
4
BWF
BASEL2019
SWITZERLAND
TOTAL
WORLD
CHAMPIONSHIPS
BASEL2019
SWITZERLAND
TOTAL
YONEX
swiss
badminton
Basel
swiss
olympic
swiss
paralympic

Revealing the knee joint loading during directional badminton lunges via subject-specific modelling

Qichang Mei*, Yaodong Gu, Justin Fernandez

Email: qmei907@aucklanduni.ac.nz

NINGBO UNIVERSITY

THE UNIVERSITY OF AUCKLAND
Te Whare Wananga o Tamaki Makaurau
NEW ZEALAND

AUCKLAND BIOENGINEERING INSTITUTE

Background

- Knee joint - one of the most injured sites among badminton players;
  - patellar tendinopathy & patellofemoral pain;
  - up to 42.7%.

  (Jérgensen et al, 1987; Shariff et al, 2009; Yung et al, 2007)

- Knee brace & knee tape – commonly observed;

- Conservative & compensatory movements - reduced performance & other injury risks.

  (Huang et al, 2014; Lin et al, 2015)

- Mechanism: Chronic injury – Repetitive sub-maximal lunges;
  Acute injury – Maximal lunges + inciting factors.

Objectives

- Current approaches of musculoskeletal (**MSK**) modelling and Finite Element (**FE**) simulations provide feasible and reliable solutions;

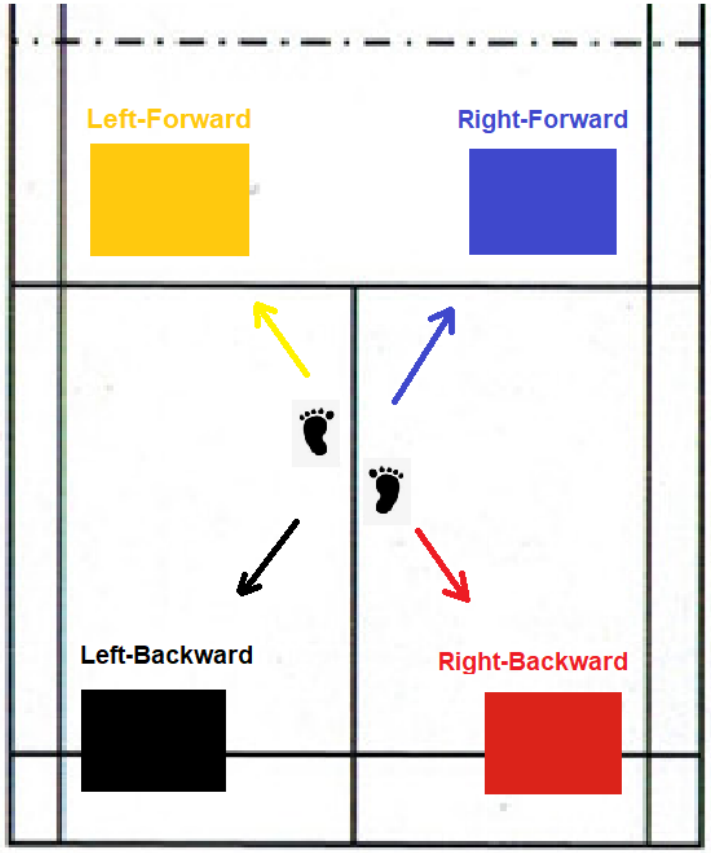
- Aiming to reveal the **1)** knee joint kinematics (angles in degree);
  2) knee joint moment (torque in Nm/kg);
  3) quadriceps muscle forces (in Body Weight, BW);
  4) knee joint contact forces (BW);
  5) patellar and femoral cartilage stress (MPa).

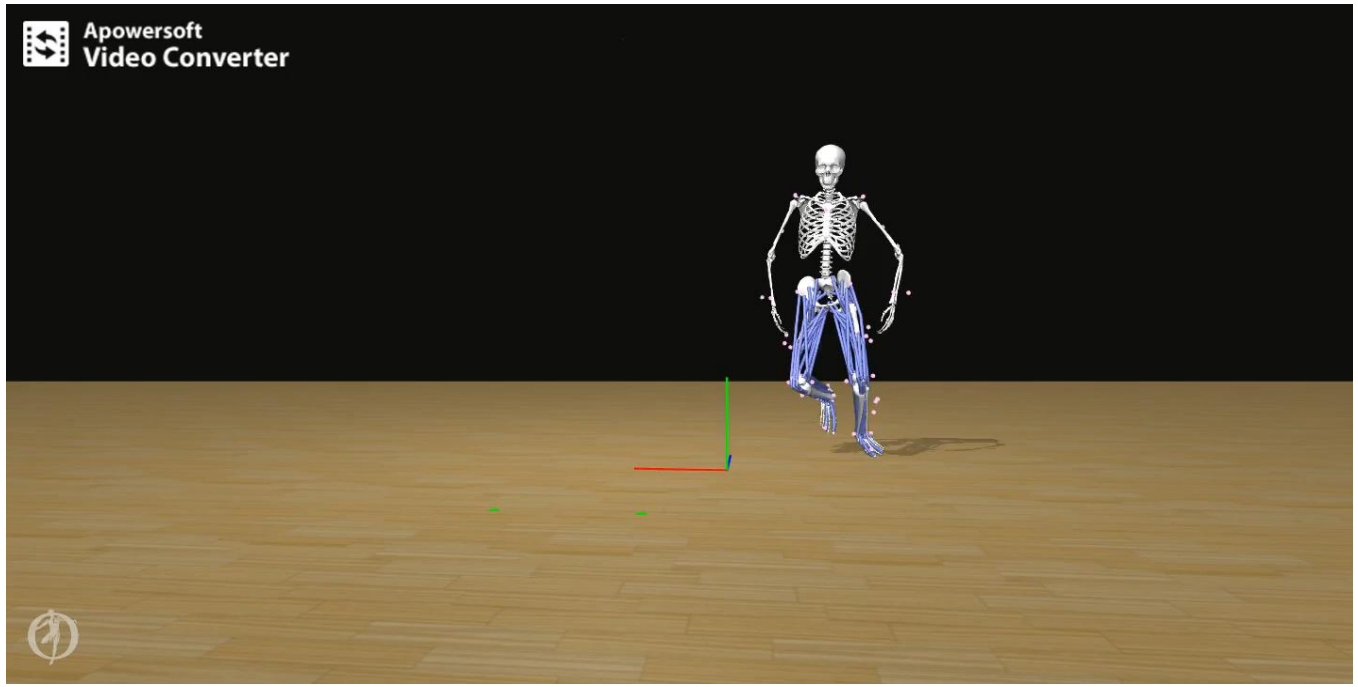
Methods

- **20** badminton athletes (national level) (right hand & right leg dominant)

  12 males (age: 20.5±3.1yrs, height: 176±4.9m, mass: 68.6±5.6kg);

  8 females (age: 19.3±4.1yrs, height: 165±3.8m, mass: 57.6±3.5kg);





(Mei et al, 2017, Journal of Sports Sciences)

