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KINEMATICAL ASPECTS OF FOOT MOVEMENTS DURING GAIT IN EARLY MULTIPLE SCLEROSIS PATIENTS

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Renewed interest in gait and balance in Multiple Sclerosis emerges, as the 1st International Symposium on Gait and Balance in Multiple Sclerosis testifies (International Journal of MS Care, 2011). However, little attention is given to the swing phase of gait in early Multiple Sclerosis patients. As stated by Bethoux & Bennett (2011) "…space and time requirements, complexity of data analysis, and prohibitive cost of the equipment and its operation, combined with a comparatively low reimbursement rate, confines the clinical use of … gait analysis systems…". These authors suggest using e.g. the GAITrite system to capture gait characteristics. By this system, Yentes and co-workers quantified the medio-lateral sway of the foot as a parameter for Multiple Sclerosis progression (Yentes et al., 2012).

Remarkably, various early diagnosed Multiple Sclerosis patients produce audible shuffling sounds, caused by the lateral soles of their shod feet over the ground, during the terminal-swing phase of gait (van Zwieten et al., 2013). It is worthwhile to have a closer look at this almost pathognomonic phenomenon. The common cause seems to be foot-drop including foot-inversion. Foot-inversion is defined as turning the sole of the foot inward; while foot-eversion is turning the sole outward (van Zwieten et al., 2007). In early Multiple Sclerosis, the background of this lateral foot-shuffling seems evident, namely weakness of foot dorsiflexor muscles plus weakness of foot evertor muscles. In early Multiple Sclerosis, however, both muscle-groups may be supported or strengthened – not only by resistance training (Yahia et al., 2011), but also by e.g. Two Degree-of-freedom Ankle-Foot Orthoses (Agrawal et al., 2005) or

Functional Electrical Stimulation Devices (Mount and Dacko, 2006; Esnouf et al., 2010).
Some other aspects must be kept in mind. During the swing phase "...when the foot is in the air and not restricted by ground contact, ...motions are eversion (foot rolls inward while lateral side of foot comes up), dorsiflexion (foot/toes move up), and abduction (foot turns out to the side)" (Dierks, 2011). Recent quantitative data on exercise therapies of ankle weakness patients clearly show that normal foot eversion goes together with simultaneous shank internal rotation (Drewes et al., 2009; Hoch, 2011). This obvious "mechanical coupling" relationship, well-known from the closed kinematic chain concept, thus also holds true for the open kinematic chain, that is: during the swing phase of gait. Its background is the "cardan-like" construction of the human ankle joint (Maestro, 2004; Sheehan Gavelli, 2012).

From a functional-anatomical point of view, normal internal shank rotation during knee flexion is effectuated by the medial hamstring muscles (Lynn and Costigan, 2009). Most authors therefore agree on training Multiple Sclerosis patients´ hamstrings (Feys and Van Asch, 2008). Strength training of hamstring muscles appears to have positive effects on muscular function and gait speed in Multiple Sclerosis patients (Mevellec et al., 2003).
Finally, we presume that the abnormal lateral foot shuffling in swing may easily lead to the much-dreaded tripping, stumbling and falling with their far-reaching consequences. This should be avoided as much as possible.

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Abstract
Multiple Sclerosis patients sometimes experience their forward swinging feet to catch the floor unintentionally. Minimally impaired Multiple Sclerosis patients, during terminal-swing phases of gait, may even produce shuffling sounds, by the lateral soles of their feet over the ground. To prevent tripping, such patients should train their medial hamstring muscles.