POPULATION-BASED MODELLING INSIGHTS IN JOINT FUNCTION AND LOADING IN SUBJECTS WITH KNEE OSTEOARTHRITIS

Ilse Jonkers, Giacomo Di Raimondo, Miel Willems, Bryce A Killen

Human Movement Biomechanics Research Group, Movement Science Department, KU Leuven, Leuven Belgium

Background

Over the past 20 years, the field of human movement biomechanics collected a huge amount of integrated 3D motion capture data in both healthy subjects and those with various musculoskeletal pathologies. This has resulted in a large data set of kinematics and kinetics describing locomotor function, during a range of activities of daily living in a large population. Further, with accelerated acquisition and increased quality of medical imaging, rich data sets on musculoskeletal geometry are also steadily becoming more available. While this data is often used to perform a case-by-case cross sectional analysis on specific individuals, they remain a sparse sample of specific populations. Therefore, we explored emerging techniques for population-based modelling approaches. Given the relevance of mechanical loading as driving factor and its high prevalence [1], the use, applicability, and relevance of these model-based approaches in knee OA will be discussed.

Recent Advances

Two specific population-based methods will be introduced, both based on data reduction and principal component analysis: The first is based on principle components derived from motion capture data – specifically joint angles or kinematics [2]. Using existing datasets from both healthy control subjects, and patient with knee OA, we determined and defined the average 3D kinematic gait pattern during walking gait along with the primary variations seen within a studied knee OA population. The second, relates to knee joint alignment – specifically femoral and tibial bone and cartilage geometry [3]. Using SSM modelling approach, the average geometry and primary variation in geometry are determined. In isolation, each of these approaches can determine specific kinematics and/or geometric variations which are unique to each population and may relate to disease onset or progression. Further, based on clustering methods, specific knee OA phenotypes can be defined, identifying subjects at risk of accelerated progression.

In combination with state-of-the-art musculoskeletal modelling, both these methods provide exciting opportunities to unravel the knee joint loading landscape of the knee OA joint. By using the statistical distributions of gait kinematics, and joint geometry – we can, at least in theory, clinically relevant parameters from MSK modelling such as joint contact forces and pressure. Using novel state-of-the-art methods, we can include different joint geometries in our musculoskeletal models to determine the effect of joint geometry on estimated joint contact parameters. Further, using reconstructions of gait patterns – the effect of different gait patterns on joint contact loading parameters can be determined.

Ilse is currently Professor at the Department of Movement Science, KU Leuven. She obtained her PhD in Rehabilitation Science at KU Leuven. She was a post-doctoral fellow at KU Leuven in 2000-2009 and Stanford in 2004-2006. She is director of iSi Health – the KU Leuven Institute of Physics-based modeling for In Silico Health. Her present research mainly focuses on In silico informed interventions for MSK health. She is an author of 207 publications in peer- reviewed journals, 4 book chapters and more than 300 contributions to International and National Conferences.

Future directions

Population-informed models and simulations, if informed by rich enough data, will be used to develop machine learning based approaches to estimate joint loading parameters based on lower dimensional data (e.g., joint dimensions combined with 3D accelerometer data).

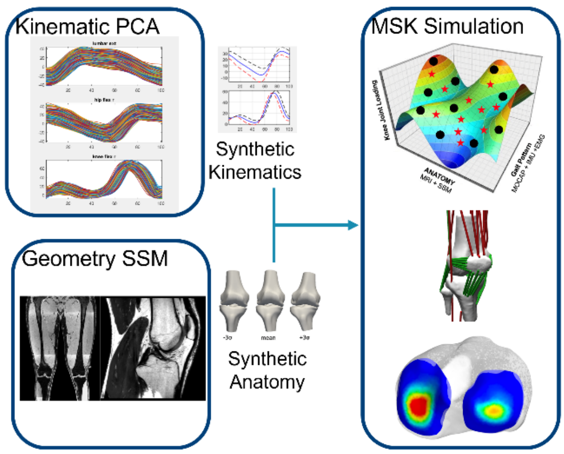

Figure 1: Schematic representation of population-based joint loading landscape.

References

1. Andriacchi et al., Ann. Biomed. Eng., 32(3):447-57, 2004
2. De Roech et al., Front. Bioeng Biotechnol.,9:696360, 2021
3. Van Dijck et al., Comp Meth Biomech Biomed.,21(9):568-78, 2017

Acknowledgements

Research Fund Flanders G0E4521N