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Coupling between visual information and body sway in adults with Down syndrome

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A B S T R A C T

Background: Prior studies suggest that infants with Down syndrome (DS) need more experience to acquire a similar relationship between visual information and body sway than infants without DS. However, it is unclear how adults with DS deal with visual information to control posture.
Aim: To examine the coupling between visual information and body sway in adults with DS.
Methods: Twenty adults with DS (25.8 ± 4.0 years) and twenty age- and sex-matched controls (25.6 ± 4.0 years) stood upright inside a “moving room” in two experimental conditions: continuous (room oscillated continuously at 0.1, 0.2, and 0.5 Hz) and discrete (room moved forward or backward for a brief moment). Tridimensional body sway and moving room displacement data were registered.
Results: Individuals with DS coupled their body sway to the imposed visual stimulus, but showed higher position variability at frequencies other than the frequency of room movement (0.48 cm) and lower coherence (0.80) than controls (0.40 cm and 0.90, respectively).
Conclusions: Adults with DS were able to couple to the visual cue, but with differences in terms of the scaling of postural responses to spatial parameters of the visual stimulus.

What this paper adds?

This study clearly showed that individuals with DS were able to obtain visual cues from the movement of the room, and to produce correspondent body sway. However, they seem to experience problems in obtaining visual cues that would provide accurate information about body position and velocity in conditions in which the visual cues are not highlighted. When visual cues were manipulated and visual information is enhanced, for example when the room moved, individuals with Down syndrome properly coupled their body sway to this information. These findings not only contribute to understanding about the functioning of the postural control system of individuals with Down syndrome, but also draw attention attention to future strategies that could be implemented to enhance visual cues, providing more reliable information about body sway in this population.

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1. Introduction

Individuals with Down syndrome (DS) show several differences in their motor performance as compared to controls (Cabeza-Ruiz et al., 2011; Cimolin et al., 2011; Galli et al., 2008; Rigoldi, Galli, Mainardi, Crivellini, & Albertini, 2011; Spanò et al., 1999; Vieregge, Schulze-Rava, & Wessel, 1996; Webber, Virji-Babul, Edwards, & Lesperance, 2004). In general, movements of individuals with DS are slow (Almeida et al., 2000; Davis & Kelso, 1982; Shumway-Cook & Woollacott, 1985), with excessive muscle co-activation (Almeida, Corcos, & Latash, 1994; Almeida et al., 2000; Carvalho & Almeida, 2009; Latash, Kang, & Patterson, 2002), characterized by muscle weakness (Angelopoulou, Tsimaras, Christoulas, Kokaridas, & Mandroukas, 1999; Croce, Pitetti, Horvat, & Miller, 1996), and coordination problems (Ringenbach, Chua, Maraj, Kao, & Weeks, 2002; Spanò et al., 1999). Sensory deficits (Chen & Fang, 2005; Cole, Abbs, & Turner, 1988; Hodges, Cunningham, Lyons, Kerr, & Elliott, 1995; Virji-Babul & Brown, 2004), muscle hypotonia (Kokubun et al., 1997; Rigoldi et al., 2011) and atypical cerebellar volume (Aylward et al., 1997) has been suggested as the key causes for these motor differences.

Despite these well-known differences, some studies have shown that in specific conditions the motor performance of individuals with DS is similar to controls (Almeida et al., 2000; Gomes & Barela, 2007; Latash, 2000; Villarroya et al., 2012; Vuillerme, Marin, & Debú, 2001). Latash, Almeida, and Corcos (1993) Latash, (2000) have suggested that instead of problems in the motor control system, motor performance differences of individuals with DS are due to impairment in the decision making process. Likewise, our earlier results (Gomes & Barela, 2007) did not indicate any functional changes in the postural control system of adults with DS, as they were able to use the sensory information similarly tocontrols during maintenance of upright stance.

The performance of any motor task depends on the capacity of the motor control system to integrate and "weight" accurately sensory cues coming from multiple sources (Oie, Kiemel, & Jeka, 2002) and to use the information furnished by these cues to produce appropriate muscle activity. Moreover, acquisition and refinement of motor skills have also been suggested to occur as this intricate relationship between sensory information and motor activity is mastered (Barela, 1999; Barela, Jeka, & Clark, 1999; Barela, Jeka, & Clark, 2003). Unfortunately, very little is known regarding how individuals with DS use sensory information to modulate motor activity, and most of the available knowledge relates to infants (Butterworth & Cicchetti, 1978; Polastri & Barela, 2005) and children (Wade, Emmerick & Kernozek, 2000), and many important issues still remain unclear.

A clever strategy to examine how sensory information is related to motor activity is to manipulate cues from a sensory channel, while maintaining the cues from the other channels unaltered, and to observe changes in motor activity due to the sensory manipulation(Schöner, Dijkstra, & Jeka, 1998). A few studies have employed this strategy, using a moving room to examine how visual information is integrated into motor action in individuals with DS (Butterworth & Cicchetti, 1978; Polastri & Barela, 2005; Wade et al., 2000). Polastri and Barela (2005), for instance, observed that infants with DS need more time and experience in order to acquire a similar relationship between visual information and body sway as infants without DS. Moreover, the delay to achieve the developmental milestones exhibited by infants with DS could also be due to their need for more experience and exposition to sensory and motor experiences. However, it is unclear if adults with DS still differ in the use of visual cues to control postural sway when compared to neurologically normal adults. Therefore, the goal of this study was to examine the use of visual information to control postural sway and to examine the coupling between visual information and body sway in adults with DS.

2. Methods

2.1. Participants

Twenty adults with Down syndrome (13 males and 7 females, mean age: 25.8 ± 4.0 years) and twenty age- and sex-matched controls (mean age: 25.6 ± 4.0 years) participated in this study. Participants with DS were recruited from special schools, whereas participants in the control group were university employees and undergraduate and graduate students. Participants in the control group and parents of the participants with DS reported no known musculoskeletal injuries or neurological disorders (besides DS) that might have affected their ability to maintain the upright stance. All participants had normal or corrected-to-normal vision. Prior to the study, participants or parents, in the case of participants with DS, gave informed consent for participating in the study. The study was conducted in accordance with the Declaration of Helsinki and approved Institutional Ethical Review Board.

2.2. Procedures

Each participant came to the Movement Studies Laboratory at São Paulo State University where the experimental procedure was outlined to participants and body mass and height measures were obtained. The experimental task consisted of maintaining upright position inside a "moving room". The moving room consisted of three walls and a ceiling (2.1 m long × 2.1 m wide × 2.1 m height) mounted on four wheels that slid on rails, allowing back and forth movement of the room, independent of the floor. The walls were painted in white and black, creating a pattern of 22 cm wide vertical white and black stripes in order to increase visual contrast. A 800 lumens compact fluorescent light bulb was used to maintain consistent light conditions throughout the data collection process. The room movement was produced by a servo-mechanism system con-