On the biomechanical relationship between external hip, knee and ankle joint moments and the internal knee compressive forces

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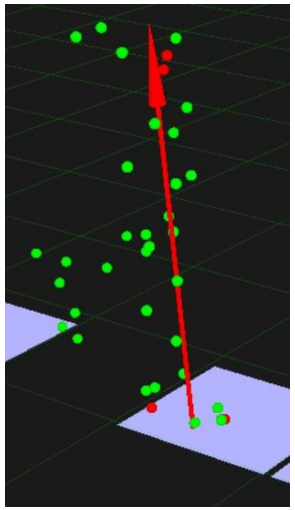
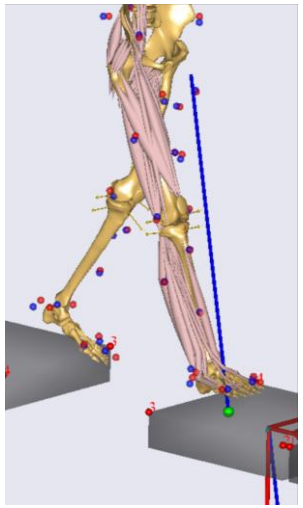
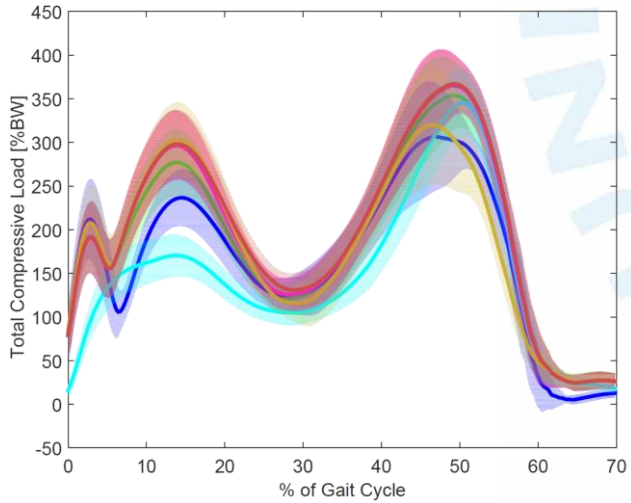
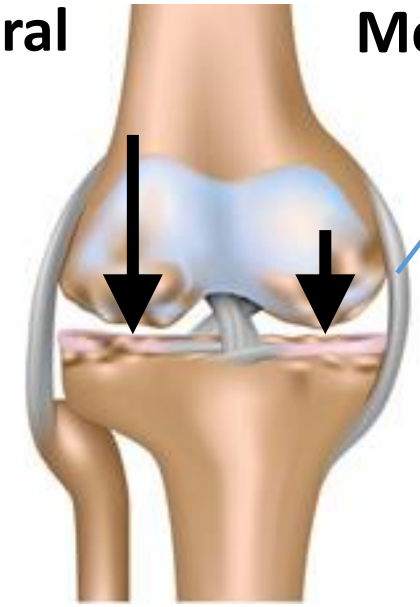




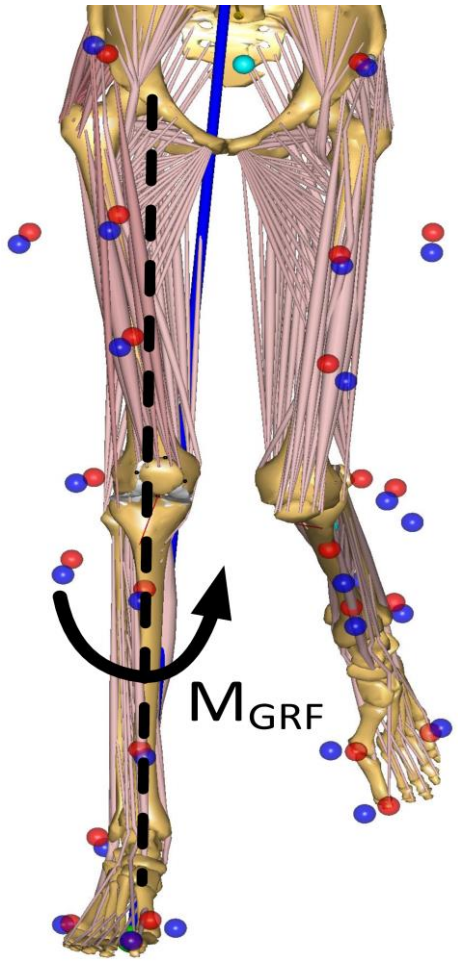


Motivation – Knee Osteoarthritis (KOA)

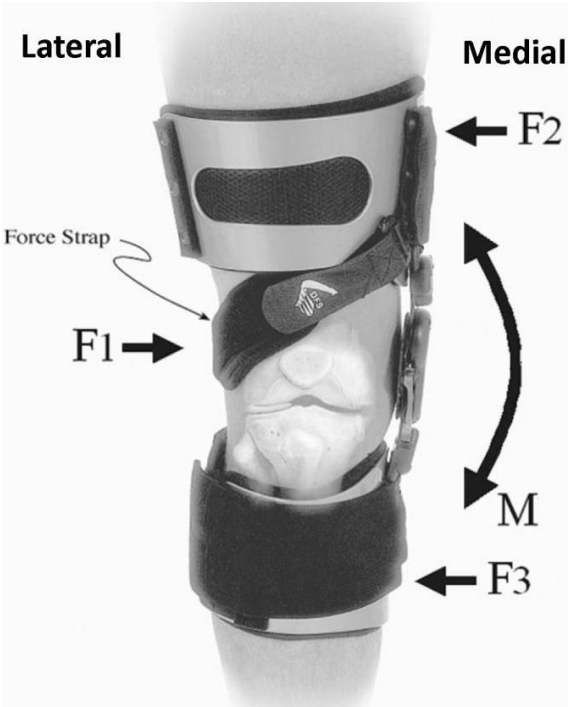


- Inflamation
- Stiffness
- Pain

- >9.5 million EU KOA patients (Peat G. et. al, 2001)
- Multi-factoral disease
  - Genetic
  - Previous ligament ruptures
  - Overloading



Non-invasive treatments of KOA



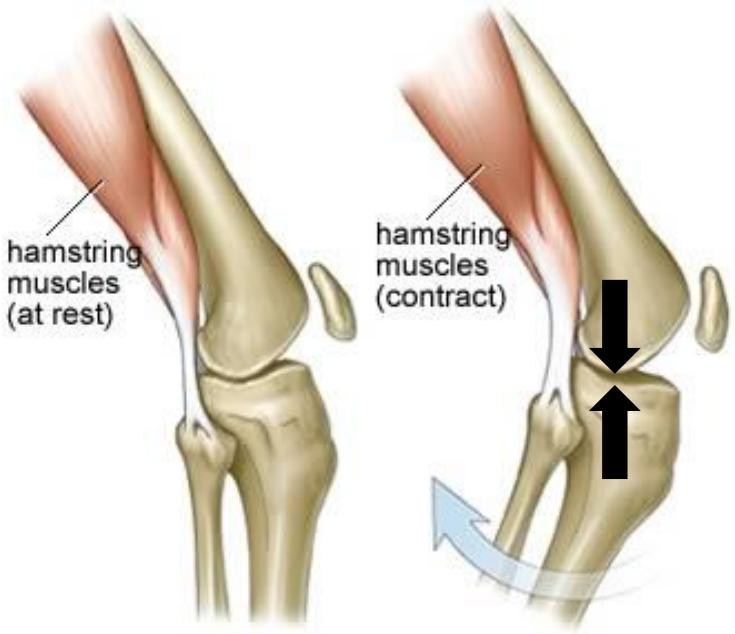
Modified picture from (Pollo et al. 2002)

