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Assessment of upper body accelerations in young adults with intellectual disabilities while walking, running, and dual-task running

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ABSTRACT

There is an increasing interest about upper body accelerations during locomotion and how they are altered by physical impairments. Recent studies have demonstrated that cognitive impairments affect gait stability in the elderly (i.e., their capacity for smoothing upper body accelerations during walking) but little attention has been paid to young adults with intellectual disabilities. The purpose of this study was to examine upright stability in young adults with intellectual disabilities during walking, running, and dual-task running (playing soccer). To this aim a wearable trunk-mounted device that permits on-field assessment was used to quantify trunk acceleration of 18 male teenagers with intellectual disabilities (IDG) and 7 mental-age-matched healthy children (HCG) who participated in the same soccer program. We did not find any significant difference during walking in terms of speed, whereas speed differences were found during running ($p = .001$). Upper body accelerations were altered in a pathology-specific manner during the dual task: the performance of subjects with autistic disorders was compromised while running and controlling the ball with the feet. Differences in upright locomotor patterns between IDG and HCG emerged during more demanding motor

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tasks in terms of a loss in the capacity of smoothing accelerations at the trunk level.

1. Introduction

Gait stability is defined as the ability to minimize upper body accelerations during locomotion and smooth the oscillations due to lower limb movements (Cappozzo, 1982; Iosa, Marro, Paolucci, & Morelli, 2012). Physical and neurological impairments can affect gait and decrease gait stability (Iosa et al., 2010; Iosa, Fusco, Morone, Pratesi, et al., 2012; Mizuike, Ohgi, & Morita, 2009). Further, changes in cognitive function, such as dementia, can increase the variability in gait and reduce the stability of upright locomotion (Ijmker & Lamoth, 2012; Lamoth et al., 2011).

In children with Down syndrome, laterolateral constraints at the level of the center of mass have been observed during their development of gait (Kubo & Ulrich, 2006). From childhood to adolescence, these subjects undergo fewer changes than age-matched healthy subjects, establishing compensatory strategies that are geared more toward managing stability than decreasing energy cost (Rigoldi, Galli, & Albertini, 2011).

Autistic children have greater postural instability during their first steps compared with healthy toddlers (Esposito, Venuti, Apicella, & Muratori, 2011). However, movement planning in them appears to depend on the requirement of a goal-directed action (Vernazza-Martin et al., 2005). In general, locomotor stability is attenuated in persons with cognitive disorders when they perform another task while walking (dual task) (Ijmker & Lamoth, 2012; Lamoth et al., 2011). In spite of these findings, many aspects of upright locomotor stability have been poorly examined in adolescents with intellectual disabilities, particularly upper body accelerations during walking and more demanding locomotor actions.

There is a growing body of literature on upright gait stability in healthy subjects and patients with neuromotor impairments, as measured using accelerometers during walking (Kavanagh, Barrett, & Morrison, 2004; Kavanagh & Menz, 2008), running (Bergamini et al., 2012; Böhm & Döderlein, 2012; Iosa, Morelli, Marro, Paolucci, & Fusco, 2013), and other types of locomotion (Masci, Vannozzi, Getchell, & Cappozzo, 2012). Most of these studies have implemented a wearable device that contains a triaxial accelerometer that lies close to the center of mass (i.e., in the lower region of the back trunk) and extracts parameters that are related to gait stability. The most common parameter is the root mean square (RMS) of accelerations along the 3 body axes. RMS acceleration was suggested by Moe-Nilssen as a measure of the dispersion of acceleration to quantify impairments in balance (Moe-Nilssen, 1998a, 1998b). When an object is linearly moved at a constant speed its acceleration is equal to zero, but when a man walk at a constant speed, the accelerations of his trunk are only hypothetically equal to zero. So gait instability can be defined as the amount by which accelerations are far from zero, and the RMS of accelerations is a suitable measure of dispersion of acceleration relative to zero (Menz, 2002). However, because of the kinematic link between acceleration and velocity, an increase in upper body acceleration could be attributed to an unsteady speed related to pathological instabilities as well as to an increase in walking speed. So, acceleration RMS values need to be normalized by speed to suitably assess only the upper body dynamic instabilities imputable to an impaired control of stability (Iosa, Fusco, Morone, Pratesi, et al., 2012). Recent studies (Iosa, Fusco, Morone, Pratesi, et al., 2012; Senden, Savelberg, Grimm, Heyligers, & Meijer, 2012) have supported the use of RMS acceleration to quantify instabilities of the trunk during locomotion and have correlated this value and clinical scores that are related to balance. As reported in a review of Kavanagh and Menz (2008), the lower section of the trunk is the most common location for a single accelerometer that assesses gait stability (i.e., in proximity to the center of mass).

Moreover, measuring accelerations is important, because the maintenance of upright posture, typical of humans while walking, is effected by processing signals from the vestibular system, which