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Gross motor skills are related to postural stability and age in children with autism spectrum disorder

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ABSTRACT

Motor skill and postural stability deficits are commonly reported for children with autism spectrum disorder (ASD), however the relationship between these variables is not well established. We explored the relationship between motor skills, postural stability, restricted and repetitive patterns of behavior, diagnosis, age, and sex. Children (11 with and 11 without ASD), 5–12 years of age, participated in the study. The Test of Gross Motor Development-3 (TGMD-3) was used to assess fundamental motor skills. Postural sway was measured on a force plate during quiet standing on a solid and compliant surface. Center of pressure was calculated and used to compute sway area. Linear regression analysis showed that sway area on a solid surface, age, and diagnosis were significant predictors of motor skill performance (R^2 = .854). Severity of ASD, as assessed by the Repetitive Behavior Scale-Revised (RBS-R), was not predictive of motor skills. Children with ASD exhibited deficits in postural stability compared to children without ASD. Postural stability appears to influence the ability of children to perform gross motor skills. However, the RBS-R does not seem to be a useful tool for identifying those children with ASD who exhibit the greatest deficits in motor skills.

1. Introduction

Autism spectrum disorder (ASD) is one of the most prevalent developmental disabilities in North America. The core characteristics of ASD are deficits in social communication and restricted and repetitive patterns of behavior (American Psychiatric Association [APA], 2013). In addition, children with ASD have been documented to exhibit motor skills which lag behind those of their peers without ASD (Berkeley, Zittel, Pitney, & Nichols, 2001; Green et al., 2009; Staples & Reid, 2010). Deficits in motor skills may prevent children and adolescents with ASD from engaging in play during recess, and leisure time, and eventually adopting an active lifestyle as they mature. Indeed physical activity levels of children with ASD have been found to be lower than the level of age-matched peers without disability (MacDonald, Esposito, & Ulrich, 2011). There is increasing concern in the research community that sedentary lifestyles will negatively impact long-term health and wellness among the growing population of individuals with ASD (Must et al., 2014).

In order to promote the health and wellness of individuals with ASD researchers have attempted to describe and understand the commonly observed poor motor skill performance among these individuals. Over the past decade researchers have studied the motor performance of individuals with ASD and found deficits in several areas of function

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including impairments in motor anticipation, dyspraxia, and postural control (Fournier et al., 2010; Schmitz, Martineau, Barthelemey, & Assaiante, 2003). Though IQ has been linked to the severity of motor deficits for children with intellectual disability, motor impairments are found in persons with ASD both with and without comorbid intellection disability (Green et al., 2009). Thus, there is a general consensus in the literature that ASD is associated with specific motor impairments that are not entirely due to intellectual function (Travers, Powell, Klinger, & Klinger, 2013).

Deficits in a wide array of motor function including gait, postural stability (i.e., balance), manual dexterity, object control, and locomotor skills have been reported (Ghaziuddin and Butler, 1998; Staples & Reid, 2010). Postural stability, the ability to maintain one's center of gravity within a given base of support, is a fundamental and early developing motor skill which allows a person to maintain upright stance (Shumway-Cook & Horak, 1986). This skill is a prerequisite for the performance of many motor tasks such as riding a bicycle, sitting on a swing, or throwing a baseball (Flatters et al., 2014). Recent studies suggest that postural stability, as measured by postural sway area, sway path length, or sway velocity, is less developed in children with ASD when compared to their peers without ASD (Fournier et al., 2010; Graham et al., 2015; Minshew, Sung, Jones, & Furman, 2004; Molloy, Dietrich, & Bhattacharya, 2003; Travers, Powell, Klinger, & Klinger, 2013). Though a variety of instruments (e.g., force plate, Neurocom Balance Master©, Wii Balance Board, etc.) and variables have been used to assess postural stability this does not seem to influence the observed differences between children with and without ASD reported in the literature (Graham et al., 2015; Minshew et al., 2004; Radonovich, Fournier, & Hass, 2013; Stins, Emck, de Vries, Doop, & Beek, 2015; Travers et. al., 2013). Minshew and colleagues evaluated postural stability in 79 individuals with and 61 individuals without ASD between the ages of 5 and 52 years. The results of this cross sectional study indicated that there was a delay in the development of postural stability for individuals with ASD. Additionally, typical adult levels of postural stability where not achieved among the adults with ASD in this cohort (Minshew et al., 2004). It is important to note that participants in this study did not have an intellectual disability thus the observed impairments in postural stability were linked with ASD. The authors hypothesized that impaired postural stability is one of the manifestations of the neural abnormalities which cause problems with sensory integration and general neural circuitry among individuals with ASD.

