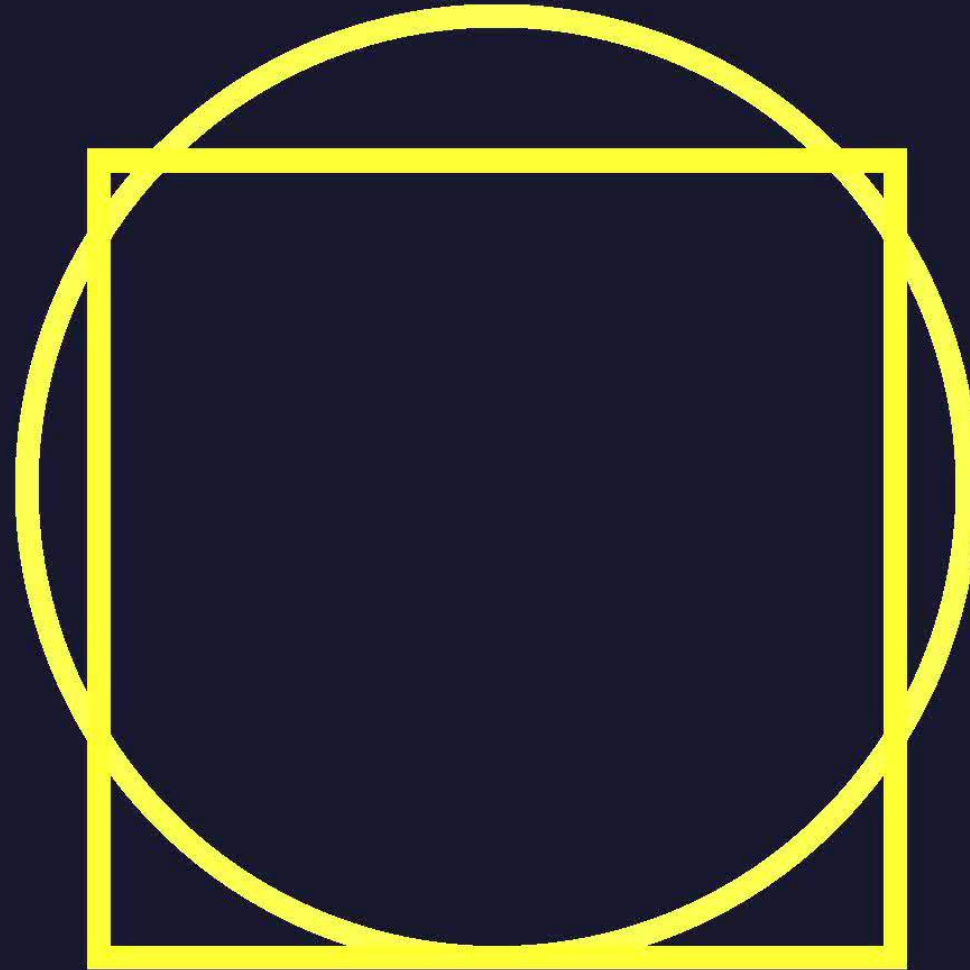


Biomechanical analysis and visualization



James Shippen PhD CEng

BoB Biomechanics Ltd

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MATLAB modelling and simulation

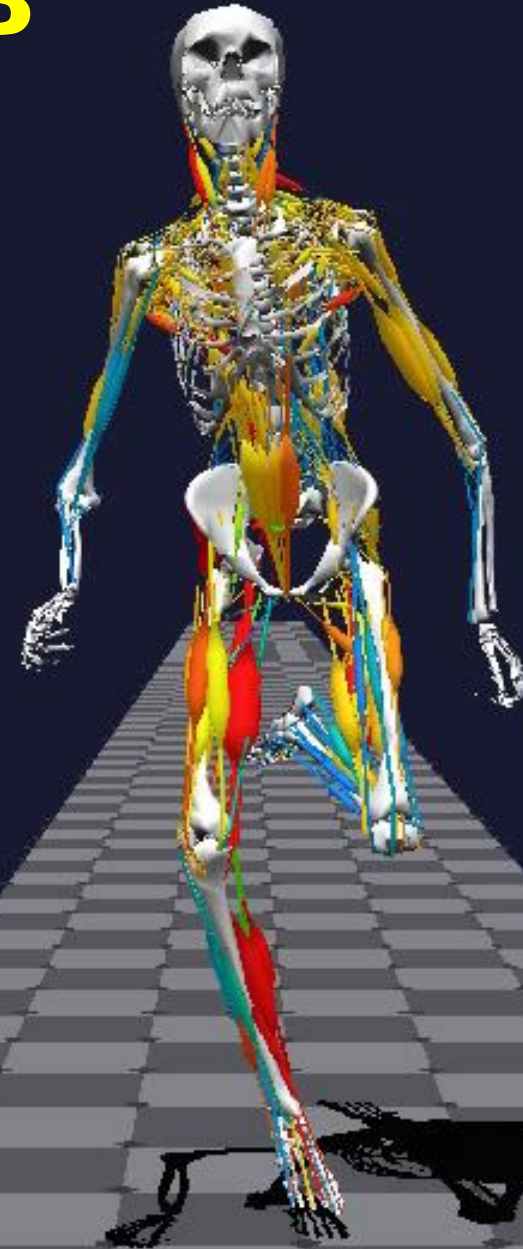
MATLAB contains many tools for modelling and simulation.

But there is a hole in its capabilities!



Biomechanics of Bodies - **BoB**

- MATLAB does not contain a human body model.
- **BoB** Biomechanics Ltd has researched and developed **BoB**.
- **BoB** brings a musculoskeletal model of a human into MATLAB.



Biomechanics of Bodies - **BoB**

BoB was developed in the MATLAB environment using M-code and MATLAB graphics.

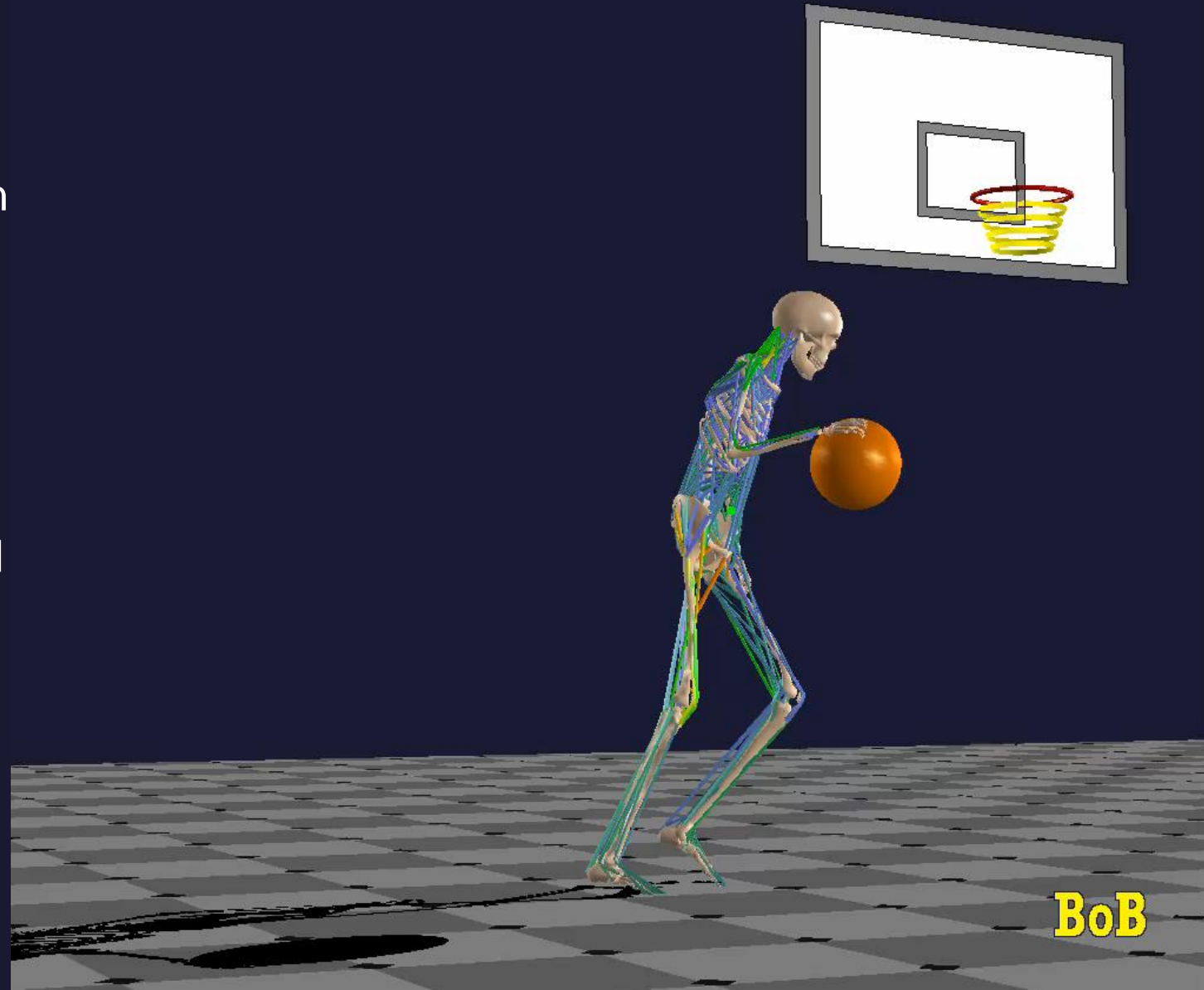
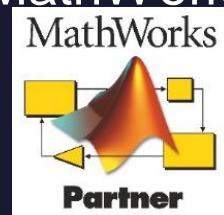
BoB is based on research published in peer reviewed journals.

