Establishing Consensus for Modelling and Simulating Knee Biomechanics: The KneeHub Project

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Summary

Reproducibility and credibility of knee models is important for the clinical adoption of modelling and simulation. Context-of-use dictates what data and modelling decisions are required to obtain desired outcomes. This paper presents *KneeHub* and our plans to engage with the research and clinical community to define and develop consensus simulation workflows for knee joint modelling.

Introduction

Computational modelling is an enabling technology for personalised clinical care of knee injury and disease. Despite the prevalence of knee modelling, reproducibility and credibility of simulations remains poor, due to diverse and ambiguous modelling decisions. To understand the variability of modeling decisions, our NIH-sponsored *KneeHub* project evaluated the influence of independent modeling workflows on model outputs (Figure 1). We showed that even when target simulation scenarios and the source data to build models remained the same, variations in modeler's choices introduced uncertainties that influenced predictions [1,2].

To improve reproducibility of knee models, we are implementing a Delphi method to establish expert consensus on processes that define modelling and simulation workflows for specific contexts-of-use. Here we describe our approach to establish two context-dependent, consensus workflows.

Methods

An international panel of experts has been formed to anonymously review and prioritise two contexts-of-use (Phase 1). Context dictates model fidelity and specificity, data to build and validate, and computational strategy and resources. We have performed literature searches across four databases (PubMed, Google Scholar, Dimensions, Semantic Scholar) using seven combinations of terms (e.g. "knee AND finite element") to understand the breadth and popularity of use scenarios. For each combination of search terms, a list of peer reviewed articles was obtained (280 in total) and sorted according to study focus, predicted outcome, clinical question, loading, pathology or injury, and intervention.

The expert panel will review the context-dependent modelling processes and credibility activities (Phase 2). Within each context-of-use, workflows are influenced by available data, computational resources, and subject variability. We will design questionnaires to define the modelling processes within each context-dependent workflow that require consensus. The panel of experts will then achieve consensus by engaging through an iterative survey-based portal. This will also inform credibility activities for customisation of existing frameworks. Group responses will be analyzed, and further group feedback will be requested until consensus is achieved, as per the Delphi process.

Results and Discussion

We found distinctly different literature results across the four databases that were searched. Using the first 10 articles the relatively simple search using "knee AND finite element" resulted in 28 unique and only 6 repeated manuscripts across the four databases. Ongoing analysis is identifying and ranking technical and clinical context to receive feedback from the expert panel on what they consider to be significant to their work or community. The systematic documentation, categorization, and ranking will be presented at the ISB meeting, providing a venue to recruit additional stakeholders that have an interest in participating in the Delphi process.

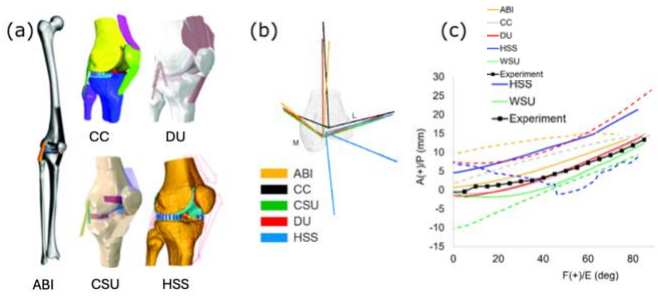

Figure 1: (a) Example models from the five KneeHub teams. (b) Femur coordinate frames from each team before updating to consistent placement/orientation. (c) Pre- (dashed) and post-(solid) calibration predicted anterior-posterior displacements.

Conclusions

This study serves as the initiation of specifying consensus-based modeling and simulation processes for two relevant contexts of use. The outcome from the Delphi process will result in a consensus document for each context-of-use, which will be published and disseminated to the wider community.

References

[1] Rooks N et al. (2021). *J Biomech Eng*, **143**.
[2] Andreassen T. (2023). *J Biomech Eng*, **145**