Neurology and Neurosurgery

Research Article

The effect of integrative neuromuscular training on postural control of children with autism spectrum

Javad Shavikloo[1]* and Aliasghar Norasteh[1]

[1]Department of Corrective Exercises and Sports Injuries, University of Guilan, Iran

[2]Department of Sport Sciences, Imam Khomeini International University, Qazvin, Iran

Abstract

Objective: The prevalence of autism spectrum disorder has dramatically increased over the past decades. People with autism disorder have weakness in maintaining the balance and disturbance of the posture due to developmental deficits in the nervous system and inferiority. Thus, the aim of this study was to evaluate the effect of integrative neuromuscular training on postural control of children with autism spectrum.

Methods: This experimental study was conducted with pre/post-test design with the control group. The statistical population of the present study was all children with autism spectrum disorder in Qazvin town, among whom 24 were selected using Gilliam Garz Diagnostic Index and randomly divided into two groups of intervention (12) and control (12). Then, the intervention group was performed integrative neuromuscular training three times a week, but the control group did not performed a special integrative neuromuscular training program during the research period. ANCOVA test was used to analyse the data via SPSS software at the significant level of $P < 0.05$

Results: The results indicated a significant difference in BESS and SEBT over six weeks in for the intervention group ($P \le 0.05$). Also, the results indicated significant differences in three excursions (Anterior, Postromedial, and Postrolateral) for intervention group ($P \le 0.05$).

Conclusion: Integrative neuromuscular training program has a positive effect on postural control ability of the children with autism spectrum. so, these training can be prescribed as an effective program for the rehabilitation of children with autism spectrum.

Introduction

The movement in prenatal mankind begins in a simple and elementary way and becomes more complex and complete during the process of development. This natural need for life is the first means of expressing the child and his connection. The first experiences and lessons learned during this period are effective in subsequent learning. The normal development of children follows a relatively predictable pattern, but sometimes there are several factors such as genetic issues, infection, traumatic injury and poisoning, lack of oxygen, and, on the other hand, emotional deprivation causes problems in the process. And as a result of coarse and delicate motor skills, motor coordination and even language, they will not go through their natural process and the person will be in trouble. One of the groups that has problems with their growth process is children with autism spectrum disorder [1]. Autism is a neurological disorder that typically occurs in the nascent period. This anomaly prevents the child from being able to communicate with others, socialize, and participate in imaginative plays. The disorder, which is scientifically recognized as a Pervasive Developmental Disorder, prevents the child from growing. The autistic spectrum is a kind of lifelong mental-neurological disorder characterized by defects in social, linguistic, non-linguistic, imaginative plays and Stereotyped behaviour [2]. Most people with autism have mental disabilities, and about 20% of them have normal intelligence [3,4].

In general, qualitative differences in primary motor behaviour can be the first characteristics of autism spectrum disorder. Children with autism spectrum disorder (average age of fewer than 4 years old) are very slow when compared with their peers [5]. They are far behind their peers in the initial motion profiles, such as keeping the head in a state of standing, sitting smoothly without a support, walking and kneeling on the hands and knees, getting up and walking without support [6]. Motion disturbances include disorders of basic movement control (walking, muscle tone, posture, coordination, and balance), common in these children. Parents and professionals often see that children with autistic spectrum show abnormal walking, hypotonia, imbalance and lack of manual skills and coordination [7-9]. It was also shown in the research that there is a significant difference between the children of the autistic spectrum and their healthy counterparts in all aspects of physical fitness, including strength and muscular endurance, static and dynamic balance and flexibility [9]. In another study, Molloy et al. [10] concluded that core stability in children with autism was lower than healthy children.

By surveying the problems and studying the research on children with autism spectrum disorder, it seems that these children need more research in their motor development. The research has also shown that by enriching the environment and developing appropriate training opportunities, these children can be brought closer to their normal course of life. Basic motor skills constituent all movements of the body.