BoB is distributed as a standalone executable and P-code.

BoB can share data with MATLAB and MATLAB users can write their own bespoke code.

BoB is accredited by the MathWorks Connections Program.

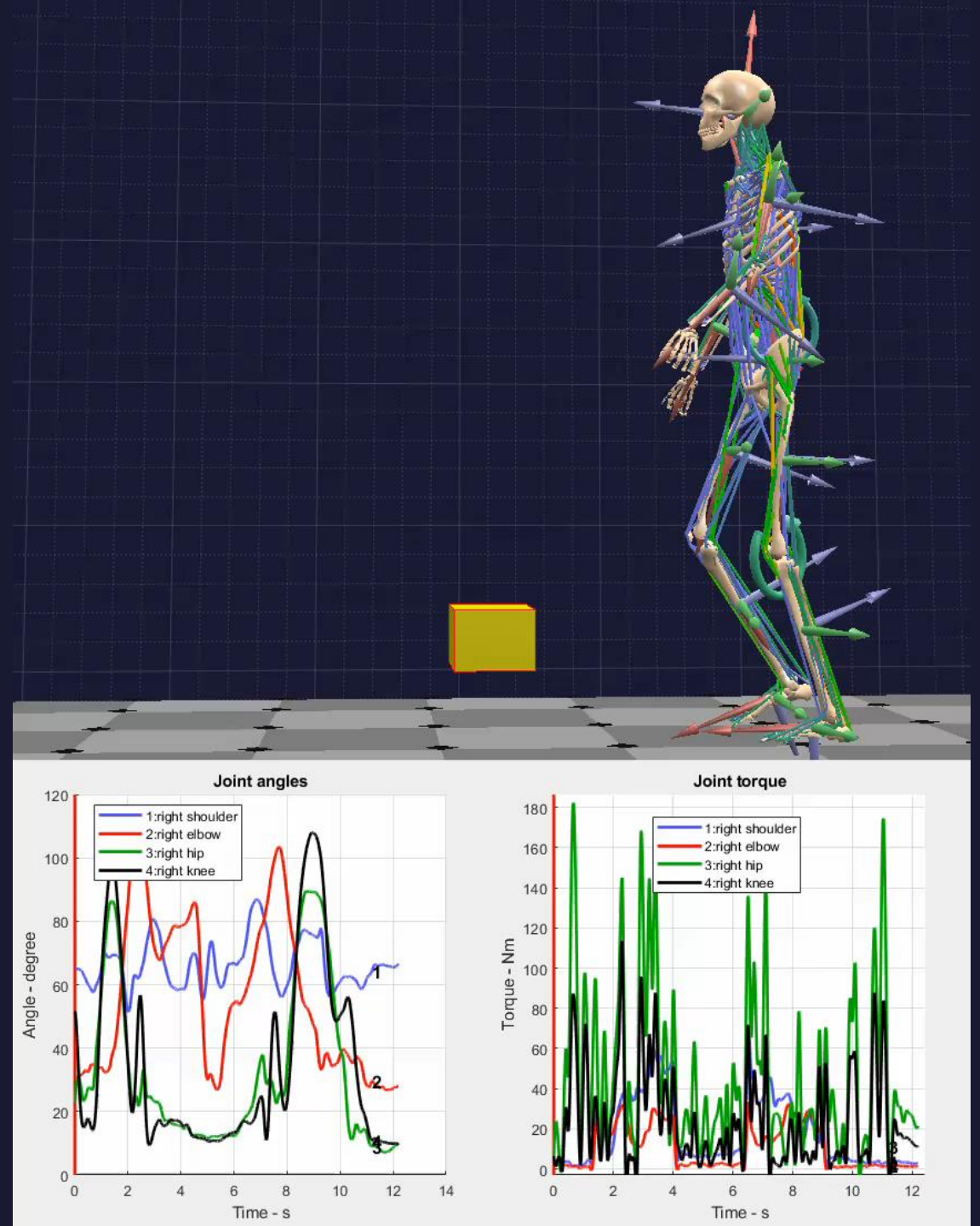
BoB
Biomechanics



BoB

BoB capabilities

- **BoB** provides objective information on the biomechanics of people.
- **BoB** enables the calculation of a broad range of biomechanical metrics including: forces, torques, trajectories, velocities, accelerations, distances, angles, energy and powers and much more.....
- These calculations can be output as tabulated data file, graphs, and displayed as objects in the workspace.



BoB – Benefits

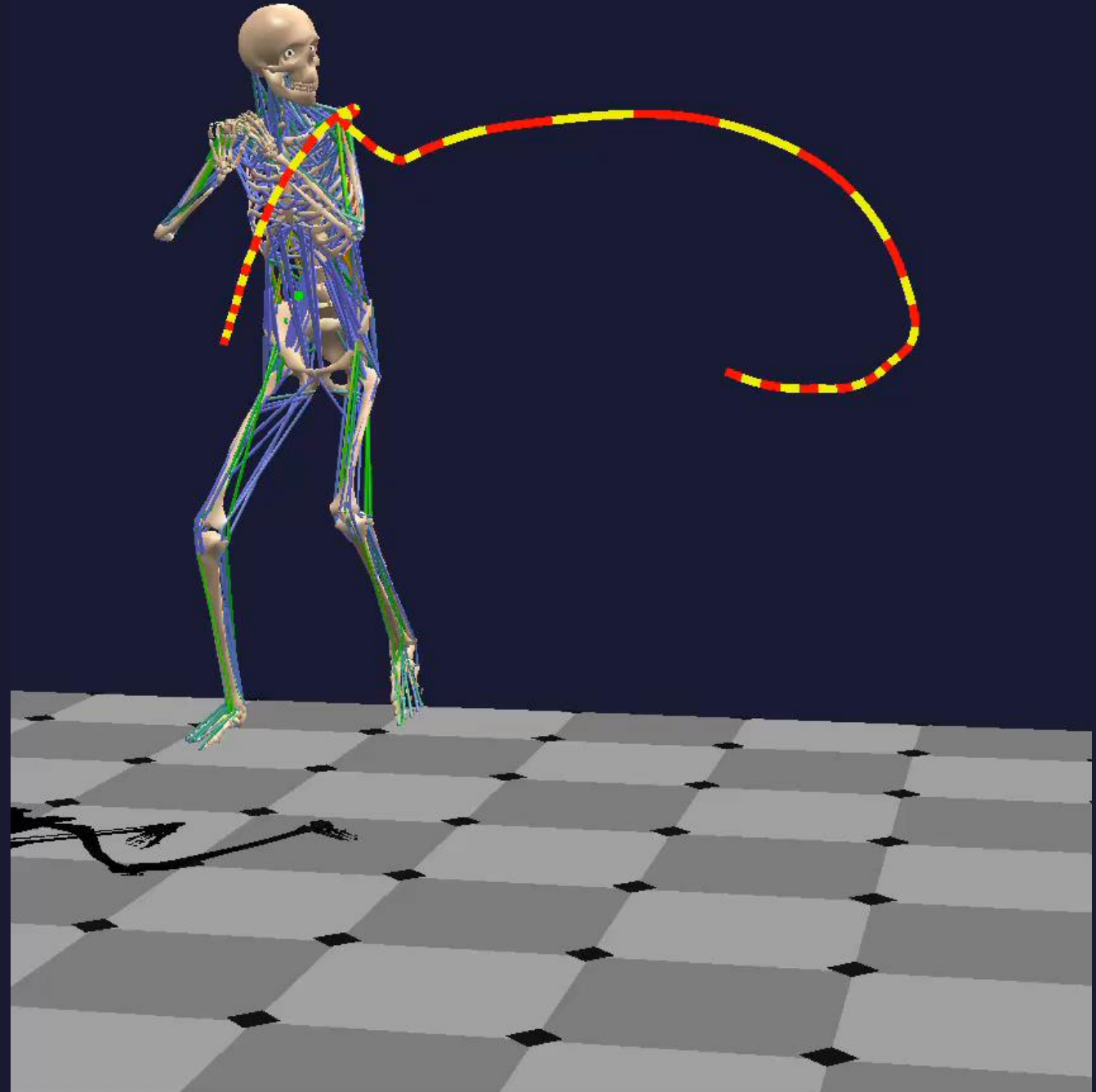
- **BoB** inserts the person into the design process to save time and money.
- Extend the MATLAB analysis scope.
- Rapidly try numerous “what if?” experiments.
- **BoB** reduces need to place people in hazardous situations.
- **BoB** reduces the need for experimental prototyping.



