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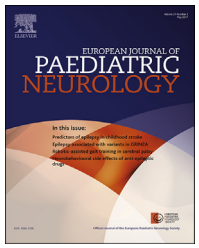

Original article

Robotic-assisted gait training improves walking abilities in diplegic children with cerebral palsy

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ABSTRACT

The robotic-assisted gait training therapy (RAGT), based on intensity and repetition of movement, presents beneficial effects on recovery and improvement of postural and locomotor functions of the patient. This study sought to highlight the effect of this RAGT on the dynamic equilibrium control during walking in children with Cerebral Palsy (CP) by analyzing the different postural strategies of the fullbody (upper/lower body) before and after this RAGT in order to generate forward motion while maintaining balance. Data were collected by a motion analysis system (Vicon® – Oxford Metrics). Thirty children with bilateral spastic CP were evaluated using a full-body marker set which allows assessing both the lower and upper limb kinematics. The children were divided into two groups in such a way as to obtain a randomized controlled population: i) a group of fourteen children (Treated Group) underwent 20 sessions of RAGT using the driven gait orthosis Lokomat®Pediatric (Hocoma) compared to ii) a group of sixteen children without sessions of Lokomat®Pediatric (Control Group) receiving only daily physiotherapy. Significant improvements are observed between the TG pre- and post-test values of i) the kinematic data of the full-body in the sagittal and frontal planes and ii) the Gross Motor Function Measure test (D and E). This study shows the usefulness of this RAGT mainly in the balance control in gait. Indeed, the Treated Group use new dynamic strategies of gait that are especially characterized by a more appropriate control of the upper body associated with an improvement of the lower limbs kinematics.

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1. Introduction

Cerebral palsy (CP) represents a group of non-progressive disorders due to lesions or abnormalities of the brain in the developing fetus or infant.[1] Children with cerebral palsy (CP) often have atypical body posture patterns and abnormal gait patterns resulting from functional strategies to compensate for primary anomalies that are directly attributable to damage to the central nervous system. These anomalies can lead in the longer term to adaptations in the motor control in these children.[2–4] The majority of these children have gait impairments. However, most clinical studies using quantitative gait analysis generally focus on lower limb strategy and tend to ignore upper body strategy (head and trunk movement, arm swing) which are greatly involved in maintaining dynamic balance during gait. To our knowledge, only few studies[5–11] have shown that CP gait is characterized by strong postural instability and stiffness of the whole body, particularly of its upper part with bloc patterns translating a decrease of rotation of trunk and head in relation to the pelvis. This stiffness of the upper body, and primarily the trunk, allows the child to control and to decrease the effect of lower limb movements on the head and therefore to stabilize the head during walking. This stabilization plays a very important role in the dynamic characteristics of walking.[12,13] The literature on full-body movement during gait in children with CP is more scarce, even nonexistent for comparative analysis before/after a robotic-assisted gait training therapy (RAGT) such as with the Lokomat® (Hocoma AG, Volketswil, Switzerland) which is increasingly introduced in pediatric rehabilitation (cf. Fig. 1). This therapy is used in the treatment of children with CP in an attempt to improve standing and walking abilities. Based on the body weight supported treadmill training principle, its main purpose is to re-acquire functional gait through an intensive and repetitive gait pattern simulation for the lower limbs and a sensory stimulation through visual and auditive feedbacks of different serious games (task-oriented training).[3,14–18]

Few studies[19–26] have demonstrated positive results from the RAGT on the locomotor parameter values (mainly speed gait, frequency and stride length), on the gait endurance (6 min walking test) and on the performance of functional tasks (dimensions D and E of the Gross Motor Function Measure – GMFM). To the best of our knowledge, only one study[27] concludes that spatio-temporal parameters and kinematics, gait symmetry, Gait Gillette Index and COP data do not show statistically significant variations due to the robotic treatment. The authors precise that the lack of statistically significant improvement in clinical evaluation is probably due to the high number of children classified with Gross Motor Function Classification System (GMFCS) level III and IV (children are classified as moderately severe to severe, they use methods of mobility that require technical walking aids such as the walker, the manual wheelchair or motorized wheelchair). Another study[28] also found non-significant results (spatio-temporal and kinematics parameters) except for the range of pelvic motion in the frontal plane on the right side in the study group.

However, all these studies[19–28] do not address the possible effect of RAGT on total-body kinematic gait parameters for these children and more particularly on the dynamic

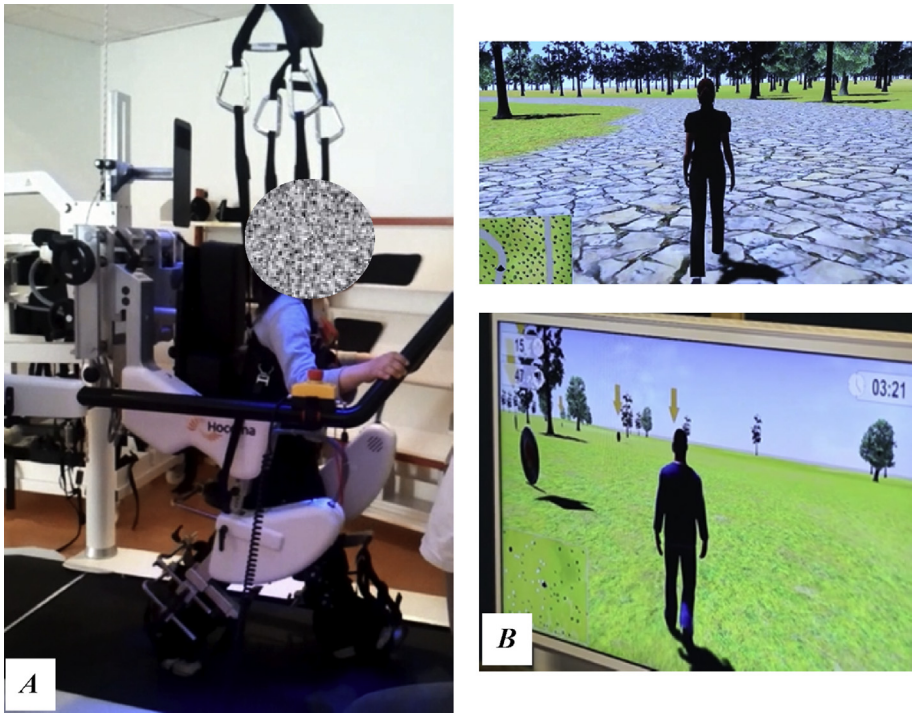

Fig. 1 – A: view of Lokomat®Pediatric; B: view of the visual interface during a session of robotic-assisted therapy. The Lokomat®Pediatric consists of a treadmill, a dynamic unloading system to relieve body weight, and two lightweight robotic actuators (exoskeleton), which are attached to the subject's legs.