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The influence of dual-task conditions on movement in young adults with and without Down syndrome

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ABSTRACT

This investigation compared spatial and temporal movement parameters of a sample of young adults with Down syndrome (DS) ($N = 12$) and individuals without disabilities (IWD) ($N = 12$) under dual-task conditions. Subjects performed a walking task at a preferred speed in isolation and again while holding a plate and cup, carrying tray and cups, talking on a phone, or buttoning a shirt. Spatial and temporal values were compared using a 2 (group) $\times$ 5 (conditions) repeated measures analysis of variance. Analysis of spatial components separately indicated that step length, step width, stride length and stride width revealed significant group and condition interactions ($p \leq .01$). Temporal components yielded significance in velocity and single-leg support time ($p \leq .01$). The current results support the notion that along with impairments to qualitative motor skills, individuals with DS are also impaired in higher order executive functioning (EF), as measured by a dual-task paradigm. It was concluded that movements are less efficient and functional in individuals with DS when an additional task is encountered while walking. We theorized that the motor program was sufficient for general locomotion but was not sufficiently developed to allow individuals with DS to modify or alter their movements to changing cognitive conditions that increasingly taxed EF. As gait and balance are trainable in this population, we recommend developing appropriate exercise and motor skill interventions during childhood and adolescents to increase strength, stability, and more "robust" ambulatory motor schema.

1. Introduction

Down syndrome is accompanied by multisystem pathologies, which involve delays in basic motor skills, motor impairments, and abnormalities in gait and posture. Movements are often uncoordinated, slower, variable, and hesitant in initiation, and the ability of these individuals responding to changes in the environment is deficient (Savelsbergh, van der Kamp, Ledebt, & Plninsek, 2000). In addition, cognitive limitations affect the ability to learn and to execute appropriate movements. Executive function (EF) – including working memory, initiation and inhibition of responses, problem solving, and strategic planning – is often lacking and limits the ability to process and use sensory information to execute movements under varying cognitive and environmental contexts. The more complex the cognitive situations, the more the ability to initiate or modify movement is affected due to increased central nervous system (CNS) cortical involvement creating competition for executive functioning (Allali et al., 2008). Consequently, developing movement patterns among individuals

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with Down syndrome (DS) is hampered by difficulties both in motor strategies and in impaired EF (Horvat, Croce, & Zagrodnik, 2010). Overall, atypical motor behaviors observed in individuals with DS, have been explained as due to cognitive limitations, biomechanical deficits, neurological deficits, abnormal sensorimotor integration, and/or a compromised somatosensory system (Carvalho & Vasconcelos, 2011).

2. Background

Locomotion and movement from point-to-point include three components of executive functioning: switching, updating (working memory), and inhibition, all of which are inefficient in individuals with DS (Horvat & Croce, 1995). The ability to generate movement patterns in response to environmental variation requires the ability to control forces that produce locomotion, while concurrently making corrections or adjustments to the motor pattern (Yogev-Seligmann, Hausdorf, & Giladi 2007). This ability to process and use competing stimuli produces significant variations in movement parameters in older adults or individuals with intellectual, neurological, or health-related disorders (Springer et al., 2006; Yogev et al., 2005; Yogev-Seligmann et al., 2007). Likewise, healthy adults and children also exhibit slower movements when required to walk and perform another task at the same time (Virji-Babul, Kerns, Zhou, Kapur, & Shiffrar, 2006). In children with DS (ages 5–6 years) Virji-Babul and Brown (2004) reported variations in matching motor performance with obstacle height that were related to processing problems when compared to a group of typically developing children. Similarly, Horvat et al. (2003, 2010) reported that individuals with intellectual disabilities, including DS, have difficulty using sensory and environmental information when preparing and executing movements.

Inefficient cognitive functioning in children with DS may contribute to their overall difficulty in performing a particular task (e.g., walking) while attending to other tasks (e.g. carrying a tray and cups). Their reduced ability to multi-task may be due to difficulties either in processing competing stimuli to facilitate movement or being inflexible when making corrections while navigating in different environments. The lack of this ability may be the primary factor that contributes to the movement inefficiency observed in this population. According to Hartman, Houwen, Scherder, and Visscher (2010), current literature suggests that children with intellectual disabilities experience problems with qualitative motor performance, especially in object control skills and EF. Moreover, these authors concluded that motor and executive deficits appear to be related and are inextricably intertwined; hence, poorer motor control and performance results in poorer EF and vice versa.

Previous work by Agiovlasitis, Yun, Pavol, McCubbin and Kim, (2008) and Horvat, Croce, Zagrodnik, Brooks, and Carter (2012) reported variations in spatial and temporal gait parameters between young adults with DS and age-matched individuals without DS, especially when shifting from a preferred walking speed to one requiring a fast or hurried pace. This preliminary investigation provided the basis for our premise that a preferred or self-selected speed reflects variations in spatial components such as stride length and width, while temporal components such as swing and stance time were negligible. During fast walking, variability increased for all spatial and temporal factors reflecting the difficulty individuals with DS have in responding to processing sensory information during divergent ambulatory tasks (Horvat et al., 2012).

This earlier research provided the rationale for investigating spatial and temporal movement parameters in DS under dual-task conditions. The ability to respond to external stimuli that require flexibility in movement initiation is hypothesized to be less functional in DS. This is consistent with earlier work by Rigoldi, Galli, and Albertini (2011) who indicated that individuals with DS learn to walk but lack precision in their movements. Overall, dual-task interference from competing cognitive and motor demands have not been thoroughly addressed in young adults with DS. It was hypothesized that as the cognitive demands increased, the ability of individuals with DS to perform spatial and temporal gait movements would become more variable and less efficient than that observed in their non-disabled peers. It is also expected that the degree of cognition involved in the task would affect performance. It is essential to emphasize that our main focus in this investigation (as well as in our prior research) is not on biomechanics of gait per se, but rather on the ability or inability to control the movement pattern. Hence, gait parameters provide us with the vehicle to monitor variations in movement.

3. Methods

3.1. Participants

Twelve individuals (18–28 yrs) with DS and 12 individuals without disabilities (IWD) were matched according to age, gender, and activity participation. Participants were recruited through community agencies (i.e., Special Olympics), local public schools, and community recreation centers. Because we were interested in a consistent movement pattern we selected individuals who were able to walk 20 ft, and demonstrated similar movement of left and right legs. Hence we verified that all participants were able to complete a basic motor program of walking 20 ft. Control group participants were volunteers who were contacted through email, phone or advertisements posted at the University of Georgia and community organizations. Specific testing protocol was approved by the IRB at the university, while parents and guardians of individuals reviewed a description of the testing protocol and signed informed consents prior to participation. Participant characteristics can be found in Table 1.