

Structural exercise-based intervention for health problems in individuals with autism spectrum disorders: a pilot study

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Abstract. – OBJECTIVE: Exercise-based intervention promises to be more effective in a structured framework for individuals with autism spectrum disorders (ASD). The aim of this study was to observe changes in behavior of individuals with ASD by investigating their physical status after the structured exercise-based intervention.

PATIENTS AND METHODS: The exercise intervention integrated an 8-week exercise program that included aerobic, resistive, and neuromuscular exercises. Body composition and the Autism Treatment Evaluation Checklist (ATEC) were evaluated to assess changes after the exercise-based intervention.

RESULTS: After the exercise intervention, the fat mass of individuals with ASD were significantly reduced, and their behavior improved markedly.

CONCLUSIONS: This pilot study demonstrated that individuals with ASD require long-term, structured exercise-based intervention, and that such exercise-based intervention is effective for improving their health.

Key Words:

Autism, Autism Treatment Evaluation Checklist (ATEC), Body Composition, Exercise intervention.

Introduction

Autism spectrum disorders (ASDs) are a group of complex neurodevelopmental disorders¹⁻³. Their symptoms typically include motor impairment, bizarre behaviors, repetitive behaviors, sensory overload, etc. To address these behavioral characteristics, behavioral interventions are commonly used in autism therapy and are mostly focus on amelioration of communication, social, and cognitive deficits. However, previous studies have found that a lack of physical activity probably reduces the effects of these

interventions⁴. Moreover, a lack of physical activity induces greater health risk in patients with autism¹. As increasing evidence suggests that exercise-based interventions are effective in assisting behavioral intervention, further investigations are required⁵. Exercise-based interventions are purposed, structured, and organized physical activity programs with the purpose of benefiting health³. Given that lack of physical activity has emerged as a critical health problem, exercise-based interventions are promising approaches not only for benefiting health, but also for addressing motor impairments and enhancing physical fitness in terms of an FITT (Family Implemented TEACCH for Toddlers Study) model, including frequency, intensity, time, and type of exercise^{2,6}. Aerobic training programs have been the main approach used in exercise-based interventions for individuals with ASDs, using convenient and diversified programs. Typical activities have included treadmill use, cycling⁷, and exergaming⁶. In recent years, other types of exercises were introduced, including jumping, climbing, throwing, aquatic exercises, martial arts, yoga, and tai chi¹. Increasingly, evidence indicated that a structured exercise program, combining components of aerobic, resistance, flexibility, and neuromuscular training, would result in maximum gains in fitness and body composition for individuals with ASD^{1,2,6}. However, most of the previous studies have focused on one particular exercise type, to enhance physical activity and reduce the autism-specific impairments of individuals with ASDs, while use of a structured exercise program for individuals with ASDs has received little attention. In addition, a number of studies have shown the potential benefit of exercise-based interventions on behavioral functions of individuals with ASDs⁵. Most indi-

viduals with ASDs demonstrate poor motor skills and preferentially engage in sedentary activities⁸. The dietary patterns and antipsychotic prescription drugs, combined with lack of exercise, are thought to lead to weight gain in these individuals¹, while physical problems are also more severe in individuals with ASDs. Exercise is known to benefit mental health, physical problems, and skill development. Additionally, there is empirical evidence of the efficacy of exercise-based interventions in improving fitness and obesity status in individuals with ASDs. Body composition is a typical indicator used in weight control⁹, and can be used to investigate body improvement due to exercise-based interventions. Considering the above-mentioned reasons, the purpose of this study was to evaluate changes in behaviors as well as the body composition and physical status, in individuals with ASDs after implementing a structured exercise-based intervention.

Patients and Methods

Patients

The study was approved by the local Ethics Committee (protocol number 16-0104) in accordance with the Ethics Standards of the relevant institutional and the National Research Committee, and adhered to the tenets of the Declaration of Helsinki of 1964 and its later amendments or comparable Ethical standards. Additionally, parental consent and participant assent was obtained for participation of all patients. Twenty-four adolescents with ASDs, between the ages

of 11 and 14 years (male = 20, female = 4) were recruited from Nanjing Ming-Xin Children's Intelligence Training Center. All participants had mild-moderate or severe ASDs, according to their Social Responsiveness Scale (SRS) score; this is a validated and reliable tool for assessing the severity of ASD¹⁰. In addition, none of the patients had concomitant complicating conditions, such as epilepsy, high blood pressure, or other diseases of concern. The baseline information of the participants is outlined in Table I.