BoB applications

BoB applications include:

- Academic research
- Product development
- Sporting performance optimization
- Healthcare
- Ergonomics
- Injury prevention and reduction
-anywhere where human motion and loading is of interest.

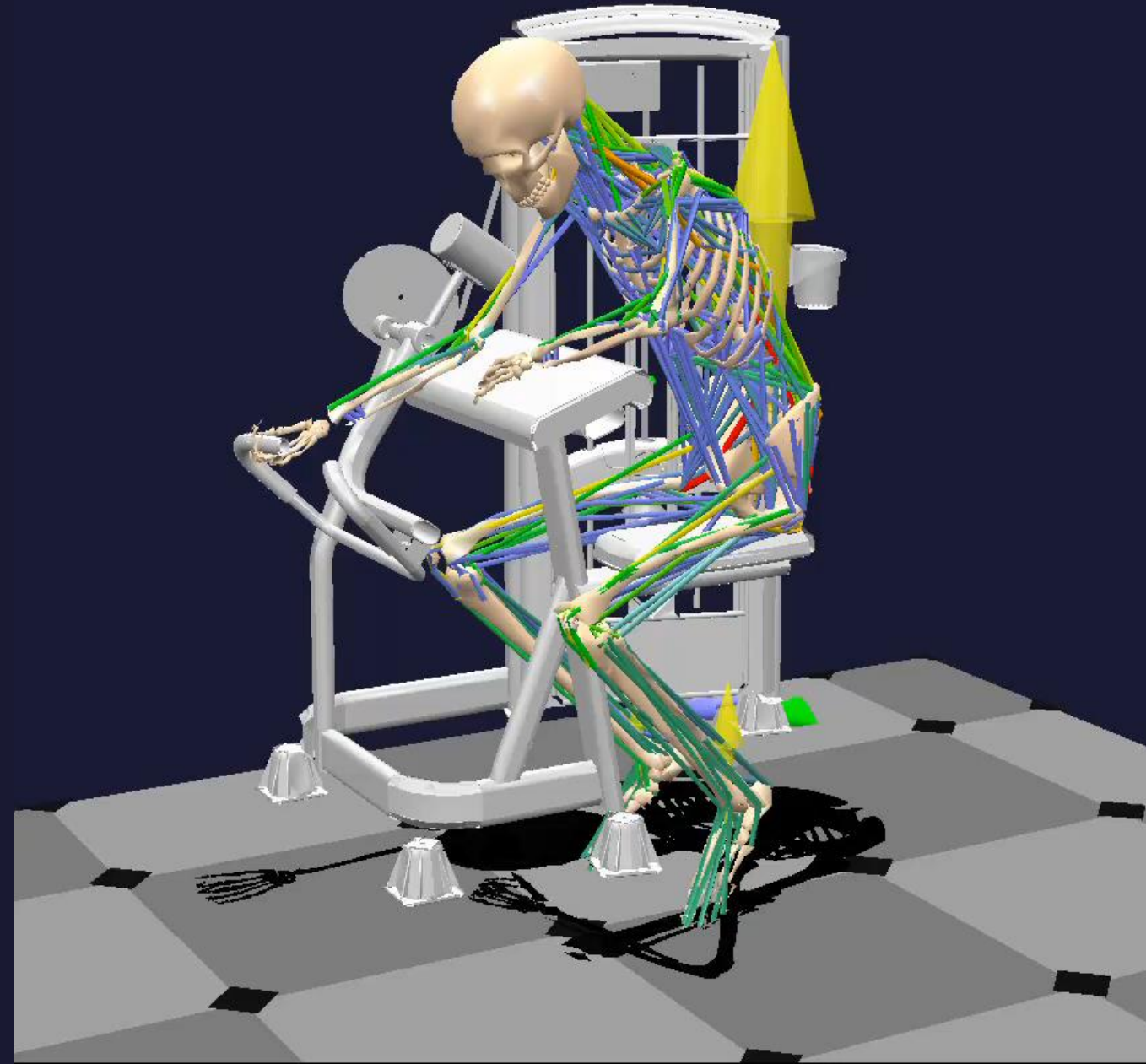


BoB graphics



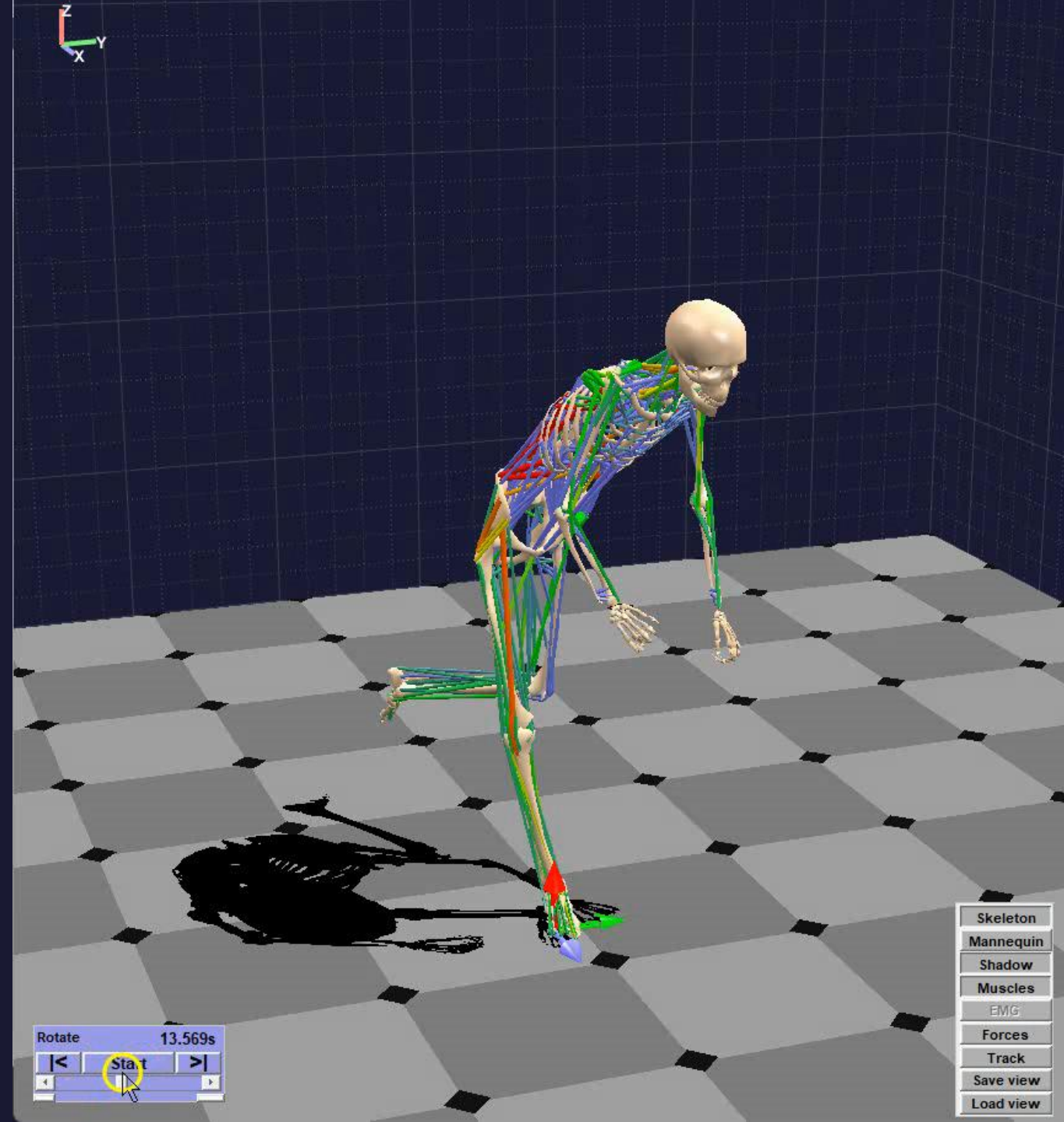
- **BoB** uses only MATLAB Graphics and M-code – no third party packages.
- **BoB** can display the full skeletal mechanism and over 600 muscles with colour coding of muscle activities, together with biomechanical information in real time.
- Users can use MATLAB Graphics tools to display their own ancillary objects in the **BoB** workspace.

(all of the videos in this presentation were generated using **BoB** and MATLAB Graphics)



BoB viewer

- **BoB** contains a 3D viewer enabling real-time display and interaction with the subject and the analysis results.

