Simulating the effects of repeated sprints

This document and tutorial aims to assess the effects of 12 maximal repeated sprints.
The tutorial was created by Basilio Goncalves and Hans Kainz. Results from [1], [2].

I. Objectives

Background

Field and court sports typically require repeated bouts of sprinting [3][4]. Kinematic and kinetic alterations following repeated sprinting discriminate player performance level and potentially relate to risk of musculoskeletal injury [5][6]. Hip contact forces, although not a direct measure of chondrolabral stresses [7], are often used to investigate hip loading in healthy populations [8].

Purpose

The purpose of this tutorial is use OpenSim to investigate the effects of repeated sprints on muscle and joint contact forces.

II. Simulate external biomechanics

- Click the **File** menu and select **Open Model**.

- Select the ***Rajagopal_generic_increased_max_force.osim***, and click **Open**. This model has been adjusted to have maximum isometric forces 5 times greater than

- Use the **Scale Tool** to scale the model.

- Run the next steps for both trials (Run_baseline and Run_post_fatigue):
  o Inverse kinematics
  o Inverse dynamics
  o Residual reduction analysis
  o Static Optimization
  o Joint reaction analysis

Note: check the set-up files including paths and time ranges for each of the trials. Check the OpenSim documentation for guidelines about the errors.

Questions

1. What was the average running speed during baseline and post fatigue?

2. How did the ground reaction forces change from baseline to post fatigue?

3. How did the hip, knee, and ankle joint angles change from baseline to post fatigue?

4. From baseline to post fatigue, what joint moment decreased the most, hip knee, or ankle?

5. Were the residual moments post fatigue different from those at baseline?

III. Simulate muscle and joint contact forces
Although joint kinematics and joint moments allow us to

- Run the next steps for both trials (Run_baseline and Run_post_fatigue):
  - Static Optimization (use the adjusted model from the RRA tool as the input model for this step)
  - Joint reaction analysis (present the results in the parent frame)

- Outside OpenSim (e.g. Excel, Matlab, or Python), **calculate** the resultant hip, knee, and ankle joint contact forces.

- **Plot** results:
  - **Reserve** moments for hip, knee, and ankle.
  - Electromyography, muscle activations, and muscle forces for the following muscles:
    - **vastus medialis**
    - **rectus femoris**
    - **biceps femoris long head**
    - **gastrocnemius medialis**
    - **gluteus maximus**
  - Components and resultant hip and knee **joint contact loads**.

Note: Make sure the stating and end time of all the plots are similar.

Questions
1. Do the reserve moments differ from baseline to post fatigue?

2. How do the muscle activations compare with the measured electromyography signals?

3. What muscle produced the largest peak muscle forces at baseline? And after fatigue?

4. Which muscle was more affected by the repeated sprints?

5. What joint loads changed the most following the repeated sprints?

IV. References

[1]   B. A. M. Gonçalves *et al.*, *Sport. Heal. A Multidiscip. Approach*, 194173812211315, (2022)

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[3]   V. Di Salvo *et al.*, *Int. J. Sports Med.*, 30, 3, 205–212, (2009)

[4]   B. Cunniffe *et al.*, *J. Strength Cond. Res.*, 23, 4, 1195–1203, (2009)

[5]   F. M. Impellizzeri *et al.*, *Int. J. Sports Med.*, 29, 11, 899–905, (2008)

[6]   C. Lord *et al.*, *J. Sci. Med. Sport*, 22, 1, 16–21, (2019)

[7]   G. Ng *et al.*, *Clin. Orthop. Relat. Res.*, 477, 5, 1053–1063, (2019)

[8]   G. Giarmatzis *et al.*, *J. Bone Miner. Res.*, 30, 8, 1431–1440, (2015)