

USING A ROBOT-ASSISTED GAIT ORTHOSIS TO ASSESS LOWER LIMB PERFORMANCE IN NEUROREHABILITATION

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ABSTRACT

Robot-assisted gait devices provide intensive, repeated practice of task-specific movements. New developments of rehabilitation robots, as well as advances in technology, allow new forms to control and assess the performance of the lower limb during gait training. The Lokomat (Hocoma AG, Volketswil, Switzerland), an actuated exoskeleton over a treadmill with a body weight support system, controls leg movement towards a predefined trajectory of a physiological gait pattern by actuating hip and knee torques. Here, we investigated the combined effects of different Lokomat settings (guidance force, bodyweight support and treadmill speed) on the torque and kinematic profiles provided by the robotic device in neurologically intact adults (n=19). The results show that the outcome measures, namely hip/knee torques and deviation of the cyclogram from the desired trajectory, are significantly influenced by the settings. These intrinsic kinematic and torque measures during assisted treadmill walking provide real-time movement feedback about the participant's performance. Furthermore, in research and clinical applications, this monitoring can help to adapt and improve a therapy strategy and documents the rehabilitation progress.

Keywords: robot-assisted walking, Lokomat, kinematic assessment, guidance force, impedance control.

INTRODUCTION

Robot-assisted gait devices provide intensive, repeated practice of task-specific movements that have been shown to improve walking in patients with neurological disorders [1]–[4]. The main purpose of robotic rehabilitation devices is not only to achieve a more intense gait training [5] but also to allow an objective measure of patient performance compared to manually assisted treadmill gait training [4].
One such device is the Lokomat (Hocoma AG, Volketswil, Switzerland) which consists of an exoskeleton with integrated computer-controlled linear actuators at each hip and knee joint, a body weight support system, and a treadmill (Fig. 1, A). This rehabilitation device controls leg movement towards a predefined trajectory of a physiological gait pattern by controlling the hip and knee joint torques of the exoskeleton [6]. A cascaded control system (Fig. 1, B) integrates a first-order impedance controller (proportional- derivative, PD) for angle deviations and second-order proportional (P) torque controller. The control coefficients can be directly modified by the guidance force (GF) setting which is a crucial parameter of Lokomat settings. GF changes the stiffness of the controllers and allows more or less deviation from the desired leg trajectory. Treadmill speed (SP) and body weight support (BWS) may also influence sensory feedback and the intensity of the training, which may affect the ability of a participant to comply.

Here, we investigated the combined effects of Lokomat settings (GF, SP, BWS) on the robotic-assistance torque profiles and the deviation between the desired and actual trajectory in an able-bodied study group. The study presents how different Lokomat configurations alter the gait kinematics and robotic torques in order to establish baseline patterns against which subjects with neurological disorders can be compared.