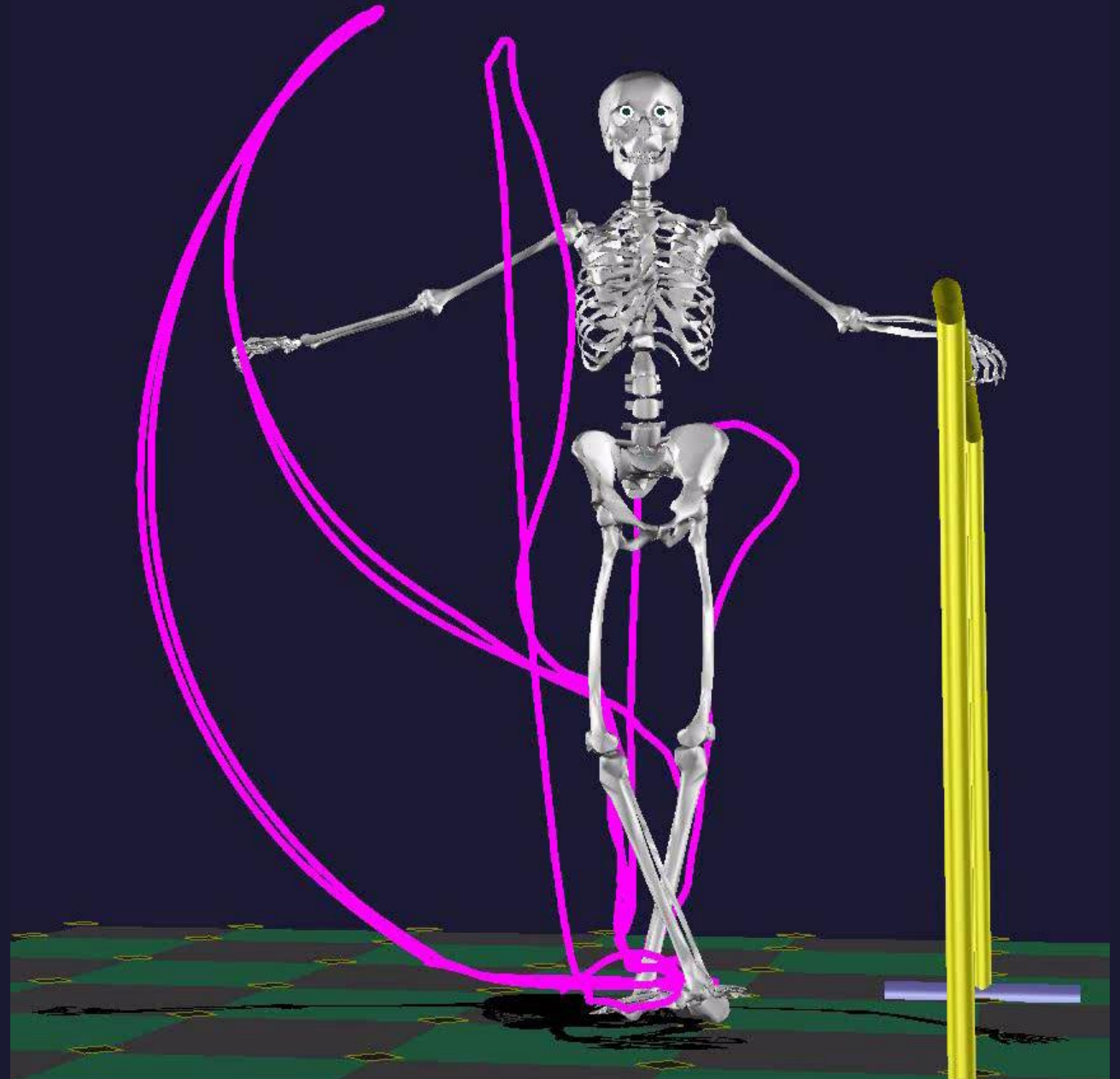


BoB musculoskeletal model

BoB contains the mechanism of the human skeleton consisting of 36 segments and 34 joints by default (user editable).

The skeletal model can be scaled to individuals' height and mass. The segmental dimensions and inertia tensors are user editable for advanced modifications.

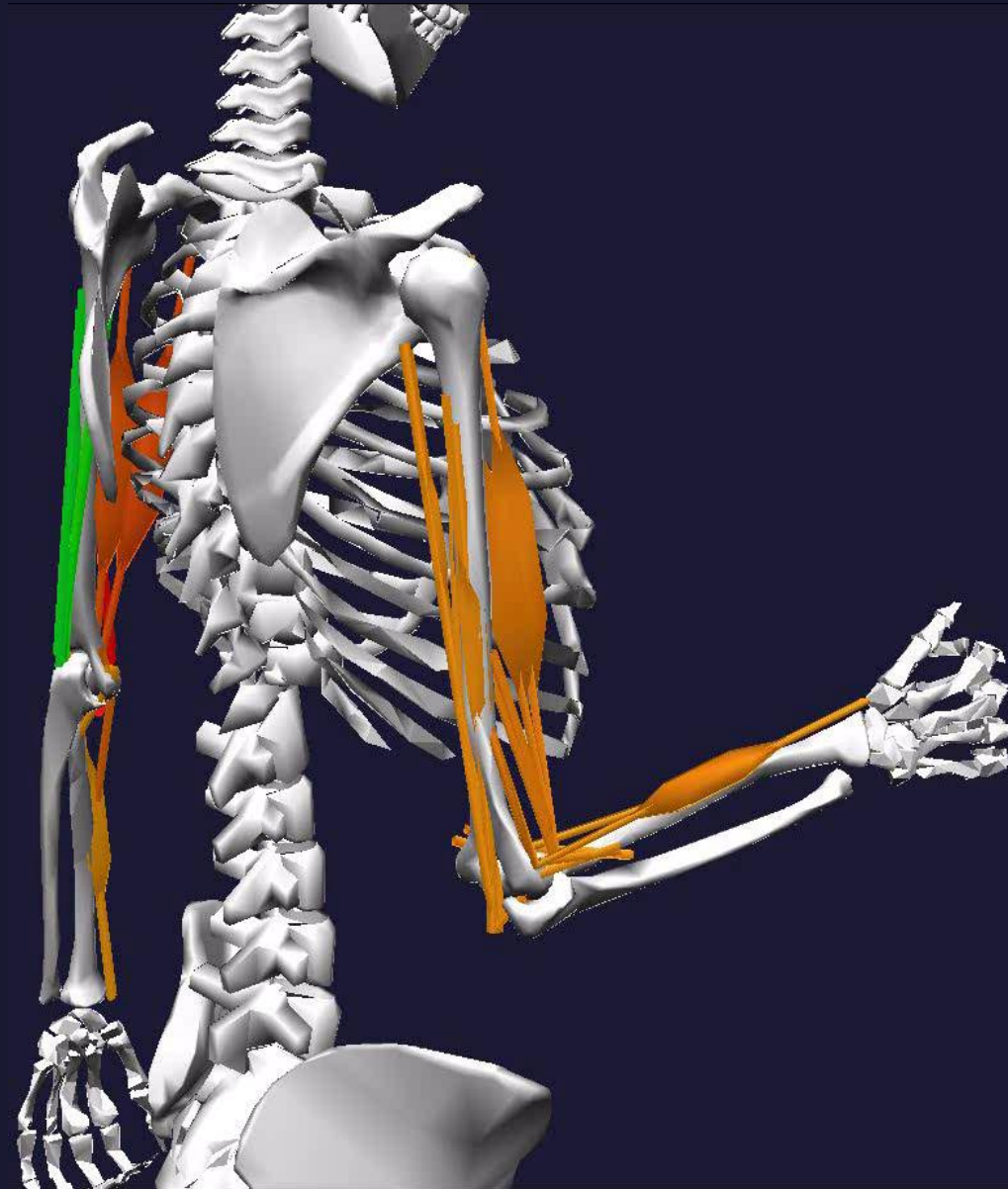
The segments are connected by joints modelling the motion of their anatomical counterparts.