Correspondence to: Javad Shavikloo, Department of Corrective Exercises and Sports Injuries, University of Guilan, Rasht, Iran, Tel: 989191933716, Fax: 98283346163, E-mail: javad.shaviklo@yahoo.com

Key words: *neuromuscular, somatosensory, control posture, autism spectrum*

Received: July 23, 2018; **Accepted:** April 20, 2018; **Published:** April 24, 2018

Strengthening of basic motor skills at an early age is important because it increases the social opportunities associated with the increased motor activity. Since the many kinds of research support the need for intervention in early motor activity as a potential driving force to enhance motor skills in normal children, the lack of material in this study is felt in children with autism spectrum disorder to be.

In total, there is little information about the levels of physical activity in children with autism spectrum disorder, which is a matter of concern. There are cross-sectional studies that show the physical activity levels of paediatric patients with autism spectrum disorders decrease during growth [11,12]. So, the issue that should be considered is that the best time to grow these skills is the age of childhood and the beginning of adolescence [13]. So, the main purpose of this study was to evaluate the effect of integrative neuromuscular training on postural control of children with autism spectrum disorder.

Materials and methods

The present study was experimental with pre/post-test design. The statistical population of this study include all boy students with autism in Qazvin town. Among them, 24 eligible subjects were selected and then, based on scores obtained from Gilliam Diagnostic Index was normalized. The Gilliam test consists of four sub-scales and each sub-scale consists of 12 items. These subscales include stereotypical behaviours, communication, social interactions, and developmental disorders, which are based on direct observation and interviews with parents and teachers of children with autism spectrum disorders and are widely used in educational and research programs used by experts [14]. In this research, Gilliam test was performed by a specialist psychiatrist and samples were selected based on the points obtained in the variables in a class. They were randomly assigned to control and intervention groups. The Gilliam test was performed by a specialist psychiatrist and subjects who received the same scores were selected and then randomly assigned to control and intervention groups. This selection was made with the consent of parents and school officials, and the participation was voluntary. Entry requirements were: being male, the age range of 6-10 years, and confirmation of autism disorder in the child. Conditions for not entering the study were: visual impairment, orthopaedic and cardiovascular problems, and disturbances in the vestibular system.

Ethical considerations

The College's Ethics Council reviewed this study for ethics. The Physical Education Department of the Imam Khomeini International University approved the study. Before starting the research, the College's Ethics Council fully evaluated the whole research process (research objectives, how measurement of variables was going to be performed, and duration of the research period).

Test star excursion balance

This test is a valid and reliable instrument for quantifying the dynamic balance [15]. The SEBT involved a taped star pattern with eight excursions each at 45 degrees from each other, on an even floor surface. Due to the similarity of the Test Star Excursion Balance results from the Y balance test, we used the Y balance test [16]. Subjects placed their non-dominant foot on the middle of the star pattern, while their dominant foot reached as far as possible to each of the three excursions (anterior excursion, posteromedial excursion, poster lateral excursion) while maintaining a single leg stance while reaching with the opposite leg to touch as far as possible along a chosen excursion. They touched the farthest point possible, and as light as possible, along a chosen excursion with the most distal part of their reach foot. Subjects were then instructed to return to a bilateral stance while maintaining their balance. A practice session of six times in each excursion followed by a one-minute rest and subsequently the measured average of three trials for each excursion was recorded as the subject's dynamic balance scores (Figure 1).

Balance error scoring system

In this test, which is used to measure static, six different situations have been considered, including three positions standing on the hard surface and three standing positions on the soft surface. Hard surfaces include carpet or flooring and a soft surface, including a padded foam cushion with a size of 41 × 50 × 6 cm. Standing positions also include standing on both legs in pairs, standing together on both legs, one way back and standing on the same. In all situations, the eyes of the subjects are closed, and the hands stick to the sides. The subject performs each situation for 20 seconds and calculates the total number of errors that occur in these six states as his grade. Errors include: detaching the hands from the waist, opening the eyes, lifting the heel or toes, relying on the ground, attaching or abducting more than 30 degrees of thumb, a collision of the foot with the ground, or a disturbance of balance for any reason. Before performing the test, each subject has performed three tests to getting known with the test (Figure 2) [17].

