Human Movement Science 41 (2015) 20–31

Contents lists available at ScienceDirect

Human Movement Science

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

Postural control during gait initiation and termination of adults with incomplete spinal cord injury ☆

Jean-François Lemay *, Cyril Duclos, Sylvie Nadeau, Dany H. Gagnon

School of Rehabilitation, Université de Montréal, Montreal, Canada[1]
Pathokinesiology Laboratory, Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal — Institut de réadaptation Gingras-Lindsay-de-Montréal, Montreal, Canada[2]

A R T I C L E I N F O

PsycINFO classification:
3297

Keywords:
Gait initiation
Gait termination
Biomechanics
Balance
Spinal cord injuries

A B S T R A C T

Gait initiation and termination are potentially challenging tasks for balance due to the transition from a quasi-static bipedal phase to a dynamic single-support phase. The purpose of this study was to compare the bipedal and single-support phases of gait initiation and termination in individuals with incomplete spinal cord injury (ISCI). Twelve individuals with ISCI were evaluated on the dynamic and postural components of balance using the stabilizing and destabilizing forces during gait initiation, termination and natural gait. Phase comparisons were made using non parametric tests. Visual inspection of the force profile of the factors explaining the forces was also conducted. Gait termination challenged more the postural control during the single-support phase than the bipedal phase for the dynamic component of the stabilizing/destabilizing forces model ($p = .002$). For gait initiation, the most challenging phase varied with the components analyzed (single-support phase for the dynamic component, bipedal phase for the postural component) ($p \leqslant .008$). The single support phase is more challenged

☆ Jean-François Lemay is supported by a doctoral scholarship from the Fonds de la recherche du Québec-Santé (FRQS). Dany H. Gagnon holds a Junior 1 Award from the FRQS. Cyril Duclos, Sylvie Nadeau and Dany H. Gagnon are members of the Quebec-Ontario Spinal Cord Injury Research Group and the Multidisciplinary SensoriMotor Rehabilitation Research Team. The equipment and material required to complete this project at the Pathokinesiology Laboratory was financed in part by the Canada Foundation for Innovation. This project was funded in part by a research grant from the Craig H. Neilson Foundation.
* Corresponding author at: Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal – Institut de réadaptation Gingras-Lindsay-de-Montréal, Pathokinesiology Laboratory, 6300 avenue Darlington, Montreal, QC H3S 2J4, Canada.

E-mail address: jf.lemay@umontreal.ca (J.-F. Lemay).

[1] www.readap.umontreal.ca.

[2] www.pathokin.ca.

http://dx.doi.org/10.1016/j.humov.2015.02.003

during gait termination (both components) ($p \leqslant .015$) while the bipedal phase is more challenged during gait initiation (dynamic components) ($p = .012$). The stabilizing force and the speed of the center of mass on the one hand, and destabilizing force and the distance between the center of pressure and the base of support on the other hand, had a similar profile. The single-support phase of gait termination was the most challenging among all phases evaluated, being as challenging as the single-support phase of level natural gait. This phase should be targeted in rehabilitation in order to improve balance and decrease the risk of falling in this population.

1. Introduction

Standing postural control is impaired following a traumatic spinal cord injury (SCI). Although over 80% of individuals with an incomplete SCI (ISCI), commonly classified as an AIS D level (American Spinal Cord Injury Impairment Scale), will eventually recover a functional walking status (Scivoletto & Di Donna, 2009), the residual sensorimotor deficits will affect their ability to stand safely (Barbeau, Ladouceur, Norman, Pepin, & Leroux, 1999). This is demonstrated by the high incidence of falling occurring in this population, varying from 39% (over a 6 months period) to 75% (over a year period) according to studies (Amatachaya, Wannapakhe, Arrayawichanon, Siritarathiwat, & Wattanapun, 2011; Brotherton, Krause, & Nietert, 2007; Phonthee, Saengsuwan, Siritaratiwat, & Amatachaya, 2013). As a result, numerous fall-related impairments and disabilities such as physical injuries and an impeded social participation are reported (Amatachaya et al., 2011; Brotherton et al., 2007; Phonthee et al., 2013). Describing standing postural control in this population is therefore needed to develop treatment strategies aimed at reducing the risk of falling.

This lack of postural control may be related to the difficulty in controlling the center of pressure (COP) during quasi-static and dynamic standing activities. The COP, representing the point application of the ground reaction force vector, is used to quantify quasi-static postural control in standing since it regulates the position of the center of mass (COM) over the base of support (BOS) (Prieto, Myklebust, Hoffmann, Lovett, & Myklebust, 1996; Winter, 1995). Compared to able-bodied individuals, individuals with SCI have an increased mean velocity, sway area and root mean square distance of the COP during quasi-static standing (Lemay et al., 2013), an increase in postural sway as measured by the stability index and Fourier index of the Tetrax® (Lee et al., 2012), and a lack of precision of COP movement when reaching maximally in specific directions (Lemay, Gagnon, et al., 2014). During gait, an increased variability of the margin of stability, a measure of postural control based on the distance between the COP and the extrapolated COM, is observed (Day, Kautz, Wu, Suter, & Behrman, 2012) as well as an increased distance between the COP and the BOS and a reduced COM speed during the single-support phase of gait (Lemay, Duclos, Nadeau, Gagnon, & Desrosiers, 2014). Postural control deficits are thus present in quasi-static as well as in dynamic tasks in this population.

Gait initiation (GI) and gait termination (GT) also challenge COP and COM control (Chang & Krebs, 1999; Sparrow & Tirosh, 2005). Indeed, a fine control of the COM by the COP is needed during the transition between the relatively stable quasi-static bipedal phase and the more challenging and dynamic single-support phase that are present in both tasks (Chang & Krebs, 1999; Halliday, Winter, Frank, Patla, & Prince, 1998; Jian, Winter, Ishac, & Gilchrist, 1993; van Keeken, Vrieling, Hof, Postema, & Otten, 2013; Viton et al., 2000). Since their controls depend on the integrity of sensorimotor functions of the lower extremity and trunk (Mickelborough, van der Linden, Tallis, & Ennos, 2004; Remelius et al., 2008; Sparrow & Tirosh, 2005), impairments in GI and GT are expected following a SCI although it has never been reported to this day.