BoB musculoskeletal model

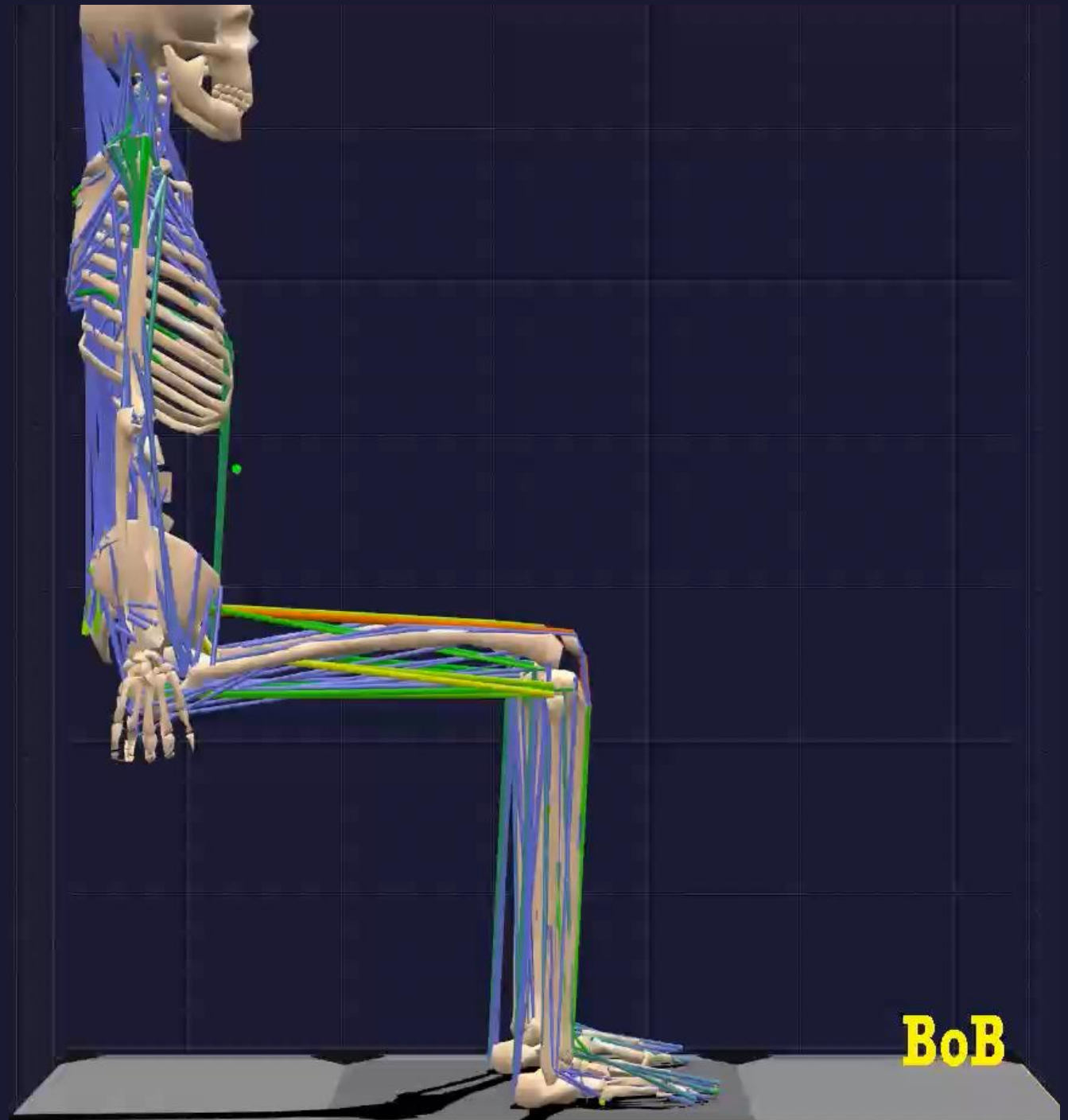
The **BoB** muscle model contains over 600 muscle units (user editable).

BoB uses Hill's 3 element muscle model and includes skeletal and muscular wrapping.



