Maastricht University

Simulating gait in patients with knee osteoarthritis

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Valorisation

Relevance

Knee osteoarthritis (OA) is the main cause of pain and disability in elderly affecting ten percent of elderly of 55 years or older.[1] The incidence of knee OA is rising, since risk factors as high body weight and aging of the population are increasing.[2] Furthermore the annual healthcare costs in the Netherlands for knee OA are immense; in 2015 they exceeded 500 million euros.[1] Joint replacement is an irreversible intervention and should be considered in patients failing other treatments and who often have more severe knee OA.[3] However, joint replacement surgery should be limited in order to reduce overall costs, since most OA related costs are associated with hospitalization in joint replacement surgery.[1,3] Furthermore, patients that received surgery will need postoperative therapy or possibly need revision surgery in case of treatment failure, resulting in accompanied additional costs. Early detection in combination with an optimal management using non-surgical treatments could prevent or retard progression of OA.[3]

Understanding the pathomechanics of knee OA can aid in the maintenance of healthy cartilage.[4] Therefore it is important to quantify joint loading in patients with knee OA using gait analysis. This thesis provides evidence that advanced computer models can give additional information on internal joint loading (chapter 3). These musculoskeletal computer models are, however, dependent on input parameters that are sometimes difficult to quantify. Scaling can easily personalize musculoskeletal models (chapter 4), but accuracy might be questionable for a specific individual in a clinical setting. Imaging is expected to give better estimations, but is time-consuming and expensive (chapter 5 and 6). Moreover, clinical application of these advanced methods might become challenging. Therefore, the level of personalization in musculoskeletal models should be carefully considered for its specific purpose, taking into account the accuracy that is needed versus the given effort.

Target groups

I. Patients

It is not anticipated that patients with knee OA directly benefit from the results of this dissertation. However, on the long term, patients will profit from a better understanding of pathomechanics of knee OA. Early stage knee OA or subjects prone to develop knee OA could be detected through non-invasive gait analysis. Furthermore, nonsurgical strategies (e.g. gait training) can be developed in order to decrease progression of knee OA or to cope with knee pain.[5-8] The primary goal of nonsurgical treatments is to postpone or prevent joint replacement, which is accompanied with high chances of complications and intensive rehabilitation.

A direct benefit for patients or subjects prone to OA from this dissertation is the importance of body mass on joint loading. Chapter 2 showed that body mass in combination with OA presence contribute significantly to higher knee joint loading compared to the presence of knee OA alone. Literature has shown that obese patients benefit from weight loss, which might reduce knee pain on the short term and possibly delays progression of knee OA.[9]

A second benefit for patients is that voluntary modifications in their gait pattern can be advised. These modifications might reduce joint loading and possibly effecting disease progression and pain.[8] In Chapter 2 and 3 we showed that a slower speed of propulsion decreases peak joint loads, whilst total load during a gait cycle increases, which is in accordance to literature.[5,10] Other researchers suggest that trunk sway and toe-out angle are also important determinants of knee loading.[8,11] Moreover, patients might benefit from implementing voluntary modifications to their standard gait pattern in order to reduce joint loads and possibly cope with the accompanied knee pain.

II. Health care professionals

Health care professionals can benefit from a better understanding of the pathomechanics of knee OA. Non-surgical strategies as mentioned above can be advised to patients in order to delay the progression of knee OA.

The aging population is prone to develop cartilage defects in the knee. In combination with the knowledge that joint replacements have limited life expectancy, non-surgical strategies that postpone joint replacement surgery are crucial. Non-surgical strategies with scientific evidence can provide health care professionals with additional tools for patient care.

This dissertation provides evidence that health care professionals should encourage weight loss in obese patients. Chapter 2 of this dissertation described that obese patients with knee OA have significant higher knee loads during walking compared to lean patients. These high knee loads might accelerate the progression of knee OA. Moreover, this provides evidence that weight loss programs should be recommended for obese patients.

To date, musculoskeletal models and gait analysis are increasingly used in clinical care, however, the complexity and additional procedures limit wider application. Furthermore, the lack of proper validation prevented the implementation of musculoskeletal models by health care professionals.[12] Although musculoskeletal models and gait analysis are becoming more user-friendly, which is an important step for clinical application.

III. Researchers

Other researchers can build upon the scientific conclusions of this dissertation. For example, in chapter 2 we found that the external knee adduction moment was mostly altered due to a higher body mass in patients with osteoarthritis. Researchers should acknowledge the importance of body weight in gait analysis.

In chapter 3, we found that the mediolateral component of the joint reaction force (i.e. shear force) was increased in patients with knee OA using musculoskeletal models. This parameter was able to show differences between healthy and knee OA on slow walking speeds, whilst knee adduction moments were not significantly different. Therefore, the shear force derived from musculoskeletal models might be a better indicator for knee OA gait compared to the knee adduction moment. Moreover, the usage of musculoskeletal models should be considered for acquiring additional information from traditional gait analysis.

Advanced personalized musculoskeletal models are supposed to increase accuracy compared to generic models, but also demand more resources. For example, magnetic resonance imaging is able to determine soft tissue properties (chapter 5), which enables musculoskeletal models to implement detailed subject-specific parameters (chapter 6). On the other hand simple rule-based scaling can provide good estimations of these parameters (chapter 4). Therefore, researchers should consider alternative approaches to personalize musculoskeletal models that are adequate for its specific purpose, but are less time-consuming and less time-consuming than advanced imaging.

Recommendation for further research

In this dissertation we were interested in the effect of osteoarthritis on gait. Therefore, we included a group of lean patients with knee OA and a weight, gender and age matched healthy control group. Since we suggested that weight might contribute to this effect, we included also an obese knee OA group. However, we did not anticipate that weight was the major contributor to changes in the knee adduction moment. In future research a fourth group of matched healthy obese subjects might contribute to a full understanding of the relation between weight, knee OA pathology and knee adduction moments.

Advances in musculoskeletal modelling enabled fast calculations of biomechanical characteristics. For example, these computer models are capable to detect alterations in pathological gait. The future challenge of these models is the further personalization in order to acquire accurate model outcomes that are clinically applicable. Furthermore, sensitivity analyses are useful for determining the consequences of inaccuracies.

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