Protocol - MSK

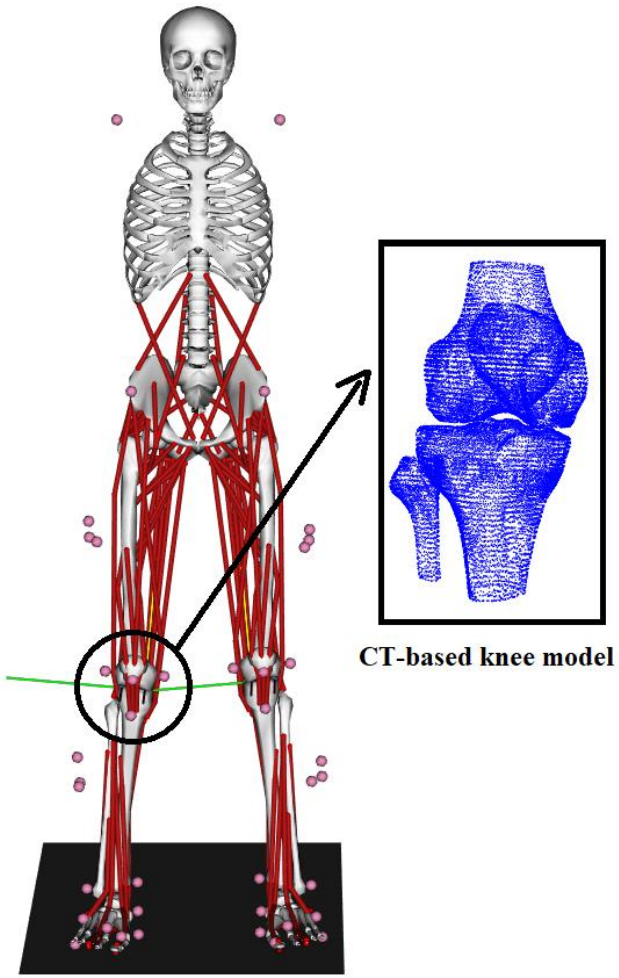
- Subject-specific model *Scaling*
  - Static markers
  - Body mass (kg)
  - Imaging data (Knee CT)

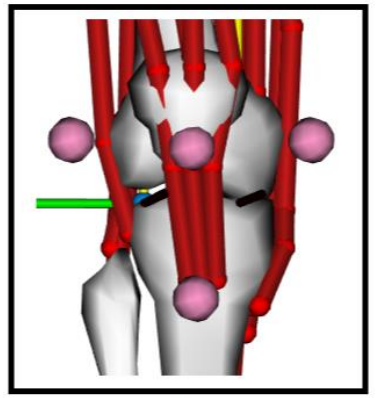
- *Inverse kinematics*
  - Joint angles

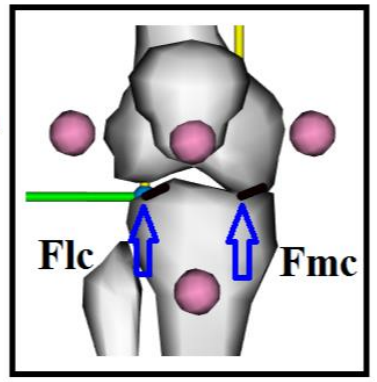
- *Inverse dynamics*
  - Joint moments

- *Static optimization*
  - Muscle activation & force

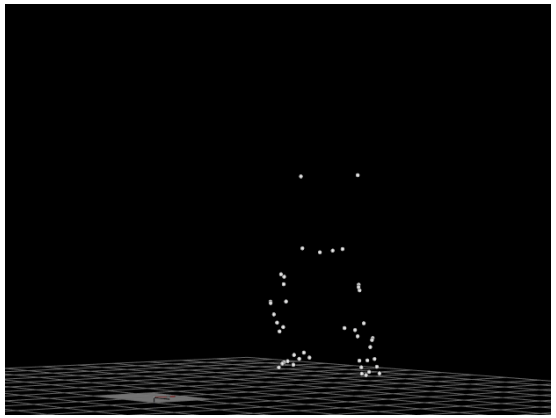
- *Joint Reaction*
  - Joint contact force



