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Effect of Exercise on Children with Autism Based on a Meta-Analysis †

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Abstract: How exercise influences the treatment of autistic children is explored in this paper to provide a reference for their treatment. The relevant data were collected from the results of research on campaigns and autism published in 2006–2018 using computer search methods. The data include 282 research objects in five groups. The Jadad scale scores were 0–2. The result of the meta-analysis conducted using Stata12.0 showed a significant improvement in the symptoms of autistic children. For moderate autism, the effect of exercise was consistent with high credibility, while for severe autism, the effect was not consistent with low credibility. It was found that the symptoms of moderately autistic children showed improvement with exercise, but not in severely autistic children, although the effect of exercise on severe autism is prospective. Thus, more research is required on the effect of exercise on severe autism.

Keywords: autistic children; controlled trial; meta-analysis

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1. Introduction

Autistic children are defined as having autism spectrum disorder (ASD), which causes difficult communication, language problems, limited interests, and repetitive behaviors. It is a serious mental and intellectual disability of children found all over the world [1]. The prevalence of childhood autism has been increasing for several decades. There has been much research on the development of diagnostic measures [2]. Untreated autism prognosis may lead to lifelong disability, and several patients exhibit disorders in behavior and even juvenile delinquency. Autism pressures the parents of patients in terms of expenses and feelings, and puts a heavy burden on schools [3].

Autism in children has been researched extensively from medical and psychological perspectives as well as from educational perspectives. Communication disorders, limited interests, and hobbies of autistic children especially affect the patient's lives. However, research has revealed that physical exercise improves the mood and personality of autistic children and relieves depression from stress and anxiety significantly [4]. Recent research by Taiwanese scholars has proved that exercise effectively mitigates childhood autism. These studies provide an important basis for verifying that physical exercise is effective in treating autistic children.

However, such research conclusions need further confirmation, as the scales adopted in the research on childhood autism are different. In addition, the research subjects are from different regions, and the intervention measures and methods are different. The degree of autistic symptoms of the children examined is also different. Considering such limitations, in this paper, research on the influence of exercise on autistic children with different symptoms is conducted using meta-analysis as a statistical analysis tool. The

effect of exercise is quantitatively evaluated and explained to provide a reference for further exploration of how to improve the symptoms of childhood autism.

2. Data and Method

2.1. Data Retrieval

Data for this research was retrieved from the Database of Chinese Academic Journal (CNKI), Wanfang, and VIP. Relevant journals, theses, conference papers, non-randomized controlled trials, case studies, reports, reviews, data information, and periodic publications published from 2006 to 2018 were included in the retrieval list. The references in the documents were also used for data retrieval. Keywords such as exercise, physical exercise, autistic disorder, and autism were used for collecting data. The criteria for retrieval included control attributes, research objects (only children), and prescribed physical exercise. The "Childhood Autism Rating Scale" or "Autism Behavior Checklist" was adopted as the scale for measuring the level of childhood autism. The CARS scale was used with the criteria of 0–30 for non-autism, 30–36 for mild to moderate autism, and higher than 36 for severe autism. The ABC scale adopted in this research had the criteria of $\geq$31 for suspected autism and $\geq$62 for diagnosed autism.

2.2. Method

Two researchers independently read the documents to extract data that included authors, time of publication, implementation method of physical exercise, the difference in experimental and control groups, and the difference in the average scores and standard deviations of the scales before and after physical exercise. Differences in retrieving data were discussed or consulted with experts. To evaluate the quality of the retrieved data, the Jadad scale was used [5]. The scoring criteria included randomization and concealment, blind method, withdrawal, and missing visits. On a scale of 0–5, 0–2 points were classified as low quality, while 3–5 points were classified as high quality.

