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ABSTRACT BOOK

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Bayesian parameter estimation of ligament properties based on tibio-femoral kinematics during squatting

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The possible applications of musculoskeletal knee models (MSKMs) in a clinical setting are numerous, e.g. surgical navigation and clinical decision making. Such applications require MSKMs that result in an accurate prediction of kinematics and ligament strains. The objective of this study is to estimate the ligament material properties and attachment sites of an MSKM for seven specimens based on knee rig experimental data during a squatting motion. This allows assessing if ligament properties can be estimated based on squat movement kinematics as well as quantifying their variability between specimens. We used Bayesian parameter estimation to account for uncertainty in the experimental data (σ = 0.5 mm or ° [1]) by optimization of an input parameter space consistent with all possible solutions. The set of solutions accounts for physiologically relevant ligament strain (ε < 6% [2,3]). The transitional Markov Chain Monte Carlo algorithm was used [4,5]. To perform the parameter estimation with feasible computational cost, an artificial neural network of the musculoskeletal knee model was trained. The figure shows the histograms resulting from the parameter estimation for the reference strain and linear stiffness for the AnteroLateral ligament (ALL) and the AnteroLateral (PCL0) and PosteroMedial (PCL1) Posterior cruciate ligaments. Each specimen is assigned a color where the transparency is consistent with the probability of the solution. It can be seen that no unique solution can be found solely based on measured kinematics of a squat motion as multiple solution clusters are found for each of the specimens. This shows that further research is required into alternative (combinations of) movements that would lead to a unique solution and can be accurately measured in vivo. The large variation between specimens shows that a small range of ligament properties that represents the patient population cannot be established. To limit ligament properties uncertainty in clinical applications, research will need to invest in establishing patient specific uncertainty ranges and/or in vivo measuring methods.

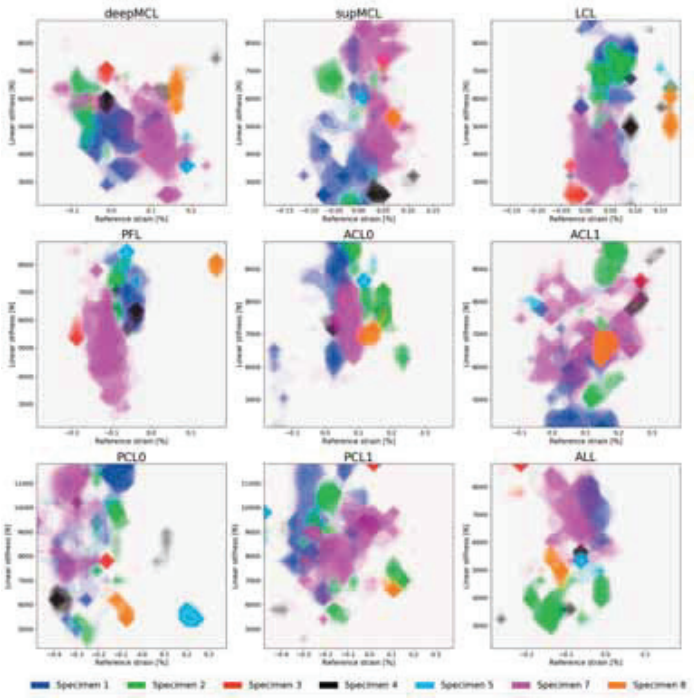


Figure caption: Results of the Bayesian parameter estimation.

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