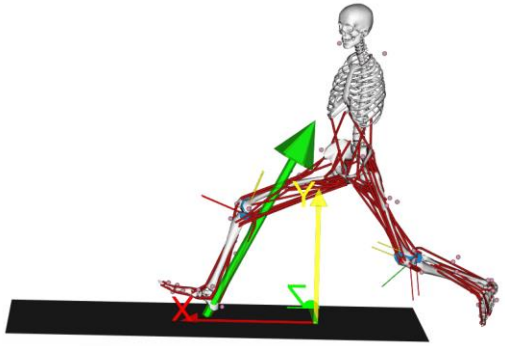




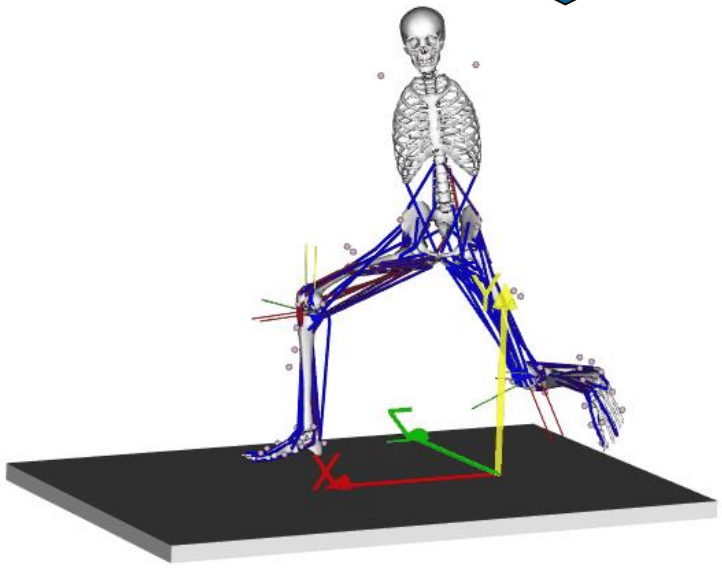
Protocol - MSK-FE



1. MoCap (trc & mot)

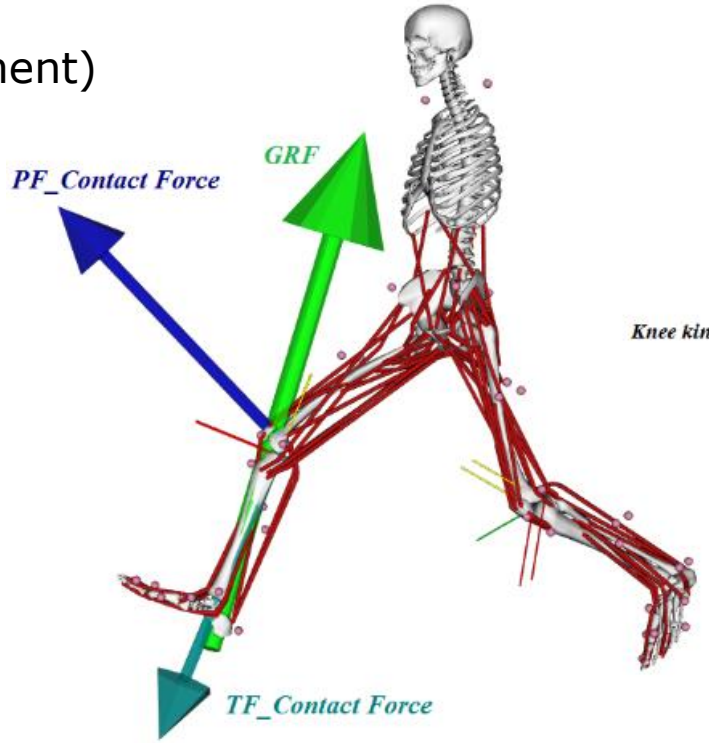


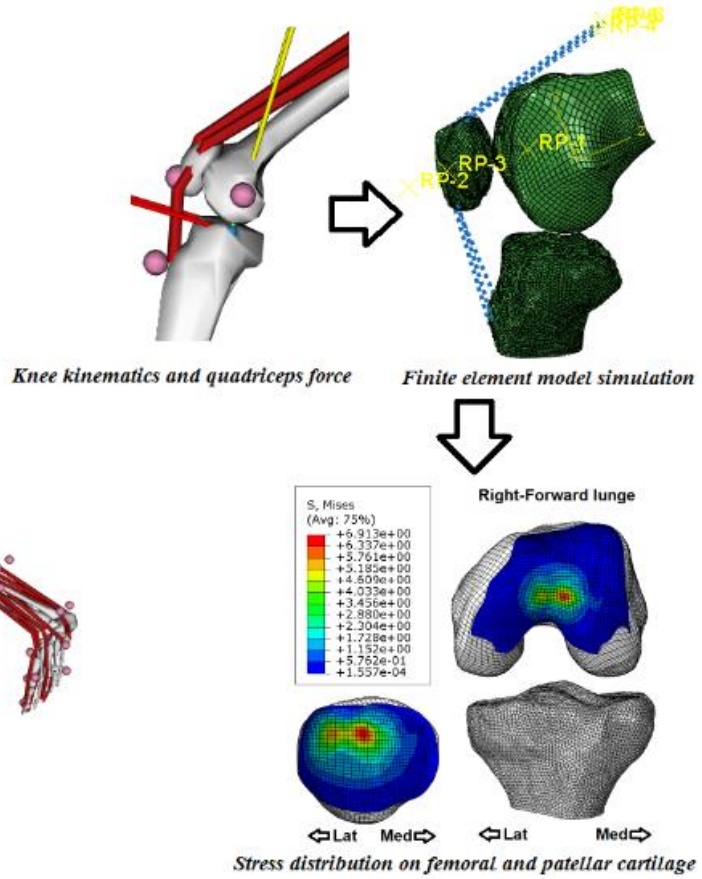
2. IK (angle) & ID (moment)



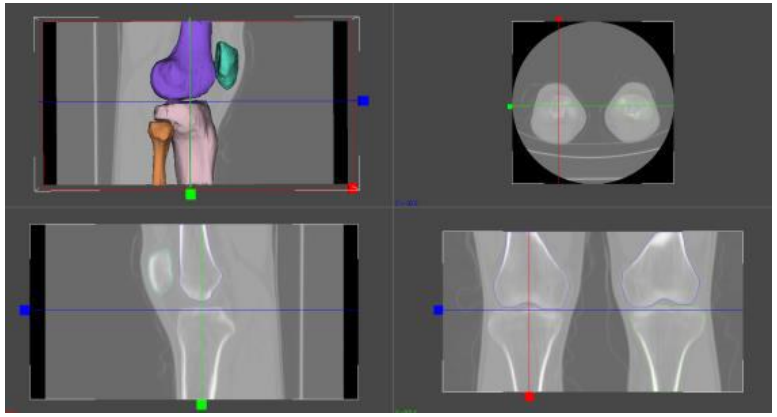
3. SO (muscle force) & JR (contact force)

