HOW INTERNAL KNEE COMPRESSION FORCES ARE MOST EFFECTIVELY REDUCED BY APPLIED HIP, KNEE AND ANKLE JOINT MOMENTS

Jonas S. Stoltze, John Rasmussen and Michael S. Andersen
The XXVI Congress of the International Society of Biomechanics, Brisbane, Australia, July 24

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Motivation – Knee Osteoarthritis (KOA)

Lateral Medial

- Inflammation
- 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

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

Modified picture from (Pollo et al. 2002)
Investigate how internal knee joint loads depend on external moments

Hypothesis: Joint loads depend as much on muscle contraction as on KAM
10 healthy subjects, 3 gait trials each (self-selected speed)
• Recorded with marker-based motion capture
• Measured ground reaction force

Skals et. al, 2016
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 $\rightarrow$ Reducing joint load

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How Internal Knee Compressive Forces are Most Effectively Reduced by Applied Hip, Knee and Ankle Joint Moments
Method

Example of knee flex-ext
Results – Parameter study

**Knee Fle-Ext muscle compensations**

<table>
<thead>
<tr>
<th>% of Gait Cycle</th>
<th>Total Load [%BW]</th>
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<tr>
<td>0%</td>
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<td>20%</td>
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**Ankle Plant-Dors muscle compensations**

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Results – Total compression load

40% Muscle Compensation

Shaded area: ± 1 SD

- Normal
- Hip Fle-Ext
- Knee Fle-Ext
- Ankle Plant-Dors

Lateral Medial

Sagittal plane
Coronal plane
Transverse plane

% of Gait Cycle

Total Compressive Load [%BW]
Method – Combined load cases

Hip+Knee

Hip+Ankle

Knee+Ankle

Hip+Knee+Ankle
Results – Total compression load

40% Muscle Compensation

Shaded area: ± 1 SD

Total Compressive Load [%BW]

% of Gait Cycle

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Results – Medial condyle load

Shaded area: ± 1 SD

No Ext
Hip+Knee
Hip+Ankle
Knee+Ankle
Hip+Knee+Ankle
Knee Var-Val

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Results – Lateral condyle load

Shaded area: ± 1 SD

No Ext
Hip+Knee
Hip+Ankle
Knee+Ankle
Hip+Knee+Ankle
Knee Var-Val

Lateral Load [%BW]

% of Gait Cycle

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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
  - Two moments active individually

- Take home message:

  Muscle compensation might be a more efficient approach for joint load reduction than external KAM compensation
Thank you - Questions