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Standing balance on unsteady surfaces in children on the autism spectrum: The effects of IQ

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ABSTRACT

Background: Postural stability difficulties are commonly reported in people on the autism spectrum. However, it is unclear whether unsteady surfaces may exacerbate postural stability difficulties in children and adolescents with autism spectrum disorder (ASD). Understanding balance on unsteady surfaces is important because uneven surfaces are commonly encountered in daily life.

Methods: Twenty-one youth on the autism spectrum and 16 youth with typical development (ages 6–16 years, IQ ≥ 79) stood on both a fixed and unsteady (tiltable) platform, and center of pressure was measured.

Results: The group with ASD exhibited differentially more postural sway on the unsteady surface compared to the group with typical development. However, there was substantial variability within the ASD group. Follow-up analyses suggested that much of the variability in postural sway in the ASD group was accounted for by IQ.

Conclusions: Clinically, these findings suggest that not all individuals with ASD struggle more with postural stability on unsteady surfaces. Instead children and adolescents with ASD and below-average IQ may have particular difficulty on unsteady surfaces and may require accommodations. Further, these findings lay the groundwork for future research to investigate the underlying mechanisms of poorer balance across the autism spectrum.

1. Introduction

Maintaining balance during standing may be perceived by many as a simple task, but postural control requires complex adjustments to ever-changing internal and external input (Horak, 2006; Lockhart & Ting, 2007). In individuals on the autism spectrum, there is evidence for a diversity of motor difficulties (for a meta-analysis, see Fournier, Hass, Naik, Lodha, & Cauraugh, 2010) and atypical sensory profiles (for a review, see Baranek, Little, Diane Parham, Ausderau, & Sabatos-DeVito, 2014), which individually or in combination could result in postural stability challenges. The environment may further challenge postural stability, as much of the ground on which we balance has the potential to be unsteady (i.e., uneven terrain, slick surfaces, etc.). If people on the autism spectrum struggle to maintain balance on unsteady surfaces even more so than typically developing peers, this would create additional obstacles to being able to complete tasks required for independent living. Understanding how postural stability differs in

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autism compared to typical development will allow us to better determine appropriate accommodations for balance challenges in individuals on the autism spectrum. Moreover, by identifying who on the autism spectrum may struggle most with postural stability, we may better determine potential mechanisms underlying balance challenges in this population and to determine which individuals would benefit most from accommodations. Therefore, the purpose of the present study was to examine group differences in postural stability during upright standing on both fixed and unsteady surfaces in children and adolescents on the autism spectrum compared to age- and performance IQ- matched peers with typical development.

A handful of studies suggest that balance may be impacted in people on the autism spectrum (for a review and meta-analysis, see Lim, Partridge, Girdler, & Morris, 2017). Standardized assessments that use balance times to measure postural stability have shown that people on the autism spectrum maintain standing balance for a shorter amount of time (or for a fewer number of hops) compared to typically developing peers (Ghaziuddin, Butler, Tsai, & Ghaziuddin, 1994; Green et al., 2002, 2009; Jansiewicz et al., 2006; Noterdaeme, Mildenberger, Minow, & Amorosa, 2002; Papadopoulos et al., 2012). Similarly, measures of postural sway, typically performed on a force plate or balance board, have indicated more sway in people on the autism spectrum during quiet standing (Fournier, Kimberg et al., 2010; Kohen-Raz, Volkman, & Cohen, 1992; Radonovich, Fournier, & Hass, 2013) and dynamic standing (Wang et al., 2016). However, even in studies where no group differences in postural stability emerged in more basic balance poses (i.e., two-footed, eyes-open standing) (Travers, Powell, Klinger, & Klinger, 2013; Weimer, Schatz, Lincoln, Ballantyne, & Trauner, 2001), decreased postural stability was observed in people on the autism spectrum in the more challenging balance poses, such as one-footed standing (Graham et al., 2015; Travers et al., 2013; Weimer et al., 2001), dual-task conditions (Chang, Wade, Stoffregen, Hsu, & Pan, 2010; Memari, Ghanouni, Shayestehfar, & Ghaheri, 2014), eyes-closed standing (Molloy, Dietrich, & Bhattacharya, 2003), and standing on a foam cushion (Minshew, Sung, Jones, & Furman, 2004; Molloy et al., 2003).

