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Postural sway patterns in children with autism spectrum disorder compared with typically developing children

Amir Hossein Memari [a,*], Parisa Ghanouni [b], Shahriar Gharibzadeh [c], Jandark Eghlidi [b], Vahid Ziaee [a], Pouria Moshayedi [d]

[a] Tehran University of Medical Sciences, Sports Medicine Research Center and School of Medicine, Tehran, Iran
[b] Shahid Beheshti University of Medical Sciences, Rehabilitation Center, Tehran, Iran
[c] Amirkabir University of Technology, Department of Biomedical Engineering, Tehran, Iran
[d] Department of Neurology, David Geffen School of Medicine, University of California, Los Angeles, USA

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ABSTRACT

Postural control is a fundamental building block of each child's daily activities. The aim of this study was to compare patterns of postural sway in children with autism spectrum disorder (ASD) with typically developing children (TD). We recruited 21 schoolchildren diagnosed with ASD aged 9–14 and 30 TD pupils aged 8–15. Postural sway parameters in composite, anteroposterior and mediolateral axis were reported. Furthermore we examined the impact of age and characteristics of autism on postural sway. Children with ASD exhibited higher amount of sway in anteroposterior range ($p < 0.001$), mediolateral range ($p = 0.002$), root mean square ($p = 0.001$), mean velocity ($p = 0.03$), and sway area ($p = 0.007$) compared with their TD peers. Children with ASD showed higher instability in mediolateral than anteroposterior axis though TD children demonstrated higher sway scores in anteroposterior than mediolateral direction. The rate of autism symptom severity significantly affected the postural sway in children with ASD ($p < 0.05$). In conclusion, patterns of postural control seem to be different in children with ASD compared with TD counterparts. This could be partially due to clinical features were underlying in ASD.

1. Introduction

Autism spectrum disorder (ASD) is a kind of child-onset lifelong neuro-developmental condition which its prevalence has raised drastically throughout the recent decades (Hertz-Picciotto & Delwiche, 2009; Matson & Kozlowski, 2011). The diagnosis can be determined by three key core features: language, social communication, and strange behaviors (DSM-IV-TR, 2000; Melville et al., 2008). In addition to the cardinal disabilities, children with ASD usually suffer from deficits in various motor control areas. Motor problems such as clumsiness in task execution, difficulties in planning, gross or fine motor deficits, lack of fluency and coordination in actions can be taken in to account (Ming, Brimacombe, & Wagner, 2007). Although sever or rigorous motor problems are not necessarily associated with ASD, recent investigations recommend to pay more attention to physical and motor symptoms as a part of autism diagnosis process and profile making (Memari, Kordi, Ziaee, Mirfazeli, & Setoodeh, 2012; Minshew, Sung, Jones, & Furman, 2004).

* Corresponding author at: Tehran University of Medical Sciences, Sports Medicine Research Center, No. 7, Al-e-Ahmad Highway, P.O. Box 14395-578, Tehran, Iran. Tel.: +98 21 88630227/88630228; fax: +98 21 88003539.
E-mail addresses: amirmemari@farabi.tums.ac.ir, sportpsych@tums.ac.ir (A.H. Memari).

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Keeping upright posture is a fundamental skill which has become an important focus of attention in motor research. Postural stability is the ability to maintain and keep the projected center of mass (COM) in the base of support (Dusing & Harbourne, 2010). Position of the ground reaction forces which exerted to confront body's weight is known as center of pressure (COP) (Shumway, 2000, chap. 4). Oscillation of COP indicates neuromuscular reactions against the motion of body mass which provides stability and determines how much efforts are needed to retain the steadiness of body (Shumway, 2000, chap. 4). A few studies have identified that children with ASD encounter more problems to control their posture compared with typically developing (TD) children (Chang, Wade, Stoffregen, Hsu, & Pan, 2010; Fournier et al., 2010; Kohen-Raz, Volkman, & Cohen, 1992; Minshew et al., 2004; Molloy, Dietrich, & Bhattacharya, 2003). Weimer, Schatz, Lincoln, Ballantyne, and Trauner (2001) indicated that length of time for one-leg standing was significantly poorer in children with ASD than control. Poorer postural control in autistic children can be due to improper modulation for sensory inputs and motor outputs (Gepner, Mestre, Masson, & de Schonen, 1995). In children with ASD, premature and poor postural stability can limit the ability of locomotion and performing motor skills which in turn negatively affect their daily activities (Fournier et al., 2010).