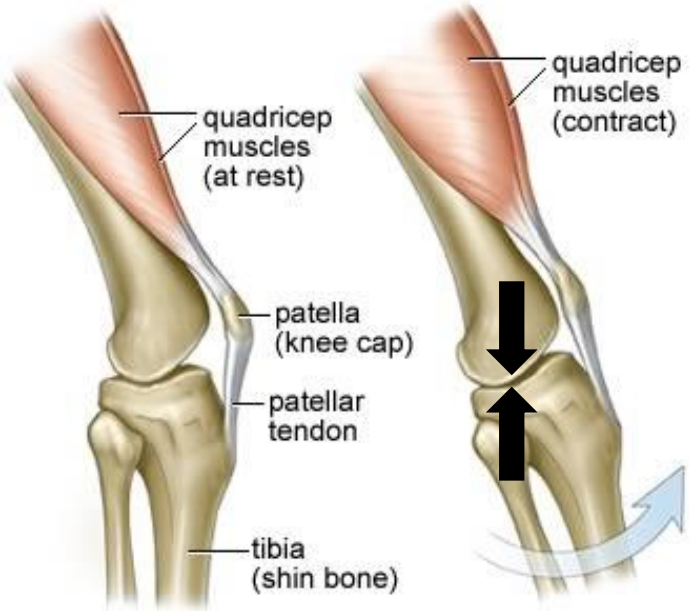
- Skin surface displacement
- MCL may be too stiff
- Shifts load but not reducing

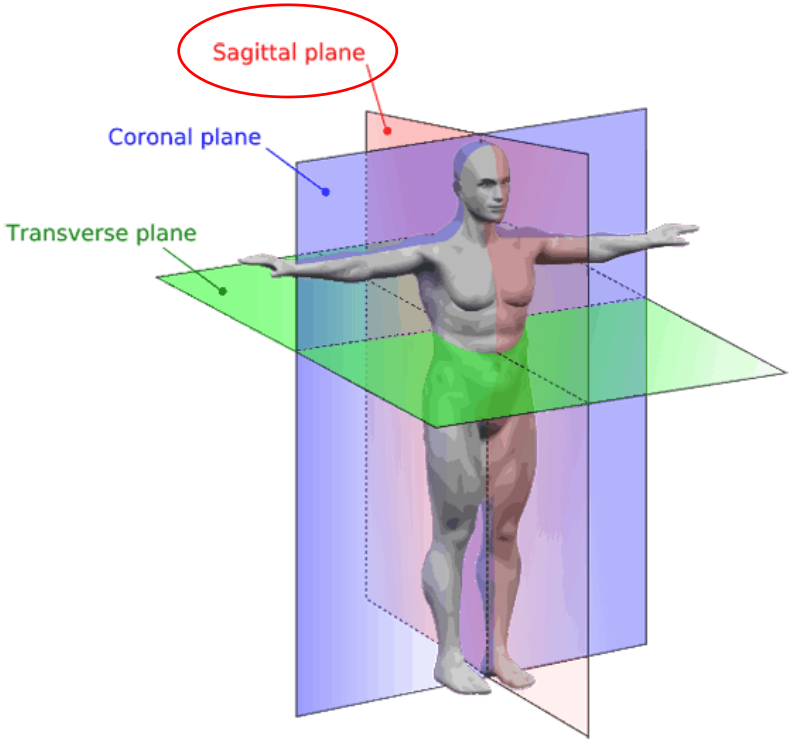
Aim

Investigate how internal knee joint loads depend on external moments

Hypothesis: Joint loads depend as much on muscle contraction as on KAM



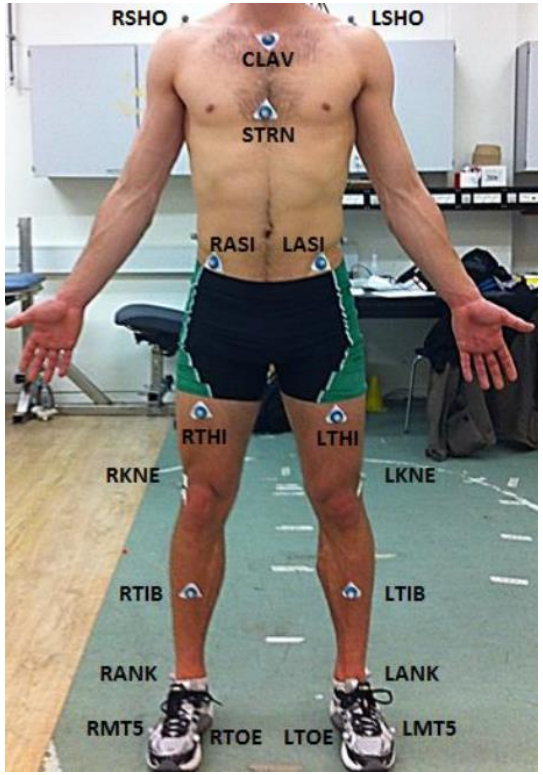


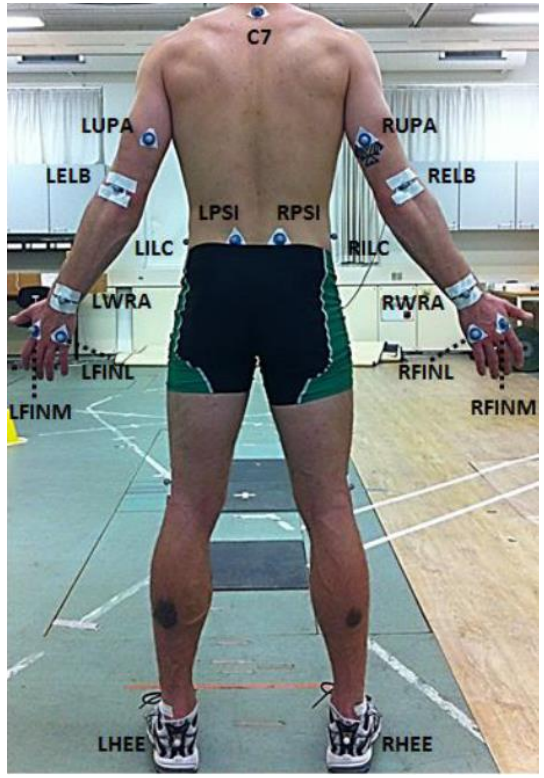


Method

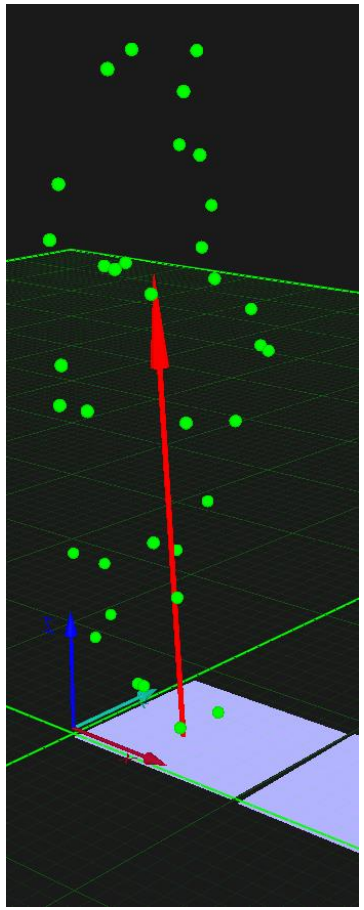
10 healthy subjects, 3 gait trials each (self-selected speed)

