A BIOMECHANICAL MODEL-BASED SYSTEM FOR ASSISTING IN CLINICAL EXAMINATION OF PARKINSON'S DISEASE PATIENTS

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Introduction

Parkinson's disease (PD) is a neurodegenerative disease that damages the human motor system. Various disease assessment scales are used in the diagnosis and severity assessment of neurodegenerative diseases. For PD, the most widely used rating tool is Unified Parkinson's Disease Assessment Scale (UPDRS) [1], which includes various motor tasks such as gait or hand movements, which physician visually evaluate and then a score of 0 to 5 is assigned based on the guidelines. However, specific aspects of movements are evaluated mainly qualitatively and subjectively [2-3]. Technological innovations make it possible to integrate wireless sensors into health monitoring systems and obtain not only qualitative, but also quantitative information on the movements performed by subjects with PD [4]. Kinematic data of movement alone provide only limited information about the performance of the movement but can be used as inputs of numerical musculoskeletal models. Modelling of the musculoskeletal system is a digital technology that is used to study muscle forces, tendon system forces and joint surface contact forces during movement that cannot be measured directly [5-7]. The main goal of this study is to present an application example of the biomechanical model-based system to assist in clinical examination of patients with PD. The current abstract presents an example of application to examine the gait of PD during clinical screening according to UPDRS Part III. The concept of the system is provided in Figure 1.

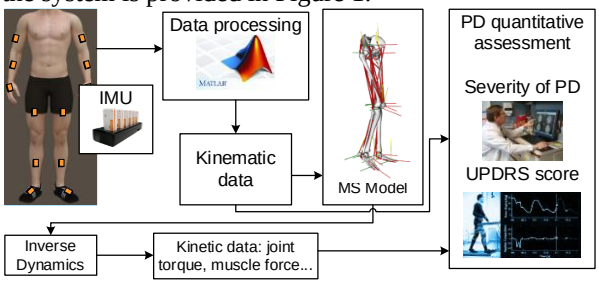

Figure 1: A biomechanical model-based system to assist in clinical examination.

Methods

Kinematic data of the gait of the patient with PD were collected using 6 IMU sensors (Shimmer Sensing, Ireland), which were attached to the thigh, shank, and foot of both legs. Two groups of PD patients participated in the study: 15 PD subjects (mean age 61.1±11.2) and 12 healthy subjects (mean age 57.8±7.58) who were control subjects. The PD group was also divided according to the UPDRS score: UPDRS 0 (n = 7) and UPDRS 1 (n = 8), where 0 and 1 represent severity (1 being more severe than 0). Subjects performed movements with upper extremity and walking task of 5 meters. The study was approved by the local bioethics committee. IMU data (linear acceleration, angular velocity, and magnetic heading in 3D) was sampled at 51.2 Hz, stored onto PC, and processed via MATLAB. 10 degrees of freedom musculoskeletal model (MS model) of lower extremities with 18 Thelen muscle models [7] was developed in OpenSim. Inverse dynamic analysis was performed, and various kinetic parameters were calculated (joint torque, muscle forces, etc.) in each phase of the gait cycle. Statistical significance was evaluated using ANOVA.

Results

The torque values of the PD group during different gait cycles are higher than those of the CO group. Figure 2 shows joint torque of the knee joint during a gait cycle.

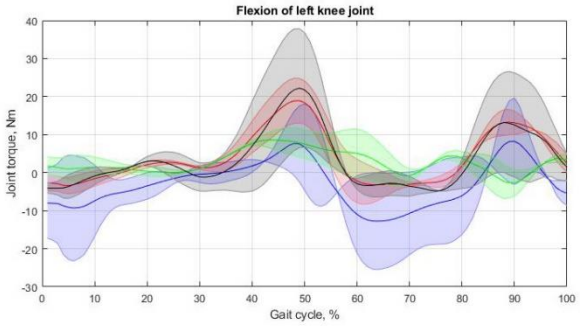

Figure 2: Knee joint torque: blue – CO, red – PD, green – UPDRS0, black – UPDRS1, shaded areas represent standard deviation.

Statistically significant differences were estimated between CO and PD groups in left knee flexion during early amortization (from 0 to 10%) phase of gait cycle.

Conclusions

Developed system can collect and evaluate data from the movements of the upper and lower extremities utilizing more accessible IMU sensors. Joint torque as kinetic parameter allows quantitative assessment during clinical examination of PD.

References

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