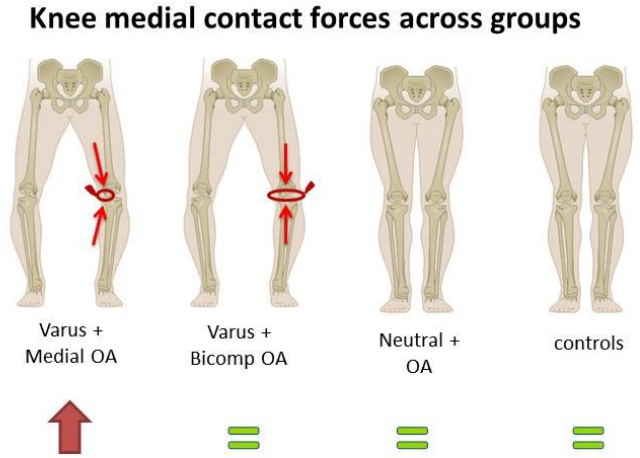
The webcast will start in a few minutes….

Knee internal contact forces in the knee osteoarthritis population



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Outline

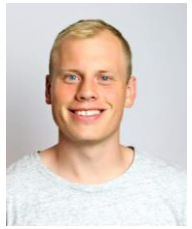
- Brief introduction
- Today’s webcast:
  - Clinical application of a biomechanical model to estimate knee contact forces in patients with osteoarthritis
  - Identification of clinical subgroups which may benefit from biomechanical interventions
- Questions and answers

Presenter:

Andrea Dell'Isola
Lecturer in Biomechanics
Edinburgh Napier University

Panelist:

Michael Skipper Andersen
Associate professor
Aalborg University



Host:

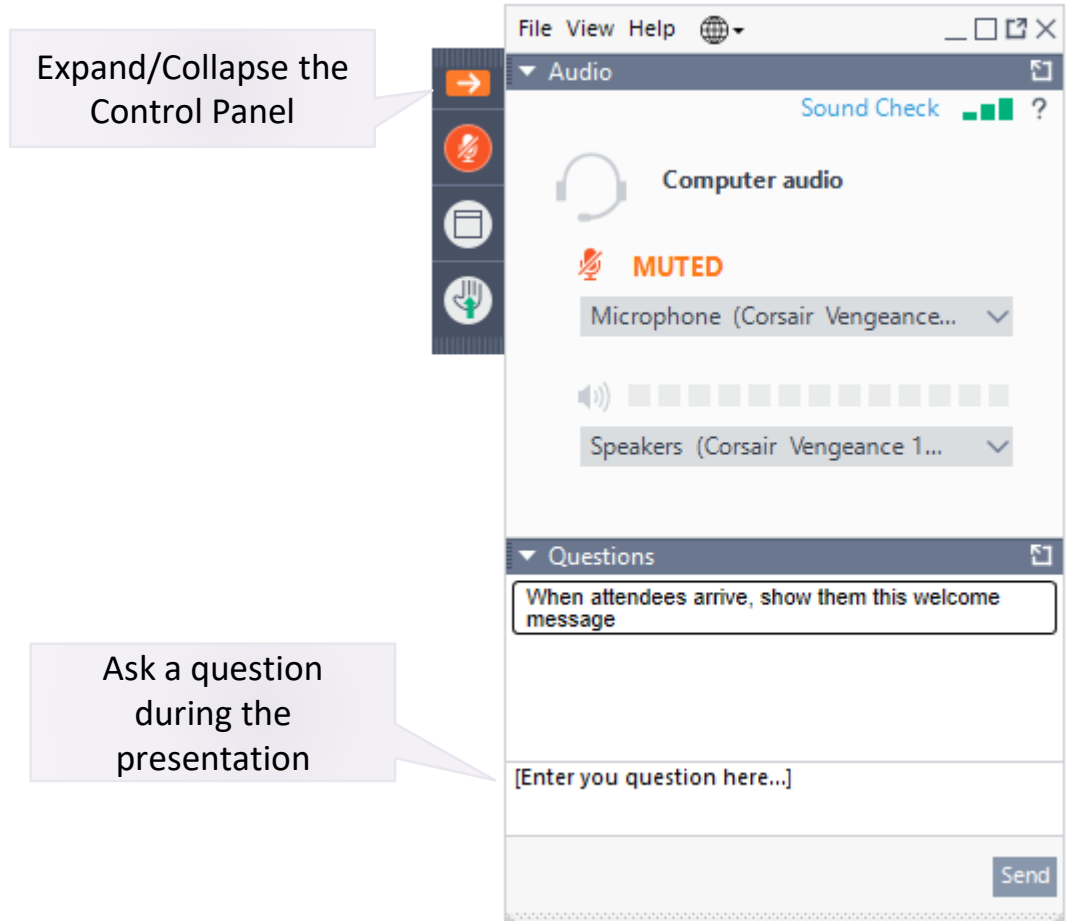
Kasper Pihl Rasmussen
Simulation Engineer
AnyBody Technology

Control Panel

The Control Panel appears on the right side of your screen.

Submit questions and comments via the Questions panel.

Questions will be addressed at the end of the presentation. If your question is not addressed we will do so by email.



