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PLANTAR PRESSURE BASED ESTIMATES OF FOOT KINEMATICS DURING GAIT – A LEAST SQUARES OPTIMIZATION APPROACH

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Summary: Despite the availability of marker-based 3D motion capture systems that allow accurate description of foot kinematics and kinetics, ankle-foot specialists tend to rely mainly on plantar pressure data to evaluate foot pathologies and to describe treatment strategies. The use of pressure systems is also related to the high economical cost and long preparation times of marker-based technologies. We hypothesized that it is possible to enhance the potential of plantar pressure evaluation to compute ankle-foot kinematics, requiring less preparation time favoring its use in clinical practice. We developed a model-based algorithm to estimate ankle-foot kinematics based on plantar pressure data and the trajectories of a limited amount of markers. The marker set consisted of a cluster of three shank markers and either (A) two markers, one positioned at the upper posterior part of the calcaneus and one at the first phalanx or (B) one marker, positioned at the head of the second metatarsal. The algorithm is based on a least squares optimization approach that minimizes the weighted difference between simulated and measured plantar pressure and marker data. Marker positions and plantar pressures are simulated in OpenSim using a musculoskeletal shank and foot model with six bodies and fourteen degrees of freedom coupled with an elastic foundation contact model. Plantar pressure based estimates of foot kinematics were evaluated by comparison to kinematics estimated using an extended marker set with fourteen markers on the foot and six markers on the shank. The average root mean square difference was 3.86° for marker set B and 3.16° for marker set A. The maximum root mean square difference was 14.34° for the forefoot-toes plantarflexion/dorsiflexion using marker set B and 6.98° for calcaneus-midfoot eversion/inversion using marker set A. Within this work we showed the feasibility to quantify ankle-foot kinematics based on plantar pressure measurements, thereby increasing its potential to assess pathologies and evaluate treatments in standard clinical practice. In the future, it should be explored if the motion capture markers can be replaced by inertial measurement units or even by skin-base markers tracked by video cameras in order to further simplify the acquisition process.