Previous studies showed that as children grow up, postural sway decreases; thus they are gradually able to control their body (Hellebrandt & Braun, 1939; Hytönen, Pyykkö, Aalto, & Starck, 1993). However there has been little discussion about the effect of age on postural sway in individuals with disabilities particularly ASD (Kohen-Raz et al., 1992). Minshew et al. (2004) indicates a significant association between age and the amount of sway in ASD; however, this concept has recently been challenged by studies demonstrating no age effect on sway parameters (Fournier et al., 2010).

Although all of the previous studies replicate and agree on poor postural stability in children with ASD, far too little attention has been paid to the role of severity of disorder in postural control. Kohen-Raz et al. (1992) conveyed that symptom severity in ASD is positively related to the amount of sway while Molloy et al. (2003) findings could not confirm this association. Consequently, debate continues about the link of postural control to autism symptoms severity.

Sway parameters are categorized as directional or composite measures. Directional measures indicate oscillations in each axis separately: anteroposterior (AP) or mediolateral (ML). However, composite measures are single parameters which consider movements in both directions. Although directional parameters may be clinically critical, there are only a few studies investigated directional measures. Authors show that children with ASD have higher sway in mediolateral direction (Fournier et al., 2010; Kohen-Raz et al., 1992).

There are a number of COP sway parameters (such as mean velocity and sway area) which can be calculated by posturography. It is noteworthy that each of these distinctive parameters has the unique potential to depict the different aspects of postural control (Bigelow, 2008). Considering all together, postural sway and amount of attempts to keep the body upright can be precisely estimated. However, most studies in autism have only been carried out on a small number of sway variables (Fournier et al., 2010; Molloy et al., 2003). And there have been no controlled studies which comprehensively compare differences in parameters such as mean frequency and sway area.

Generally, inconsistent findings may be in part due to the different assessment tools with different mechanisms of examining sway indices. For example, EquiTest estimates sensory organization (Minshew et al., 2004), Tetra-Ataxiametry method assesses the weight distribution (Kohen-Raz et al., 1992), force plate evaluates ground reaction forces (Fournier et al., 2010) and magnetic tracing measures the sway of head and upper trunk (Chang et al., 2010). Additionally, conflicting results from mix samples with a wide age range, from clinical and community based samples and including low and high functioning participants has made generalization impossible.

Given together, there is still a lack of knowledge about the postural sway parameters in ASD regarding demographics as well as clinical features. In the present research, we aimed to examine postural control indices in ASD vs. TD group according to their age and the score of autism characteristics. Besides, we intended to investigate directional measures other than composite measures. We hypothesized that children with ASD have a propensity to sway more than their TD peers in all of the sway parameters. We further hypothesized that autism character is associated with postural control.

2. Methods

2.1. Participants

A total of 51 participants were assigned to the study in two groups: ASD and TD. The first included 21 boys diagnosed with high functioning ASD (IQ $>$ 80) aged 9–14 years old. 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) by a child psychiatrist or psychologist. The participants were included from autism specific schools in Tehran. Children were excluded if they had a severe musculoskeletal disorder, severe behavioral problem and uncontrollable seizure, using any assistive devices or postural supports. Also, 30 healthy age- and gender-matched TD children (aged 8–15) recruited from a community school as the control group. These children were medically screened and determined to have no musculoskeletal or neurological disorders and were intact in vestibular and visual performance. Parents or caregivers provided informed written consent and each child assented for study participation. The study was approved by the Medical Ethics committee of Tehran University of Medical Sciences.