4. FE simulation (cartilage loading)

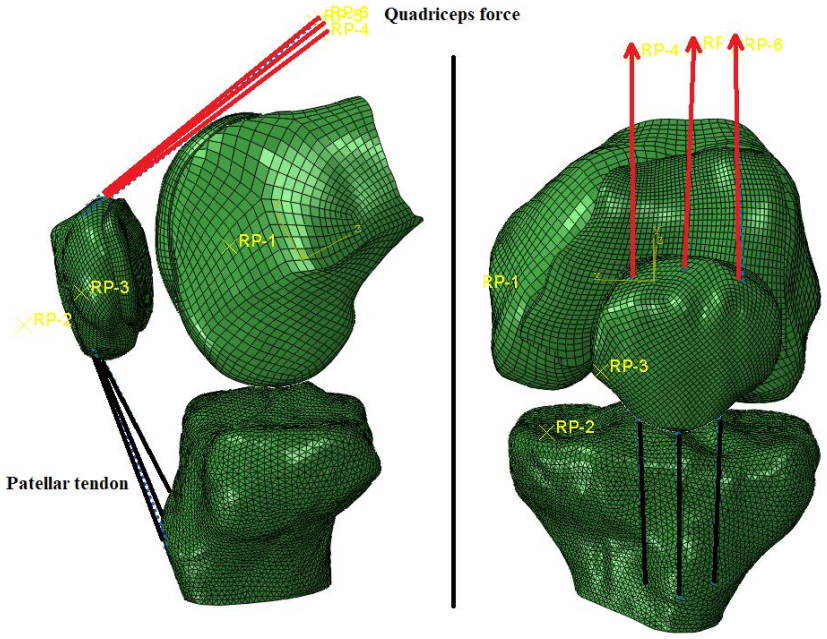




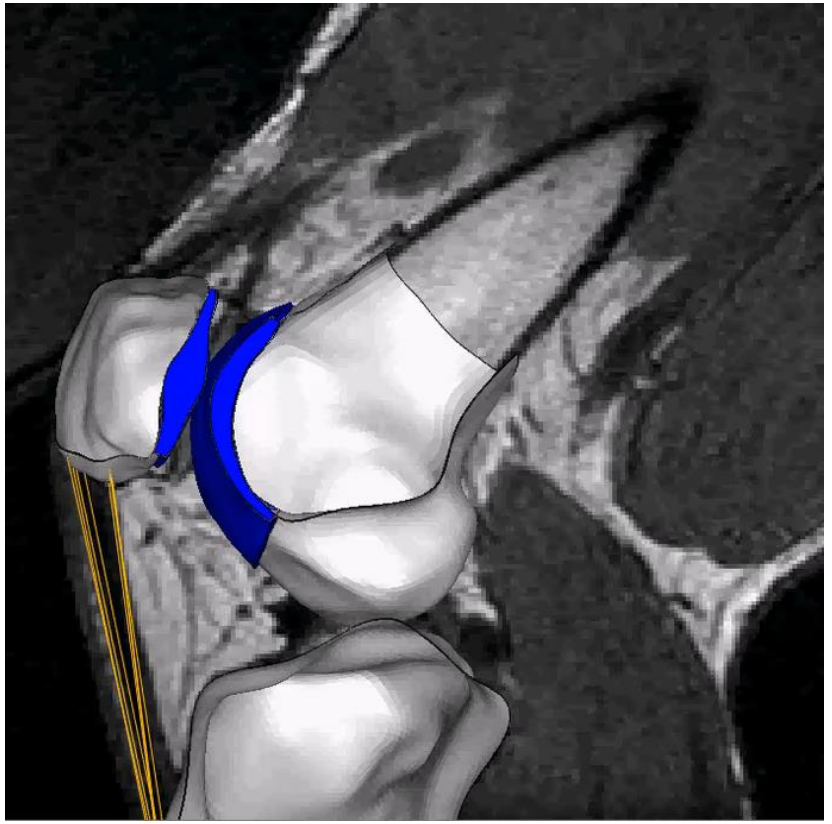
Protocol – FE simulation



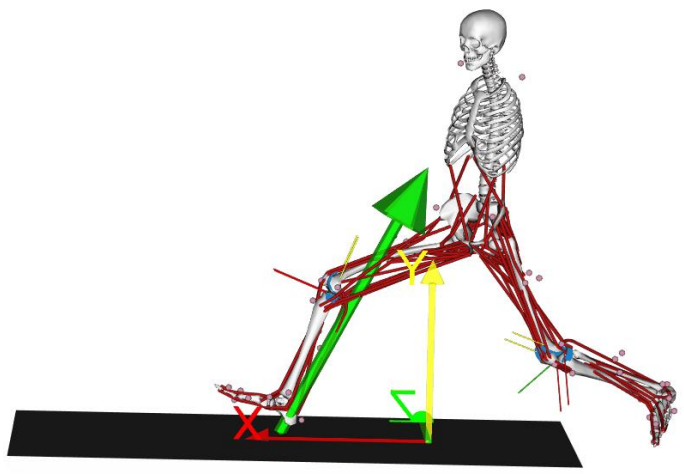
Segmentation
+
Mesh

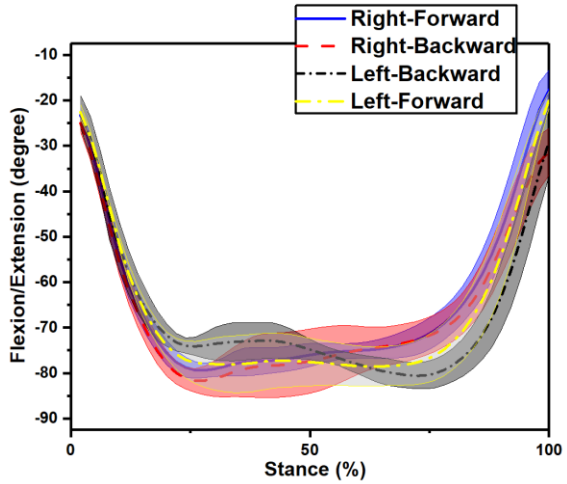


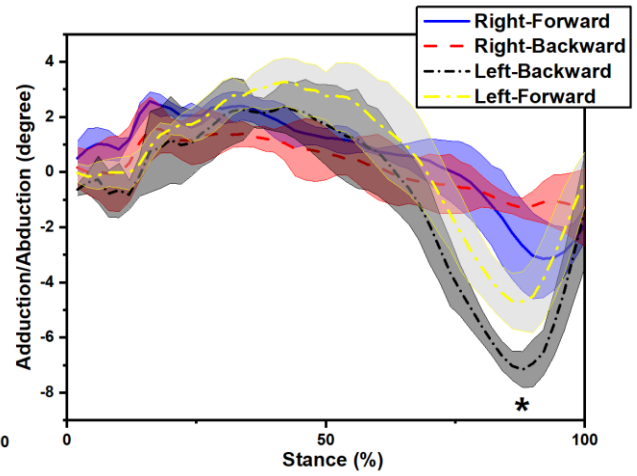
Assign material properties
+
Apply Load
+
Boundary conditions

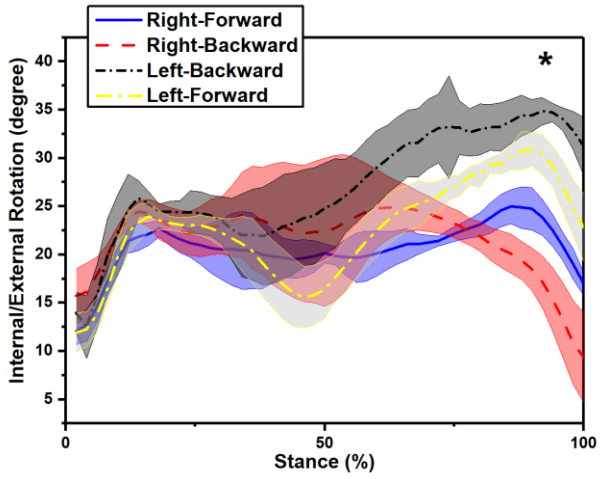


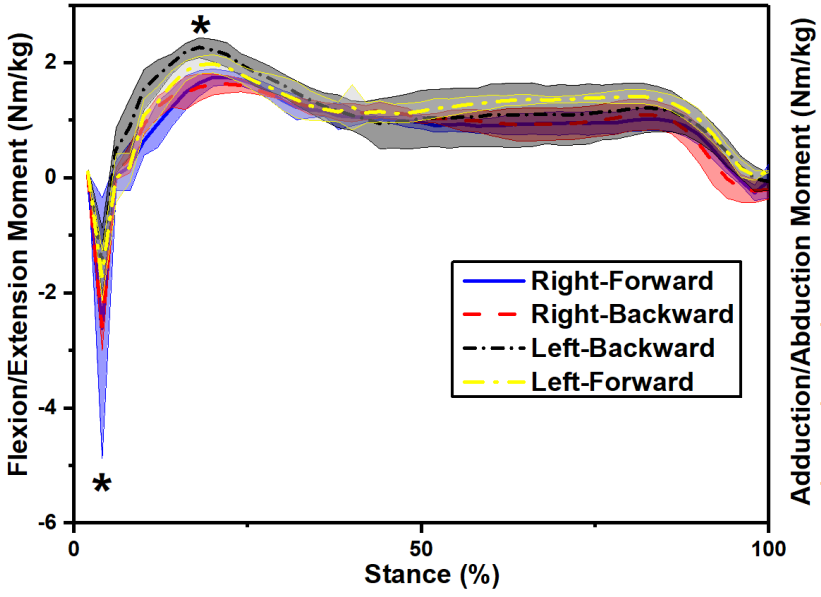
Results (Angle & Moment)