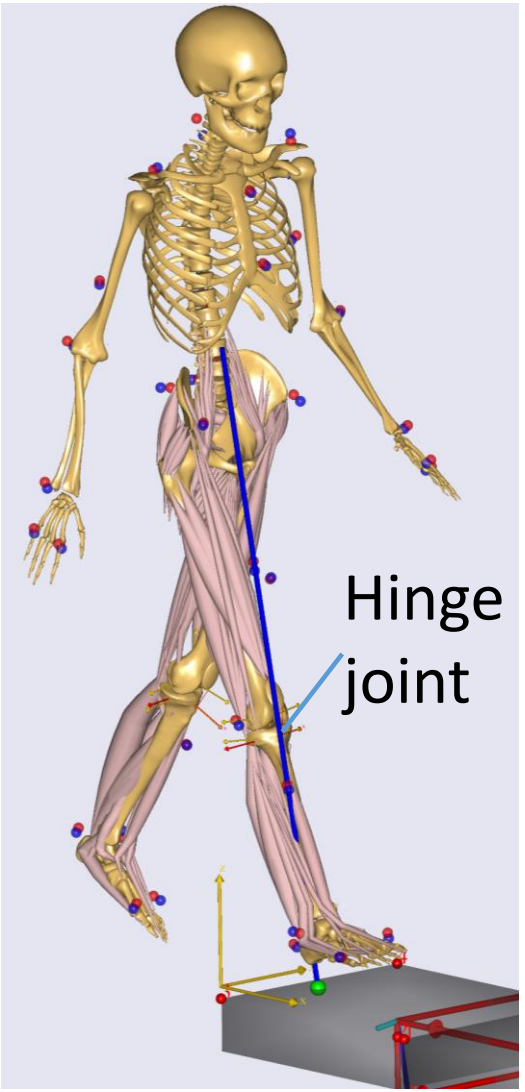
- Recorded with marker-based motion capture
- Measured ground reaction force





Skals et. al, 2016

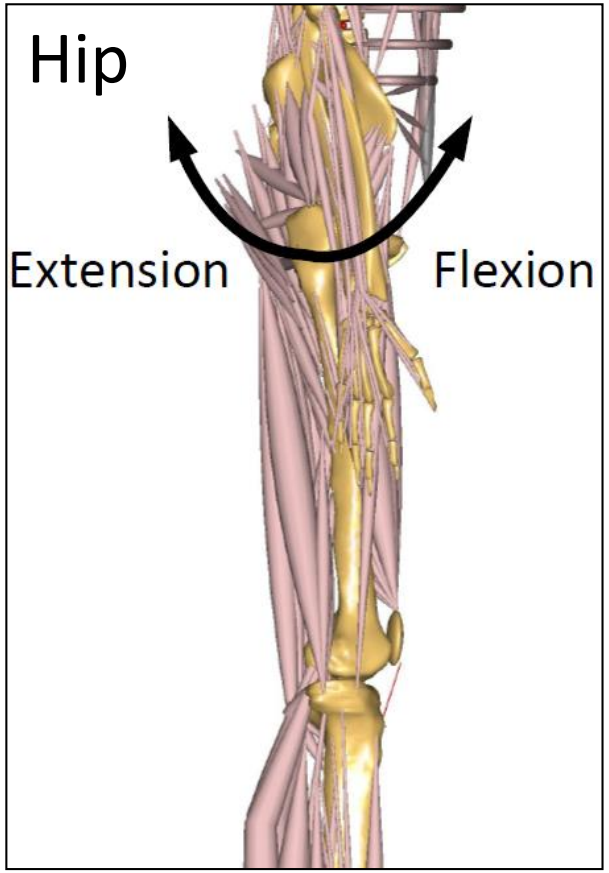


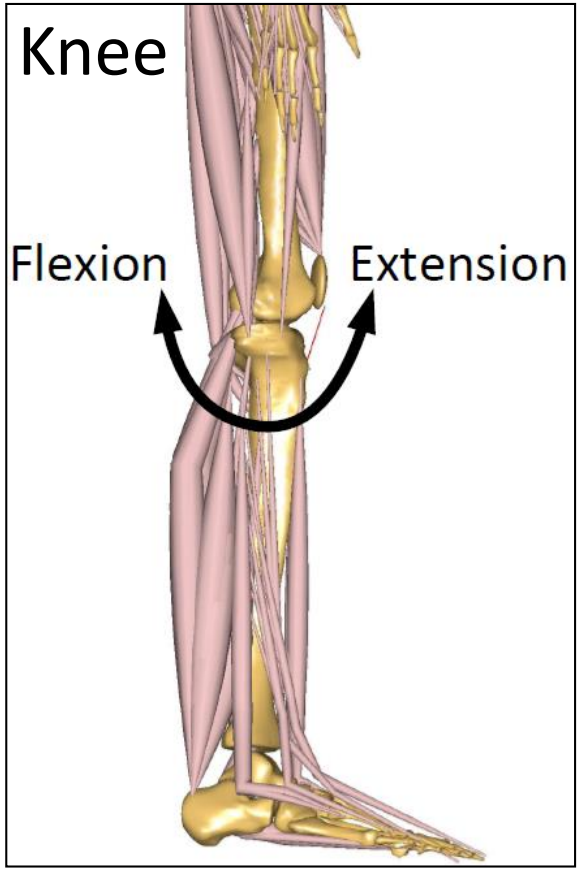


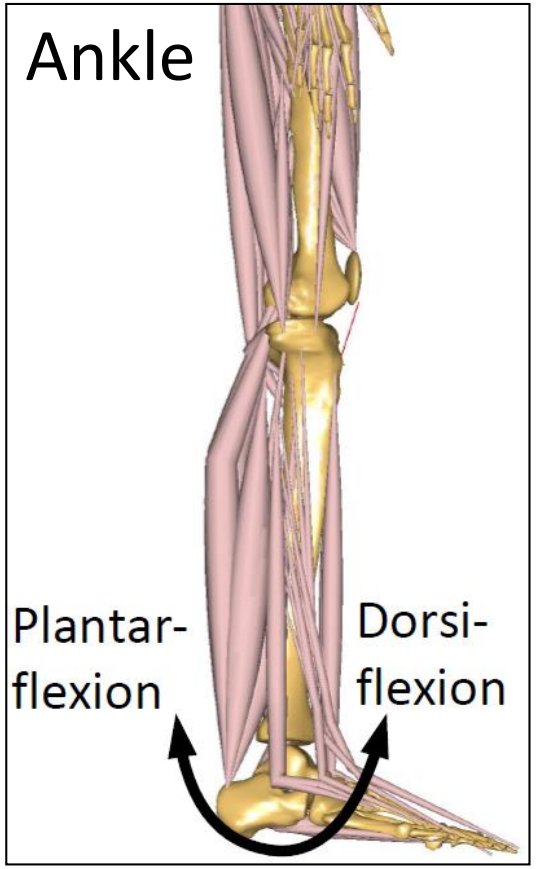
Method

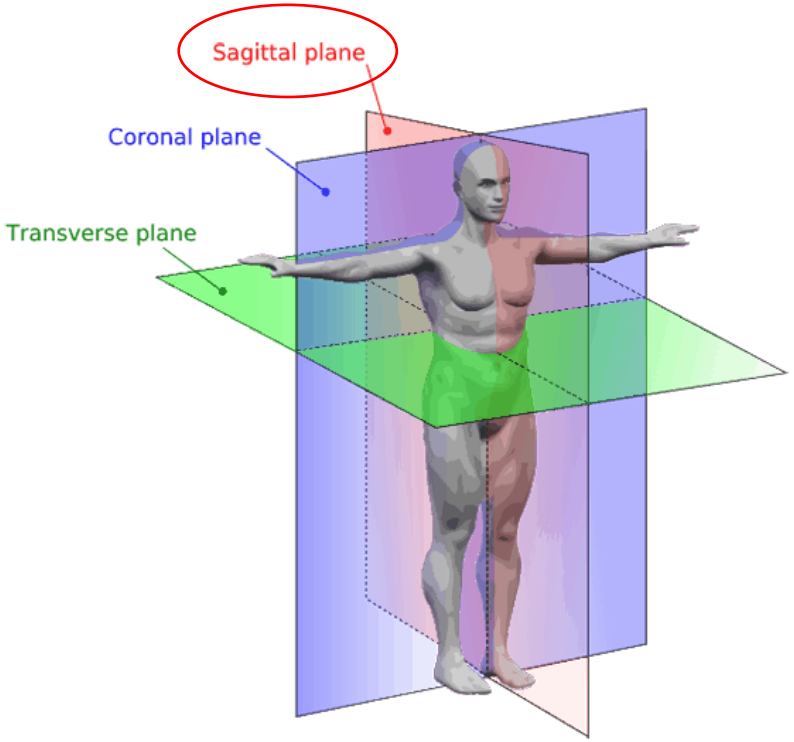
Apply external joint moments to simulate a brace *in-silico*