Musculoskeletal Simulation

Motion data

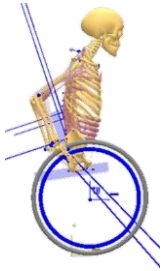
Kinematics + Forces

ANYBODY Modeling System

Body Loads

- Joint moments
- Muscle forces
- Joint reaction forces

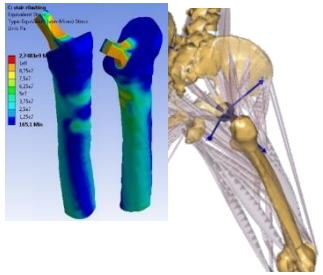
Movement Analysis



Product Design Optimization

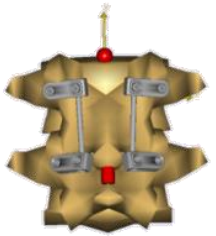
ANYBODY Modeling System

Ergonomic Analysis

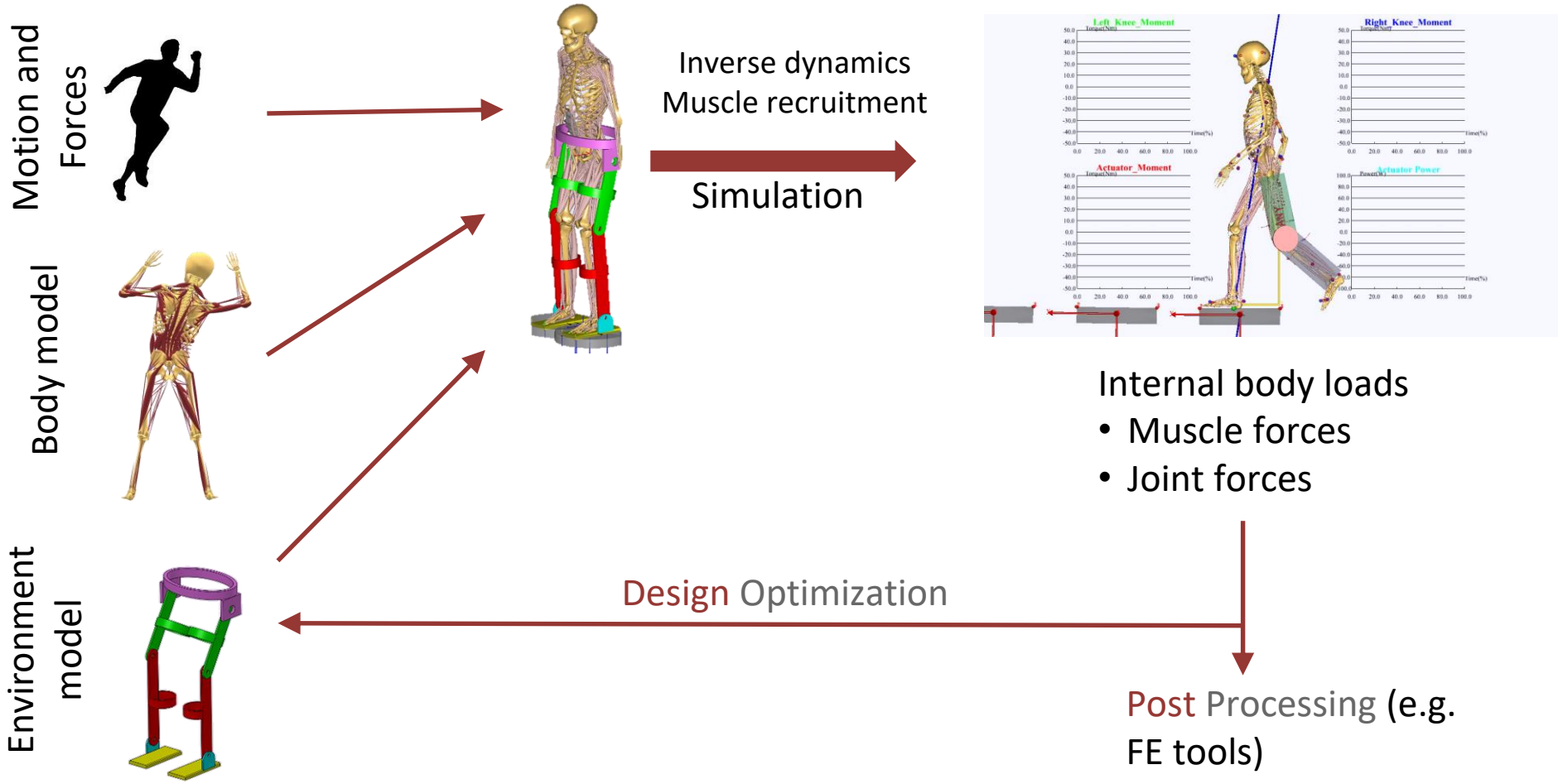


Load Cases for Finite Element Analysis

Surgical Planning and Outcome Evaluation



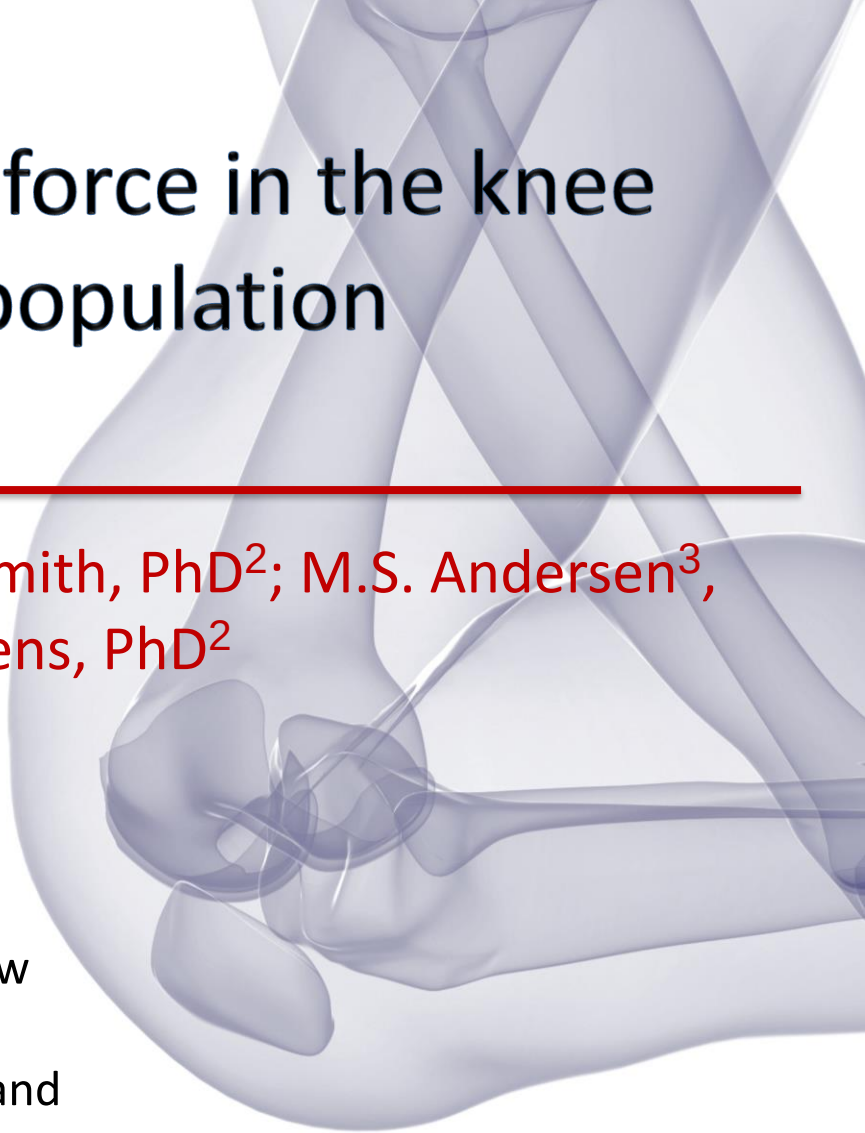
AnyBody Modeling System



Knee internal contact force in the knee osteoarthritis population

Andrea Dell'Isola, PT, PhD[1,2]; S.L. Smith, PhD[2]; M.S. Andersen[3], PhD; M. Steultjens, PhD[2]

1 School of Applied Science, Edinburgh Napier University
2 Institute of Applied Health Research, Glasgow Caledonian University
3 Department of Mechanical, Manufacturing and Management Engineering, Aalborg University



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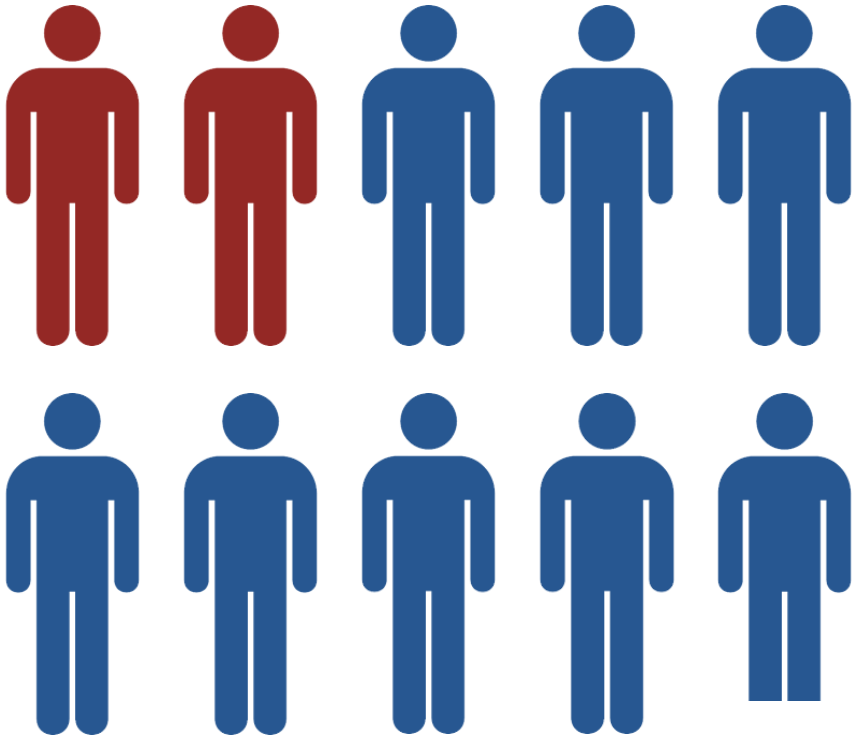
Osteoarthritis

Osteoarthritis is the most common joint disease and is listed among the top 5 cause of disability worldwide (WHO; 2016).



Knee Osteoarthritis

- The knee is the most affected joint.
- Treatments are limited to pain management.
- High complexity and heterogeneity

(Karsdal 2016)

DISEASE **MODEL**

Osteoarthritis (OA) is not a single disease or process,

but rather the clinical and pathological outcome of a

range of disorders initiated by biological, morphological and structural components (Andriacchi 2009)

DISEASE **MODEL**

Altered loading
Normal physiology

Normal loading
Altered physiology

Malalignment
Muscle weakness
Trauma

Inflammation
Metabolic factors
Genetic factors

Phenotype

a (group of) characteristic(-s) indicative of a unique underlying mechanism explaining KOA-related outcomes (e.g. pain, physical function, joint damage) in a distinct subgroup of KOA patients.

Dell'Isola *et al. BMC Musculoskeletal Disorders* (2016) 17:425
DOI 10.1186/s12891-016-1286-2

BMC Musculoskeletal Disorders

RESEARCH ARTICLE Open Access

Identification of clinical phenotypes in knee osteoarthritis: a systematic review of the literature