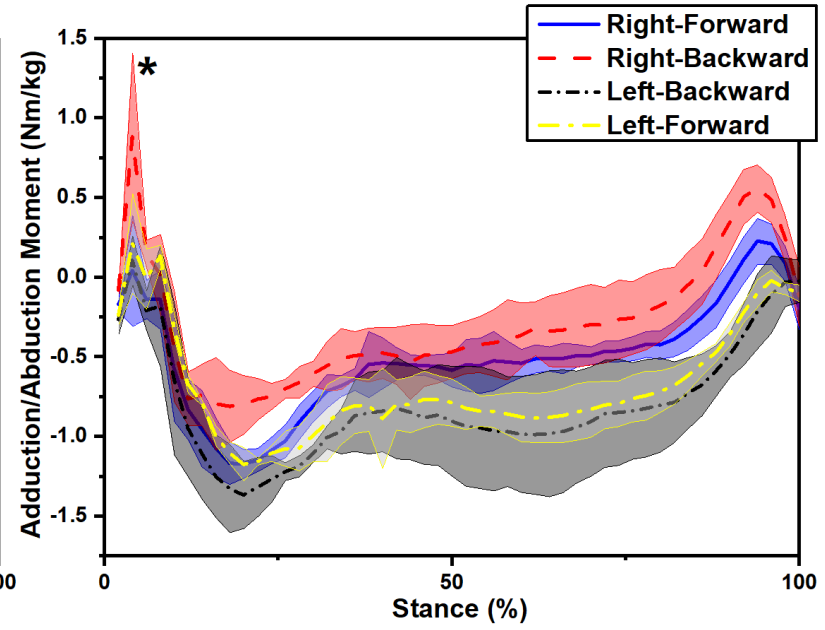


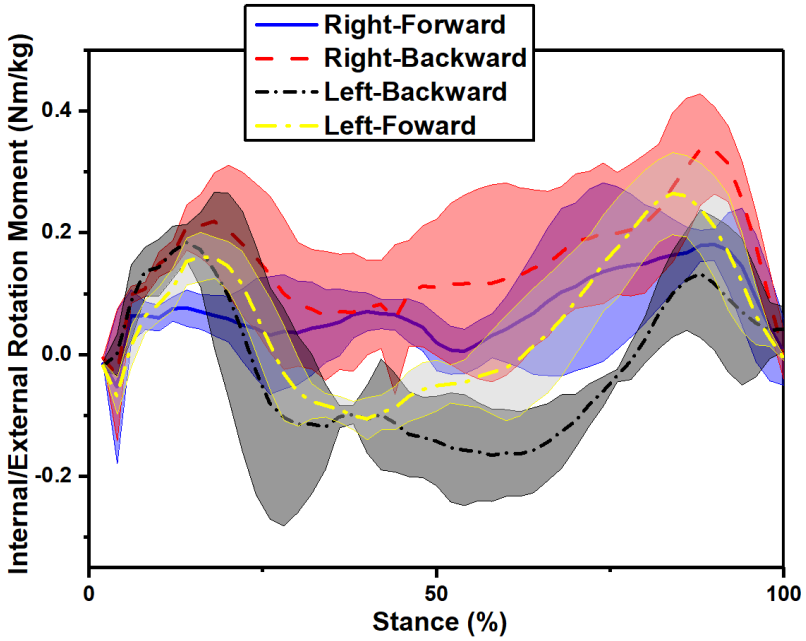




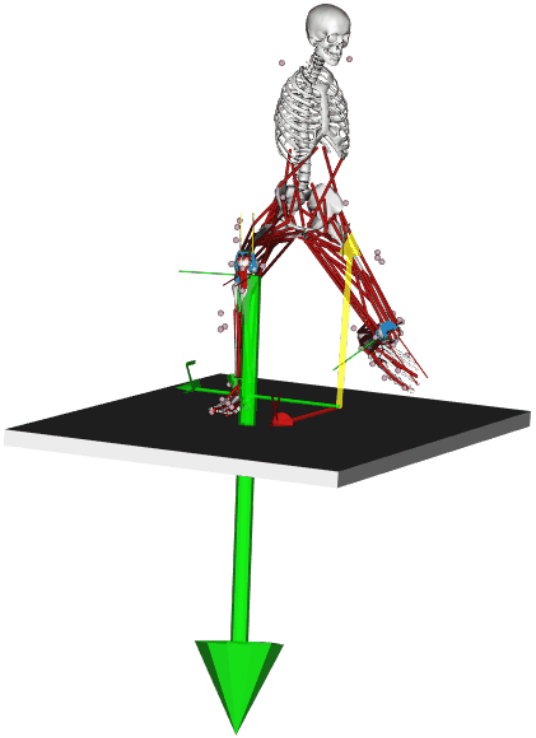


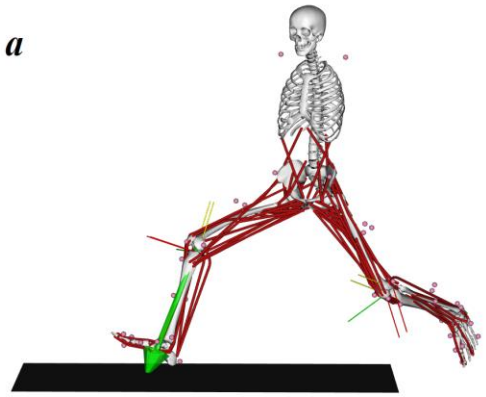


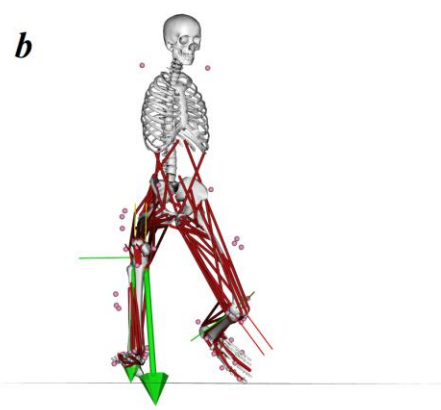


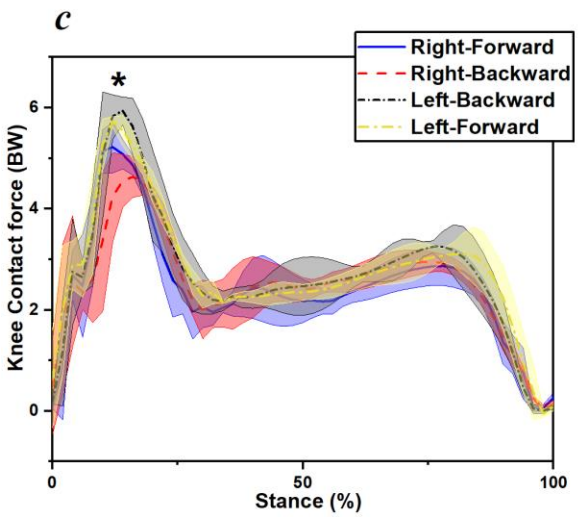


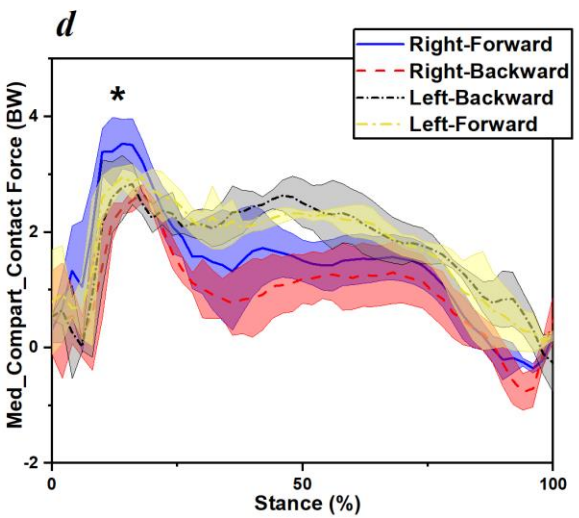
Results (Knee contact force)

