

Research Project

Stop tip-toeing around toe-walking: towards a better understanding and more effective treatment of toe-walkers with cerebral palsy

Third-party funded project

Project title Stop tip-toeing around toe-walking: towards a better understanding and more effective treatment of toe-walkers with cerebral palsy

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Background and Rationale: Walking is the most common and necessary form of movement for humans, as it ensures active participation in activities of daily life. In the initial stages of learning to walk, gait is rather unstable as well as variable. During this initial phase, children need to successfully perform the entire gait cycle that involves touch-down (characteristic heel-strike where the ankle is flexed), lift-off and swing phases. The characteristic heel-strike is critical to walking both effectively (stable) and efficiently (energy). Children that suffer from neuro-developmental disorders (e.g. cerebral palsy, CP) are often not able to heel-strike, they tend to keep walking with a forefoot or flatfoot pattern (i.e. toe-walking). Children that toe-walk often show poorer levels of static and dynamic stability, leading to a lower quality of life compared to typically developing children (TD). Current research suggests multifactorial adaptations in central and/or peripheral nervous as well as the musculoskeletal system contribute to and result from toe-walking. Current treatment mainly focuses on physically restoring the capability to heel-strike, however, adherence to walking with heel-strike is poor. From clinical experience, we hypothesize psychological factors (primarily fear-of-falling) as well as inadequate reflex control might contribute to toe-walking behavior. Currently, the interplay between the nervous-, musculoskeletal-, and psychological systems and their impact on resulting walking patterns are poorly understood. In order to sustain effective gait by means of effective interventions, it is therefore critical to understand the interplay among the mechanisms that underpin toe-walking adaptation.

Overall Objectives & Specific Aims: The purpose of this study is to explore the interplay among nervous-, musculoskeletal-, and psychological systems and how they impact toe-walking behavior, and vice versa. Here, we will determine the effect of psychological factors (via the use of a custom-designed virtual reality environment) on static vs. dynamic stability, motor control and coordination (indirect assessment of central nervous system function), as well as reflex control (Hoffmann-reflex, H-reflex, performance of peripheral nervous system). In addition, we will also investigate the effect of restoring heel striking in toe-walkers based on the indices as mentioned above.

Expected Results: It is expected that toe-walkers will show poorer stability during standing and walking, have a reduced H-reflex amplitude, reduced number of muscle synergies as well as increased fear-of-falling compared to TD. With the use of a custom-made virtual reality (VR) environment, the fear-of-falling in children will be increased. VR induced fear-of-falling will lead to poorer stability during standing and

walking tasks in TD; in toe-walkers such reactions are present already without VR but worsen during VR conditions. By restoring (via the use of orthoses) heel-strike in toe-walkers stability during standing and walking tasks will be improved, number of muscle synergies will be increased, fear-of-falling will be reduced, and performance on VR induced fear-of-falling will be improved.

Impact: Although development of heel-strike behavior takes place early in life, not all children demonstrate this feature during walking in daily life. Lack of heel-strike behavior is less efficient and leads to poorer quality of life. Management strategies to restore this critical feature of walking, have failed primarily due to the fact that although the capability might be restored, the adherence to walking with heel-strike is poor. By focusing on understanding the interplay between nervous-, musculoskeletal-, and psychological factors that might predispose individuals to toe-walking, we will provide solutions to design effective treatment strategies in the future.

Keywords Gait analysis, toe-walking, virtual reality, cerebral palsy

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