Investigating the accuracy of simulated knee joint contact forces using the Rajagopal Opensim model versus the sensor-based in-vivo forces during walking and squatting

Oral Presentation

Pooria Asgari; Shahrzad Zandi * ; Farhad Tabatabai Ghomshe
Department of Sports medicine, Faculty of Physical Education and Sport Sciences, University of Tehran, Tehran,Iran(shzandi@ut.ac.ir)

Abstract

Introduction: Investigating the joint contact forces helps us understand the joint deformations and can be used in injury prevention, rehabilitation, manufacturing prosthesis, etc. Recently, there has been trends toward using musculoskeletal simulations to calculate these forces. The aim of this study was to investigate the accuracy of simulated knee joint contact force using the Rajagopal [1] Opensim model versus the sensor-based in-vivo forces measured by implanted knee prosthesis.

Methods: Six subjects with instrumented knee prosthesis (68±8years old, 88±12kg weight. 173±4cm height) participated in this study. Kinematic and kinetic data, real-time knee implant positions and the in-vivo knee contact forces were recorded using motion analysis system, force platforms, moving fluoroscopy and the instrumented prosthesis. After synchronization and scaling Rajagopal Opensim model, batch processing of workflows (inverse kinematics, inverse dynamics, static optimization and joint reaction force analysis) was performed for each task. All the processing was performed with MATLAB scripting and Opensim's Application Programming Interface (API).

Results: Statistical Parametric Mapping (SPM) showed significant difference between joint reaction forces modeled with Rajagopal model and in-vivo contact forces for both squatting and walking. RMSE was 1.48 and 3.37, and the r^2 error was 0.63 and 0.57 for walking and squatting, respectively. The differences were significant in the first 18% (Heel-contact), 45-55% (double-support), and also 85-95% of the gait cycle (terminal-swing). In squatting, the differences were significant for the 22-69% of the task.

Conclusion: Based on the findings, Rajagopal model showed low accuracy for simulating joint reaction forces during gait and squat. It had the tendency toward overestimating forces for both tasks. Simulations were more accurate for static activities such as squatting. These findings can be used for validation purposes in non-invasive knee joint reaction force studies. Our study provides a good guide for researchers to choose the appropriate model for each task

Keywords

joint contact forces; Musculoskeletal modeling; Opensim

Reference:

1. Rajagopal, A., et al., Full-body musculoskeletal model for muscle-driven simulation of human gait. IEEE transactions on biomedical engineering, 2016. 63(10): p. 2068-2079.