- **40**% compensation of muscle work → Reducing joint load





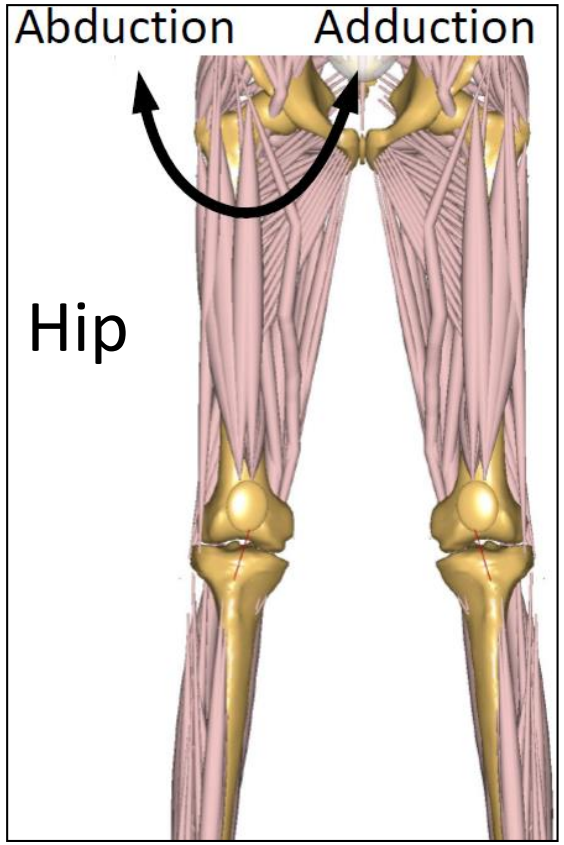


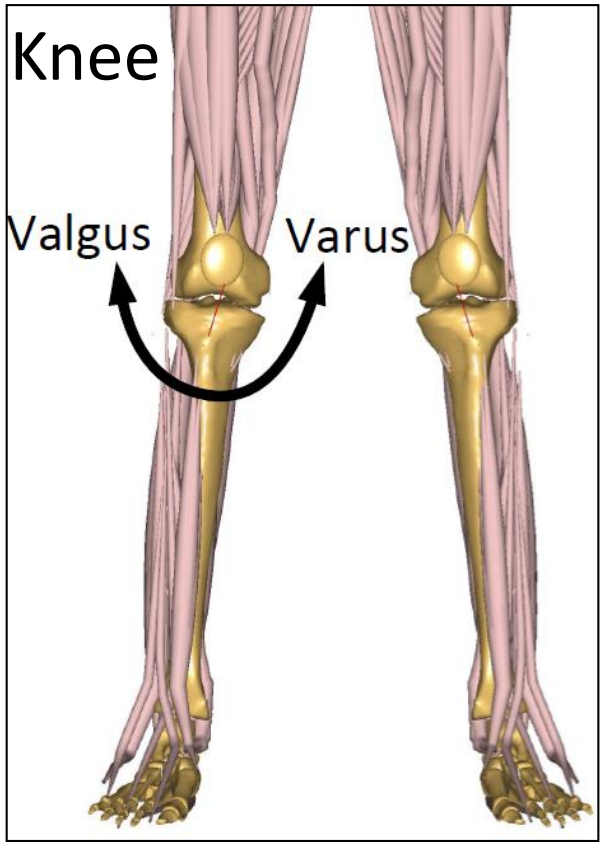


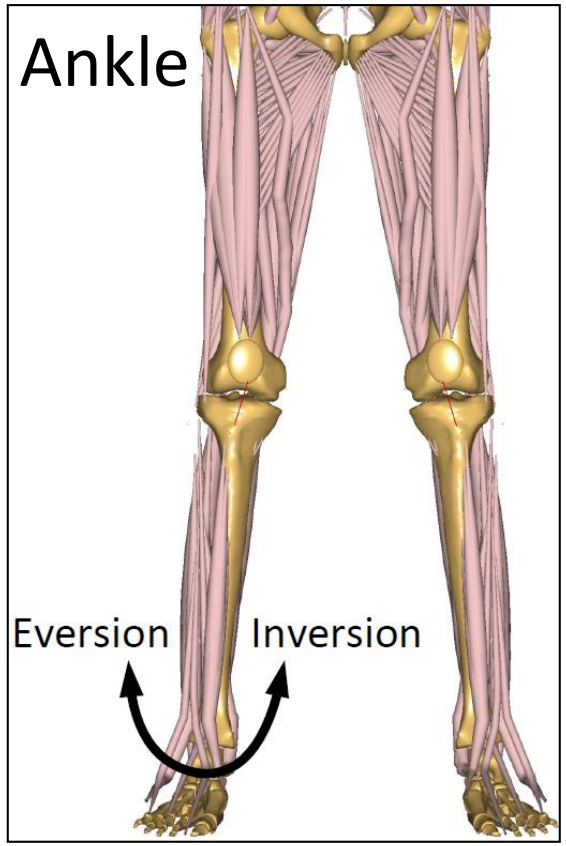
Method

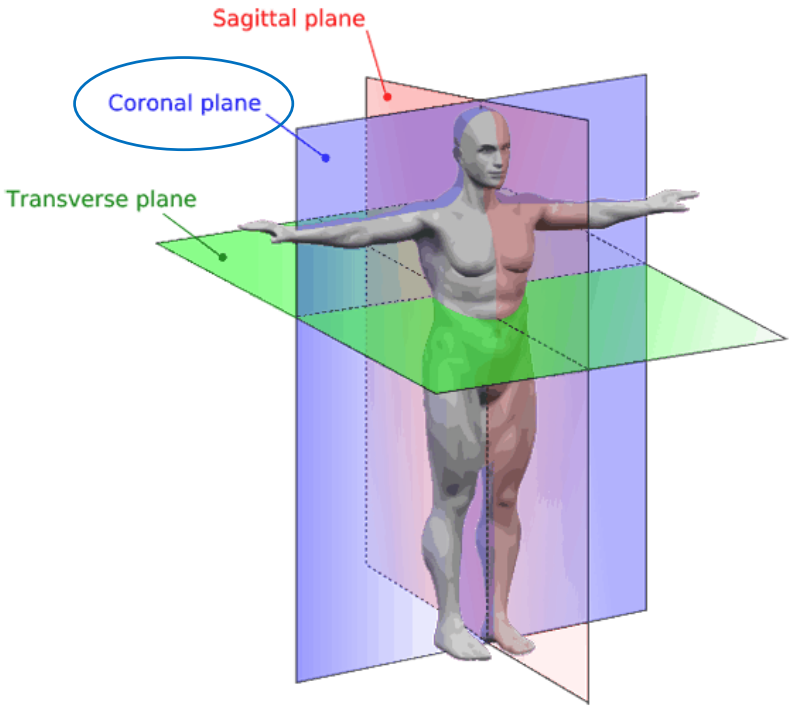
Apply external joint moments to simulate a brace *in-silico*