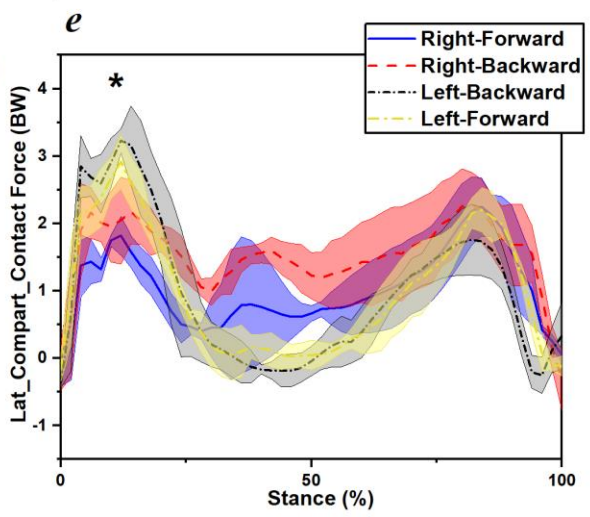




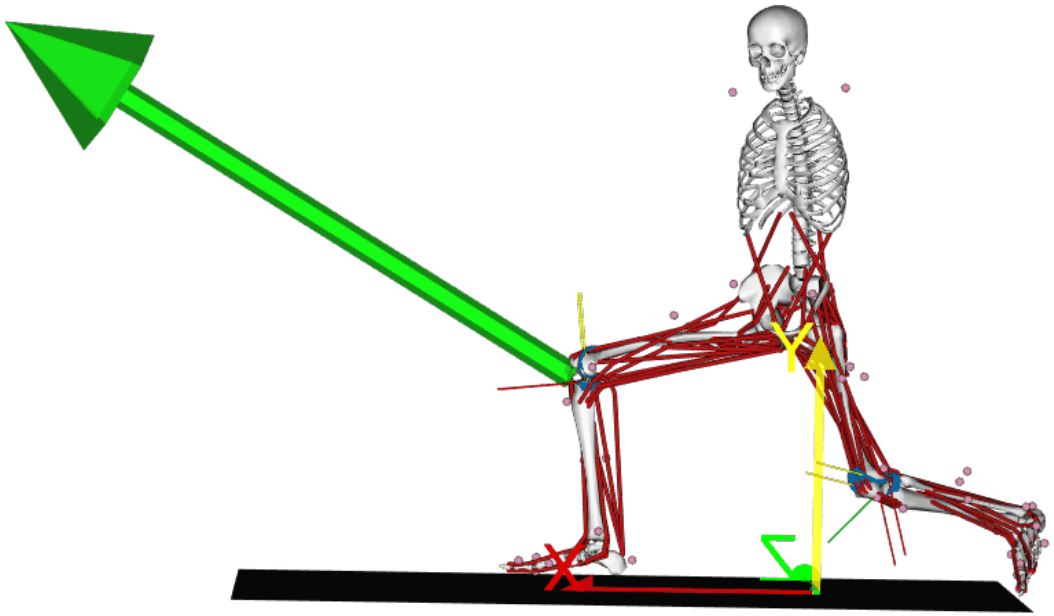


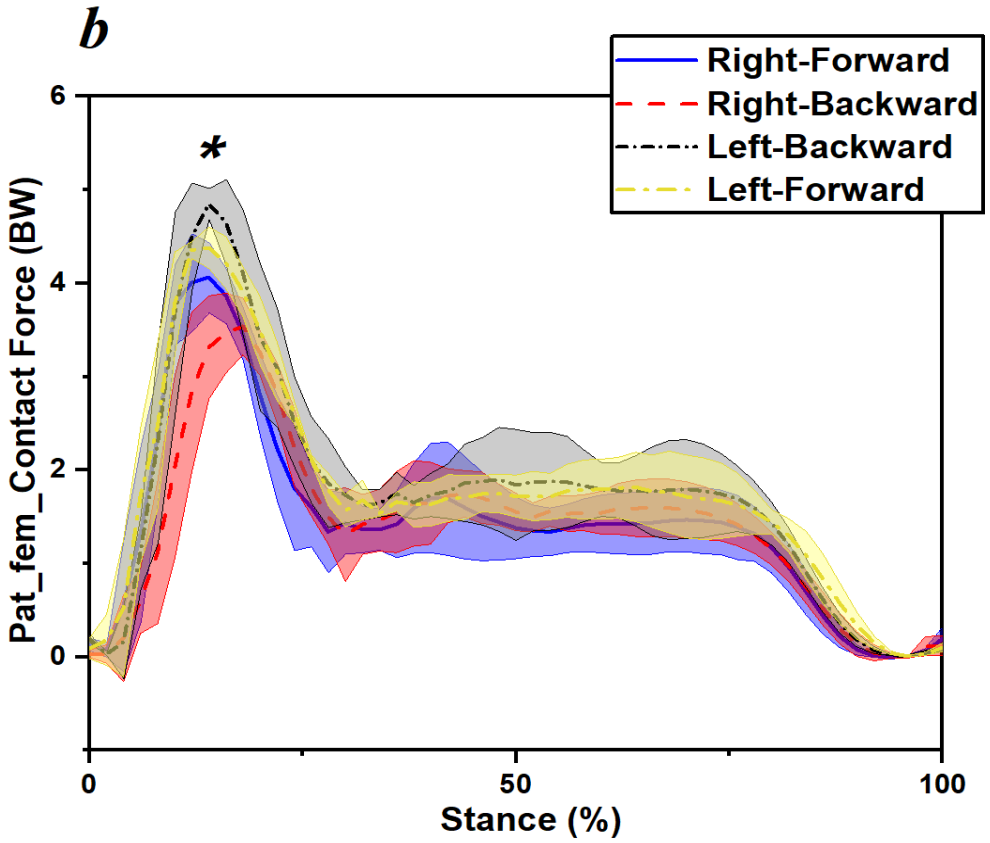






Results (PatFem contact force)