3. Results and Discussion

3.1. Retrieval Result

In total, 116 relevant documents were chosen from the database search. Among them, 63 were eliminated as they were duplicated, and 19 were not included as they were irrelevant. Out of the remaining 34 documents, 5 were finally selected following the selection criteria (Table 1). The final data contained 282 autistic children, among whom 164 were males, 78 were females, and 40 were unidentified. In Ref. [6], three experimental groups were defined with different interpersonal interactions. The experimental period in Refs. [6,7] was 4–8 weeks. The experimental period for one document was 3 months. The experimental period in two documents was 6 months. Reference [8] included mild autistic symptoms, Refs. [9,10] researched moderate autistic symptoms, and the remaining two documents explored severe symptoms of autism. All of the five articles had similar autism levels before the interventions with the same population.

Table 1. Data of selected documents in this study.

Date	Sample Size		Sample Size	Autistic Level before Intervention		Autistic Level after Intervention		Test Scale	Level
	Test	Control	Gender (Male/Female)	Test	Control	Test	Control		
2017	18	14	28/4	49.66 ± 28.506	47.71 ± 25.43	42.556 ± 26.27	57.214 ± 23.671	ABC	**Moderate**
2016	40	40	50/30	36.54 ± 6.58	35.98 ± 5.54	31.37 ± 4.24	34.84 ± 3.94	CARS	**Mild**
2017	30	30	35/25	37.96 ± 7.03	37.27 ± 10. 69	30.25 ± 7. 92	35. 91 ± 6. 23	CARS	**severe**
2018	35	35	51/19	39.33 ± 7.29	39.40 ± 7.34	29.71 ± 5.23	34.80 ± 6.19	CARS	**severe**
2018	30	10	—	60.34 ± 1.25	60.56 ± 1.12	54.98 ± 1.63	59.95 ± 1.33	ABC	**Moderate**

The five documents were published in Chinese and had a definitive scale of autistic symptoms, with comparability between the experimental and the control groups according

to the baseline data. No study mentioned the implementation of a blinded experiment. Reference [7] only mentioned withdrawal and missing visits without a specific description. On the Jadad scale, the documents with 0–2 points were classified as low-quality documents with bias.

3.2. Meta-Analysis Results

We carried out a meta-analysis to investigate the influence of physical exercise on autistic children with moderate symptoms. They belonged to the experimental groups in three documents. The result of the heterogeneity test was statistically significant, indicating that there was obvious heterogeneity among the three groups. Therefore, the standardized mean difference (SMD) was calculated to understand the combined random effect. The combined effect size of SMD for autistic children with moderate symptoms showed a significant difference between the groups with and without physical exercise. The confidence level of SMD of 95% implied that the score of autistic children with physical exercise was significantly lower than those without physical exercise. This showed a significant improvement in symptoms. For autistic children with severe symptoms, physical exercise had a certain effect, but was not statistically proven. Although the scores were different between the groups with and without physical exercise, the difference was not high enough to be accepted as significant.

3.3. Meta-Regression Analysis

The test showed obvious heterogeneity among the group of autistic children with moderate symptoms with and without physical exercise. The results of the single-factor meta-regression analysis are presented in Table 2. The standard probability of heterogeneity increased from 0.05 to 0.1, which was high enough to select for the influencing factors. The probability of the heterogeneity for sample size, autism scale, intervention time, and intervention intensity was greater than 0.1. Such a result indicates that the four factors do not influence the heterogeneity of the selected documents. However, the document quality showed $p = 0.034 < 0.01$, and it was the only factor that affected the heterogeneity. The τ^2 of document quality also showed its influence on heterogeneity. The regression coefficients of the factors showed that document quality also had an obvious effect on heterogeneity, which was related to the effect of physical exercise on the moderate symptoms of autistic children.

Table 2. Results of heterogeneous single-factor meta regression analysis for the literature included in the research.