- **40**% compensating muscle work → Reducing joint load







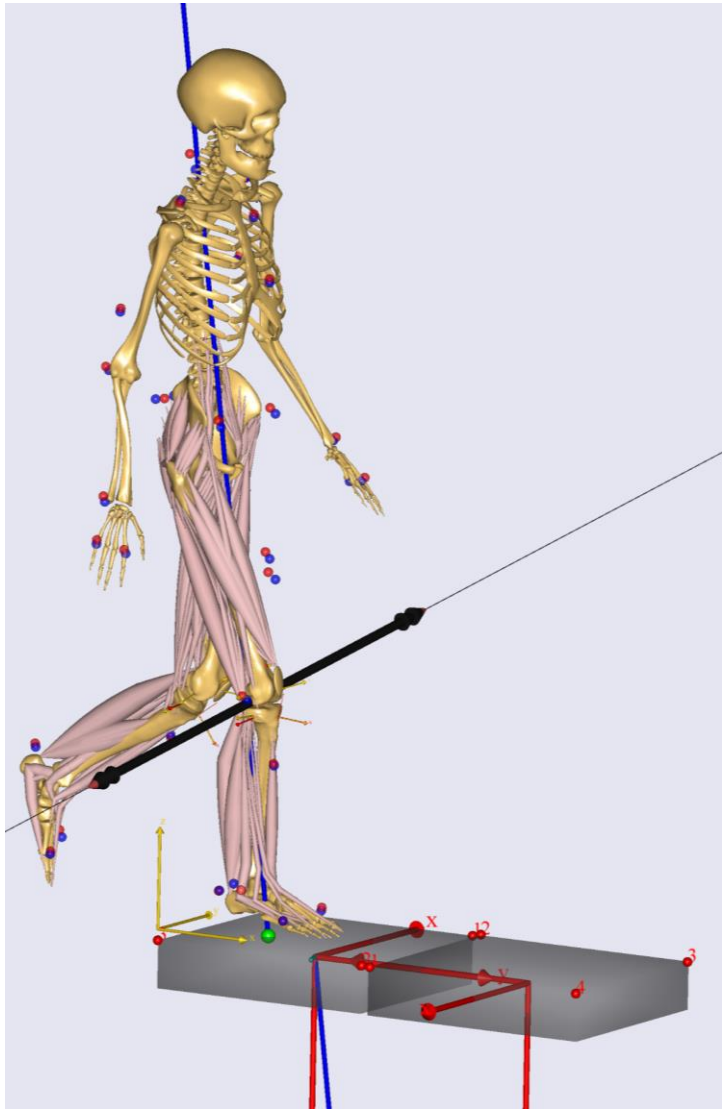


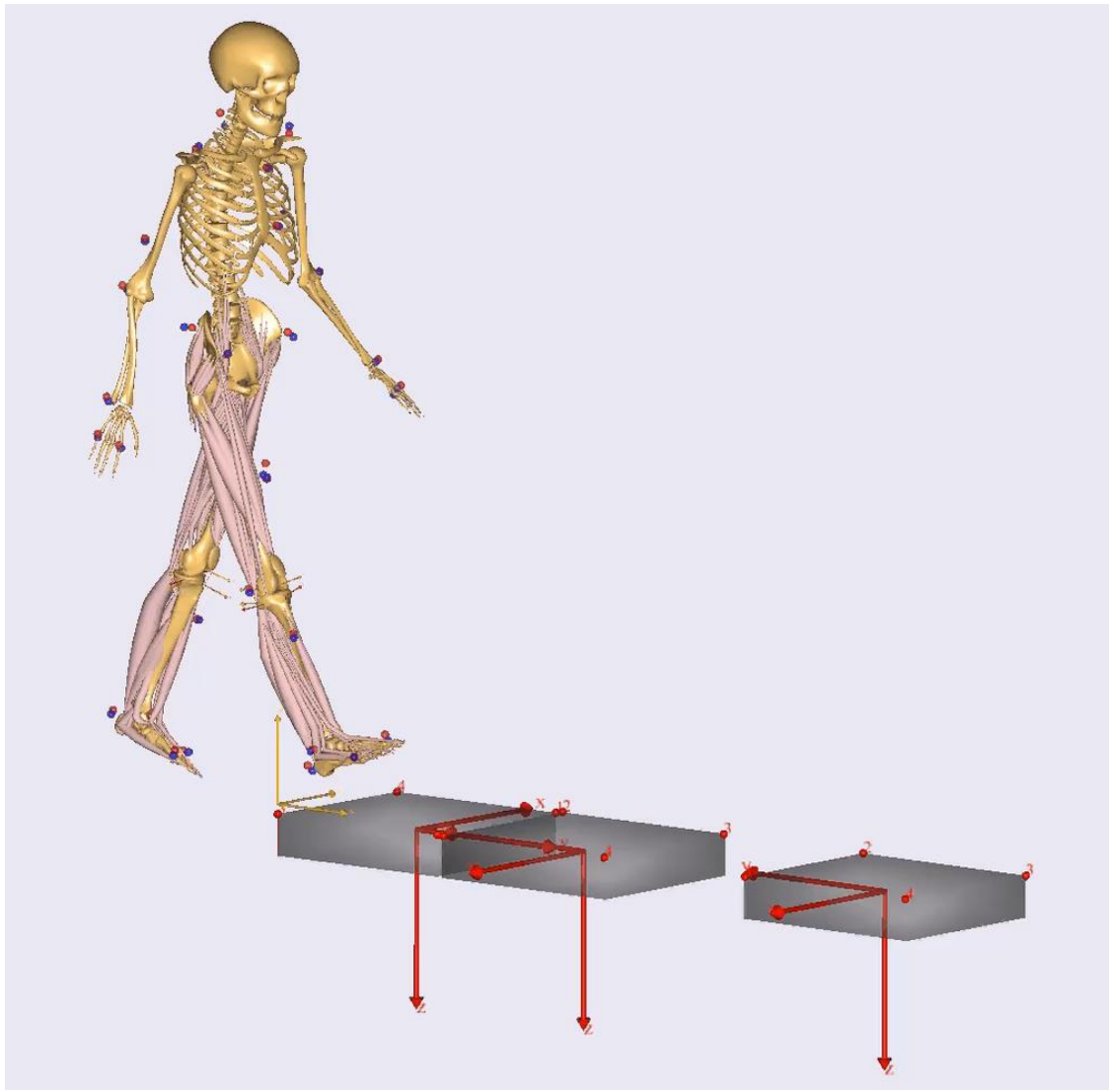
Method

Innovation Fund Denmark

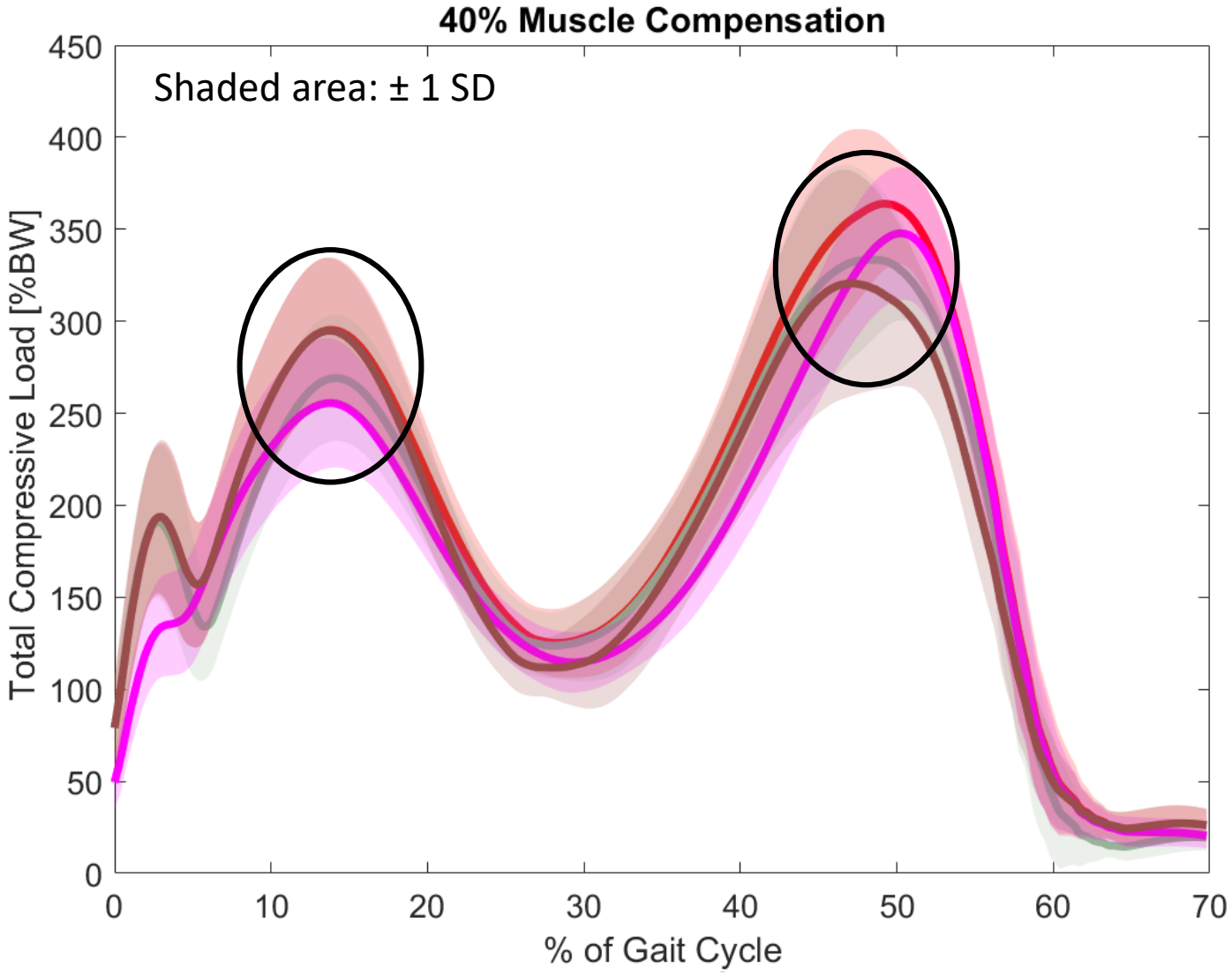
Individualized Osteoarthritis Interventions