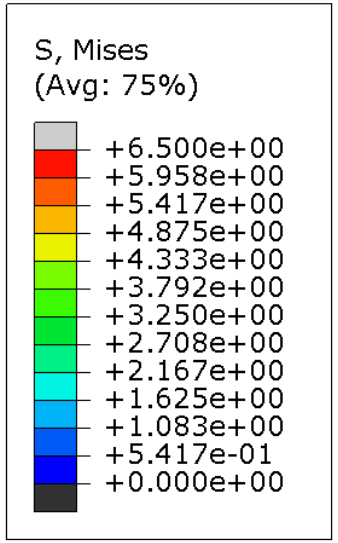


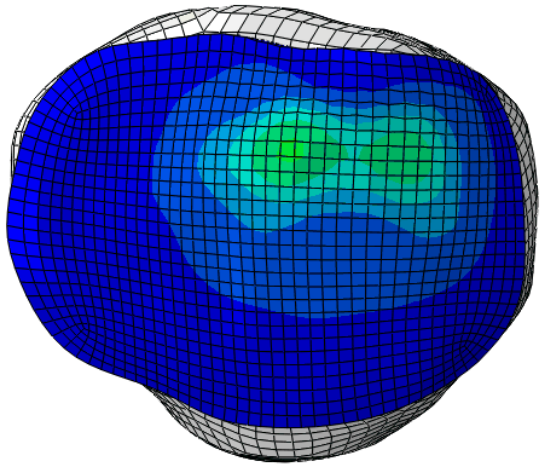


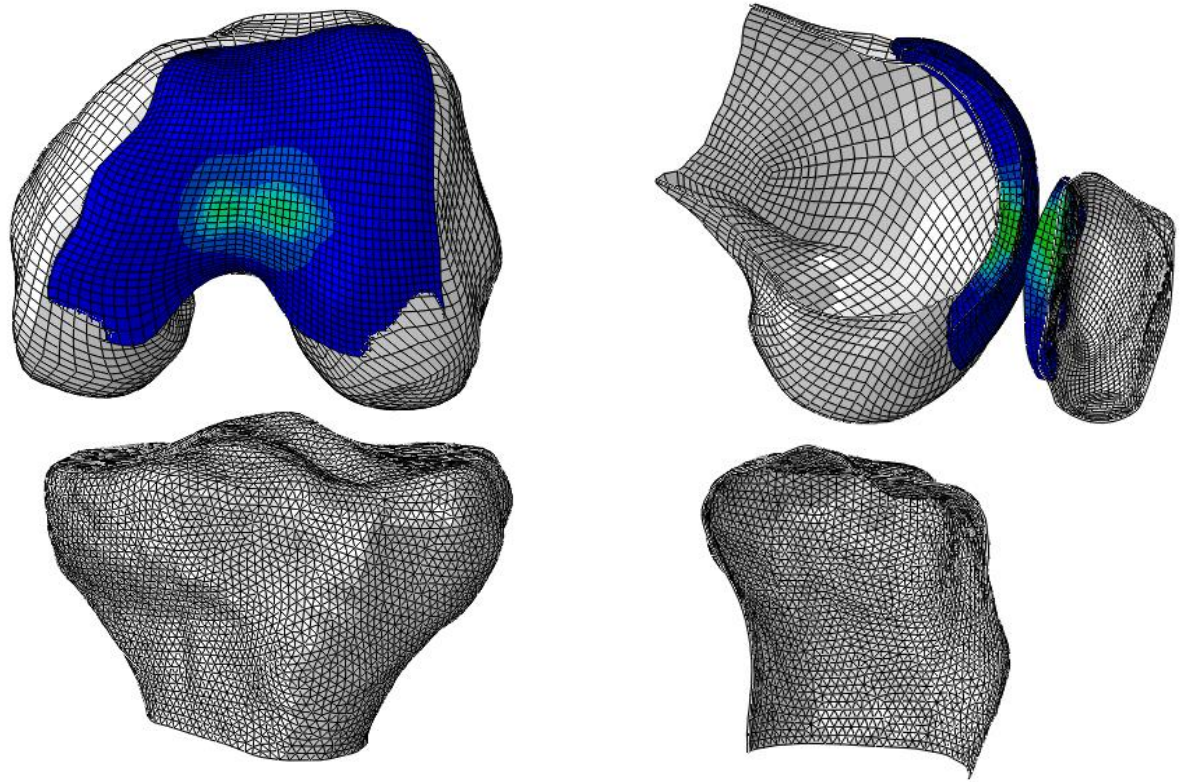
Boundary condition + Load:

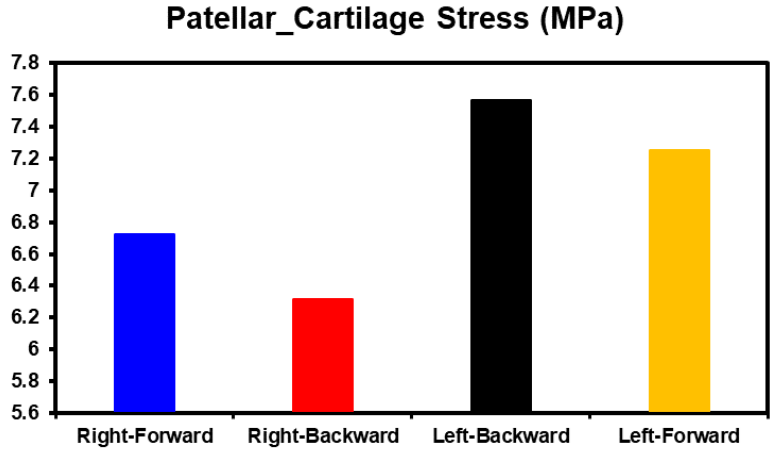
- Knee joint angle (positions);
- Quadriceps (vastus lateralis, vastus medialis, vastus intermedius and rectus femoris) muscle force (Load).

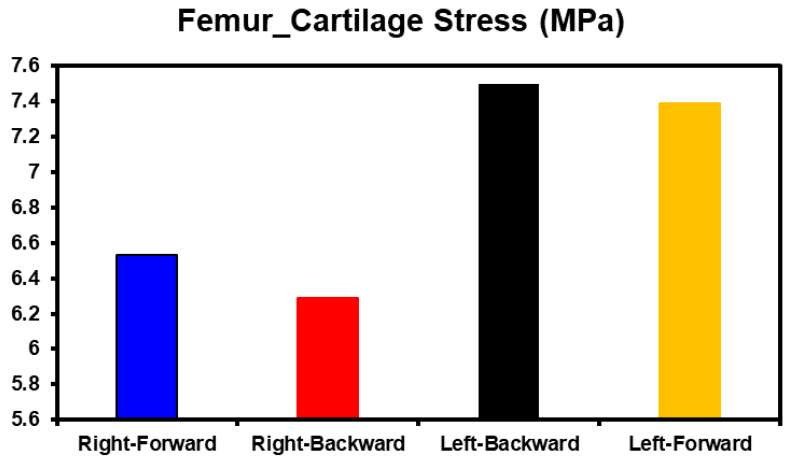
Results (PatFem Cartilage Stress)











Sub- vs Max- Lunges

- Significantly increased peak knee flexion moment were observed from sub (**2.24Nm/kg**) to maximal lunge (**4.1Nm/kg**);

- Tibiofemoral axial contact force and patellofemoral compressive force increased significantly during maximal-lunge (**8.4BW** and **8.1BW**) comparing to sub-lunge (**7.2BW** and **7.3BW**).

- Forces of vastus lateralis, vastus medialis, vastus intermedius and rectus femoris muscles increased from **0.31BW**, **1.62BW**, **1.21BW** and **3.1BW** (sub-lunge) to **0.68BW**, **1.8BW**, **1.56BW** and **3.6BW** (maximal-lunge), respectively.

