IMPACT OF EXTERNAL FLEXION MOMENT ON PATELLO FEMORAL LOADING DERIVED FROM *IN VIVO* LOADS AND KINEMATICS

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Introduction

Total knee arthroplasty (TKA) is the standard treatment for late stage knee osteoarthritis and considered one of the most successful surgical interventions in orthopaedics. However, patello-femoral (PF) complications like anterior knee pain frequently limit the functional performance of a reconstructed knee and reduce the quality of life for affected patients. While PF complications have been linked to PF contact loads, these are difficult to access *in vivo*. We therefore aimed to determine how the more accessible external knee flexion moment (EFM) is related to the PF contact force. We did so by a combining *in vivo* measured tibio-femoral (TF) loading with fluoroscopically captured *in vivo* TF & PF kinematics in a musculoskeletal analysis of lower limb loading.

Methods

Six TKA patients (aged 65-80y) from the CAMS-Knee datasets [1] with instrumented tibial components performed 5-6 repetitions each of activities known to produce high PF forces: sit-stand-sit and squat. *In vivo* TF forces were measured by an instrumented tibial component, while a mobile video-fluoroscope synchronously captured the internal TF and PF kinematics. PF forces were computed by musculoskeletal modelling using the *in vivo* measured TF forces as a boundary condition to account for the unknown level of antagonistic muscle co-contraction [2]. The TF & PF kinematics reconstructed from fluoroscopy were used to determine the functional knee flexion axis, effective lever arm of the patellar tendon and the ratio of quadriceps force to patellar tendon force. The forces were normalized to body weight (BW) while the moments were normalized to BW times body-height (BWHt). For the linear regression between the EFM and PF force, only time points with EFM > 0.001 BWHt were considered.

Results

For the sit-stand-sit and squat activities respectively, the peak *in vivo* measured TF forces were 2.81 ± 0.34 BW (mean ± SD) and 2.59 ± 0.51 BW, peak EFMs were 0.047 ± 0.007 BWHt and 0.042 ± 0.011 BWHt, while peak PF forces were 2.62 ± 0.45 BW and 2.38 ± 0.61 BW. With R^2 values of 0.94 and 0.84 the regressions between the EFM and PF force yielded slopes of 56 Ht^{-1} and 54 Ht^{-1} (Fig. 1). Given the small intercepts (0.014 and 0.023 BW) the slopes can be interpreted as fixed ratios between the two quantities.

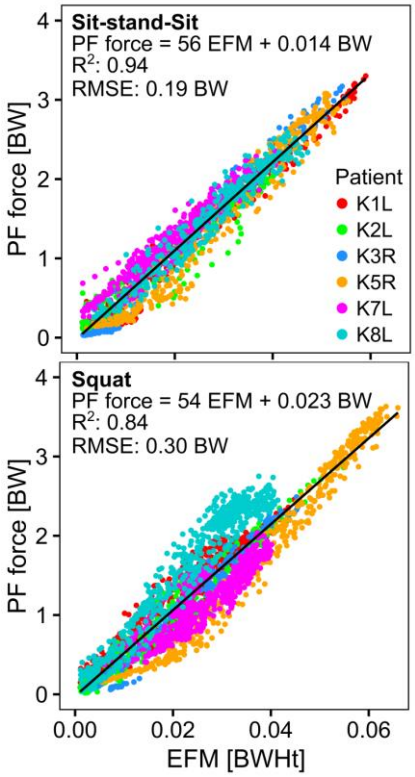

Figure 1: Linear regressions between external knee flexion moments (EFM) and patello-femoral (PF) contact forces for the sit-stand-sit and squat activities.

Discussion

The novel combination of *in vivo* forces and internal patellar kinematics enabled us to provide a reliable prediction of PF contact forces. The fluoroscopic assessment minimized uncertainties related to patella location, while the *in vivo* TF force those related to antagonistic muscle co-contraction. The peak PF forces found in this study were in a similar range to the peak TF forces. The PF forces show a strong relationship with the external knee flexion moments, despite the low number of subjects and their variability in varus-valgus knee angles, age and BMI. Our results allow a quick estimation of PF forces, as a possible source of anterior knee pain, based solely on the external knee flexion moments from quantitative gait analysis.

References

1. Taylor WR et al, J Biomech, 65:32-39, 2017
2. Trepczynski et al, J Neuroeng Rehabil. 15(1):101, 2018

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