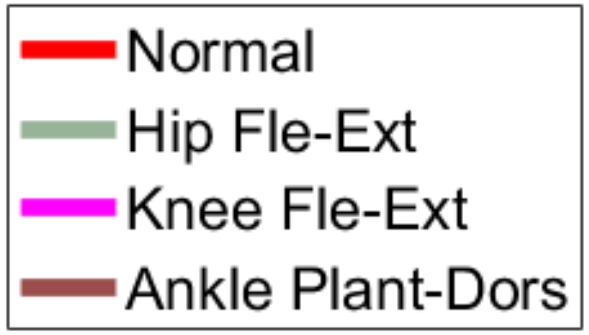
Example of knee flex-ext

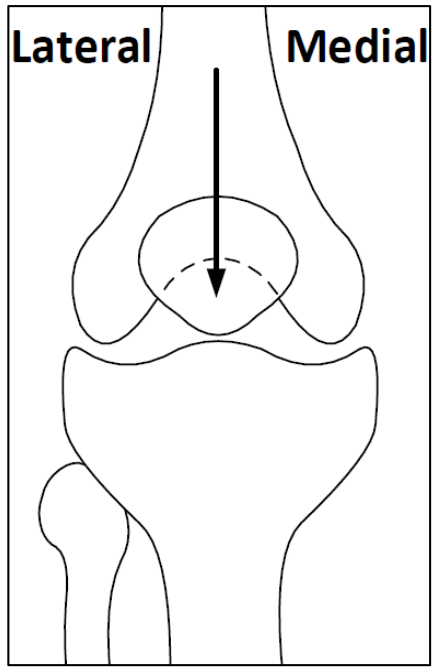


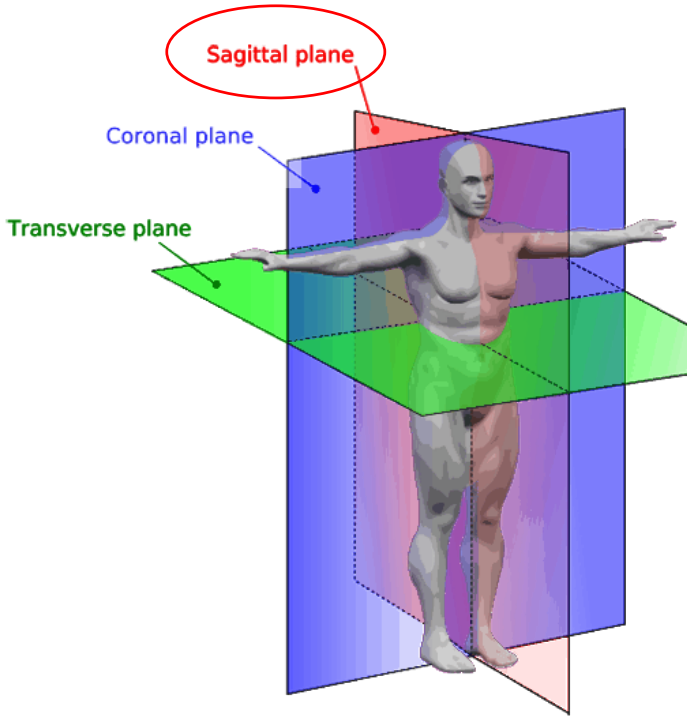


Results – Total compression load

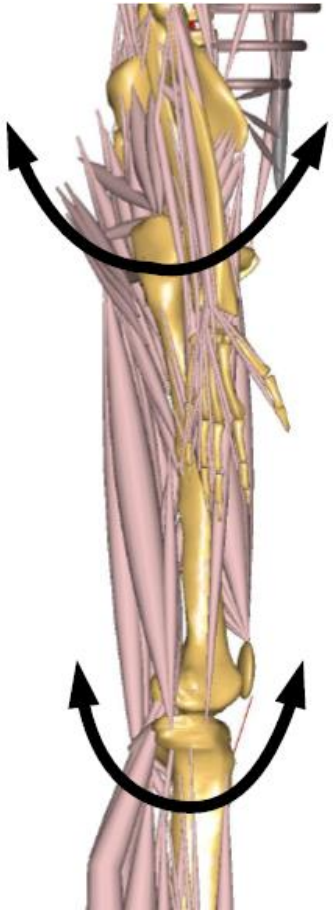




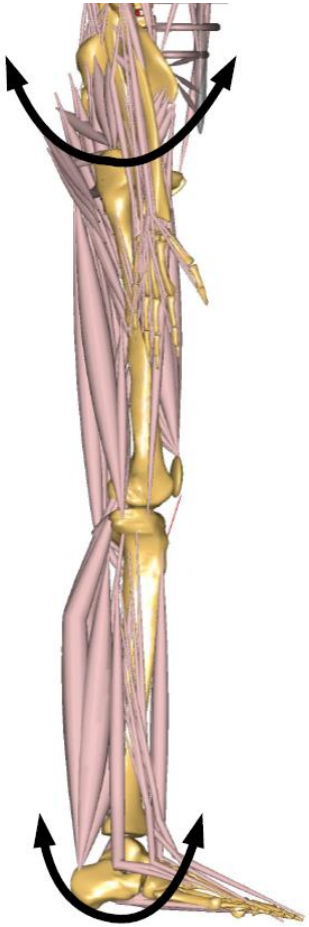




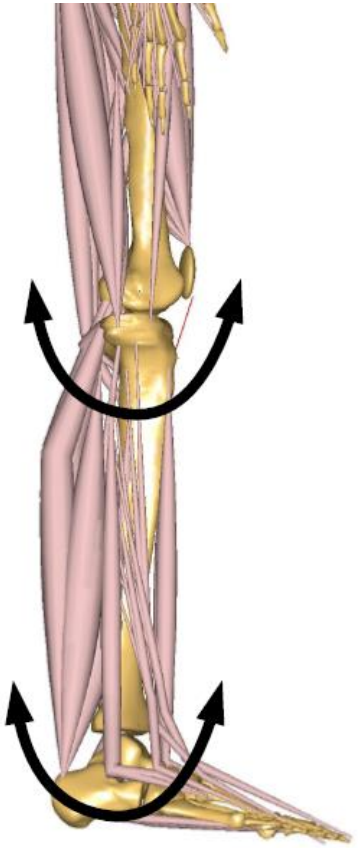
Method – Combined load cases



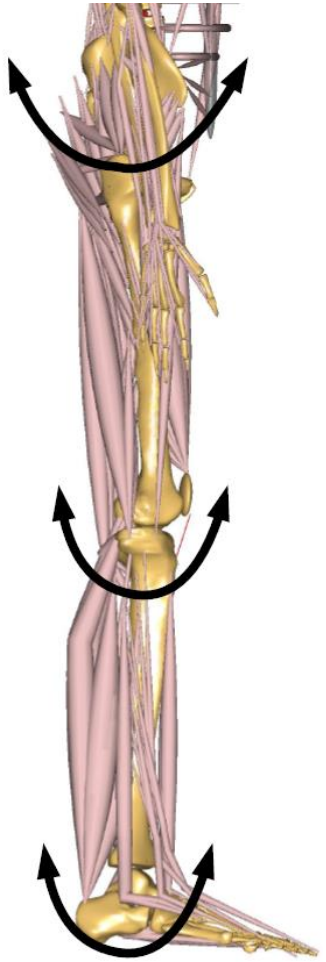
Hip+Knee



