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The influence of different walking strategies on patellofemoral and tibiofemoral contact forces in individuals with patellofemoral instability

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1. Introduction

Patellofemoral instability (PFI) and associated patella dislocations are common knee injuries in adolescents [1] and are affected by various morphologic factors [2]. Recent studies have shown how morphologic factors influence patellofemoral stability and knee loading [3,4]. However, these studies were based on the walking pattern of a single healthy person and therefore did not consider the diversity of gait patterns in individuals with PFI. Depending on the sagittal knee moment, Clark et al. [5] showed two different walking strategies, that could influence the knee loading.

2. Research question

Do patient-specific walking strategies affect the knee joint loading in individuals with PFI?

3. Methods

Musculoskeletal simulations were conducted based on retrospective gait analyses of patients with PFI (29 individuals, 34 affected knees). A generic model with 14 knee ligament bundles and defined cartilage surfaces [6] was scaled to each participant and used in combination with the concurrent optimization of muscle activations and kinematics routine [7] to calculate joint angles, moments and contact forces (CF). Participants were divided into an under-loading (UL, $N = 12$) and a normal-loading (NL, $N = 22$) group based on the knee flexion moment as defined by Clark et al. [5]. Cartilage loading predictions and morphologic parameters quantified from magnetic resonance images were compared between both groups. Normal distribution of the data was tested (Shapiro-Wilk test) and comparisons were made by using independent t-tests and statistical parametric mapping (alpha = 0.05) [8].

4. Results

The groups showed no statistical difference (NL vs UL, $p > 0.05$) in sex, age (15.4 ± 1.6 vs 16.0 ± 1.8 years), gait speed (1.23 ± 0.11 vs 1.22 ± 0.10 m/s) and knee morphology: tibial tuberosity to trochlea groove distance (15 ± 4 vs 17 ± 2 mm), Caton Deschamps index (1.16 ± 0.16 vs 1.27 ± 0.13), Dejour classification, femoral anteversion (24 ± 11 vs $22 \pm 8°$) and tibial torsion (33 ± 8 vs $36 \pm 8°$). Statistical parametric mapping showed significant differences between the groups ($p < 0.05$) in knee flexion moment, knee kinematics, vertical tibiofemoral CF as well as anterior-posterior and medio-lateral patellofemoral CF, especially in loading response and midstance (Fig. 1).

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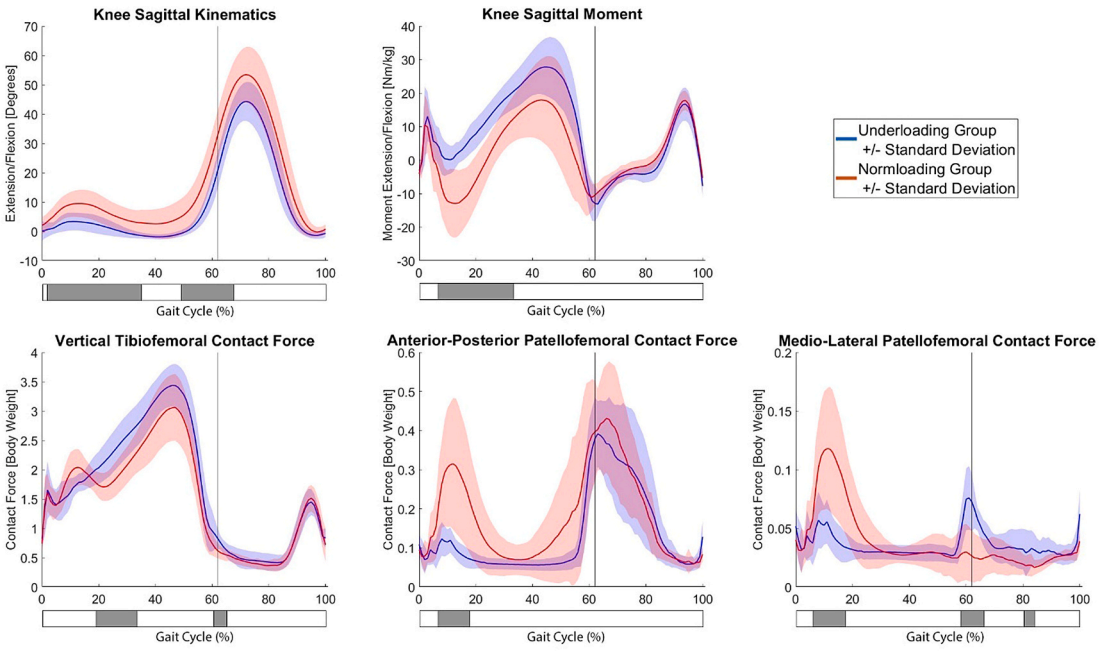

Fig. 1. "Comparison of simulation results between both groups. Grey bars represent significant differences ($p < 0.05$)."

5. Discussion

Although the groups showed no difference in sex, age, gait speed and knee morphology, we found clear differences in patellofemoral and tibiofemoral CF. The UL group walked with an extended knee and lower knee moment during weight acceptance, a so-called quadriceps avoiding pattern. Our findings showed the impact of disease specific gait pattern on knee loading in individuals with PFI. In our simulations we neglected the subject-specific knee morphology to highlight the influence of the walking pattern on joint loading. In future work, personalized knee models will be used, to predict patient-specific patellofemoral and tibiofemoral CF. In conclusion, we showed the importance of utilizing patient-specific walking pattern in the estimation of joint loading in individuals with PFI.

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