A. Dell'Isola*, R. Allan, S. L. Smith, S. S. P. Marreiros and M. Steultjens

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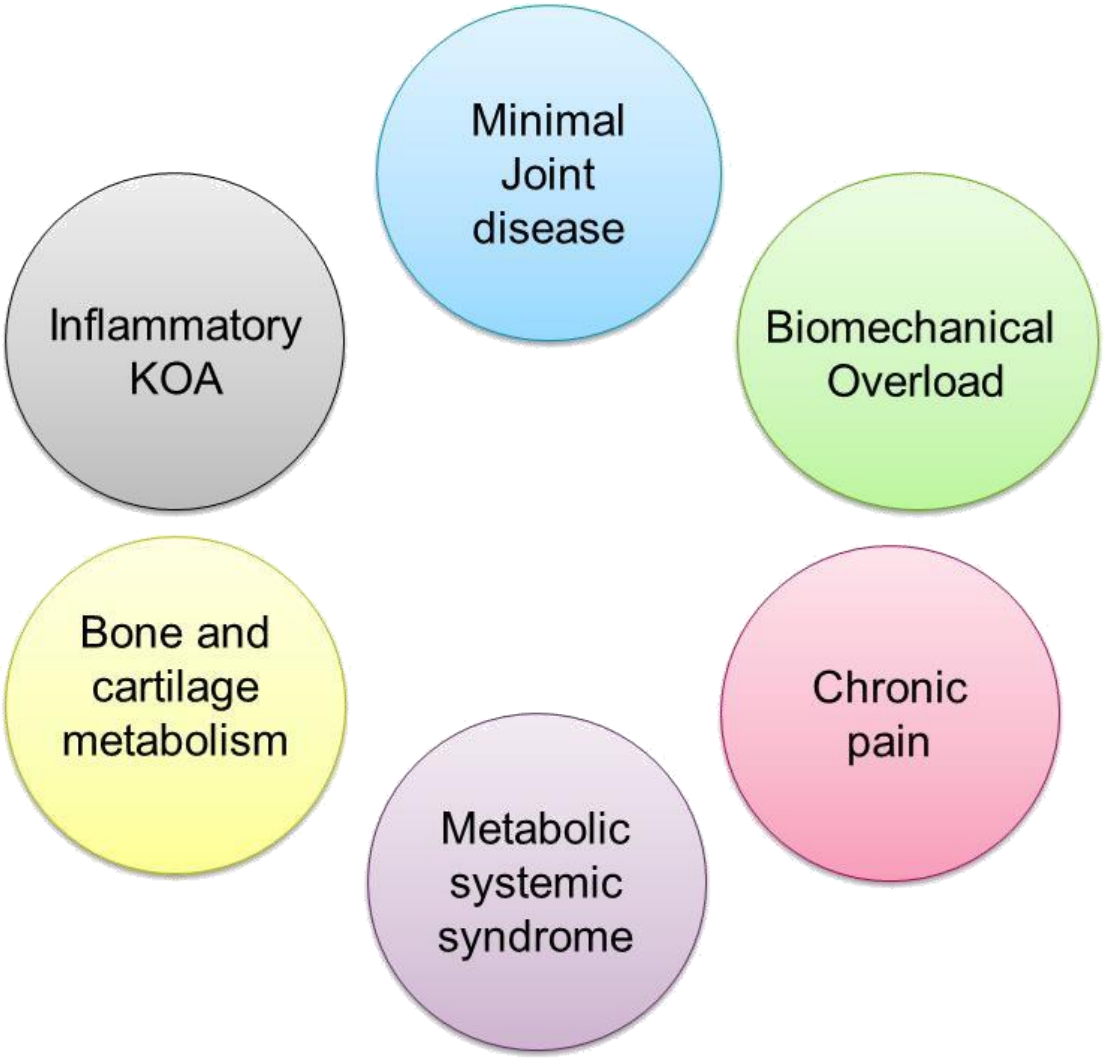
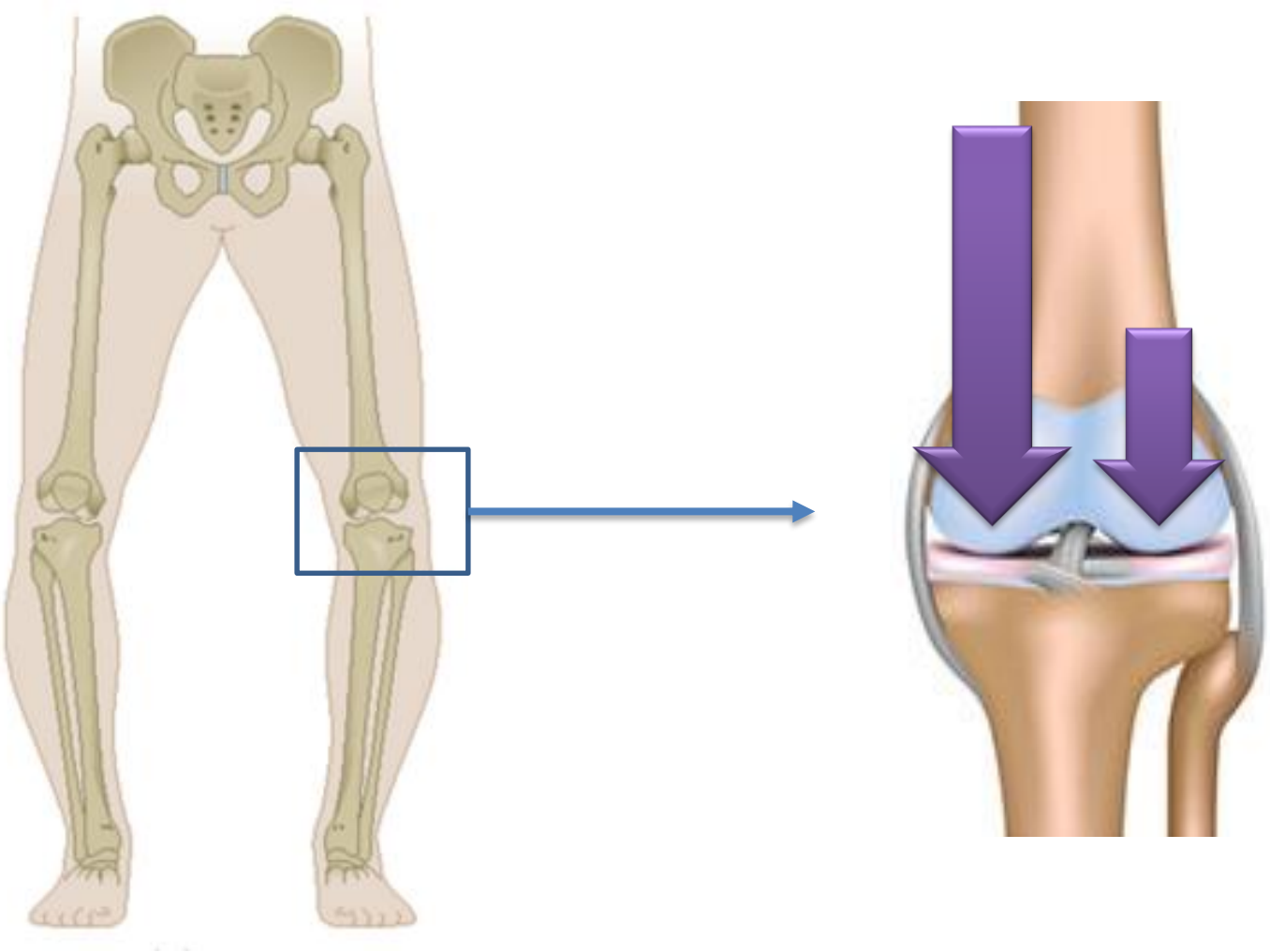
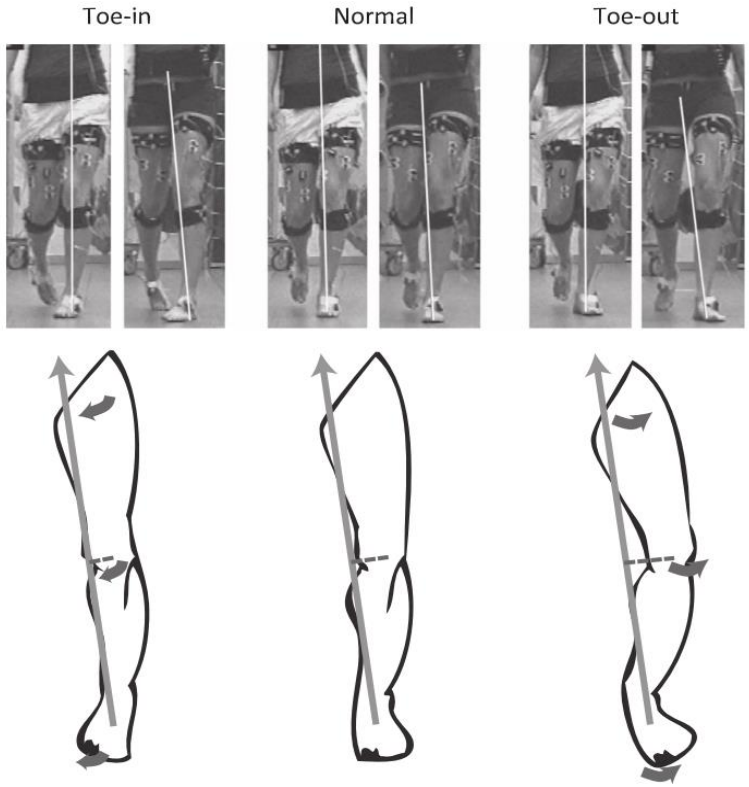

Minimal Joint disease
Biomechanical Overload
Chronic pain
Metabolic systemic syndrome
Bone and cartilage metabolism
Inflammatory KOA

Biomechanical Overload Phenotype

BIOMECHANICAL **PHENOTYPE**



BIOMECHANICAL **INTERVENTIONS**



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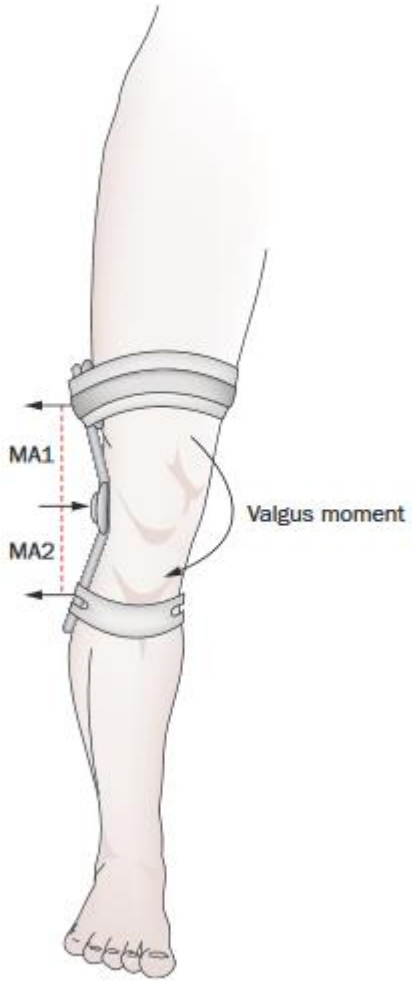
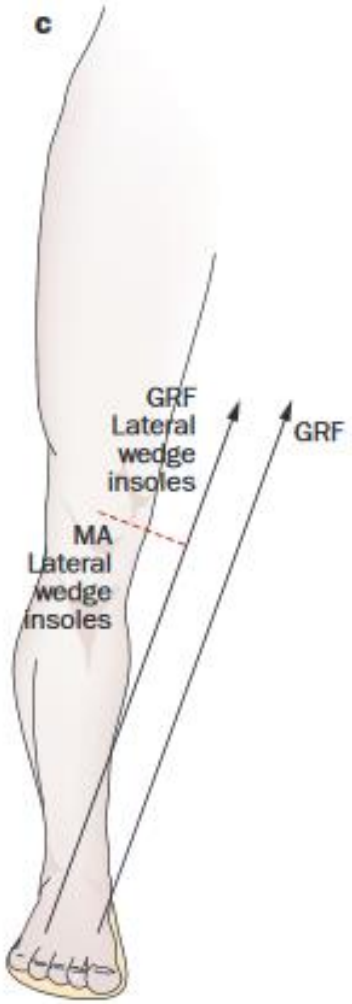
Valgus bracing