A small number of the previously mentioned studies have also examined how individual differences within the autism spectrum moderate postural stability performance. Poorer postural stability in individuals on the autism spectrum was found to relate to more severe social communication impairments (Travers et al., 2013), more severe repetitive behaviors symptoms (Radonovich et al., 2013; Travers et al., 2013), more severe emotional/behavioral challenges (Papadopoulos et al., 2012), and lower IQ scores (Minshew et al., 2004). These results underscore the need to better understand how postural stability under various conditions may interact with individual-difference variables to differentially impact the lives of individuals across the spectrum.

Taken together, the literature suggests that people on the autism spectrum may have postural stability difficulties, especially when the balance task presents a greater sensorimotor challenge. However, much of the research to date has focused on postural stability on fixed, horizontal surfaces. To our knowledge, only one study (Doumas, McKenna, & Murphy, 2016) has investigated postural control in ASD using a surface that could tilt. In that study, the front-to-back tilt of the surface continuously adjusted to how the body was leaning so that the same ankle angle was maintained across all tilt angles. This resulted in proprioceptive feedback no longer providing information regarding postural orientation. Doumas et al. (2016) found that young adults on the autism spectrum exhibited differentially more sway compared to the typically developing group in the tilt condition. While this study offers initial evidence that unsteady surfaces might be a particular challenge in adults on the autism spectrum, previous research suggests atypical development of the postural control system from childhood through adulthood in autism spectrum disorder (ASD) (Minshew et al., 2004). Thus, it is important to characterize the development of balance challenges on unsteady surfaces in children and adolescents on the autism spectrum. If postural stability on a tiltable platform were to be particularly challenging for children on the autism spectrum (even more so than in typically developing children), then this may have negative implications for functional activities such as playing on certain playground structures or even engaging in various types of exercises. Therefore, the primary aim of the present study was to examine postural stability in children and adolescents on the autism spectrum compared to children and adolescents with typical development during standing on a traditional fixed platform compared to a tiltable platform. We hypothesized that children and adolescents on the autism spectrum would exhibit differentially more postural sway on the unsteady surfaces when compared to their age-matched peers with typical development. Given the heterogeneity in clinical profiles within the autism spectrum, a secondary aim was to examine potential moderators of postural stability within the ASD group in order to identify who on the autism spectrum may have particular difficulty on unsteady surfaces and may be more likely to require accommodations.

2. Methods

2.1. Participants

This study received approval from University of Wisconsin-Madison's institutional review board (#2013-0857). Participants' consent was obtained according to the Declaration of Helsinki as revised in 2000. Written informed consent was obtained from a parent/guardian, and assent was obtained from the children. Twenty-one children/adolescents with ASD and 16 children/adolescents with typical development (ages 6–16 years) successfully completed the postural stability measurements as part of a broader study to assess multiple aspects of motor function in individuals with ASD. Participants were recruited through community fliers, and additional participants who met study criteria were recruited through the Waisman Center's participant registry. Participants with ASD were included if they had a previous diagnosis of autistic disorder, Asperger's syndrome, or pervasive developmental disorder not otherwise specified (PDD-NOS). Participants with ASD were excluded from this study if the family reported a known medical cause of ASD (i.e., fragile-X testing, tuberous sclerosis), hypoxia-ischemia, seizure disorder, or other neurological disorders. The Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999) was performed to determine that participants did not have co-occurring intellectual disorder (full-scale IQ < 70). Due to a scheduling conflict, we were unable to complete the IQ measures for one participant with ASD. Thus, this person was not included in analyses that included IQ as a variable. Autism spectrum symptoms were assessed