In an effort to understand the nature of these observed deficits, and the role of the visual, vestibular, and somatosensory systems, in the maintenance of postural stability, researchers can measure postural stability under a variety of conditions. For example, researchers often assess postural sway while asking individuals to stand on two feet with eyes open and closed, or stand on a firm and compliant surface. Several researchers have found that when balance tasks are simple, for example standing on two feet with eyes open on a firm surface there is little difference between individuals with and without ASD. However, as task difficulty increases individuals with ASD tend to show greater postural instability when compared with their typically developing peers (Graham et al., 2015; Stins et al., 2015; Travers et al., 2013). For example, when sensory input is altered by having an individual close their eyes or the size of their base of support is reduced, greater decreases in postural stability are observed for those with ASD when compared to individuals without ASD. As many motor and sports skills are performed under conditions that require limited vision or single leg weight bearing it is possible that these difficulties may hamper the development of proficient motor skills in children with ASD.

Not only have deficits in motor skills been observed among children with ASD, but these deficits have also been related to the characteristic deficits in social communication in this population of individuals. MacDonald and colleagues described an association between fine and gross motor skills and severity of social communication deficits (MacDonald, Lord, & Ulrich, 2014). If this direct relationship between motor skills and social communication deficits holds true in the general population of individuals with ASD it could be used as a simple tool for identifying those individuals who could most benefit from a motor skill intervention. Similarly, if a relationship between motor skill deficits and restricted and repetitive patterns of behavior is established this could also be used as a tool for efficiently and effectively identifying those individuals with the greatest need for a motor skill intervention. However, to date the relationship between motor skills, postural stability, and restricted and repetitive patterns of behavior remains unclear.

The Diagnostic and Statistical Manual of Mental Disorders [DSM-5] states that restricted and repetitive behaviors must be manifested in at least two of the following ways in order to meet the diagnostic criteria for ASD: (1) stereotyped or repetitive motor movements, use of objects, or speech, (2) insistence on sameness, inflexible adherence to routines, or ritualized patterns or verbal or nonverbal behavior, (3) highly restricted, fixated interests that are abnormal in intensity or focus, or (4) hyper- or hypo-reactivity to sensory input or unusual interests in sensory aspects of the environment (APA, 2013). The pathology underlying the presence of these particular behaviors is not certain, and in fact could vary by the type of restricted or repetitive behavior. However, it has been hypothesized that dysfunction in the basal ganglia, cerebellum, and associated circuitry may play a role in the appearance of restricted or repetitive patterns of behavior (Lewis & Kim, 2009). Importantly, these areas of the brain are also significant in motor control (Lopez, Lincoln, Ozonoff, & Lai, 2005), thus it is possible that there is an association between motor control and restricted and repetitive behaviors (Radonovich et. al., 2013). Radonovich et al. (2013) recently found that restricted and repetitive behaviors and postural stability were related in a group of 18 children 3–16 years of age with ASD, however the association between motor skills and restricted and repetitive behaviors was not explored.

Though deficits in motor skills and postural stability have been reported among children with ASD at present it is not known how these deficits are related to one another. In order to develop effective interventions for the improvement of balance and motor skills among children with ASD it is imperative that we understand the factors that may influence these deficits. Therefore the purpose of this study was to examine the relationship between gross motor skills, postural stability, and restricted and repetitive behaviors in children with and without ASD. Specifically we sought to examine whether or not