Structured Exercise-Based Intervention Design

Prior to the interventions, participants were screened for 2 weeks. After discussions with their guardians/parents/caregivers, a structured exercise program was designed and arranged (Table II), which integrated aerobic exercise, resistance exercise, and neuromuscular exercise. This program was integrated with their school-based courses and did not affect their daily life. The total time of the intervention was 8 weeks. The type of aerobic exercise training was walking outdoors (Figure 1A), around the Nanjing Mingxin Children's Intelligence Training Center (Figure 1B). The total distance was approximately 4 km, and the time allotted was 60 minutes. In order to control the physiological load to within a reasonable range, the operators wore real-time heart rate sensors (Polar Team Pro, Polar Electro Inc., Kempele, Finland). Heart rate was monitored to adjust the walking speed and cadence of the participants. During the walking routine, the researchers continuously encouraged and chatted

Table I. The baseline of participants.

Name	ZT	TRH	CLF	TY	DMY	LGS
Sex	Male	Male	Male	Male	Female	Male
Age	12	11	13	14	13	13
Developmental Age	8	7.5	6.8	5.0	8	4.5
Height (m)	1.78	1.65	1.70	1.70	1.58	1.83
Weight (Kg)	116.95	68.05	63.05	74.85	70.65	118.05
Severity	Serious	Serious	Serious	Serious	Moderate partial	Serious
Age of diagnosis	2	2	3	2	3	3
Medication situation	Antiepileptic drugs	No	No	No	No	No
Symptoms	Stereotyped behavior, Social	Stereotyped behavior	Emotional, Social	Stereotyped behavior, Emotional, Social	Communication Problems	Communication, Stereotyped behavior, Social

Table II. The exercise-based intervention design.

Content	Aerobic exercise	Resistance exercise	Neuromuscular exercise
Type	Outdoor walking	Jog	Paper plane
Frequency (times/ week)	3	3	2
Intensity	50-75% HRmax	10-15RM	50-75% HRmax
Time (min)	60	4sets (2-3 minutes interval),30	30

with participants for scene communication. By counting the number of steps and trees, including simulation practice, their cognitive ability was also trained. As resistance exercise training, jogging was used (Figure 1C). The participants repeatedly jumped in and out of a hula-hoop in the

outdoor playground. The program included 4 sets of jumps, with 8 jumps performed per set. The time allotted was 30 minutes. During the exercise program, the operators constantly observed the participants and corrected their posture when necessary. After the exercise program, the op-



Figure 1. The content of the exercise-based interventions.

erators inquired about participants' feelings and encourage them to describe this verbally. When the participants were unwilling to persevere with the exercise program, the operators encouraged the participants to finish the exercise program by using small gifts. The type of neuromuscular exercise training included was playing a paper plane game in the classroom (Figure 1D). There were few skill requirements for playing the paper plane and participants could play without needing to be taught. The participants threw the paper plane into a target circle, and then picked it up for the next throw. They repeatedly threw the paper plane for an allotted period of 30 minutes. As the paper plane was a light object, it was difficult to throw it into the right target; additionally, basic hand-eye coordination was required, making this exercise a suitable neuromuscular exercise activity. During this exercise, the researchers constantly observed the participants and guided them to throw in the correct direction.

Measures

Body composition was analyzed using a Tanita MC-180 bioelectrical impedance analysis (BIA) system (Tanita Inc., Tokyo, Japan). BIA is a practical and non-invasive approach for assessing body composition in individuals with ASDs⁹. Briefly, the measurements were taken with the participants standing barefoot on the device plate, with their legs and arms parallel to their bodies. The electrodes were placed on both soles and both palms. We evaluated the body status by body composition parameters with indicators, including fat mass (FM), fat-free mass (FFM), and body mass index (BMI). The test-retest procedures were performed with a 1-minute interval.

Intervention Evaluation

The effect of the structured exercise was measured using the Autism Treatment Evaluation Checklist (ATEC). The ATEC is a comprehensive assessment battery for collecting current information on a relatively wide range of behaviors and

skills in adolescents with ASDs who have taken part in physical and health-related intervention programmes¹¹. The scale covers 77 items in the areas of communication, sociability, sensory and cognitive awareness, and health and physical behavior, and also provides a total score. This assessment was performed by trained psychologists who had over 3 years' experience in treatment of ASDs.

