Isokinematic leg extension training with an industrial robot

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Abstract

Resistance training of the leg extensor muscles is an important intervention in rehabilitation and prevention of musculoskeletal disorders such as hip or knee arthrosis and osteoporosis. With current training equipment, neither the exercise trajectory can be optimized nor the loadings on structures of the musculoskeletal system can be controlled. To overcome these limitations an experimental research platform for the development of new training scenarios is developed using an industrial robot for maximum flexibility together with kinetic and kinematic data and musculoskeletal models for estimating loadings on target structures. The focus of this paper lies on the implementation of isokinematic exercise, i.e. leg extension and flexion with constant velocity. A force triggered trajectory with smooth transitions between two points needs to be planned for the robot. An algorithm which uses continuous polynomials is proposed. It consists of three parts. First, the trajectory is planned in Cartesian space by intuitive definitions of e.g. start and end point or desired velocity and minimum resistive force. The trajectory can be visualized and optimized using OpenSim together with a model of the research platform, which makes the system usable for non experts in the field of robotics. Second, a smooth trajectory in joint space is generated from the planning points, using a third order polynomial for joint velocities between two adjacent points. Third, the trajectory is adapted to the measured force at the end effector, as the robot should only move along the trajectory, if the applied force by the user is high enough. The proposed algorithm is furthermore easily expandable to arbitrary force triggered motions with definable position and velocity profiles.