MODELLING THE GAIT OF HEALTHY AND POST-STROKE INDIVIDUALS

Morgana Afonso (1), Andreia Sousa (2), João Tavares (3)

1, 3. Faculdade de Engenharia, Universidade do Porto, Portugal; 2. Instituto Politécnico do Porto, Portugal

Introduction

Gait is a complex mechanism which involves the action of the musculoskeletal system, controlled by spinal and supraspinal mechanisms [1]. After Cerebrovascular Accident (CVA), or stroke, the damage of structures involved in motor control from one side of the brain, can cause activation deficits in the muscles from the contralesional (CONTRA) side of the body – hemiparesis, leading to asymmetry in the gait pattern [2]. In gait analysis, a set of experimental methods have ben used to study the gait of one subject, including based on: visual analysis, collection of kinematic parameters acquired using cameras and reflective body markers, kinetic analysis using force platforms to determine the ground reaction force (GRF) and electromyography. Due to the recent technological advances, it became possible to create and implement complex dynamical multi-segmented models of the human body with several degrees-of-freedom to perform simulations from experimental data [3]. OpenSim is an open-source software developed in Stanford University that allows the creation of models of the musculoskeletal system and the development of subject-specific simulations of several tasks [4].
The present work describes a procedure used to perform a simulation in OpenSim of a healthy and a post-stroke individual, using real experimental data. The kinematic parameters were determined as well as the activation of two calf muscles: soleus (SOL) and medial gastrocnemius (MEDGAS).

Methods

A *.c3d file containing kinematic and kinetic data from a gait trial performed with a post-stroke individual was provided by LABIOMEP in Porto-Portugal. The data was extracted, using Matlab and the functions from the Biomechanical Toolkit (BTK). The kinematic data was stored in *.trc file and the kinetic data in a*.mot file to use as input in OpenSim. The files containing data from a healthy individual were obtained from [5] and did not require previous treatment. A healthy and a post-stroke model were created in OpenSim, and the procedure depicted in Figure 1 was implemented to each.

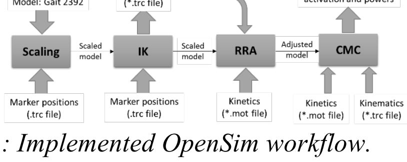

Figure 1: Implemented OpenSim workflow.

In all the steps, several iterations were made in order to minimize the errors associated and the contribution of the residual and reserve forces admitted to exist in the models to compensate their limitations.

Results

The errors associated in the processes of Scaling and IK (Table 1) in the post-stroke model were according to the values recommended in the OpenSim guide, contrarily to the ones obtained with the healthy model.

	Scaling		IK	
	PS	H	PS	H
RMS	1.49	3.02	1.19	2.25
Max error	2.05	6.14	3.98	8.56

Table 1: RMS and maximum error obtained in the process of Scaling and IK, considering the post-stroke (PS) and the healthy (H) model.

In both cases, the residual forces and moments were satisfactorily below the recommended limits in the step of RRA. Considering the healthy model, the CMC also produced acceptable values. However, peaks of residual vertical force and reserve force were found, as well as a high maximum rotational error value in the post-stroke model. The post-stroke gait pattern revealed a slight difference in the maximum angle of plantarflexion in the CONTRA side and a reduction of MEDGAS maximum activation.

Discussion

The reduced angle of plantarflexion from the CONTRA side from the post-stroke model resulted in a decrease in the activation of one plantarflexor muscle, the MEDGAS. The peaks of residual and reserve forces and maximum error obtained in the post-stroke model mean that the model was not able of fully reproduce the experimental data without the support of those additional forces, which does not really exist.
It would be recommended a future investigation using experimental data of post-stroke subjects with more pronounced asymmetry and include electromiografic-based studies in order to compare the simulated results.

References

1. M.Whittle, Butterworth-Heinemann, 2007
2. G. Chen and C. Patten, J Biomech, 41: 877-83, 2008.
3. M. G. Pandy, Annual review of biomedical engineering, 3: 245-273, 2001.
4. A. Seth, et al, Procedia IUTAM, 2: 212-232, 2011.
   C. Au, http://simtk-confluence.stanford.edu:8080/display/OpenSim/Musculoskeletal+Models, 2012

Acknowledgements

To LABIOMEP for providing the experimental data.