Training procedures

The integrative neuromuscular training program used in this study was specifically designed for primary school children and was

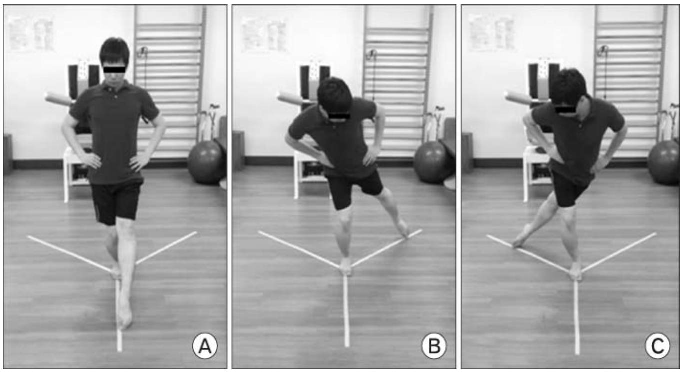

Figure 1. Subject performing Y excursion balance test

Figure 2. Balance error test (BESS) in six different situations

based on earlier reports on resistance training and neuromuscular conditioning for school –age youth (18–20). The intervention group performed the integrative neuromuscular training program three times a week (Saturday, Monday, and Wednesday) and the control group did not conduct a special integrative neuromuscular program during the research period (six weeks) but performed their routine physical activity three times a week. Of course, after the completion of the study, the training program and its movements were taught to the control group and were used by the physical education teacher for use.

The integrative neuromuscular program consisted of a five min dynamic warm-up (e.g., marching in place and multidirectional chops) followed by five primary exercises that focused on enhancing muscular power, lower body strength, and core strength (e.g., abdominals, trunk and hip), and secondary exercises that aimed at improving FMS (e.g., primarily object control and stability skills). The secondary exercises progressed from simple to complex over the six-week training period. Table 1 outlines the structure and content of the integrative neuromuscular program. Participants performed two sets on all primary exercises and during the six-week training period they progressed from 7 to 10 repetitions on the dynamic exercises and from 10 to 30 s on the plank exercises. Secondary exercises were performed in 15-30 s and the exercises progressed every two to three weeks.

Statistical analysis

In this study, Schapiro-Wilk's statistical test was used to assess the normality of the data and then, A series of 2 × 2 ANCOVA (group × intervention) analyses were computed for each dependent variable, using pre-test as covariates. Statistical analyses were conducted in SPSS Version 23. Statistical significance was established a priori at $p < 0.05$.

Results

Table 2 shows mean and standard deviation of the general characteristics of subjects in training and control groups. The mixed ANCOVA test 2 × 2 method that Y balance test and balance error score system (BESS) test include two levels of pre/post-test and group variable include two levels of control and intervention group was used to analysis. To analyse homogeneity of variance in two groups, Levin's variance analysis was used. As shown in Table 3, Levine's test was not statistically significant for any of the variables studied.

The ANCOVA analysis was used to comparing the mean scores of post-tests, dynamic balance and, static balance after controlling the pre-test effect in the two groups, its results are presented in Tables 4 and 5.

As shown in Table 5, there is a significant difference between the mean scores of post-test dynamic balance in the anterior excursion after the elimination of the pre-test effect [($p = 0.046$) and ($F = 4.487$)].