Lateral wedged insole

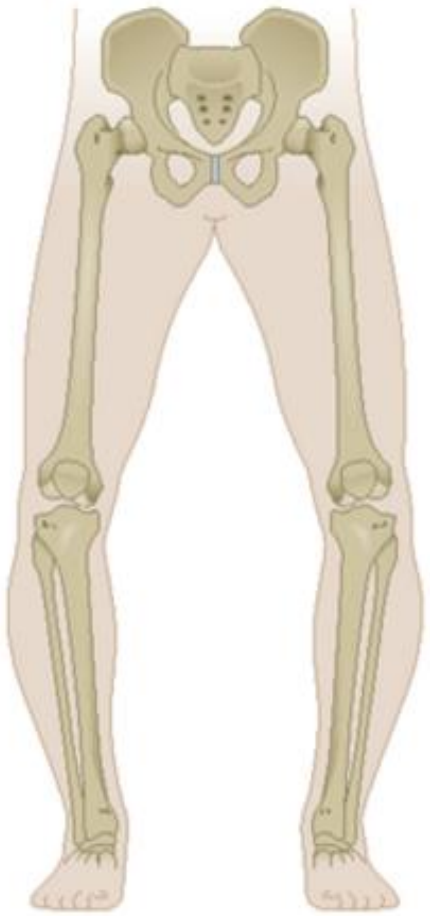


BIOMECHANICAL **INTERVENTIONS**

Current evidence regarding the effectiveness of this intervention in subjects with medial OA is contrasting

(Cochrane review; Duivenvoorden 2015)

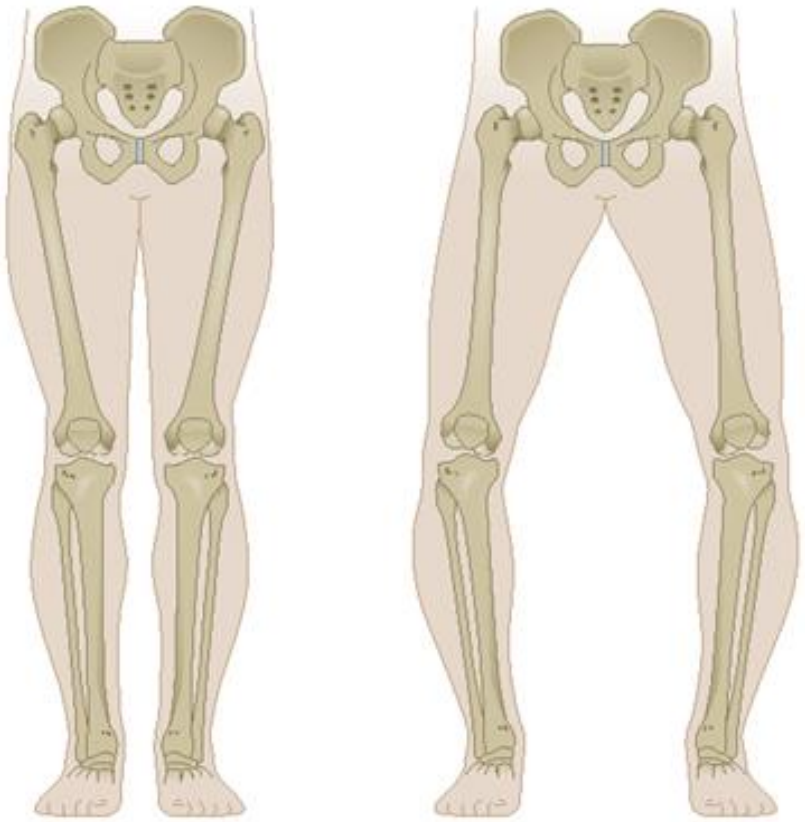
BIOMECHANICAL **PHENOTYPE**



Some knees with varus malalignment show sign of OA in the lateral compartment which should be unloaded (due to the alignment)

These patients may not have increased medial knee CFs

BIOMECHANICAL **PHENOTYPE**

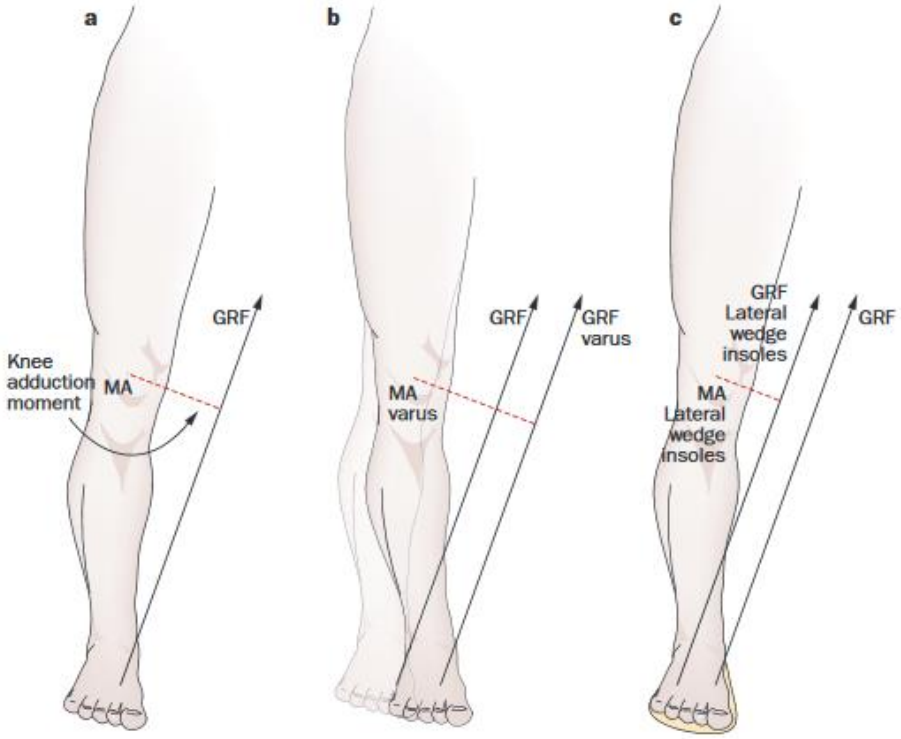


Controls Varus

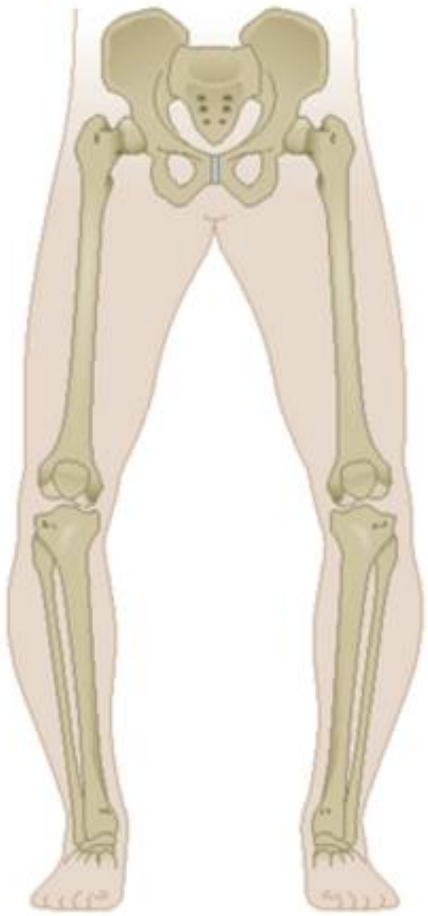
A recent study (Kumar, 2013) failed to identify differences in medial knee CF between controls and subjects with medial KOA (and varus alignment)

BIOMECHANICAL **INTERVENTIONS**

- Patient selection often based only on alignment and/or X-ray



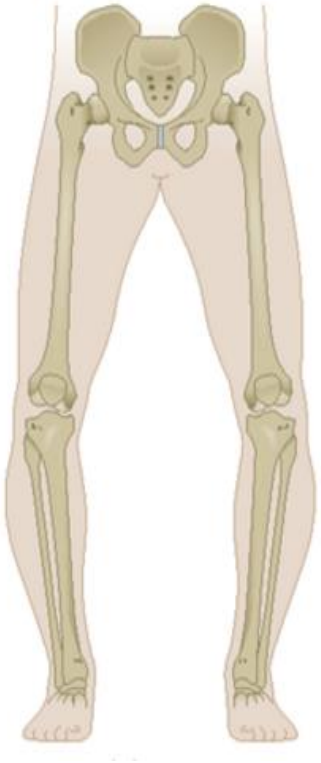
BIOMECHANICAL **PHENOTYPE**



There is the need to identify subjects characterized by increased medial knee loading in order to:

- develop personalized treatments
- improve treatment allocation

STUDY **HYPOTESIS**



Varus +
OA

Neutral Align +
OA
NA

Controls
C

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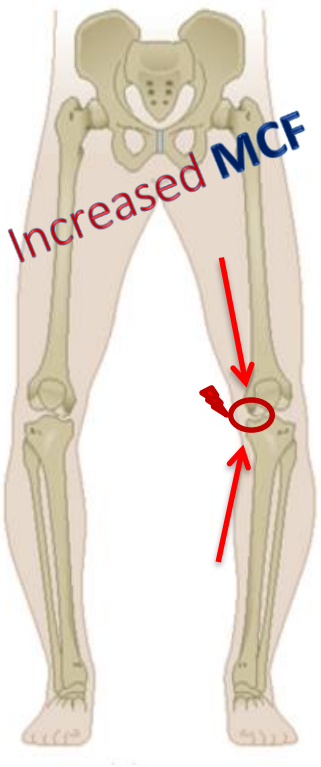
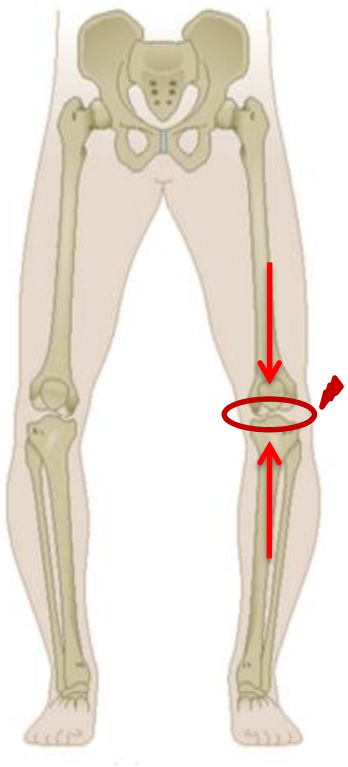
STUDY **HYPOTESIS**



Varus + medial OA

VMD



Varus + generalized OA

VGD

Neutral Align + OA

NA

Controls

C

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STUDY **AIMS**

Primary:

To compare the knee joint **CFs** across the aforementioned groups (VMD, VGD, NA, Controls)

Secondary:

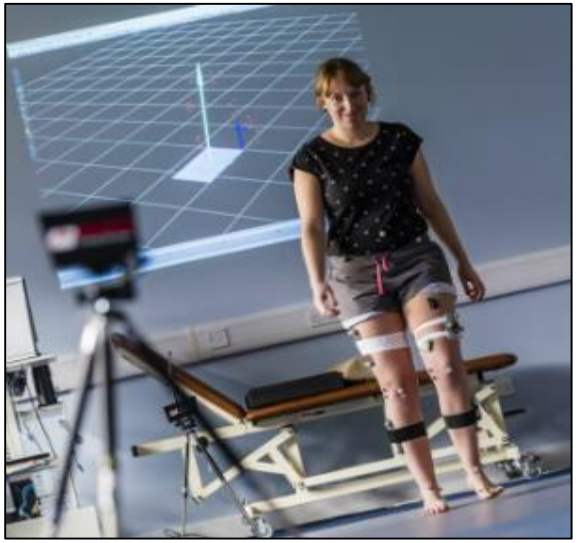
To explore the influence of the subgroup division on the relationship between alignment and medial CFs.

To compare MRI biomarkers across the aforementioned groups (VMD, VGD, NA, Controls)

STUDY **SAMPLE**

39 KOA patients; 18 controls

MRI
Gait Analysis
Clinical assessment



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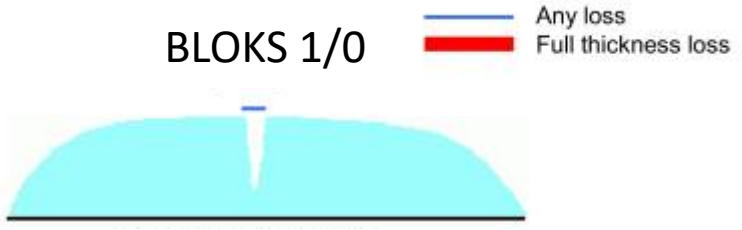
MRI assessment: BLOKS

Boston-Leeds Osteoarthritis Knee Score

- Semi quantitative score
- Cartilage damage score is composed by 2 values:
  - ➢ % of the area affected by cartilage loss (0-3)
  - ➢ % extent of full thickness lesions (0-3)

BLOKS 1/0

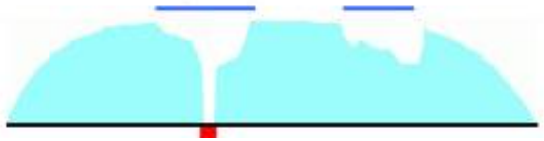


Degeneration <10% area/ no full thickness

BLOKS 2/0

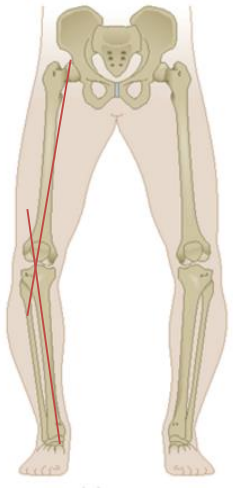
Deg. 10-75% area/ no full thickness

BLOKS 2/1



Deg. 10-75% area/ <10% area full thickness

STUDY **SAMPLE**



Alignment

Varus alignment: Hip knee ankle angle variation **≥ 2˚** in varus diraction

Neutral alignment = Hip knee ankle angle variation < 2˚ in either direction

Cartilage degeneration (BLOKS)

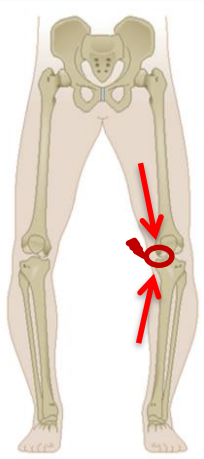
Medial OA: bloks score ≥ 2/0 medial compartment and ≤1/0 in the lateral compartment.

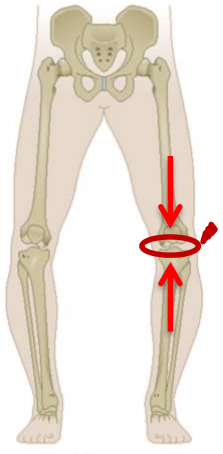
Generalized OA: Boks score > 1/0 in the lateral compartment (or > BLOKS medial compartment)

STUDY **SAMPLE**

39 KOA patients; 18 controls

- Varus
  - Varus + medial OA=12 **VMD**
  - Varus + gener. OA=17 **VGD**
- Neutral
  - Neutral align + OA=10 **NA**
- Controls= 18 **C**





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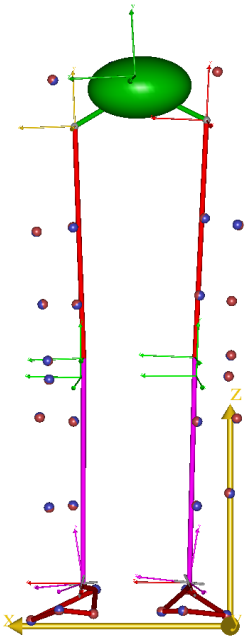
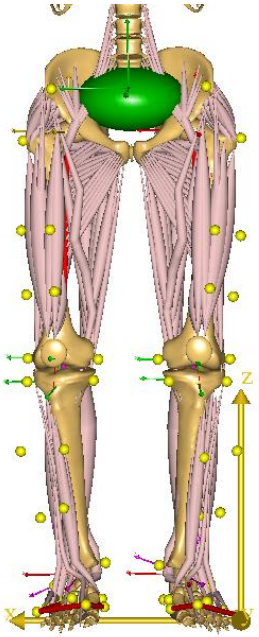
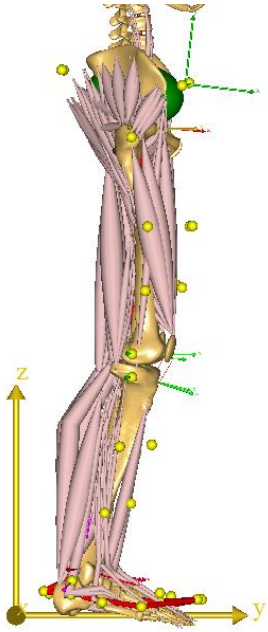
MUSCULOSKELETAL **MODEL**

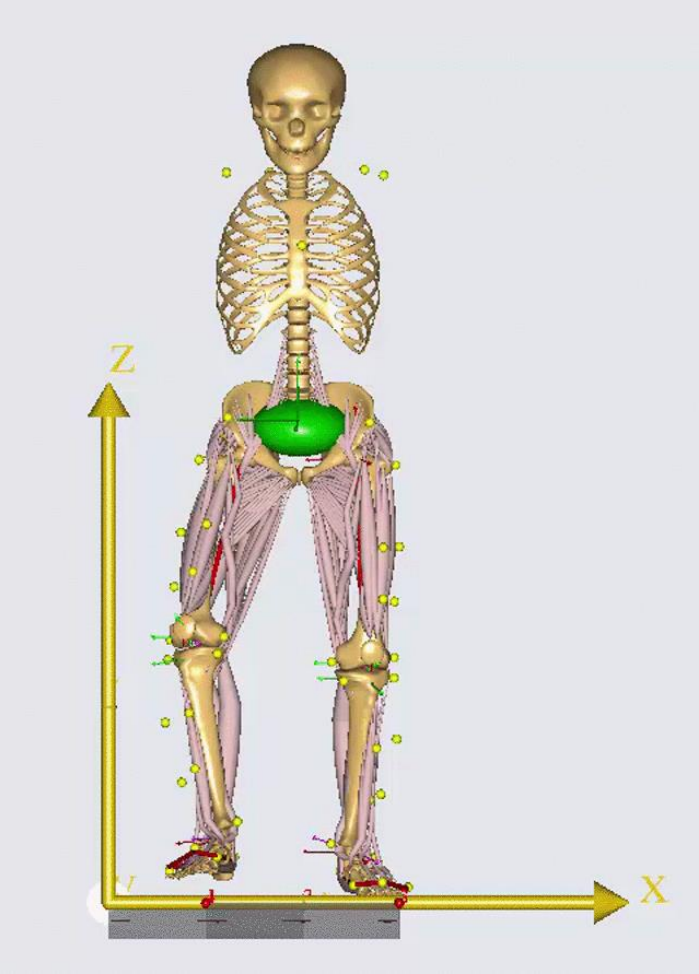
A stick-figure model was derived based on the markers from the standing reference trial the TLEM musculoskelatal model was morfed to match the stick-figure (Lund 2015)