Statistical Analysis

For the statistical analyses, the Statistical Package for Social Sciences 22.0 (IBM SPSS® Inc., Armonk, NY, USA) was used. Data were described as mean ± standard deviation and compared through the paired *t*-test. The level of significance was set at $p > 0.05$.

Results

Body Composition Changes

The body composition analysis after the 8 weeks' structured exercise program is presented in Table III. The participant's overall weight decreased by about 2.4%, and there was a significant decrease of 11.7% in fat mass. Although BMI values indicated that most of the participants remained overweight, exercise-based intervention afforded potential benefits in terms of fat loss and muscle increase.

Intervention Treatment

The mean value of ATEC scores in each subclass is shown in Table IV. Speech/language/communication, sociability, and sensory/cognitive awareness scores were markedly improved from the severe range to the moderate range, whereas health/physical/behavior scores remained in the severe range, even though this score increased by 13.3%. The average total score of participants was in the moderate category after the intervention, compared to being in the severe range before the intervention. The median scores for each scale were computed and placed as per percent-

Table III. The body composition: investigation results.

Contents	Weight (Kg)	BMI	Body fat rate (%)	Fat mass (Kg)	Fat free mass (Kg)	Muscle mass (Kg)	Bone mass (Kg)	Body water mass (Kg)
Before	80.73±24.63	27.40±6.57	32.45±8.19	27.35±14.36	53.35±10.99	50.31±10.01	3.05±0.97	35.07±1.23
After	78.81±25.24	26.90±7.11	30.10±9.90	24.16±13.78	53.85±12.73	50.55±11.96	3.03±0.98	34.58±0.97
<i>t</i>	1.800	1.244	1.707	4.165	-0.489	-0.237	1.732	1.434
<i>p</i>	0.170	0.302	0.186	0.025	0.658	0.828	0.182	0.288

Table IV. The behavior AL assessment results

Item (full-score)	Speech/ Language/ Communication (28)	Sociability (40)	Sensory/ Cognitive (35)	Health/Physical/ Behaviour (75)	Total (179)
Before	18.50±3.42	25.00±6.38	21.75±1.26	39.75±6.65	105.00±11.46
After	12.00±3.46	15.75±6.40	16.00±2.45	29.75±1.50	73.50±9.54
<i>t</i>	13.000	6.195	3.715	2.626	6.604
<i>p</i>	0.001	0.008	0.034	0.079	0.007

tiles to indicate the severity and functional status in each of these domains, as shown in Figure 2. The details observed with the structured exercise program are described for each domain below.

Speech/Language/Communication

In this domain, the participants showed clear amelioration in language and communication deficits. They benefited from the intervention control efforts of the operators. To maintain the physiological intensity of the exercise-based programs, the operators had to observe the status of the participants promptly and frequently. When participants became familiar with the operators, their hostile behaviors eventually reduced and they made efforts to communicate with the operators. Verbal activities then increased and language use gradually strengthened. Communication-feedback-communication-type events frequently occurred during the exercise-based programs, and participants’ communication skills were significantly improved.

Sociability

We observed that participants’ scores on the item of sharing favors with others increased significantly during the intervention. For safety considerations, we encouraged participants to grasp their companions’ hand or clothing during the outdoor exercises. This arrangement markedly benefitted their communication skills. It aroused awareness of teamwork, which could be generalized to other environments, such as the family and classroom. In addition, we prepared gifts that motivated the children to complete the programs. We also encouraged them to share with others. Similar activities helped the participants to improve markedly in terms of sociability.

Sensory/Cognitive Awareness

Participants demonstrated marked amelioration in cognition and sensory awareness deficits. Because most of the exercise-based intervention programs were task-driven, the participants needed to

