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ORIGINAL ARTICLE/ARTICLE ORIGINAL

Effects of robotic gait rehabilitation on biomechanical parameters in the chronic hemiplegic patients

Effets de la rééducation robotisée à la marche sur les paramètres biomécaniques de la marche chez des patients hémiplégiques chroniques

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Summary Hemiplegia is a more or less complete loss of hemibody voluntary motricity following a brain injury, usually resulting in alterations of the locomotor system with persistent disorders of movement and posture. We were interested in studying the gait pattern called ''stiff knee gait'' with the main objective to highlight the role of a robotic rehabilitation in improving or modifying/changing the walking pattern in adults with chronic hemiplegic disorders. Data were collected by a motion analysis system (Vicon® — Oxford Metrics, Oxford, UK) in order to achieve a Clinical Gait Analysis before and after a robotic gait rehabilitation (Lokomat®). Four intensive sessions per weeks during five weeks were performed by ten chronic hemiplegic adults. The results show a significant improvement in locomotor parameters (walking speed, step length, single and double support time) and in the knee kinematics. This first study provides experimental evidence of the importance and usefulness of the robotic rehabilitation as an aid in the rehabilitation of gait pattern in adults with chronic hemiplegia.

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MOTS CLÉS
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Orthèse de marche ;
Cinématique du genou ;
Paramètres locomoteurs

Résumé L'hémiplégie est une perte plus ou moins complète de la motricité volontaire d'un hémicorps suite à une lésion cérébrale, entraînant généralement des altérations de l'appareil locomoteur avec des troubles persistants du mouvement et de la posture. Nous nous sommes intéressés, pour cette étude, au schéma de marche dit « stiff knee gait » avec pour objectif principal de mettre en évidence le rôle d'une rééducation robotisée dans l'amélioration ou la modification du schéma de marche chez des adultes hémiplégiques chroniques. Les données ont été recueillies par un système d'analyse du mouvement (Vicon® — Oxford Metrics, Oxford, UK) afin de réaliser une analyse quantifiée de la marche avant et après une rééducation robotisée (Lokomat®) intensive de 4 séances par semaine pendant 5 semaines sur 10 adultes hémiplégiques chroniques. Les résultats montrent une amélioration significative des paramètres locomoteurs (vitesse de marche, longueur du pas, temps du double et du simple appui) et de la cinématique du genou. Cette première étude montre bien l'importance et l'utilité de la rééducation robotisée comme aide à la rééducation du schéma de marche chez des adultes hémiplégiques chroniques.

Introduction

The recovery of locomotor capacities is one of the primary objectives in the rehabilitation of patients with locomotor disorders. Therapeutic interventions for such conditions seek to minimise the consequences of a lesion in general [9], and provide compensatory strategies so as to improve a patient's functional independence (mobility, self-care, social integration).

In recent years, robotically driven orthoses, such as the Lokomat® (Hocoma AG, Volketswil, Switzerland), have emerged as a promising new technology in the rehabilitation of patient mobility. Purposely built to support sensorimotor learning, these systems of rehabilitation assisted by robotics are increasingly proposed to patients with locomotor disorders following cortical or sub-cortical lesions. Based on the body weight supported treadmill training (BWSTT) principle, their main purpose consists of reacquiring functional gait through intensive and repetitive simulation of the different phases of gait, and sensory stimulation feeding proprioceptive feedback [2,5]. This sensorimotor information facilitates cortical and subcortical reorganization in patients with spinal cord or brain lesions. By intensively repeating the same movement, the circuits involved in the performance of locomotor movements will be activated, allowing the nervous system to establish and/or re-establish links between the motor centers and sensory pathways, which may be affected in varying degrees depending on the lesion. Indeed, numerous studies have indicated that task-specific mass is often the fastest and most reliable method for improving patient locomotor function [6,7,10,11,13].

Research conducted with hemiplegic populations [1,4,5,12,14] has demonstrated that automated gait retraining systems have a positive global effect upon walking speed and endurance (in terms of both distance and time) as well as improving stride length, frequency and symmetry. Patients have also been observed to improve muscle power and balance in addition to reduced heart rate and oxygen consumption. The use of an automated gait retraining device as part of an individually adapted rehabilitation program may thus enhance treatment programs, assisting the recovery of functional mobility. Used in combination with traditional rehabilitation approaches, robotically driven gait orthoses may extend the intensity of therapy and improve the long-term effects of rehabilitation. Such tools should not be considered as a replacement for existing methods of rehabilitation. Robotic gait devices must only be used an adjunct to existing therapeutic techniques.

The principal objective of the current study was to demonstrate how automated gait retraining changes biomechanical parameters through the course of locomotor rehabilitation in adult patients with chronic hemiplegia. Hemiplegia is a more or less complete loss of voluntary motor function in one body half following a brain injury, usually resulting in alterations of the locomotor system with persistent disorders of movement and posture. The focus here is placed upon patients with stiff knee gait, a condition where swing-phase knee flexion is considerably diminished. Patient gait patterns were often characterized by hyperflexion during the swing phase in a measure serving to facilitate foot clearance.

The expected results were that the stroke patients would present a different organization from a mechanical point of view after rehabilitation, mainly on locomotor parameters such as the kinematics of the knee.

Methods

Participants

Gait analysis data were obtained from 10 chronic right hemiplegic patients (ischemic stroke; 12 years $\pm$ 2.1 after stroke) aged 64 years $\pm$ 1.2 with a stiff knee gait. Each participant needed to be able to walk at least 60 meters to be included in the study. In order to see the actual effects of this rehabilitation, no subjects were receiving daily physiotherapy interventions and none had undergone surgical treatment or received recent botulinum toxin injections at the time of assessment.