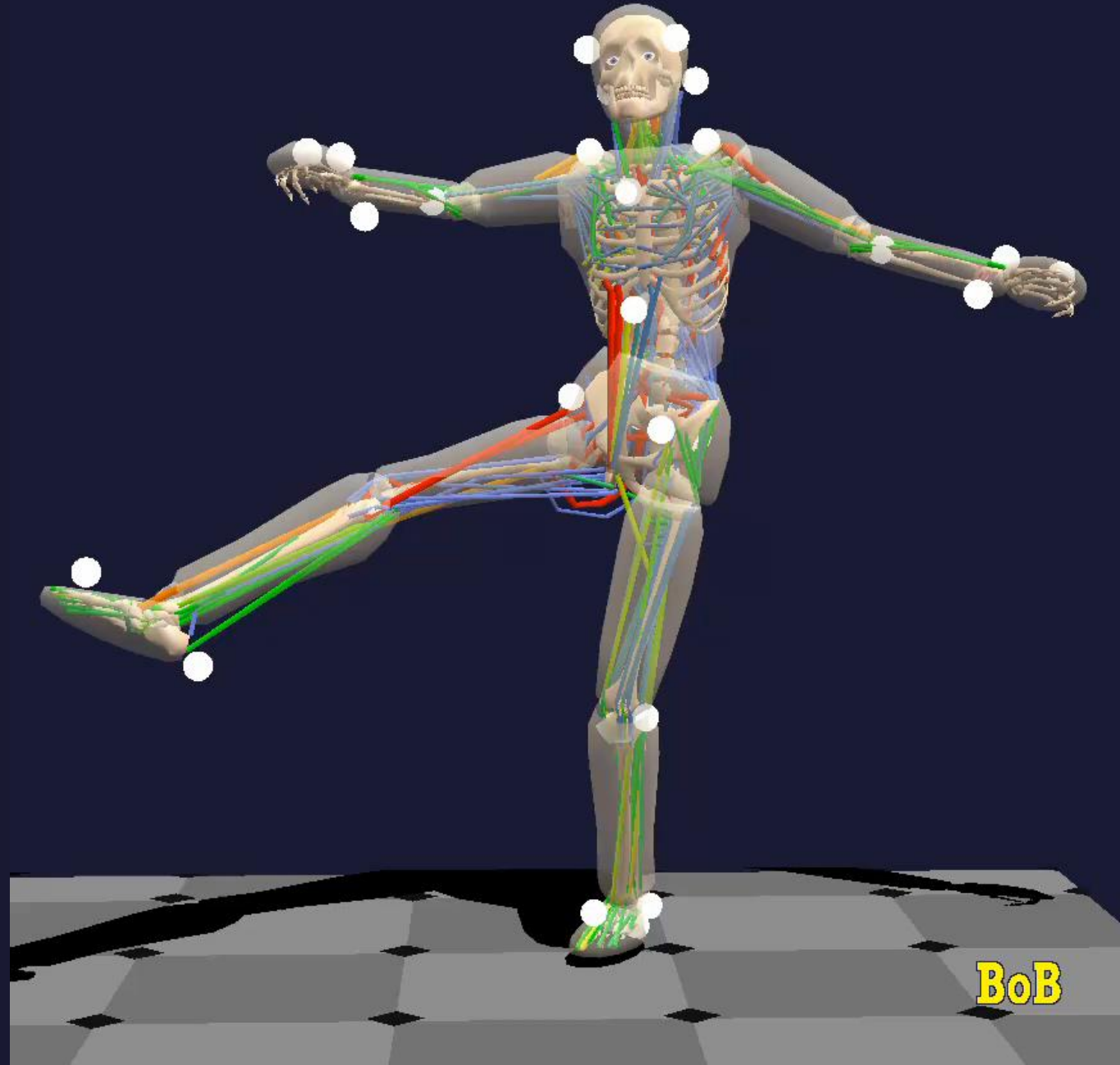
BoB motion input

Joint angle time histories



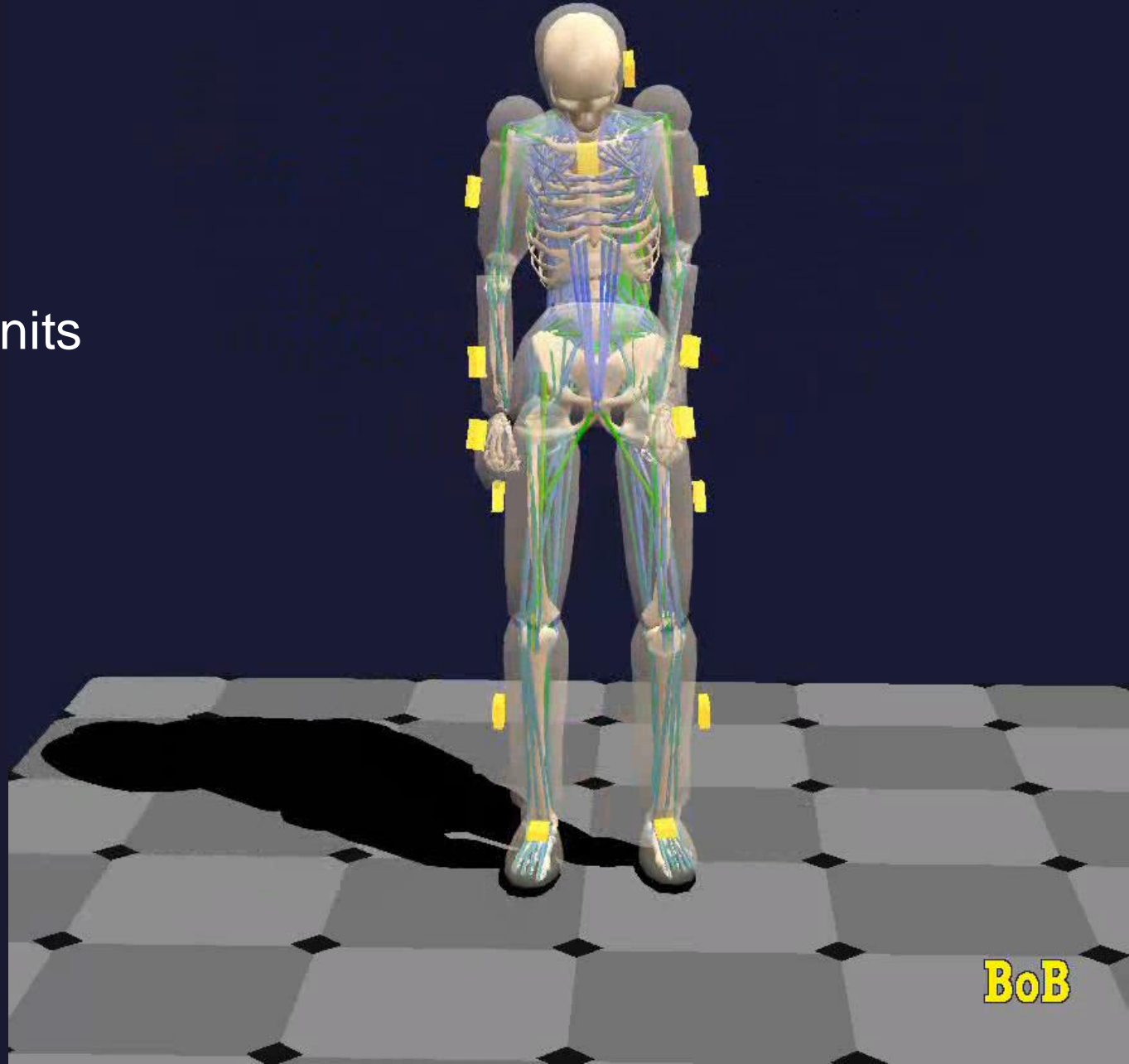
BoB motion input

Optical tracking



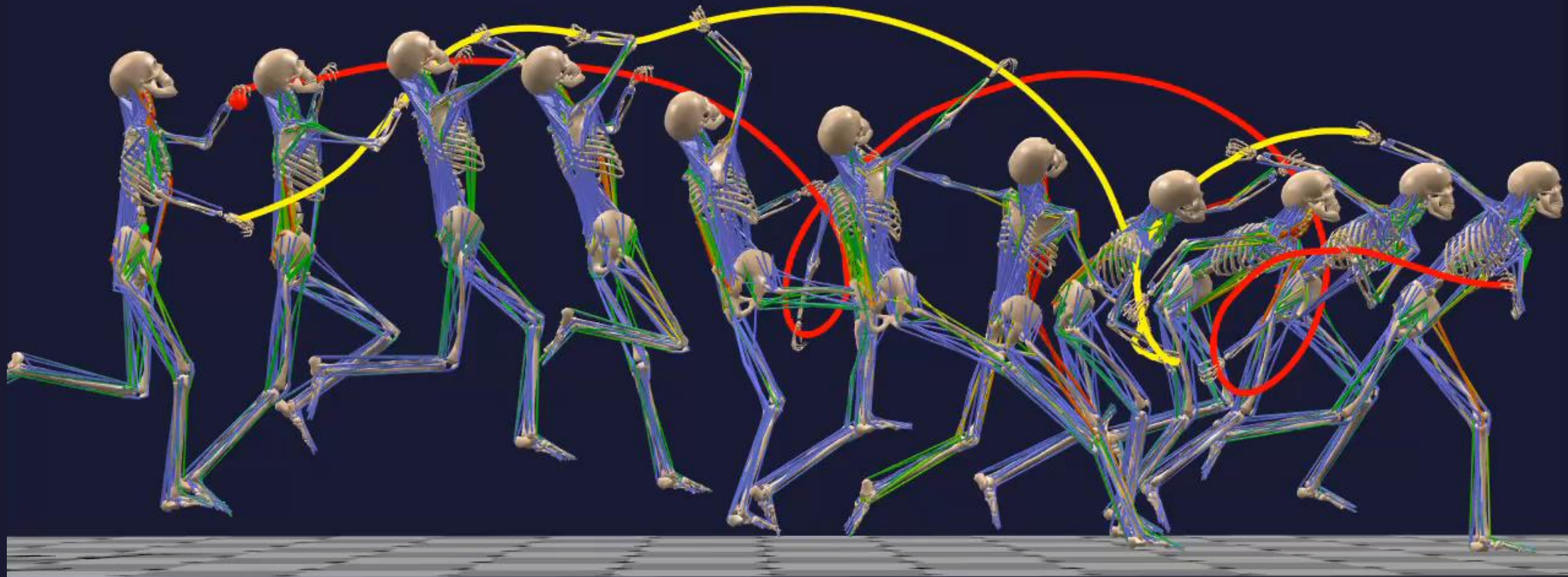
BoB motion input

Inertial Measurement Units



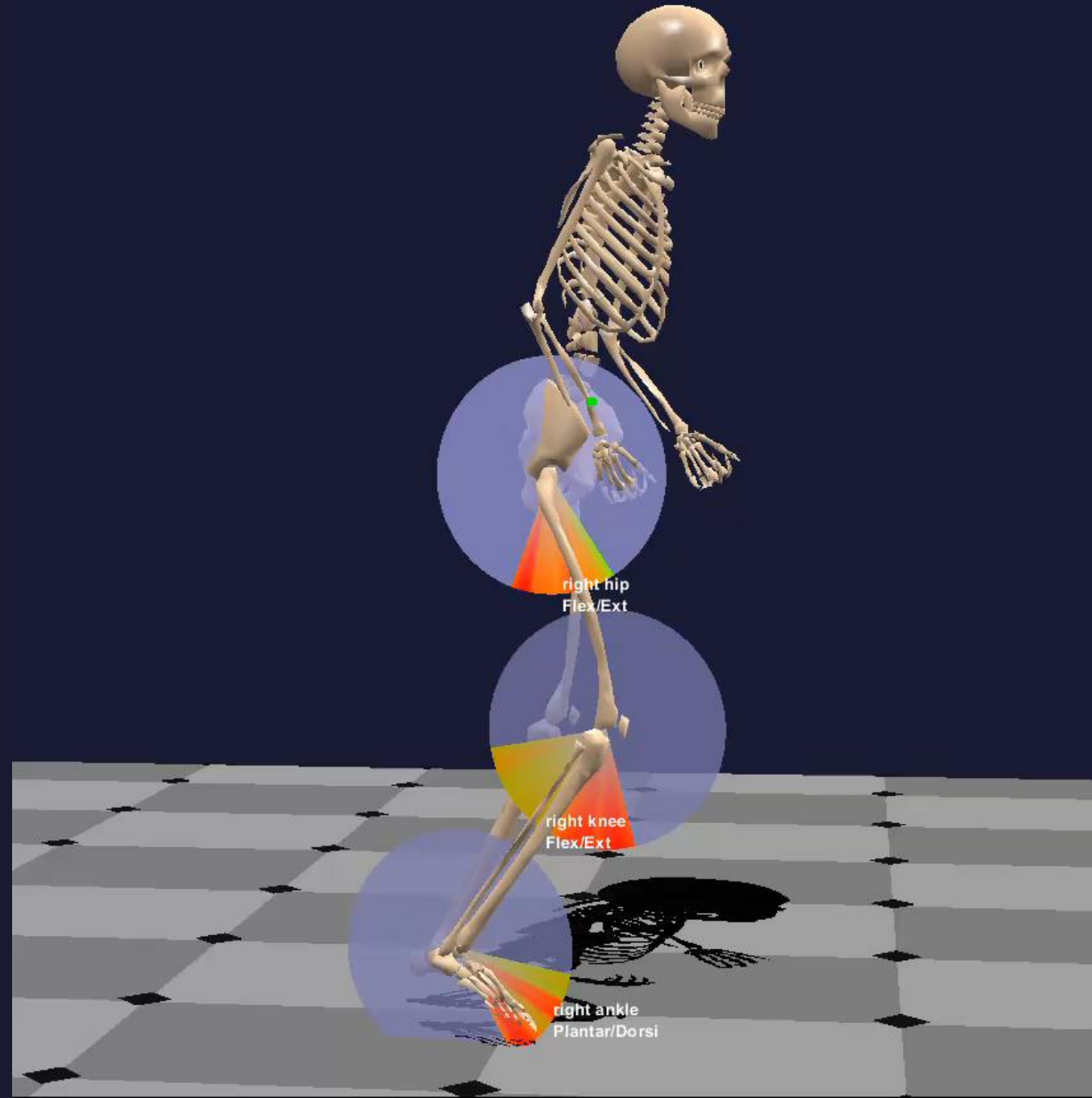
BoB output

Motion observation by anatomical trajectories and instances



