Research in Developmental Disabilities 74 (2018) 50–56

Contents lists available at ScienceDirect

Research in Developmental Disabilities

journal homepage: www.elsevier.com/locate/redevdis

Examination of gait parameters during perturbed over-ground walking in children with autism spectrum disorder

Jeffrey D. Eggleston[a,*], Merrill R. Landers[b], Barry T. Bates[a,c], Ed Nagelhout[d], Janet S. Dufek[a]

[a] Department of Kinesiology and Nutrition Sciences, University of Nevada, Las Vegas, NV, USA
[b] Department of Physical Therapy, University of Nevada, Las Vegas, NV, USA
[c] Department of Human Physiology, University of Oregon, Eugene, OR, USA
[d] Department of English, University of Nevada, Las Vegas, NV, USA

ARTICLE INFO

Number of reviews completed is 2

Keywords:
Autism spectrum disorder
Backpacks
Load carriage
Locomotion
Pediatrics
Weighted vests

ABSTRACT

Background: Many children with Autism Spectrum Disorder (ASD) are school-aged and typically carry a backpack. It is important to understand how this task affects walking. Weighted vests (WVs) often prescribed to mitigate behavioral effects of ASD. The effects of backpack and WV walking have not been examined in children with ASD.
Aims: To quantify differences in lower extremity mechanics in children with ASD during WV and backpack walking.
Methods: Eight male participants completed 15 trials in three conditions: body mass, and carrying or wearing a backpack or WV with 15% added body mass. Three-dimensional kinematic data were collected and normalized to 100% of the gait cycle. The Model Statistic was utilized to test for bilateral asymmetries between the lower extremity joints at all points along the gait cycle.
Results: Analysis revealed similar numbers of significant asymmetries in hip (71.0, 70.4, 60.6), knee (68.4, 71.5, 74.6), and ankle (64.1, 68.9, 68.4) for unloaded, backpack, and WV, respectively.
Conclusion: Participants exhibited individualized kinematic symmetry-responses to the loaded conditions compared to the unloaded condition. These findings suggest that 15% body mass backpack or WV does not affect gait symmetry in children with ASD.

1. Introduction

Autism Spectrum Disorder (ASD) has been one of the most prevalent neurological disorders in recent years in the United States (Mache & Todd, 2016; Zablotsky, Black, Maenner, Schieve, & Blumberg, 2015). Recently, ASD has been estimated to have a prevalence rate of 1 in 45 children (Zablotsky et al., 2015), which is a stark increase from the 1 in 68 children cited in 2010 (Baoi, 2010). While ASD is traditionally characterized by deficits in social and communicative skills (Baoi, 2010), there has been a recent growth in literature regarding movement abilities in children with ASD (Dufek, Eggleston, Harry, & Hickman, 2017; Hasan, Jailani, Tahir, & Ilias, 2017; Hasan, Jailani, Tahir, Yassin, & Rizman, 2017; Kindregan, Gallagher, & Gormley, 2015; Mari, Castiello, Marks, Marraffa, & Prior, 2003; Moran, Foley, Parker, & Weiss, 2013; Weiss, Moran, Parker, & Foley, 2013). In 1943, Leo Kanner initially described gait patterns in children with ASD as “clumsy” or “uncoordinated” (Kanner, 1943), yet, few researchers examined movement patterns and abilities in children with ASD until recent decades. Currently, there is evidence that supports movement dysfunction as a core

* Corresponding author at: University of Nevada, Las Vegas, 4505 South Maryland Parkway, Las Vegas, NV, USA.
E-mail address: egglest6@unlv.nevada.edu (J.D. Eggleston).

https://doi.org/10.1016/j.ridd.2018.01.004
Received 3 June 2017; Received in revised form 29 September 2017; Accepted 15 January 2018

symptom in children with ASD in regards to walking (Dufek et al., 2017; Eggleston, Harry, Hickman, & Dufek, 2017; Kindregan et al., 2015), fine and gross motor skills (Provost, Lopez, & Heimerl, 2007; Provost, Heimerl, & Lopez, 2007), postural control (Minshew, Sung, Jones, & Furman, 2004), and even reaching and grasping tasks (Mari et al., 2003).