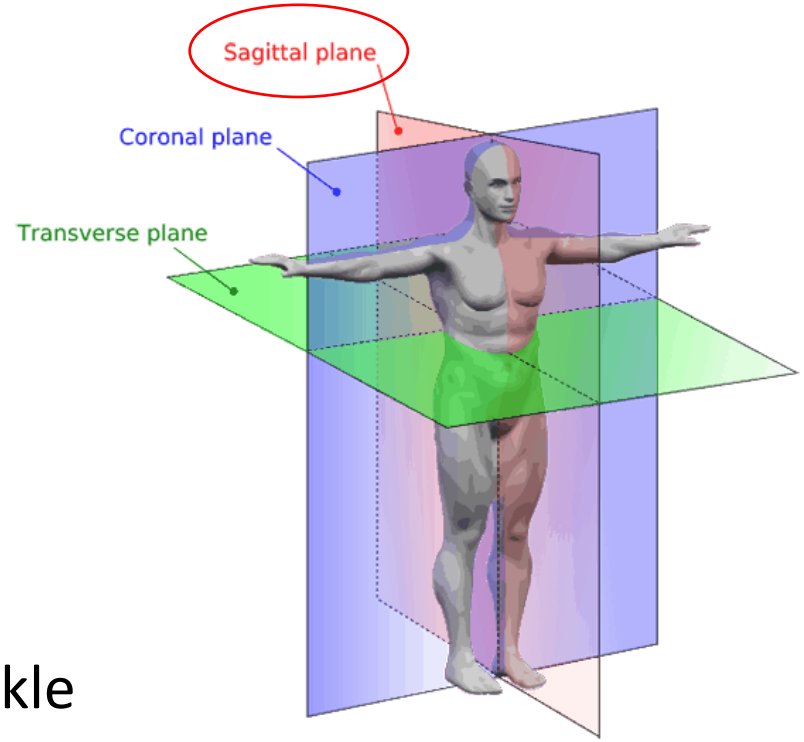
Hip+Ankle



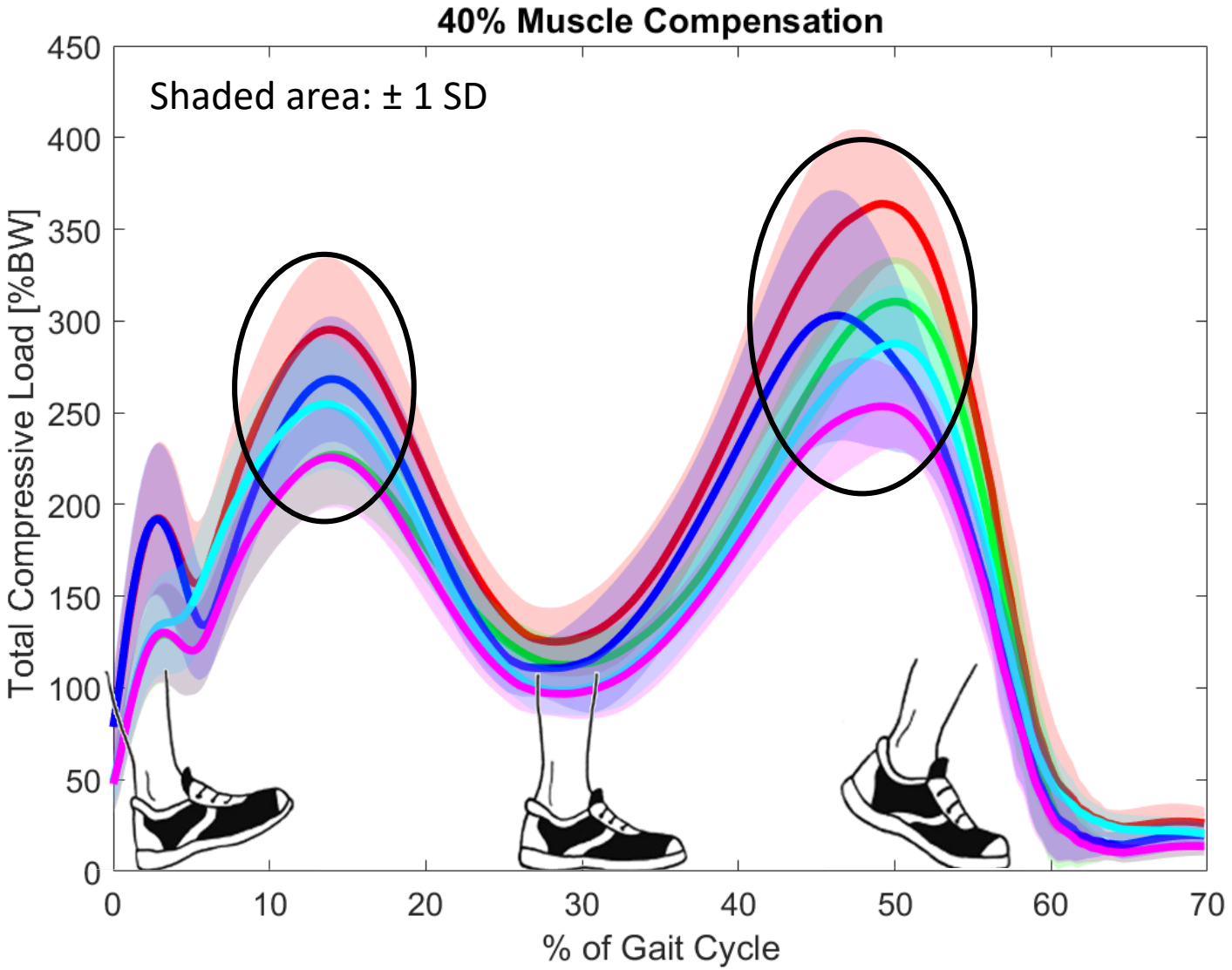
Knee+Ankle

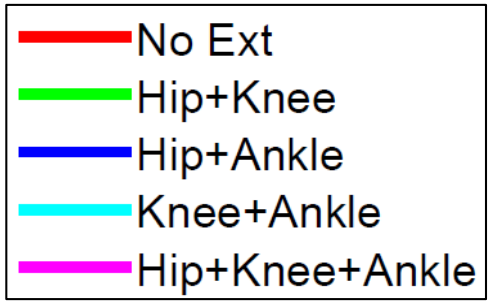


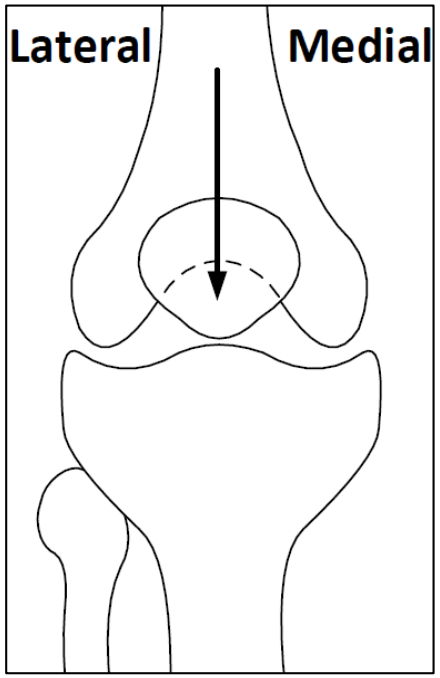
Hip+Knee+Ankle



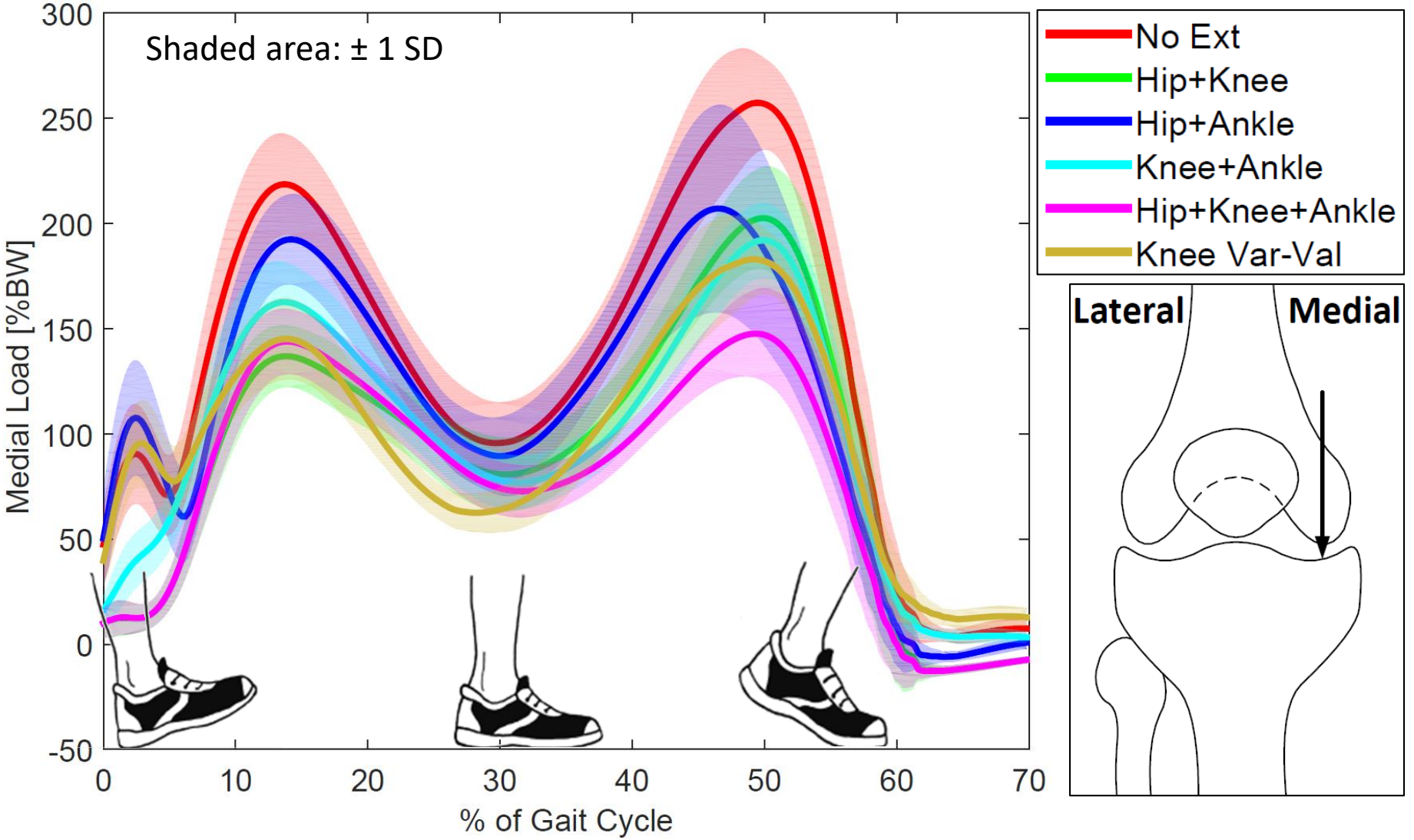
Results – Total compression load



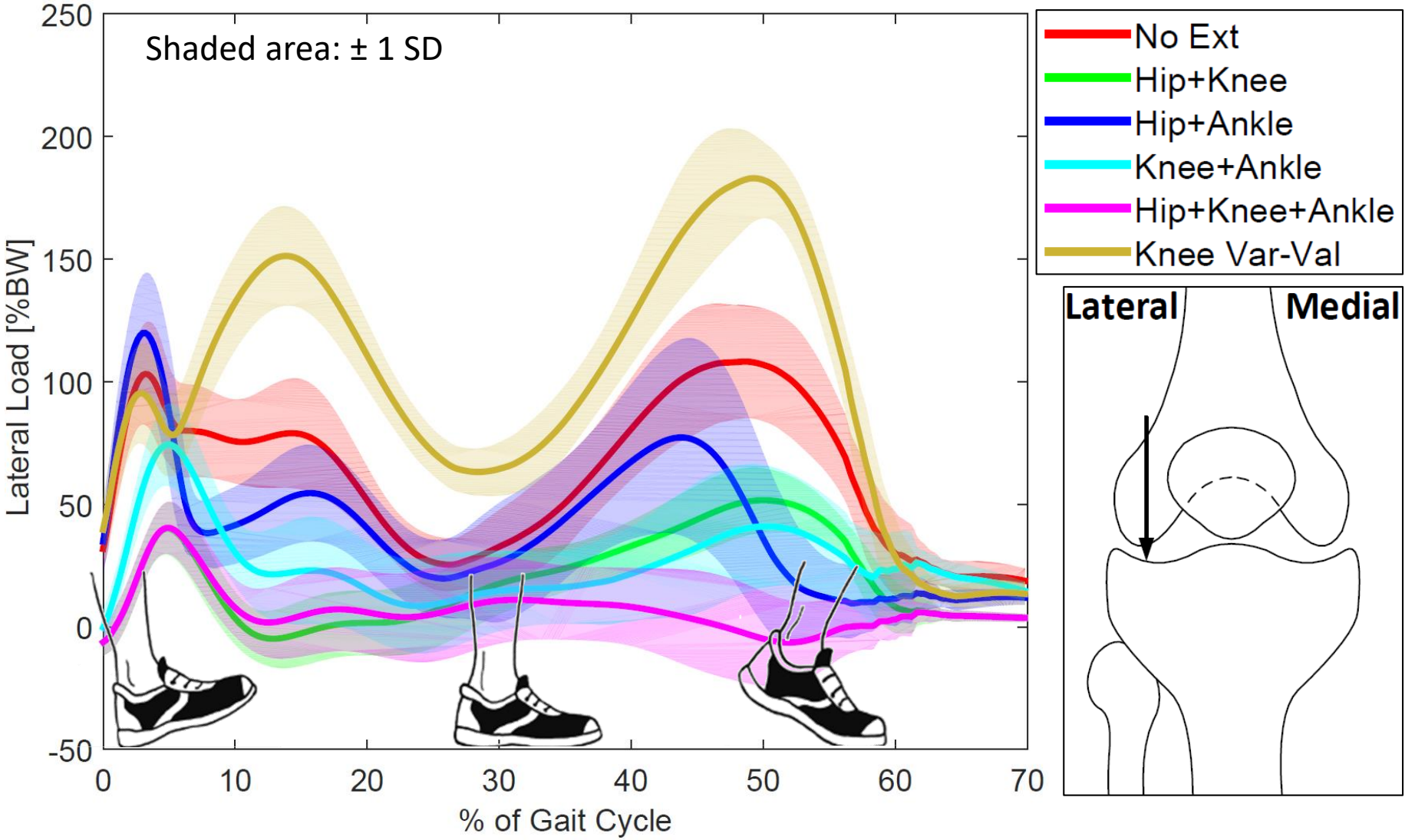




Results – Medial condyle load



Results – Lateral condyle load



Discussion and Conclusion

- Useful information for brace development
- Muscle contraction → Joint compressive force
  - First peak: Knee and hip compensation
  - Second peak: Ankle compensation
- The external moment activation is a big challenge
  - Combine two moments

- Take home message:

  Muscle compensation might be a more efficient approach for joint load reduction

Thank you - Questions

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