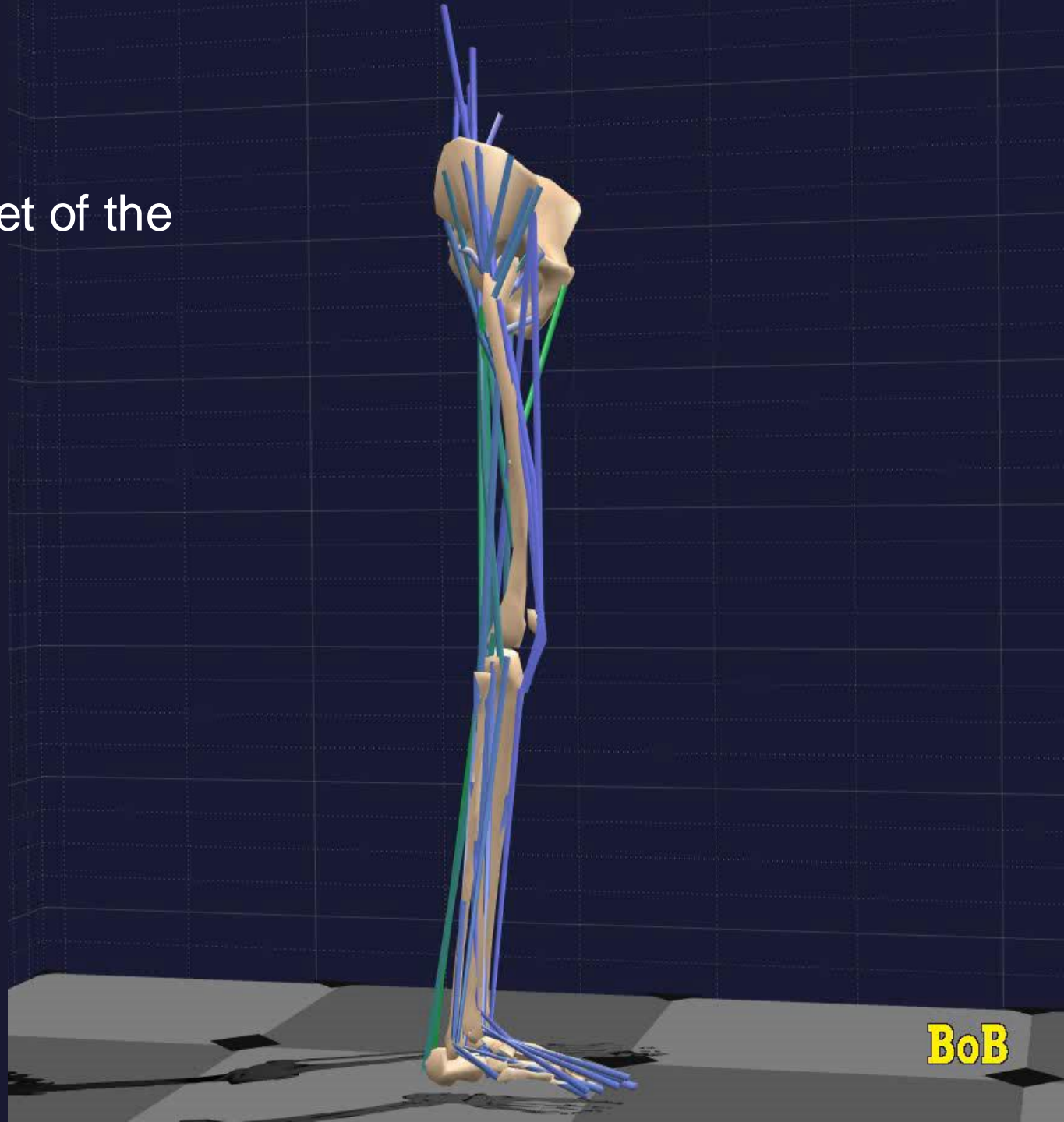
BoB output

Ranges of motion and
joint angle graphs



BoB output

BoB can display a subset of the whole body.

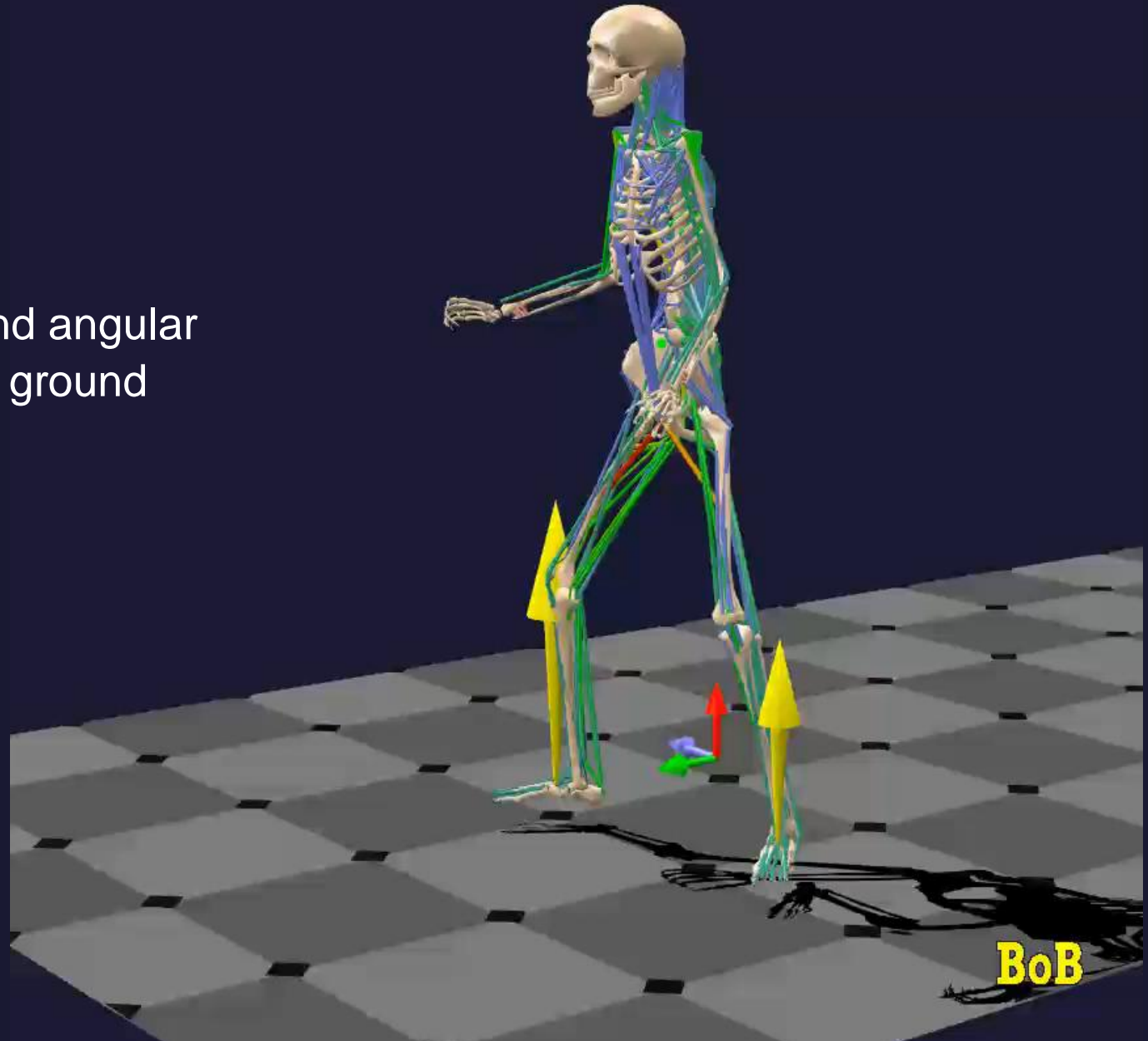


BoB output



Ground reaction forces

BoB considers the linear and angular acceleration to calculate the ground reaction forces at the feet.