Conclusions

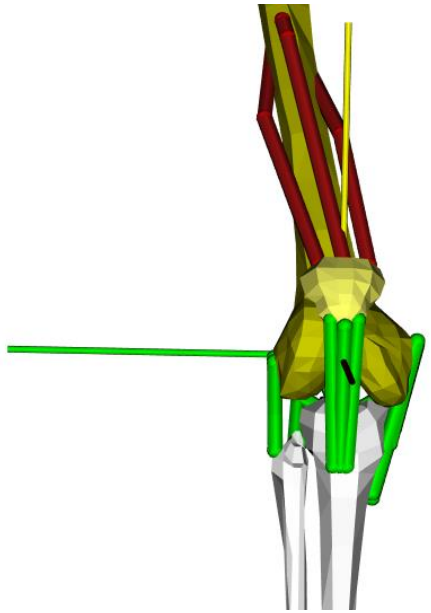
- Left-Backward and Left-Forward lunges presented higher knee contact force and cartilage stress loadings.

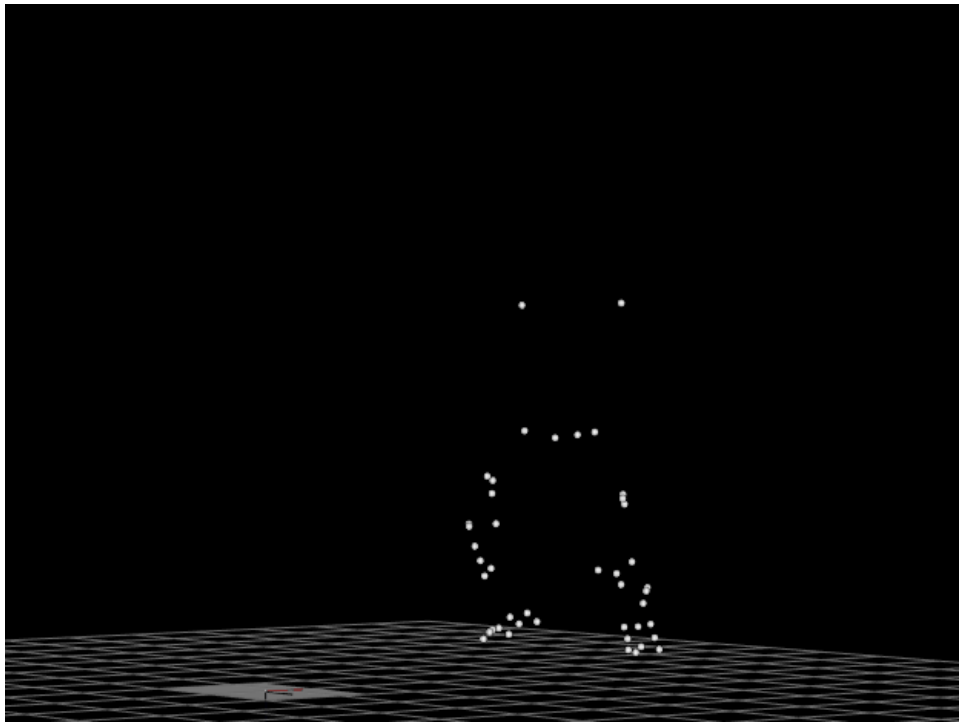
- Larger flexion and adduction moments in the Right-Forward and Right-Backward should also be noted as potential factors contributing to overuse injury risks.

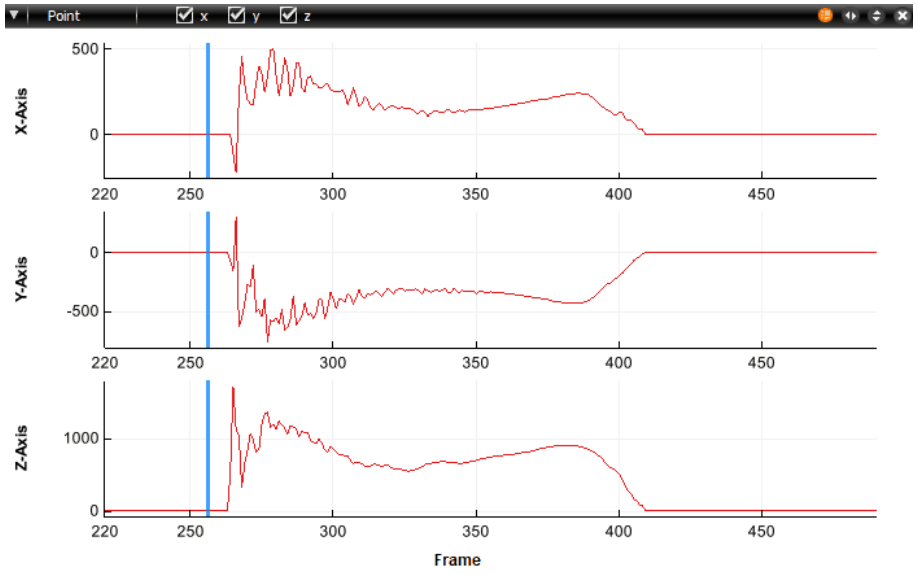
- Quadriceps muscle force contributions were revealed that could assist the training program for developing these muscles, so as to prevent potential knee pain and injuries and help improve lunging performance.

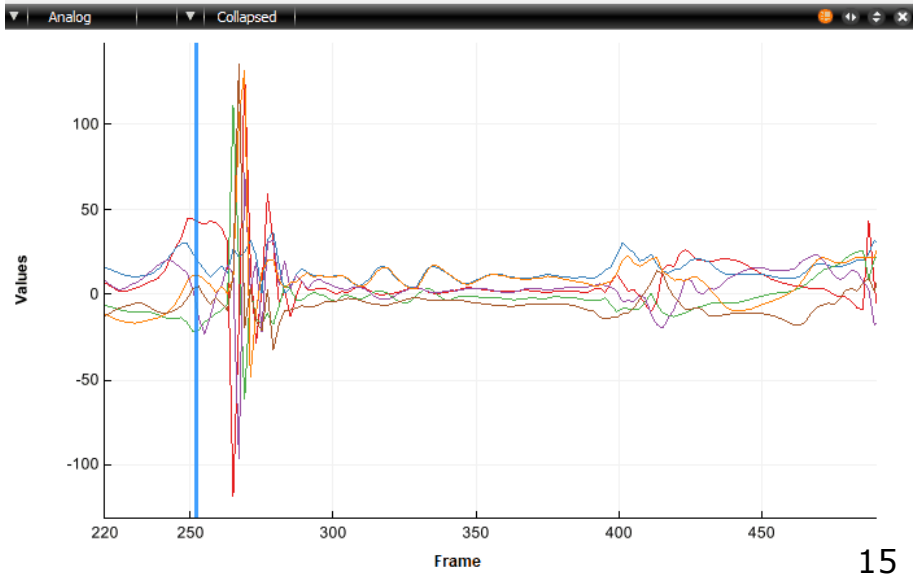
From Lab to Court

- Synchronize IMU with MoCap
- Pattern recognition (Machine learning algorithm)
- Real-time on-court monitor & Feedback









Thanks for your attention!

Acknowledgment

宁波大学大健康研究院
RESEARCH ACADEMY OF GRAND HEALTH, NINGBO UNIVERSITY

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

AUCKLAND BIOENGINEERING INSTITUTE

浙江体育职业技术学院
ZHEJIANG COLLEGE OF SPORTS

BWF