Table 1. Structure of integrative neuromuscular Program with 5 Primary Exercises and Progressive Secondary Exercises

Primary	Secondary		
Weeks 1-8	**Weeks 1-2**	**Weeks 3-5**	**Weeks 6-8**
1. Font squat	SL balance	SL balance & OH press	SL balance & CP
2. Squat jump	OH press & catch	SL OH press & catch	Get up and Catch*
3. 90° jump	Knee tap & catch	ALT knee tap & catch	Knee tap turn & catch
4. Plank	Hip twister	OH chop	Diagonal chop
5. Balloon drop & catch¥			

INT: Integrative Neuromuscular Training. SL: Single Leg, OH: Overhead Press, CP: Chest Press; ALT Alternate Right and Left Knee

*From a sitting position on the floor eighth a balloon in front of the chest, children tossed the balloon into the air and stood up as quickly as possible to catch the balloon in an athletic stance. ¥Exercise was performed with eyes open weeks 1-4 and eyes closed weeks 5-8.

Table 2. General Characteristics of Subjects (mean ± SD)

Variable	Group	Number	Mean ± SD	t	sig
Age (year)	CON	12	8.33 ± 1.23	0.496	0.625
	INT	12	1.24 ± 8.08		
Height (cm)	CON	12	131.5 ± 4.29	0.963	0.346
	INT	12	129.58 ± 5.57		
Weight (kg)	CON	12	33.33 ± 2.87	0.351	0.729
	INT	12	33.50 ± 5.40		

* Significance level is P ≤ 0.05

Table 3. Test of Homogeneity of Variances

Excursion	Variable	Levene Statistic	df1	df2	Sig
Anterior	Pre	0.013	1	22	0.912
	Pos	0.066	1	22	0.799
Posteromedial	Pre	3.087	1	22	0.093
	Pos	1.475	1	22	0.237
Posterolateral	Pre	0.676	1	22	0.420
	Pos	1.440	1	22	0.243
BESS Balance	Pre	0.001	1	22	1.000
	Pos	0.355	1	22	0.557

Table 4. Results of Ancona analysis for comparing post-test dynamic balance in two groups

Variable	Source	Sum of Squares	df	Mean square	F	sig
Anterior	Pretest	121.107	1	121.107	6.068	*0.022
	Group	89.546	1	89.546	4.487	*0.046
	Error	419.094	21	19.957	-	-
Posteromedial	Pretest	2099.328	1	2099.328	383.908	*0.000
	Group	254.203	1	254.203	46.487	*0.000
	Error	114.835	21	5.468	-	-
Posterolateral	Pretest	1501.855	1	1501.855	147.559	*0.000
	Group	125.536	1	125.536	12.334	*0.002
	Error	213.737	21	10.178	-	-

* Significance level is $P \leq 0.05$

Table 5. Results of Ancona analysis for comparing post-test static balance in two groups

Variable	Source	Sum of Squares	df	Mean square	F	sig
BESS Balance	Pretest	27.671	1	27.671	23.967	*0.000
	Group	16.465	1	16.465	14.260	*0.001
	Error	24.246	21	1.155	-	-

* Significance level is $P \leq 0.05$

Also there is a significant difference between the post-test scores for the posteromedial excursion after the elimination of pre-test effect [($p = 0.000$) and ($F = 46.487$)], and post-test scores for Posterolateral excursion after the elimination of the pre-test effect were significant [($p = 0.002$) and ($F = 12.334$)]; therefore, the mean scores of post-test the intervention group was significantly higher in the Y balance test than in the control group.

Discussion

The primary finding from this study was that participation in an integrative neuromuscular program was found to be an effective, safe and worthwhile method of conditioning for autism spectrum children. Specifically, the intervention group who performed integrative neuromuscular with balloons during the training program made significantly greater gains in muscle strength/endurance, lower body power, static and dynamic balance as compared with age-matched controls group who participated in routine physical education activities without integrative neuromuscular training. The improvements in static and dynamic balance measures are evidence of this treatment's efficacy. No injuries occurred all over the training period and our observations suggest that the training program was well-received by the intervention group. This information demonstrates the potential value of the integrative neuromuscular program for the primary school autism spectrum children.