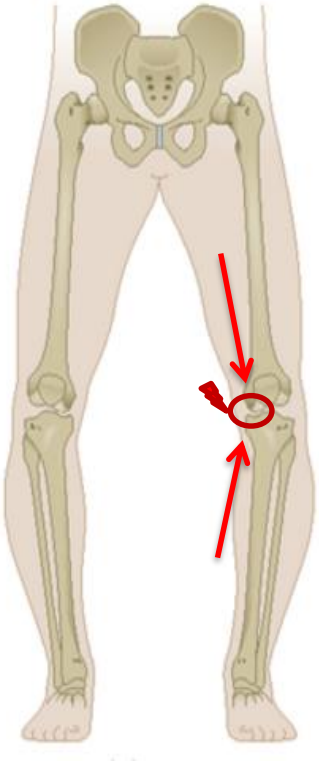


MUSCULOSKELETAL **MODEL**



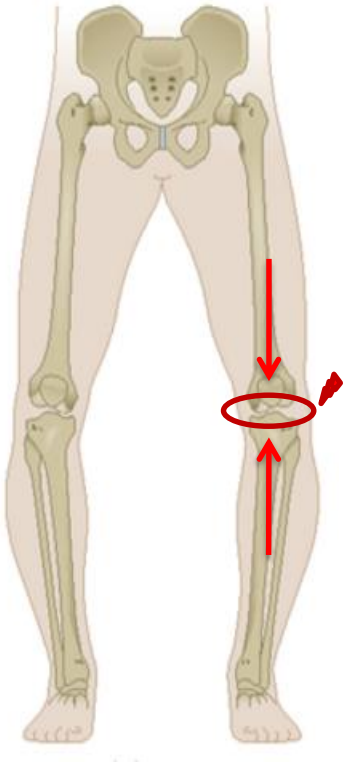
The stick-figure model was used to estimate the kinematics of the patient for dynamic trials.

RESULTS



Varus + medial OA

Vs



Varus + generalized OA

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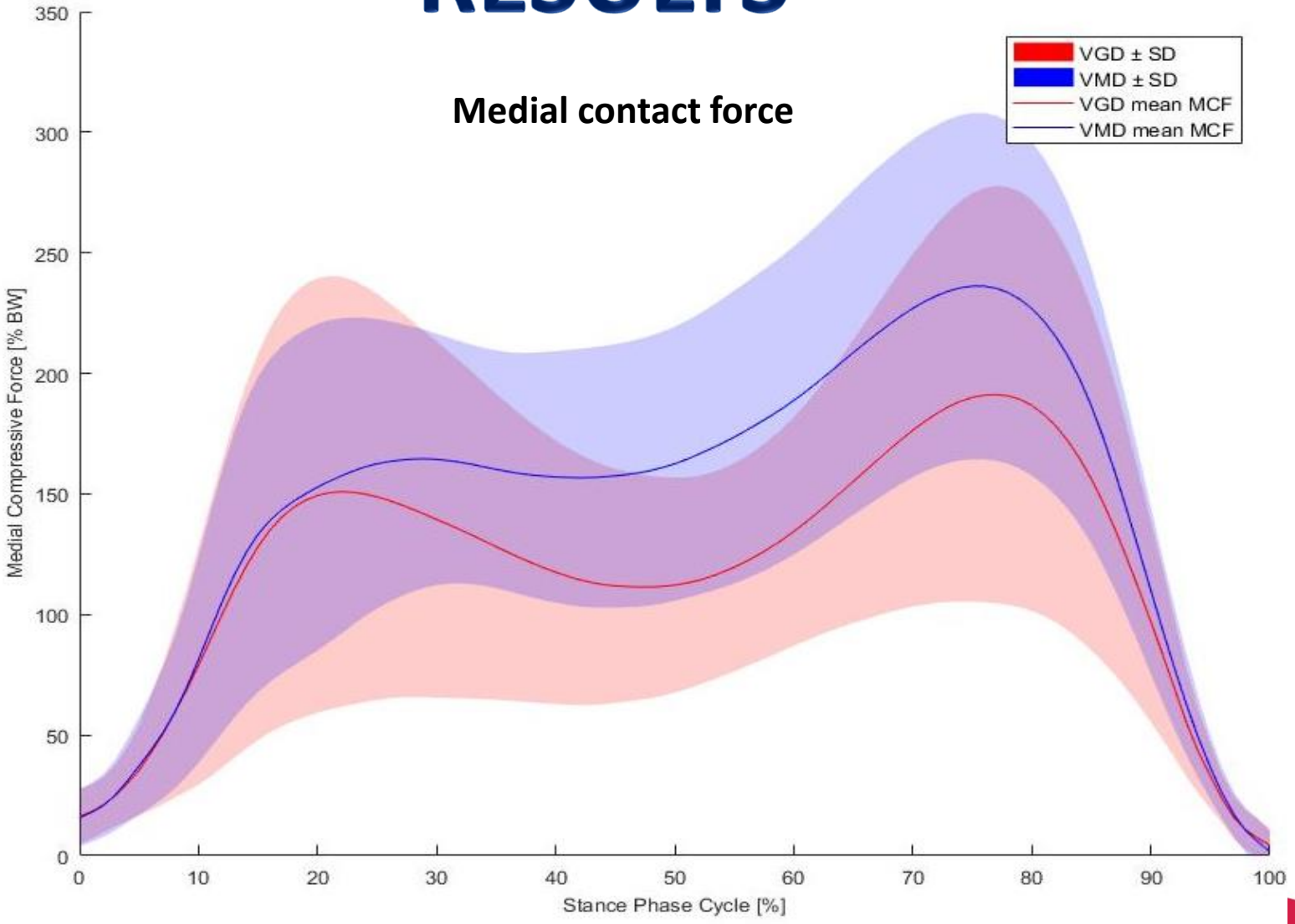
RESULTS

Medial contact force



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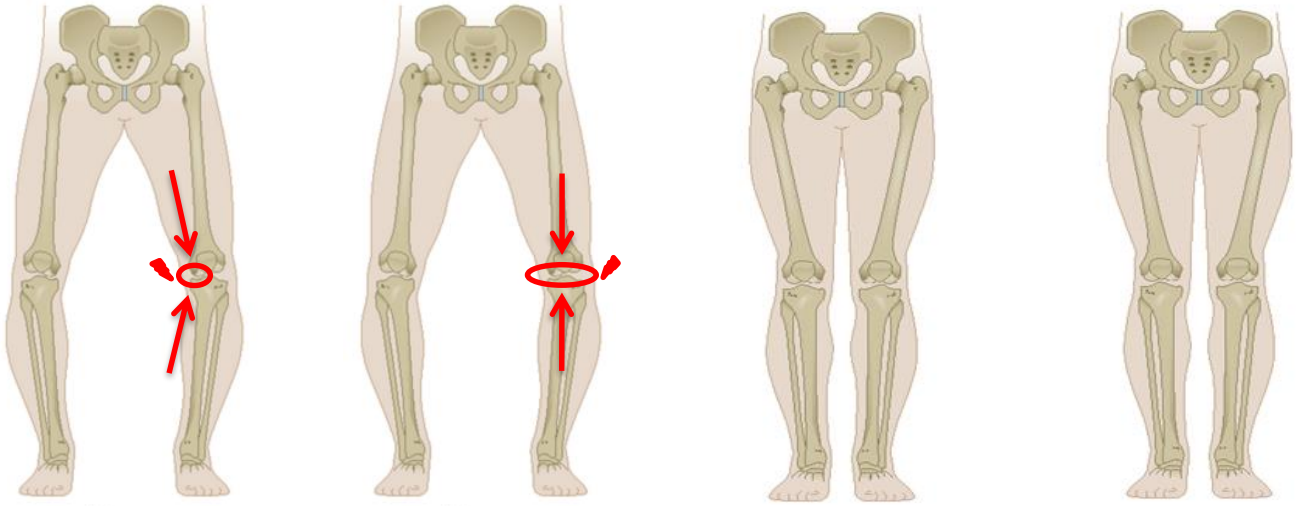
RESULTS

Knee medial contact forces (CF) across groups



Medial CF	VMD (1)		VGD (2)		NA (3)		C (4)	
	$Mean_{adj}$	SE	$Mean_{adj}$	SE	$Mean_{adj}$	SE	$Mean_{adj}$	$Mean_{adj}$
Impulse (Bw*s)	↑ 1.01^{all}	0.04	0.82	0.03	0.84	0.04	0.85	0.03
Peak (Bw)	↑ 2.30^{2}	0.08	1.97^{1}	0.06	2.07	0.08	2.13	0.06

All: significantly different from all the other phenotypes ($p < 0,05$); **1**: significantly different from group 1 (C) ($p < 0,05$); **2**: significantly different from group 2 (NA) ($p < 0,05$); **3**: significantly different from group 3 (VGD) ($p < 0,05$); **4**: significantly different from group 4 (VMD) ($p < 0,05$)

RESULTS

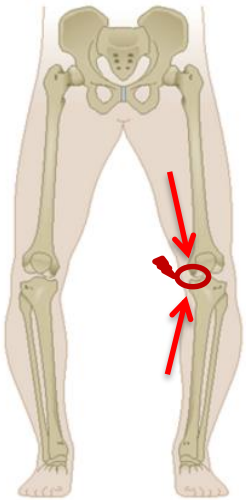
Knee internal contact forces across groups

