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The effects of balance training intervention on postural control of children with autism spectrum disorder: Role of sensory information

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ABSTRACT

Purpose: The aim of this study was to investigate the effect of balance training intervention in children with autism spectrum disorder (ASD), and to explore the relative role of the sensory systems in such kids.
Methodology: We recruited 20 school children (IQ > 80) diagnosed with ASD, and categorized them in two groups; a 10-member training group (average age: 7.70 ± 1.05) and a 10-member control group (average age: 7.90 ± 1.10). Thus, following a six-week-long balance training intervention in four conditions of bipedal upright stance [compliant (Foam) vs. non-compliant (Hard) with eyes-open (EO) vs. eyes-closed (EC)], we examined measures such as mean velocity (*V*), anteroposterior (AP) and mediolateral (ML) axis displacement, and compared the results to those calculated prior to the initiation of the intervention using MANOVA test.
Results: This study showed that the balance training program efficiently improved the postural control in ASD suffering children, and that removing the visual and plantar proprioceptive information led to increased sway in both groups. The training group performed significantly better than the control group in all conditions.
Conclusion: It is thus concludable that children suffering from ASD can benefit from such balance training programs to improve their balance and postural control.

1. Introduction

Children with autism spectrum disorder (ASD) primarily suffer from impairments in communication and social interaction, though recent literature supports the prevalence of motor impairments (Fournier et al., 2010). The prevalence rate of ASD continues to increase with 1 child in 88 having ASD, with males being 5 times more likely to be diagnosed than females (Centers for Disease Control & Prevention, 2012). ASD is a disorder with a wide range of impairments of body structures and functions, many of which impact postural control. Postural stability is defined as the ability to maintain the projected center of mass (COM) in the base of support (Dusing & Harbourne, 2010). Children with ASD showed higher

Abbreviations: ASD, autism spectrum disorder; COM, center of mass; COP, center of pressure; *V*, velocity; AP, anteroposterior axis; ML, mediolateral axis; TD, typically developing; ADI-R, autism diagnostic inventory-revised; EO, eyes open; EC, eyes-closed; MANOVA, multivariate analysis of variance.

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instability in mediolateral than anteroposterior axis though typically developing (TD) children demonstrated higher sway scores in anteroposterior than mediolateral direction (Memari et al., 2013).

On the other side, the vestibular, somatosensory (including proprioceptive and cutaneous inputs) and visual systems are the afferents involved in the complex process of maintaining upright balance in humans. Any deficit in these systems or in the integration of information from these systems could affect balance. Sensory impairments are common in children with developmental disabilities (Gal, Dyck, & Passmore, 2010), and they are at an increased risk for visual impairments (Creavin & Brown, 2009). Of particular importance are the identified deficits in postural control (Gepner & Mestre, 2002). Previous research on such children has identified deficits in motor development (Provost, Lopez, & Heimerl, 2007), coordination and general motor function (Jansiewicz et al., 2006), and the planning and execution of movement (Rinehart et al., 2006). There is a paucity of research on the use of the somatosensory and postural control for children with ASD. Kohen-Raz, Volkman, and Cohen, 1992 were the only ones to suggest that children with ASD may prefer using the somatosensory system to maintain balance. Also ASD children have been found to have deficits in various motor control areas, including hypotonia and motor apraxia (Ming, Brimacombe, & Wagner, 2007), overall gross motor development, locomotor and object control skills, manual dexterity, ball skills and balance (Green et al., 2009), and a general deficit in manual responses to visual stimuli (Todd, Mills, Wilson, Plumb, & Mon-Williams, 2009).

The efficacy of balance training programs for children is not well understood. Many interventions and exercise programs include balance components, but there are few research studies that focus solely on balance training for children with developmental disabilities. Wang and Chang (1997) specifically studied the effects of a jumping skill program on balance during gait among children with mental retardation and Down syndrome. Shumway-Cook, Hutchinson, Kartin, Msme, and Woollacott (2003) also reported improvements in balance with cerebral palsy following an intervention program. Most of the balance intervention studies involve the elderly population. But there has been no research about possible influences of balance training interventions on postural control in ASD suffering children. In general, there has been little research regarding characteristics of postural control in ASD. It has been assumed that postural control is best achieved when postural sway is held to a minimum. Based on this assumption, researches have shown that balance training can improve postural control in healthy (Kovac, Birmingham, Forwell, & Litchfield, 2004), injured/diseased (Kidgell, Horvath, Jackson, & Seymour, 2007; McKeon et al., 2008), and elderly populations (Nagy et al., 2007).

Some researchers have focused on examining the effects of various constraints (e.g., disease state, restricted vision, and heightened attentional awareness) on postural sway (Roerdink, Hlavckova, & Vuillerme, 2010). Much research has been devoted to improving postural control through exercise programs. However, there is insufficient research investigating the use of balance training programs in the developmental disabilities. On the other hand, based on neurobehavioral studies, children with ASD have structural or functional impairments (Nayate, Bradshaw, & Rinehart, 2005). In the present research, we aimed to examine the effect of progressive balance program on the improvement of postural control in children with ASD, and to measure the relative role of the sensory systems in this regard. We hypothesized that balance program could reduce postural sway in ASD suffering children. We further hypothesized removing the visual and plantar proprioceptive information could lead to increased levels of postural sway.

2. Methods

2.1. Participants

A total number of twenty participants were selected for this study, and were assigned to two groups: control group (average age: 7.90 ± 1.10) and training group (average age: 7.70 ± 1.05). Each group consisted of 10 boys aged 7–10 years old diagnosed with high functioning ASD ($IQ > 80$). Each child had to meet the criteria of ASD diagnosis on both DSM-IV (Association and DSM-IV, 2000) and the autism diagnostic inventory-revised (ADI-R) (Lord, Rutter, & Le Couteur, 1994) which was examined by a child psychiatrist or psychologist. The participants were included from autism specific schools in Ahvaz. The protocol was approved by the Review Board of Shahid Chamran University prior to participant recruitment, and all participants provided written informed consent before participation in experimental procedures. The study was also approved by the Ethics committee of Shahid Chamran University of Ahvaz.

2.2. Assessment of postural control

Postural sway data were collected using the Bertec force plate (type strain gage, 40×60). Force platform is the instrument that records the ground reaction forces excreted by an individual. The force sensors under the force plate measure the forces in the horizontal and vertical directions. The information is then transferred to a computer by a cable to enable the analysis of the data and the process of information such as position of ground reaction forces in anteroposterior and mediolateral axes. Data were sampled out at 100 Hz and the platform was calibrated before each test.

2.3. Additional assessments

Maintaining upright posture is a complex process involving multiple afferent systems. During the ‘‘eyes closed’’ tasks, subjects were blindfolded and asked to keep their eyes closed under a blindfold. High foam pad with a density of 1 lb/ft3 was