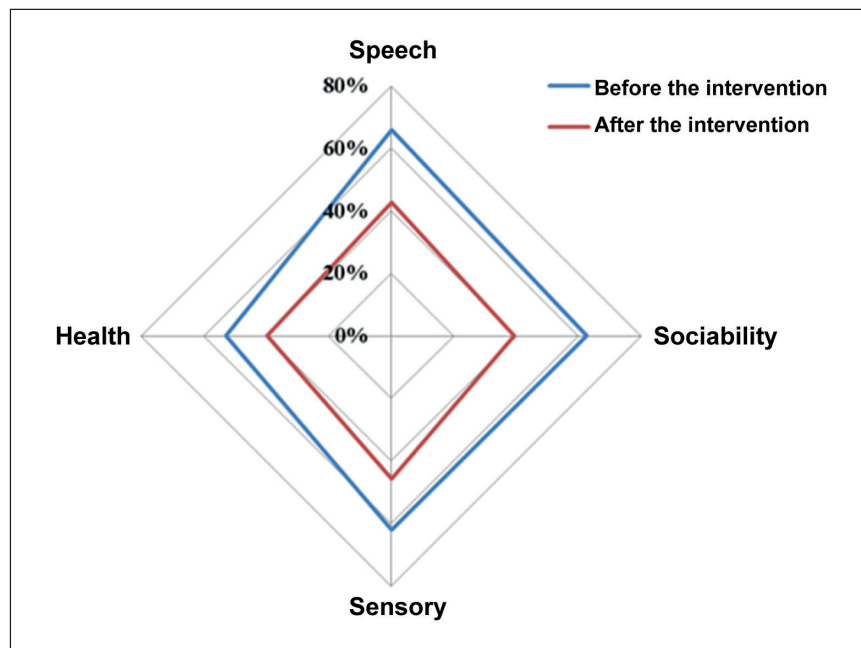


Figure 2. The percent change in items as assessed by the autism treatment evaluation checklist.

recognize their goal and requirements. Thus, their cognitive ability improved while completing tasks. Cognitive processes involved arousal of consciousness and required that participants understood their task. Their awareness of the tasks significantly strengthened. At the same time, they were frequently exposed to the fear-exclusion-adaptation procedure when their surroundings shifted in the programs. During the program, the participants' awareness was imperceptibly strengthened.

Health/Physical/Behavior

There were no statistically significant changes in the Health/Physical/Behavior domain with the program. This may be because participants did not significantly change their diet and attack behaviors during the program. The original intention of the intervention was to encourage a natural change in the participants' habits through structured exercise programs, and we therefore did not restrict their lifestyle and routines in the initial design. As the exercise-based intervention programs increased energy consumption, it directly stimulated the participants' appetite. In addition, most participants preferred high sugar and high-energy food; thus, exercise-based intervention had little effect on their dietary habits in the short-term. Exercises markedly increased their level of excitement; they were stimulated by the programs, but found it difficult to control their feelings, which were often expressed inappropriately, and aggressive behaviors were less improved. These factors resulted in scores on this subscale to remain in the severe range.

Discussion

Exercise Intervention and Autism Management

The prevalence of ASDs has continuously increased in recent years. Individuals with ASDs urgently require effective interventions and related services. Exercise-based intervention is an appropriate choice to meet these needs^{2,3}. Evidence supports that the use of exercise-based interventions in management of chronic disease conditions and people, certainly including the relatives of individuals with ASDs, are gradually coming to understand that exercise is a form of medicine. First, the goal of exercise-based intervention is the comprehensive improvement of the condition of individuals with ASDs. Most individuals with ASDs have long been overweight, as their

sedentary lifestyle poses a burden to themselves and their families and they rarely develop good exercise habits. The 8 weeks' structured exercise-based programs implemented in this study provided benefits to body status and behaviors and holds promise for comprehensive gains in the long-term.

Second, exercise-based intervention can be used as a structured form of management of ASDs, based on an FITT model. Although the dose-relationship between exercises and treatments remains unexplained, exercise-based interventions are easy to implement and to control in terms of frequency, intensity, time, and type. However, individual needs may differ. This type of treatment follows the principle of gentle enhancement and benefits from goals consequently achieved. Exercise-based intervention should ideally be administered within a structured framework.

Finally, exercise-based interventions provide a unified entry into a social activity program for individuals with ASDs. Exercise-based interventions involve daily physical activities, and cover all the life-skills and fundamental needs of individuals with ASDs. In contrast to other interventions, such as applied behavior analysis, structured exercise-based intervention increases the individual's physical activity level in an open environment. This not only helps them to learn skills and techniques to solve problems related to movement deficits, but also brings health beliefs for the patients, their families and caregivers.

Thus, the premise of exercise-based intervention is structured management. It integrates various forms, approaches, and contents in a structured framework, thereby simplifying the intervention approach and providing an effective treatment method for individuals with ASDs.

Exercise Intervention and Autism Obesity

Generally, the families of individuals with ASDs are more concerned about the behavioral problems of the patient, than about the patient's obesity. Therefore, most previous studies focused on improvement of behavior and cognitive abilities. Few studies have implemented physical exercise-based management for reducing obesity and overweight¹. There was no significant change in patients' BMI after the 8 weeks' structured exercise-based programs, and their body fat rate maintained at about 30%. However, overweight in individuals with ASDs is a complex problem,

requiring a dynamic and comprehensive approach to achieve energy balance between intake and consumption. This would require intervention in terms of physical activity, diet, lifestyle, education, environmental reform, and so on. Among these factors, exercise offers the most direct and controllable route for intervention.