More than 2.5 million children carry a backpack five days per week throughout a school year (Rai & Agarwal, 2014). However, there is still little known regarding how routine activities like carrying a backpack filled with school supplies, or how prescribed therapeutic modalities like wearing a weighted vest (Taylor, 2015), influence walking mechanics and movement abilities. When backpack loads exceed 10–15% of body mass (BM), significant movement alterations such as increases in forward trunk lean (Kim, Kim, & Oh, 2015), and step and stride length (Cottalorda et al., 2003) have been observed in children with typical development (TD). Over time, these changes can lead to severe back pain (Troussier, Davoine, de Gaudemaris, Fauconnier, & Phelip, 1994), which degrades children's quality of life. As such, it has been suggested that backpack loads not exceed 10–15% of BM for all children (Kim et al., 2015; Kistner, Fiebert, Roach, & Moore, 2013). Still, average backpack loads for school-aged children ranged higher than the recommendation, revealing a musculoskeletal health concern regarding long-term load carriage of excessively weighted backpacks (Pascoe, Pascoe, Wang, Shim, & Kim, 1997). However, no such recommendations, or knowledge of their influence, exist on children with neurological disorders, such as ASD.

A tool that is used frequently in therapeutic settings on children with ASD is a weighted vest (WV). WVs are used to reduce the negative effects of ASD such as movement stereotypy (Fertel-Daly, Bedell, & Hinojosa, 2001) and to improve focus while performing tasks (Fertel-Daly et al., 2001; Morrison, 2007; VandenBerg, 2001). When a child with ASD wears a WV, the deep pressure felt by the child may promote increased release of serotonin and dopamine (VandenBerg, 2001) as well as a reduction in 'purposeless movements' (Kane, Luiselli, Dearborn, & Young, 2004; Olson & Moulton, 2004; Stephenson & Carter, 2009; Taylor, 2015). However, there is also a body of literature that has found no improvements with WV utilization and suggests that these conflicting findings may be due to non-standardized protocols (Leew, Stein, & Gibbard, 2010; Reichow, Barton, Sewell, Good, & Wolery, 2009) and insufficient knowledge on how to properly use WVs (Reichow et al., 2009). With the wide usage of WVs on children with ASD, it is important to understand if, and the mechanisms of why, movement abilities, specifically over-ground walking, are affected by walking while wearing a WV.

It has been reported that children with ASD exhibit highly individualized asymmetrical lower extremity angular joint positions during gait (Eggleston et al., 2017), which may be problematic over time and may induce tripping or falling. There currently are no studies having examined how routine perturbations influence gait symmetry in this population. As such, the purpose of this study was to examine changes in lower extremity gait symmetry mechanics in children with ASD during over-ground walking while carrying a backpack filled with 15% of the participant's BM and while wearing a WV filled with 15% BM, evenly distributed over the trunk. We hypothesized that gait mechanics would be more symmetrical when walking with a WV in comparison to walking while carrying a backpack due to the even anterior-posterior distribution of mass in the WV condition versus the backpack. Additionally, because WVs have been shown to produce a calming effect while being worn during other tasks, logically, they may help improve gait asymmetries. There is a high probability that children with ASD may exhibit individualistic kinematic responses due to the spectral nature of, and comorbidities typically associated with ASD (Constantino & Charman, 2016), similar to the Newtonian responses observed in previous literature (James, Bates, & Dufek, 2003; Nordin, Dufek, James, & Bates, 2016). However, the findings of this study are still important due to the routine nature of walking while carrying a backpack and the prevalence of WV being prescribed as treatment modalities to children with ASD.

2. Methods

2.1. Participants

Male and female children with clinical diagnoses of ASD were recruited for participation in the current study. However, only eight male children with clinical diagnoses of ASD participated in this study (11.6 ± 4.5 yrs old, 1.45 ± 0.25m, 55.3 ± 26.2 kg); of the eight participants, two completed the study wearing their shoes, with the remaining six walking barefoot. Sample size was determined via a matched-pair *a priori* power analysis (G*Power 3.1; Dusseldorf, Germany) using the ankle data from Ozgül and colleagues (Ozgül et al., 2012) with an effect size of 2.02, power (1–β) of 0.99, and a significance level (α) of 0.05: a sample size of seven participants was deemed large enough to provide adequate statistical power. Due to the small sample size revealed by the initial estimation, a secondary sample size estimation was performed with knee data from Ozgül and colleagues (Ozgül et al., 2012). The secondary sample size estimation with an effect size of 1.16, power of 0.8, and significance level of 0.05, revealed a sample of seven participants would provide sufficient statistical power. However, since we utilized a single-subject study design, where the total number of observations per parameter has greater importance than the number of participants, the sample size may not be as important (Bates, Dufek, James, Harry, & Eggleston, 2016). To be included in the study, participants were required to have an ASD diagnosis from a medical professional, which was verbally confirmed by a parent, and were required to be able to walk while carrying up to 15% BM in a weighted vest or backpack. Prior to completing any laboratory activities, parental consent and child assent were obtained on institutionally approved documentation (protocol number 905727-10) and in accordance with the declaration of Helsinki.

2.2. Procedures

Participants completed all activities in a single laboratory session. Anthropometric data (age, height, mass) were measured and