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Patella-femoral joint loading during the modified Star Excursion Balance Test: Preliminary results of an extensive simulation study

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1. Introduction

The modified Star Excursion Balance Test (mSEBT) is frequently used [1] to screen for functional deficits in patients with various musculoskeletal conditions [2–6]. It consists of lower extremity reaching tasks in the anterior (AT), posterior-medial (PM), and posterior-lateral (PL) directions [7]. After injury or surgery, the goal of physiotherapy is to restore function. One key element during rehabilitation is to avoid overloading of the injured structures. Surprisingly currently there is hardly any information available about joint loading during functional exercises nor for typically employed screening tests. Van Rossom et al. [8] were the first attempting to close this research gap by means of musculoskeletal simulations for several functional exercises. The present study aims to continue their line of research by estimating patella-femoral (PF) joint loading during the mSEBT.

2. Research question

How high are patella-femoral joint contact forces during the mSEBT?

3. Methods

This is ongoing work. To date data of 13 healthy participants (38 ± 9 years, seven females) were partly analyzed. Marker trajectories and ground reaction forces were measured using an opto-electronic motion capture system and one force plate during two conditions: self-paced walking and during the mSEBT. The OpenSim Joint and Articular Mechanics workflow consisting of a validated multibody knee model was used in combination with the Concurrent Optimization of Muscle Activations and Kinematics (COMAK) algorithm to predict the muscle forces, secondary knee kinematics, ligament forces, and articular contact pressures for both conditions [9–11]. PF contact forces during the mSEBT were expressed in multiple of body weight (BW) and multiple of peak values during walking for ease in clinical interpretation.

4. Results

Participants presented forces of on average 10 ± 4, 15 ± 7, and 5 ± 4 multiple of peak walking for the PF contact, inferior-superior and medio-lateral shear forces, respectively. In addition, there was a moderate to strong correlation between maximum knee flexion and PF contact force (Fig. 1).

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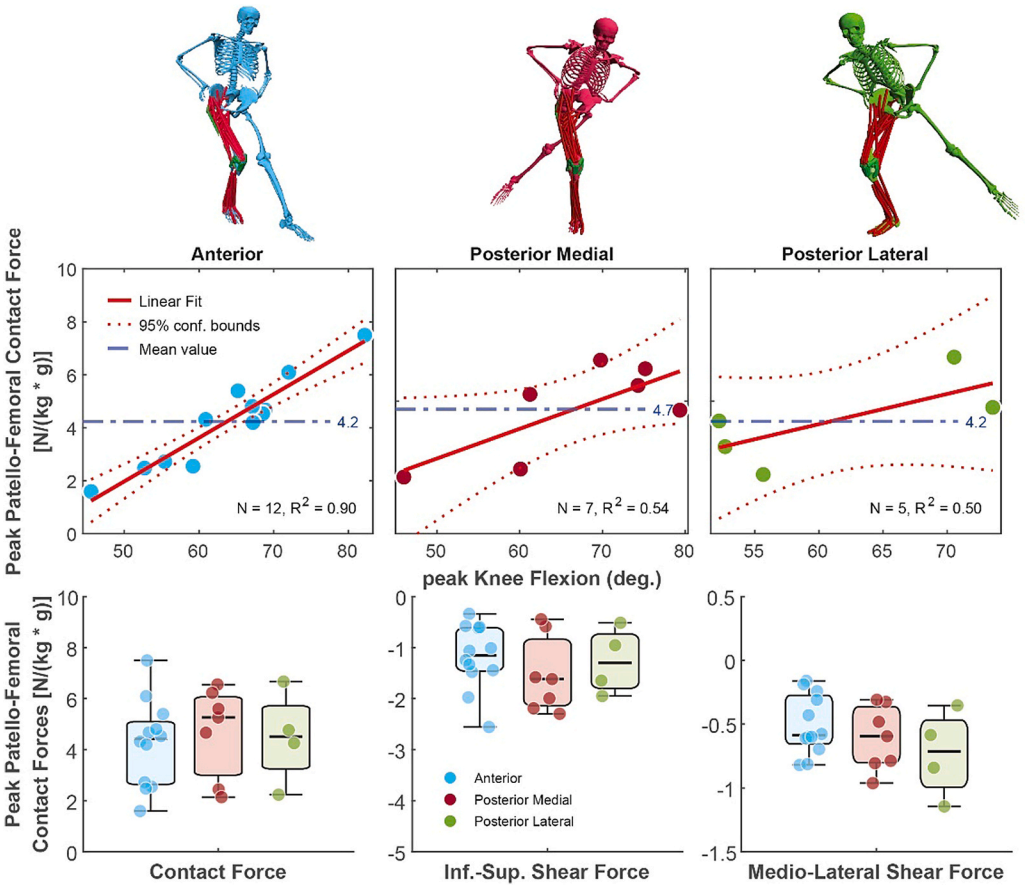

Fig. 1. Correlations between patella-femoral (PF) contact force and knee flexion (top) and PF contact and shear forces in all directions (bottom).

5. Discussion

Averaged PF contact forces showed a double peak pattern with peaks of about 0.5 BW during walking. This corresponded well with literature [12] thus supporting the plausibility of our simulations. In general, PF contact and shear forces demonstrated high amplitudes compared to walking. PF contact and shear forces reached on average amplitudes of almost 5 and 2 times BW, respectively, which is similar to loading experienced during a single leg hop [8]. Even tough sample size was currently low for PM and PL, correlations between knee flexion and PF contact force indicate highest loads during the maximum reach distance. This information might help physiotherapists to safeguard joint loading during early rehabilitation for patients with structural deficits at the PF joint.

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