	P<0.01
chao	117.91	345.49	P<0.01
simpson	0.18	0.09	P<0.01

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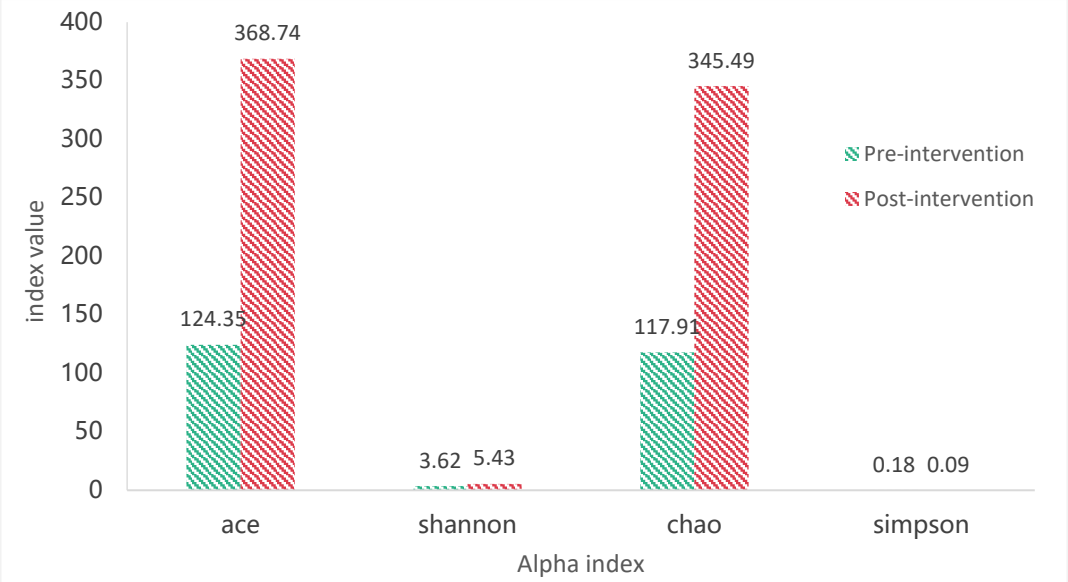

Figure 2: Results of Alpha diversity of IF in autism before and after intervention

4.3 Differences in IF between the EG with autism and the healthy CG before and after the PFT intervention

Table 3: The results of the difference between the flora of the EG and the CG

Bacterial flora	CG	Pre-intervention	Post-intervention	P-value
Firmicutes	0.4728	0.3451	0.4693	P<0.5
Faecalibacterium	0.0517	0.0164	0.0508	P<0.05
Haemophilus	0.0014	0.0179	0.0032	P<0.05
Veillonella	0.0123	0.0034	0.0148	P<0.05
Streptococcus	0.0015	0.0116	0.0034	P<0.05
Desulfovibrio	0.0001	0.0017	0.0002	P<0.05

Data were analyzed for SDs between experimental and CGs of IF using the metastats method. Differential flora were selected for presentation, and * indicates SD after intervention compared to pre-intervention. As shown in Table 3, the EG before and after intervention compared with the CG, respectively, after intervention Firmicutes (Phylum Thick-walled), Faecalibacterium (genus Fusobacterium), Haemophilus (genus Haemophilus), Desulfovibrio (genus Desulfovibrio), Veillonella (genus Veronococcus), and Streptococcus (Streptococcus spp.) were not significantly different from the CG, while all six groups were significantly different from the CG before the intervention (P<0.05), with Firmicutes, Faecalibacterium and Veillonella being lower than the CG; Haemophilus, Desulfovibrio, and Streptococcus were all higher than the CG.

5. Conclusion

In this paper, a six-week PFT intervention experiment showed that children on the autism spectrum showed significant improvement in the degree of impairment and improved their social skills and behavioral problems. The Alpha diversity index of the IF of children with ASD was also significantly improved from the results of Alpha diversity (p<0.01), reflecting that the PFT intervention improved the abundance and diversity of the IF. Therefore, appropriate PFT for children with ASD can improve children's physical fitness, guide children with ASD to adapt to crowd communication through exercise, and increase the beneficial IF of children with ASD.

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