Heterogeneity Factor	Non-Covariate tau^2	Covariate tau^2	Constant	Coefficient	SE	t	*p*
Document quality	0.7604	0.259	−0.689	−0.673	0.298	−2.29	0.034
Sample size		0.89	−1.297	−0.0001	0.005	−0.03	0.76
Autism scale		0.8361	−2.19	0.547	0.417	1.31	0.188
Intervention time		0.913	−1.27	−0.001	0.021	−0.06	0.928
Intervention intensity		0.9512	−1.569	0.13	0.532	0.24	0.817

3.4. Publication Bias Analysis

It can be seen from Table 3: Moderate autism: $t = -1.46$, $p = 0.159 > 0.05$, and the 95% confidence interval is [−6.45, 1.21] including 0. It shows that the difference is not statistically significant, that is, there is no publication bias in the three literatures included in this study on exercise intervention for children with moderate autism symptoms. Meta analysis shows that the results are relatively stable and credible; severe autism: $t = -22.65$, $p = 0.026 < 0.05$, and the 95% confidence interval is [−6.18, −1.73] and does not contain 0.

Table 3. Evaluation of publication bias in the included the literature.

Degree of Autism	Correlation Coefficient	Standard Error	T Value	P > |t|	95% CI
Moderate autism	−2.59	1.68	−1.46	0.159	(−6.45, 1.21)
Severe autism	−3.87	0.16	−22.65	0.026	(−6.18, −1.73)

For autistic children with moderate symptoms, the bias in the three documents was not significant statistically. That is, the documents showed similar results for the effect of physical exercise on autistic children with moderate symptoms. This coincided with the meta-analysis result. For autistic children with severe symptoms, the bias in the documents was statistically significant, with a publication bias in two documents. This result, alongside the meta-analysis result, indicates that further research is needed on the effect of physical exercise on autistic children with severe symptoms.

4. Discussion

The pathogenesis of autism in children is not clarified yet. The disease may be related to environmental factors (genetics), social factors (social psychology), and/or health factors (immunology, brain, endocrine, and others). The results of the second survey of disabled children in Taiwan stated that 1.10% of children with mental disabilities were aged 0–6 years old, which is 111,000 patients. In total, 36.9% of them were autistic, which is 41,000 patients [11]. It has been suggested that systematic and active physical exercise stimulates body functions and therefore improves the physical condition of patients [12]. Sports programs improve the physical conditions of children with mild intellectual disability, showing that sports play an important role in enhancing the health of children with intellectual disability in terms of body shape, quality of life, and metabolic function [13]. These studies verified the effectiveness of sports for children with autism. As differences are found in various research results due to different competencies, conditions, methods, and subjects of research, more quantitative and comprehensive analyses and interpretations of the results are demanded. A meta-analysis was used in this research to evaluate the relevant research results quantitatively and comprehensively. Especially to explain the influence of physical exercise on autistic children with severe symptoms, more precise and objective research methods and frameworks are required to obtain quantitative results that can be an important basis for the treatment of autistic children.

The results of the meta-analysis of the five selected documents are as follows. The documents had a random selection of research subjects without explaining the method. Allocation concealment and blinded methods were not used, also, except for one document which explained the withdrawal of missing visits. As the quality of the documents was not high enough, the quality and the interpretation of their results may not be adequate for further implications. The results of the meta-regression analysis also show a lower quality due to heterogeneity. Therefore, more randomized and controlled object selection and grouping are required to investigate the effect of physical exercise on autistic children with various degrees of symptoms.

5. Conclusions

The results of the meta-analysis in this research show that physical exercise significantly improves the moderate symptoms of autistic children. The total SMD, confidence interval, and standard deviation changes prove that physical exercise has a significant effect on the mitigation of moderate symptoms in autistic children. A similar effect was confirmed for the severe symptoms in autistic children, but the statistical significance was not high enough to accept it as a firm proof. In total, four out of the five selected documents show that autistic symptoms still existed with physical exercise, but with their symptoms significantly improved. This implies that the treatment of autistic children requires physical exercise. However, it is still necessary to investigate if physical exercise allows for curing

autism in children, and if the symptom of various degrees of autism in children worsens without the continuation of physical exercise.

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