	VMD (1)		VGD (2)		NA (3)		C (4)	
	$Mean_{adj}$	SE	$Mean_{adj}$	SE	$Mean_{adj}$	SE	$Mean_{adj}$	SE
Lateral CF Impulse (Bw*s)	↓ 0.39	0.04	0.42	0.03	0.49	0.04	0.48	0.03
Lateral CF peak (Bw)	↓ $1.00^{3,4}$	0.1	1.13^{4}	0.08	1.34^{1}	0.1	$1.44^{1,2}$	0.08
Total CF impulse	1.40^{2}	0.05	1.24^{1}	0.04	1.33	0.06	1.33	0.04
Total CF peak	3.25	0.12	3.10^{4}	0.1	3.40	0.12	3.50^{2}	0.10

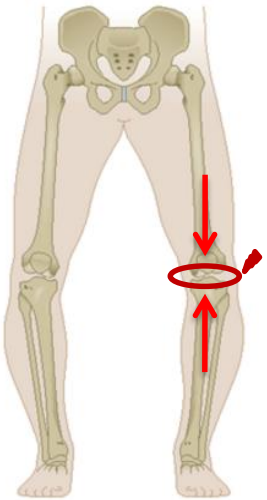
All: significantly different from all the other phenotypes ($p < 0,05$); **1**: significantly different from group 1 (C) ($p < 0,05$); **2**: significantly different from group 2 (NA) ($p < 0,05$); **3**: significantly different from group 3 (VGD) ($p < 0,05$); **4**: significantly different from group 4 (VMD) ($p < 0,05$)

SENSITIVITY ANALYSIS 1

Knee medial contact forces across groups



Varus +
Medial OA



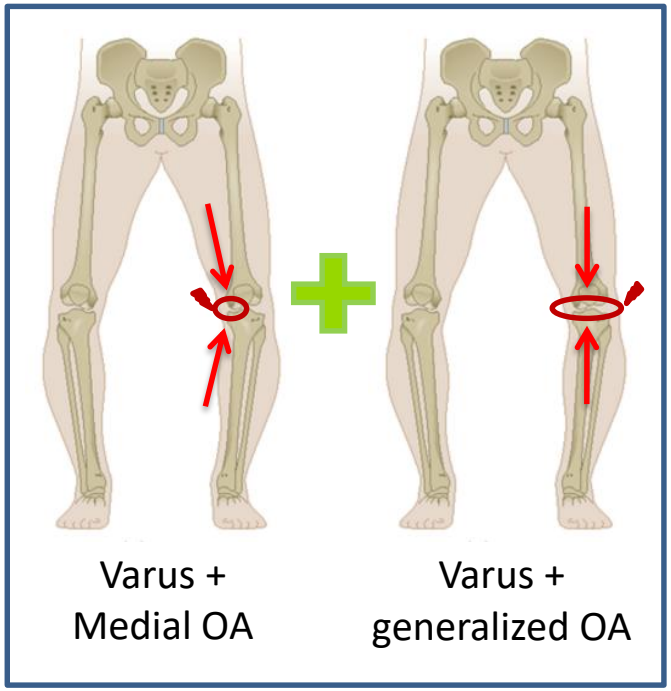
Varus +
generalized OA

Neutral +
OA

controls

SENSITIVITY ANALYSIS 1

Knee medial contact forces across groups



Varus +
Medial OA

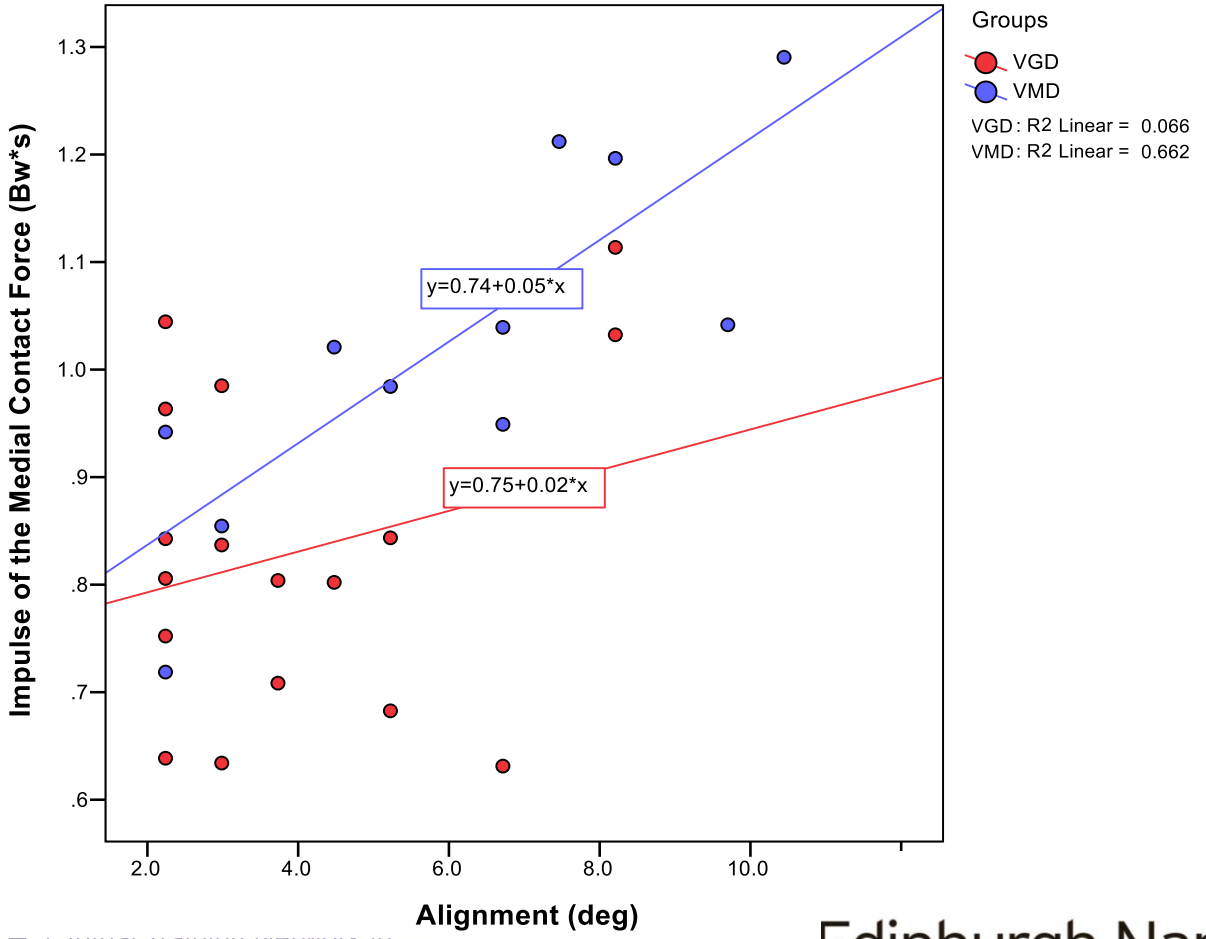
Varus +
generalized OA

Neutral +
OA

controls

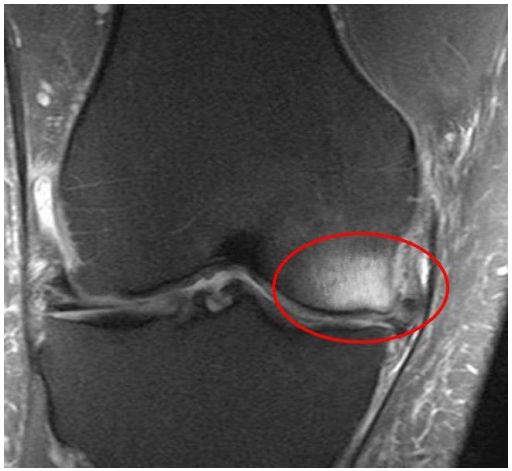
SECONDARY ANALYSIS

Mediation effect of the group membership on the relationship between the impulse of the MCF and alignment



SECONDARY ANALYSIS

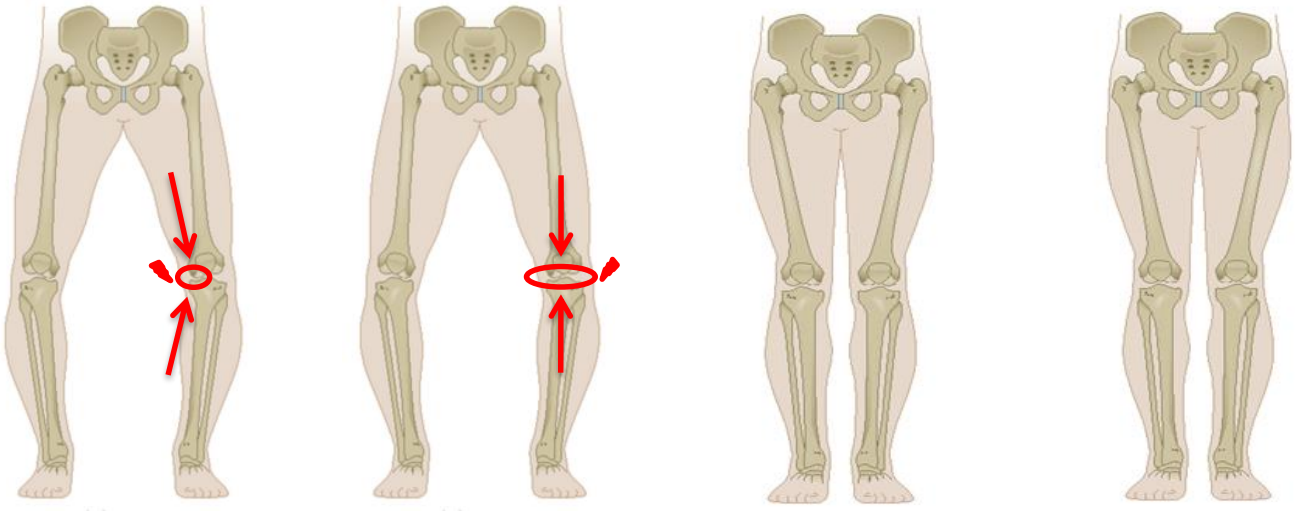
BML



Meniscal maceration

RESULTS

Prevalence of medial compartment large bone marrow lesions (BML):