First, regular exercises consume fat and improve body status for individuals with ASDs. To demonstrate the effect of exercise on body composition in patients with ASDs, Pitetti et al¹² used a 9-months treadmill training program for patients with severe ASDs. There was a significant reduction in BMI of these patients. This implies that long-term exercise-based intervention ultimately improved the body composition of patients with ASDs. Although there was no significant reduction in BMI of the participants in our study after an 8-week structured exercise-based programs, their body fat mass significantly reduced, indicating a trend for fat loss and suggesting that a longer intervention time will benefit their physical condition.

Second, exercise-based intervention achieves the goal of physical fitness in individuals with ASDs through effective management. Hinckson et al¹³ implemented a 10-week exercise and nutrition intervention for 22 patients with mental deficits or ASDs, centered on the family in order to achieve weight management. The long-term results showed that the patient's living habits fundamentally changed, although there was no significant change in their BMI. Our study arranged an exercise-based program based on the FITT framework. It ensured plentiful exercise time for the participants, 5 times per week, and 30-60 minutes per time. All exercises were performed at low physiological intensity, suitable for individuals with ASDs. This program integrated aerobic exercise, resistance exercise, and neuromuscular exercise. Such structured exercise-based interventions can achieve the goal of weight management for individuals with ASDs. Once regular exercise habits are developed, individuals with ASDs could eventually improve their overall physical fitness.

Finally, exercise-based intervention requires a structured, systematic, and personalized design for individuals with ASDs. In contrast to a single type of exercise, structured exercise-based intervention implements various types of exercise to compensate for individuals with ASDs' lack of living space, movement deficit, and loss of attention. Consequently, individuals with ASDs can

benefit from the advantages of exercise in a safe and effective program that targets coordination of the upper and lower limbs as well as sensory integration.

Exercise Intervention and Autism Behavior Changes

A structured exercise-based intervention also holds potential for improving the behavior of participants with ASDs, partly because its structure and regularity. First, exercise-based intervention significantly improved their speech and communication skills. Individuals with ASDs are commonly closed-off and reject communication. Exercise, as a profound form of internal stimulation, plays an important role in endogenous motor learning. When individuals with ASDs are willing to express themselves in terms of body language, different conditioned reflexes are triggered in the processing of environmental information. Therefore, exercise can act as a way for self-expression. The integration of multiple types of exercises in structured programs stimulates the body organs, and the desire and ability to communicate verbally are triggered under the influence of internal stimuli.

Secondly, exercise-based intervention improved the perception ability of individuals with ASDs. Exercise has been shown to improve cognitive function, especially executive function. Body movement directly and indirectly increases cerebral blood flow; thus, exercise accelerates brain oxygen and nutrition supply, and directly benefits the function of brain blood vessels and brain health, and expression of brain-derived neurotrophic factor and other biological markers of brain nerve growth. By improving brain structure, executive function is fundamentally improved. At the same time, exercise performed in open environments causes individuals with ASDs to experience both the natural environment and the social environment, prompting them to perceive different things, and stimulating their senses and desires. While the physical situation and skills of individuals with ASDs are enhanced, their self-awareness of their body is strengthened. Thus, structured exercise-based intervention can significantly improve their executive ability and cognitive ability.

Finally, exercise-based intervention promotes healthy behavior in individuals with ASDs through environmental modification. Although the structured exercise-based interventions can vary, it is difficult for individuals with ASDs to

follow such programs. Their health behaviors are influenced by many factors and therefore the success of an exercise-based intervention requires support from a reform of their environment, including their family, school, and living environment. Sudden changes in diet, nutrition, and other habits may increase problem behaviors. The structured exercise-based intervention continuously adjusts the goal of health management to support healthy behavior, although it is a long and slow procedure.

Conclusions

This study used an 8-week structured exercise-based intervention for individuals with ASDs, based on the FITT framework. The structured exercise-based intervention brought direct benefits in terms of body composition and behavior. This indicates that structured exercise-based intervention is a useful alternative intervention for individuals with ASDs.

Acknowledgements

We greatly appreciate the participants and their parents for their collaboration and the assistance of the principals and teachers. The present study was financially supported by the Natural Science Fund for Colleges and Universities in Jiangsu Province (17KJA330001).

Conflict of Interests

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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