Children with autism spectrum disorders have mental and communicative problems, from the beginning of growth, they are less likely to participate in physical activity. As a result of this, it affects muscle growth and builds muscle coordination. But a continuing firm in physical activity, it can compensate for this delay in children's motor development [21]. The effectiveness of the exercise on balance requires a response at three levels of motion. At the level of the spinal cord, its main role is to regulate muscle reflexes. The sensory information obtained from mechanical joint receptors resulting in equilibrium reflexes, in the form of reflexes, causes a contraction of support around the joint and prevents excessive pressure on inactive agents limiting joint motion.

The development of equilibrium reflexes at the brain stem level helps control body balance. At the level of the higher nervous system (cerebral cortex and cerebellum), the individual concentrates and consciously tries to consciously control his joint and balance. Control at each of these levels requires sensory information collected from visual, vestibular, and somatosensory systems. As a result, with the difficulty of practicing conditions (through closing eyes, maintaining balance on one foot and using multi-plate equilibrium boards), overload will increase on these senses and the somatosensory. Taylor et al. [22] concluded that somatosensory plays an important role in balancing control. One aspect of the role of the somatosensory of movement control and postural control is the design and modification of the movement commands before and during the implementation of a movement. The movement control system should consider the current and changing state of the joints to estimate the mechanical balance resulting from its implementation. In this context, the somatosensory has the best conditions for supplying information and transmitting it to the central nervous system; because it is a complex process that can only be carried out by the somatosensory system. Somatosensory information plays a crucial role both in the overall stability of the body and in maintaining the stability of the local areas (joint functional stability). Given that integrative neuromuscular training can reduce body swings and the displacement of the centre of gravity [23]. In the present study, this training program probably improves the somatosensory and changes in the utilizing of motor unit patterns, which increases postural stability and maintains the centre of gravity on the base of support and improves balance in these children. Today, education experts have argued that movement activities should be primarily included in student education programs, especially in preschool and primary education. Conducting training programs and participation these students in the group games plays a role in the development and improvement of the child's skills in postural control if they are used correctly and systematically.

These findings, along with the high prevalence of mental retardation (75% prevalence) in people with autism spectrum disorder, regardless of whether autism is a primary or secondary disorder in these people, the need for motor interventions in programs individual education poses these individuals, especially in the early years of life skills, provides a platform for other important learning, such as educational and social skills. Therefore, improvement and promotion of motor skills should be considered in the training programs of these people. On the other hand, motor skills in children with autism disorders can predict comprehend and expression skills as well as playing skills in these children, which is important for use in interventional programs and future research.

The results of this study indicate the positive effects of integrative neuromuscular training on the postural control performance of children with autism spectrum. Hence, the neuromuscular training program is expected to provide a good basis for coordinating the use of motor units and improving core stability so that, this group of people will get closer to normal postural control.

Acknowledgment

The present study was carried out with the cooperation of Imam Khomeini International University and the Exceptional Education Office of Qazvin. Thanks, and appreciation of all the participants and the management of the exceptional school of Misagh Qazvin who has collaborated on this research.

References

1. Jam AZ, Talab RH, Sheikh M, Torabi F, Rafie F (2018) The effect of 16 weeks gymnastic training on social skills and neuropsychiatric functions of autistic children. *Sport Sci Health* 14: 209-214.

2. Papadopoulos N, McGinley J, Tonge B, Bradshaw J, Saunders K, et al. (2012) Motor proficiency and emotional/behavioural disturbance in autism and Aspergerís disorder: another piece of the neurological puzzle? *Autism* 16: 627-640. [Crossref]

3. Bauman ML, Kemper TL (2005) Neuroanatomic observations of the brain in autism: a review and future directions. *Int J Dev Neurosci* 23: 183-187. [Crossref]

4. Autism and Developmental Disabilities Monitoring Network Surveillance Year 2008 Principal Investigators (2012) Prevalence of autism spectrum disordersóautism and developmental disabilities monitoring network, 14 sites, United States, 2008. *MMWR Surveill Summ* 61: 1-19. [Crossref]

5. Lang R, Koegel LK, Ashbaugh K, Regester A, Ence W, et al. (2010) Physical exercise and individuals with autism spectrum disorders: A systematic review. *Res Autism Spectr Disord* 4: 565-576.