	VMD	VGD	NA	C
Tibia:	83%	29%	0%	6%
Femur:	58%	18%	10%	6%

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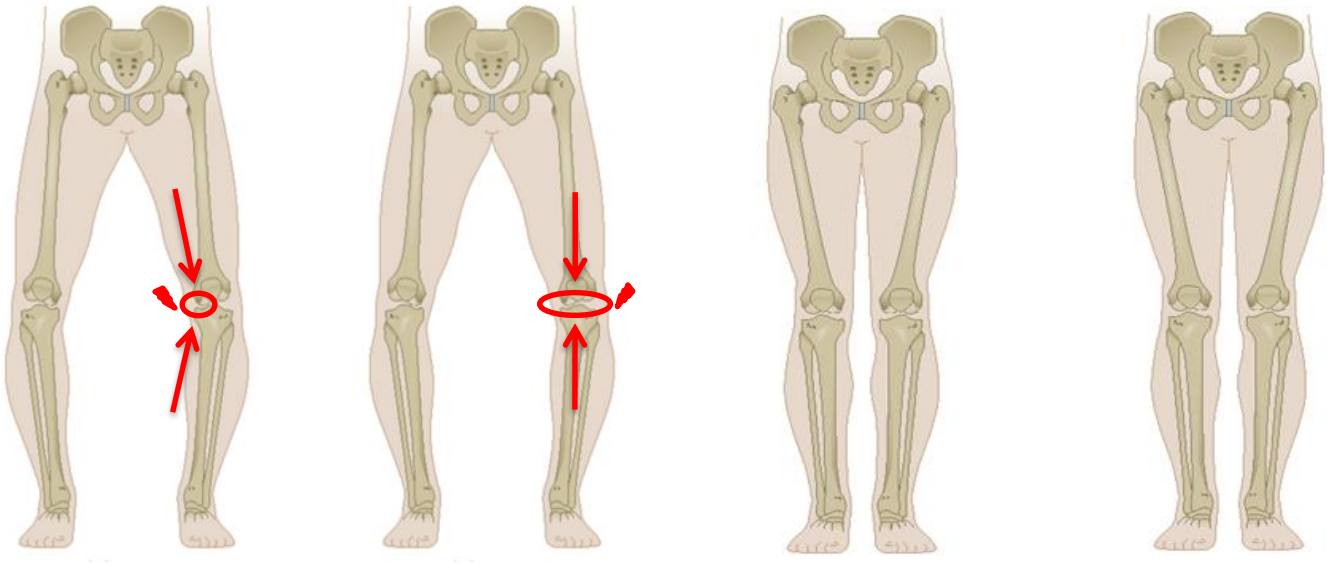
RESULTS

Prevalence of medial compartment meniscal maceration



	VMD	VGD	NA	C
M. Meniscus:	92%	28%	10%	6%

DISCUSSION 1

- **Our results suggest that varus malalignment, in the presence of lateral compartment degeneration, is not associated with the CF of the medial compartment.**

  - This may explain the different response to biomechanical intervention showed in subjects with medial disease.

DISCUSSION 2

- **The impulse of the CF was more sensitive than the peak in identifying differences between the analysed groups.**

  - This finding suggests that the impulse may be a better variable to analyse the difference in load pattern between groups and, therefore, to measure treatment effectiveness.

DISCUSSION 3

- **The higher prevalence of large BML's and meniscal maceration in the medial compartment of the VMD supports the link between increased load and knee disease**

LIMITATIONS

1. MRI costs limit clinical applicability
2. Due to the cross-sectional study design, inferences of causality cannot be made
3. CFs are estimated
4. Limited sample size.

CLINICAL IMPLICATIONS

- Malalignment alone is not sufficient to identify subjects characterized by high medial knee CFs
- The identification of a biomechanical phenotype characterized by higher internal CF may lead to improved treatment effectiveness

PAPER REFERENCE

Osteoarthritis and Cartilage

OARSI OSTEOARTHRITIS RESEARCH SOCIETY INTERNATIONAL

Knee internal contact force in a varus malaligned phenotype in knee osteoarthritis (KOA)

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Dell'Isola A, Smith SL, Andersen MS, Steultjens M. Knee internal contact force in a varus malaligned phenotype in knee osteoarthritis. Osteoarthr Cartil. Osteoarthritis Research Society International; 2017;25(12):2007-2017. http://dx.doi.org/10.1016/j.joca.2017.08.010

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KNEE MO | Initial Training Network in Knee Osteoarthritis Research

AKNOWLEDGMENTS

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Funding

MARIE CURIE ACTIONS

SEVENTH FRAMEWORK PROGRAMME

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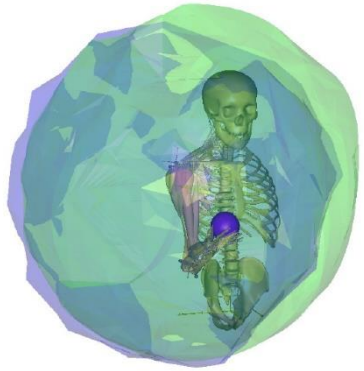
Upcoming webcasts

26 Apr: Model validation using the anatomical reachable 3-D workspace



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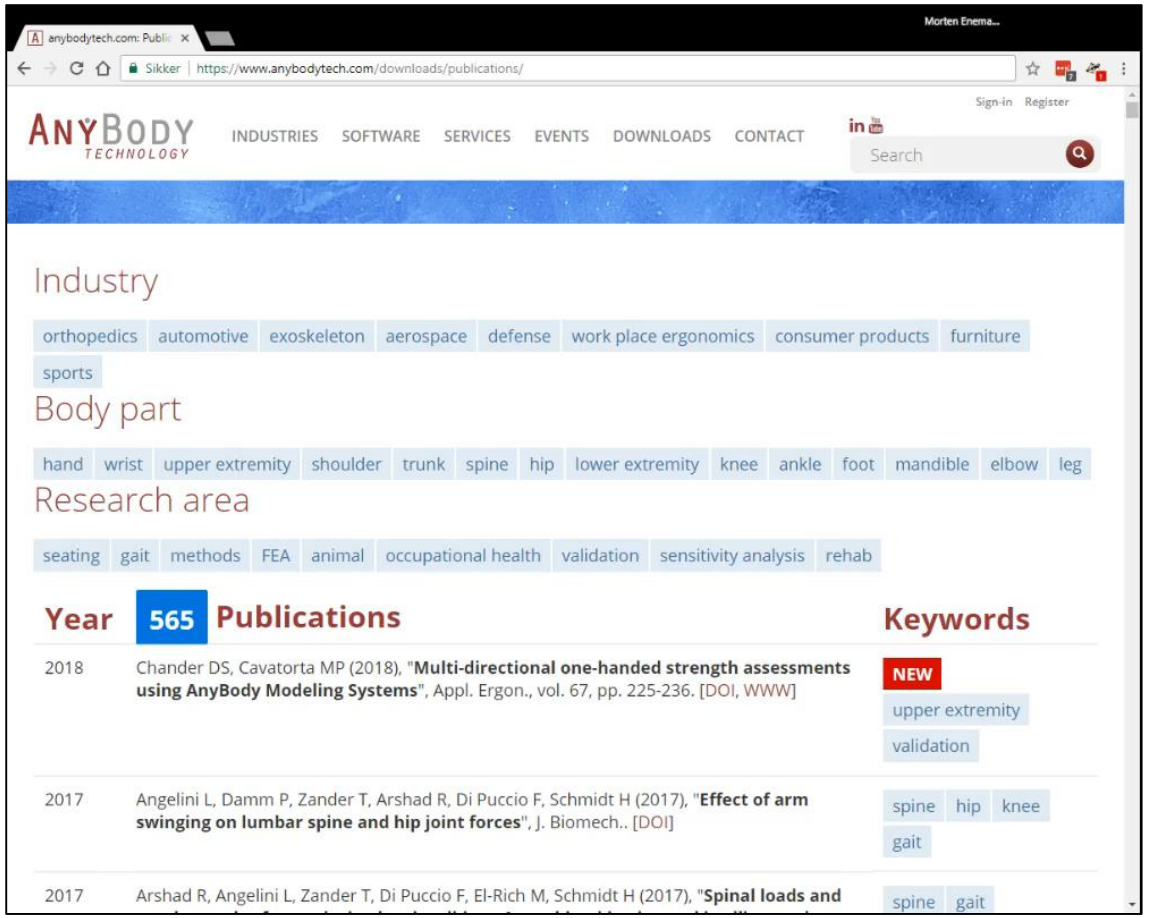
- Events, dates, publication list, ...



Events:

26-29 Mar: CMBBE 2018 in Lisbon

30 Apr- 4 May: Advanced PhD course on Musculoskeletal modeling. Aalborg University, Denmark.

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