6. Lord C, Cook EH, Leventhal BL, Amaral DG (2000) Autism spectrum disorders. *Neuron* 28: 217. [Crossref]

7. Minshew NJ, Sung K, Jones BL, Furman JM (2004) Underdevelopment of the postural control system in autism. *Neurology* 63: 2056-2061. [Crossref]

8. Dowell LR, Mahone EM, Mostofsky SH (2009) Associations of postural knowledge and basic motor skill with dyspraxia in autism: implication for abnormalities in distributed connectivity and motor learning. *Neuropsychology* 23: 563-570. [Crossref]

9. Wing L (2006) Children with autistic spectrum disorders. Included or Excluded?: Routledge; p. 53-63.

10. Molloy CA, Dietrich KN, Bhattacharya A (2003) Postural stability in children with autism spectrum disorder. *J Autism Dev Disord* 33: 643-652. [Crossref]

11. Pan CY, Frey GC (2006) Physical activity patterns in youth with autism spectrum disorders. *J Autism Dev Disord* 36: 597-606. [Crossref]

12. Lloyd M, MacDonald M, Lord C (2013) Motor skills of toddlers with autism spectrum disorders. *Autism* 17: 133-146. [Crossref]

13. Kosari S, Keyhani F, Hamayttalab R, Arab Ameri E (2012) Effect of a Selected Physical Activity Program on the Development of Motor Skills in Attention Deficit/Hyperactivity Disorder (ADHD) and Autism (HFA) Children. *Development and Motor Learning (Harakat)* 10: 45.

14. Ziublsky J, Viezel K (2013) Gilliam Autism Rating Scaleó Second Edition. Encyclopedia of Special Education: A Reference for the Education of Children, Adolescents, and Adults with Disabilities and Other Exceptional Individuals.

15. Carpes FP, Reinehr FB, Mota CB (2008) Effects of a program for trunk strength and stability on pain, low back and pelvis kinematics, and body balance: a pilot study. *J Bodyw Mov Ther* 12: 22-30. [Crossref]

16. Plisky PJ, Rauh MJ, Kaminski TW, Underwood FB (2006) Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players *J Orthop Sports Phys Ther* 36: 911-9. [Crossref]

17. Finnoff JT, Peterson VJ, Hollman JH, Smith J (2009) Intrarater and interrater reliability of the Balance Error Scoring System (BESS). *PM R* 1: 50-54. [Crossref]

18. Mediate P, Faigenbaum A (2007) Medicine ball for all kids. Monterey, CA: Healthy Learning.

19. Chu DA, Faigenbaum AD, Falkel JE (2006) Progressive plyometrics for kids: Healthy Learning Monterey.

20. Faigenbaum AD, Farrell A, Fabiano M, Radler T, Naclerio F, et al. (2011) Effects of integrative neuromuscular training on fitness performance in children. *Pediatr Exerc Sci* 23: 573-584. [Crossref]

21. Esmaeili E, Salavati M, Ma'roufi N, Esmaeili V (2006) Effect of balance board exercises on balance tests and limits of stability by Biodex balance system in normal men. *J Rehab* 7: 19-25.

22. Taylor AH, May S (1996) Threat and coping appraisal as determinants of compliance with sports injury rehabilitation: An application of protection motivation theory. *J Sports Sci* 14: 471-482. [Crossref]

23. Sekendiz B, Cug M, Korkusuz F (2010) Effects of Swiss-ball core strength training on strength, endurance, flexibility, and balance in sedentary women. *J Strength Cond Res* 24: 3032-3040. [Crossref]