BoB output

Joint torques

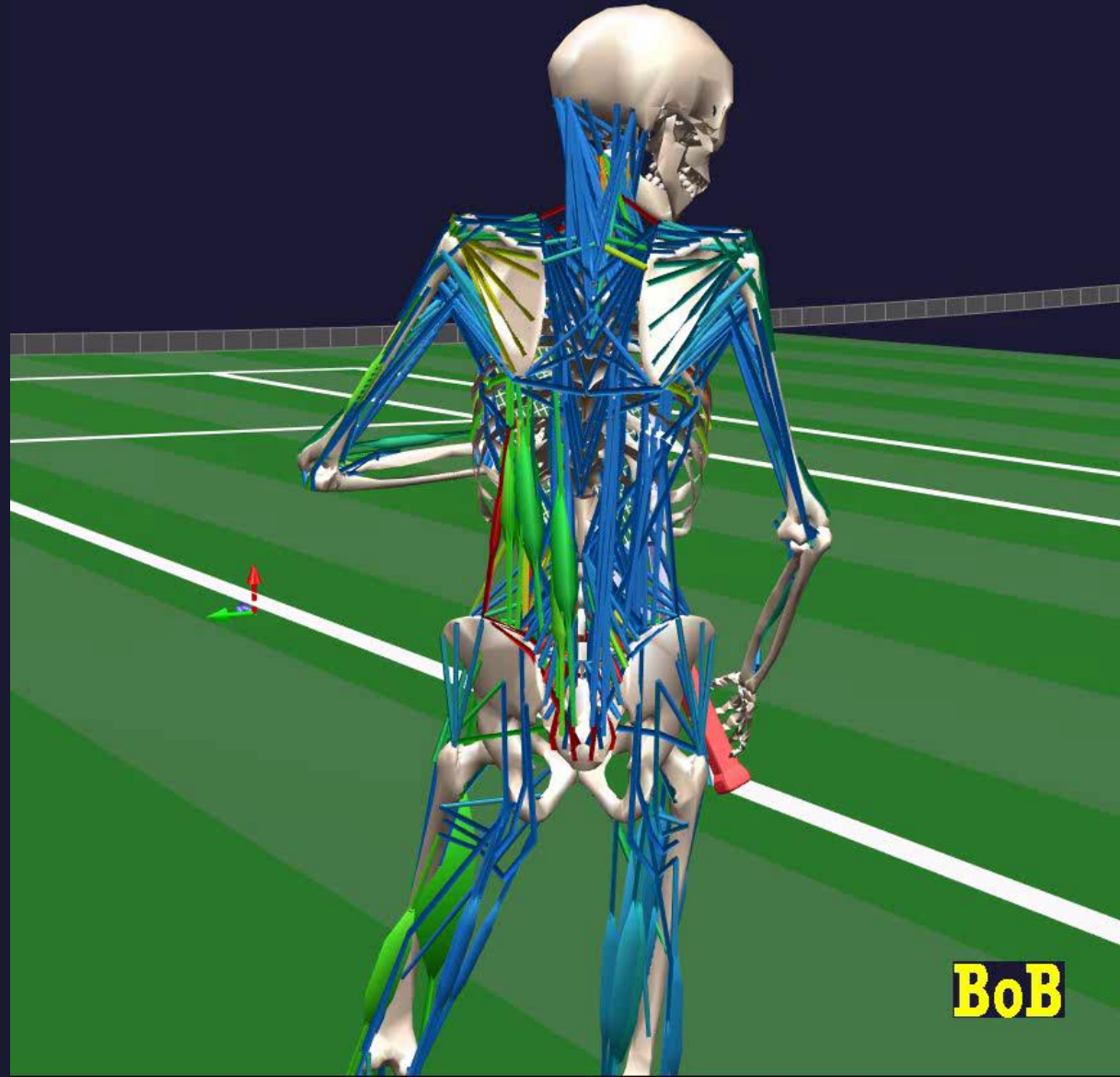
BoB using inverse dynamics to calculate and display joint torques and ground reaction forces.



BoB output

Muscle forces

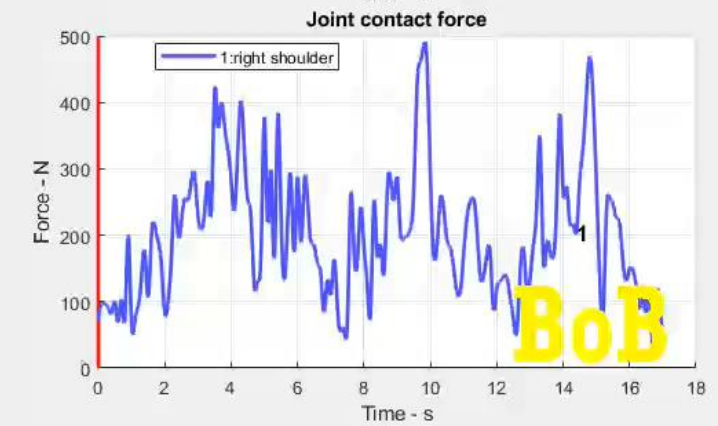
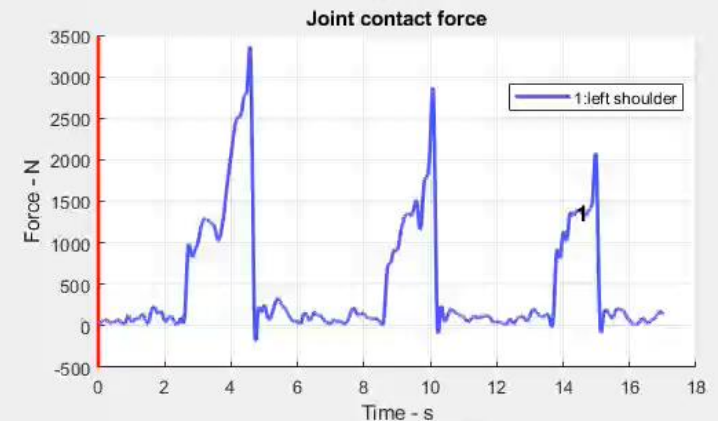
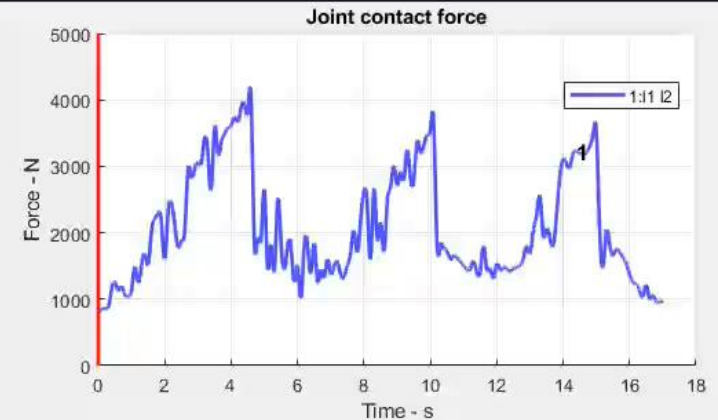
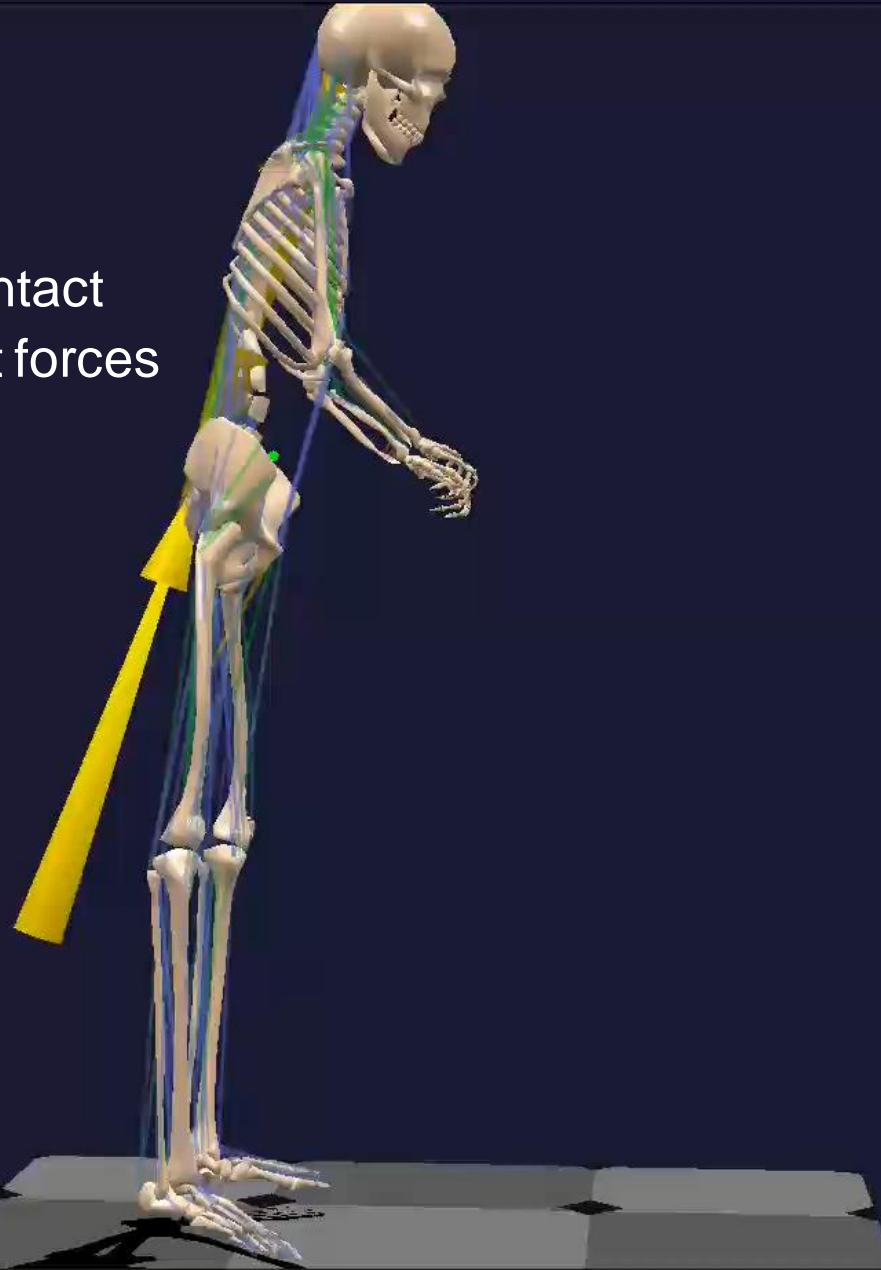
BoB calculates muscle forces by minimizing a cost function using FMINCON and QUADPROG in the Optimization toolbox.



BoB output

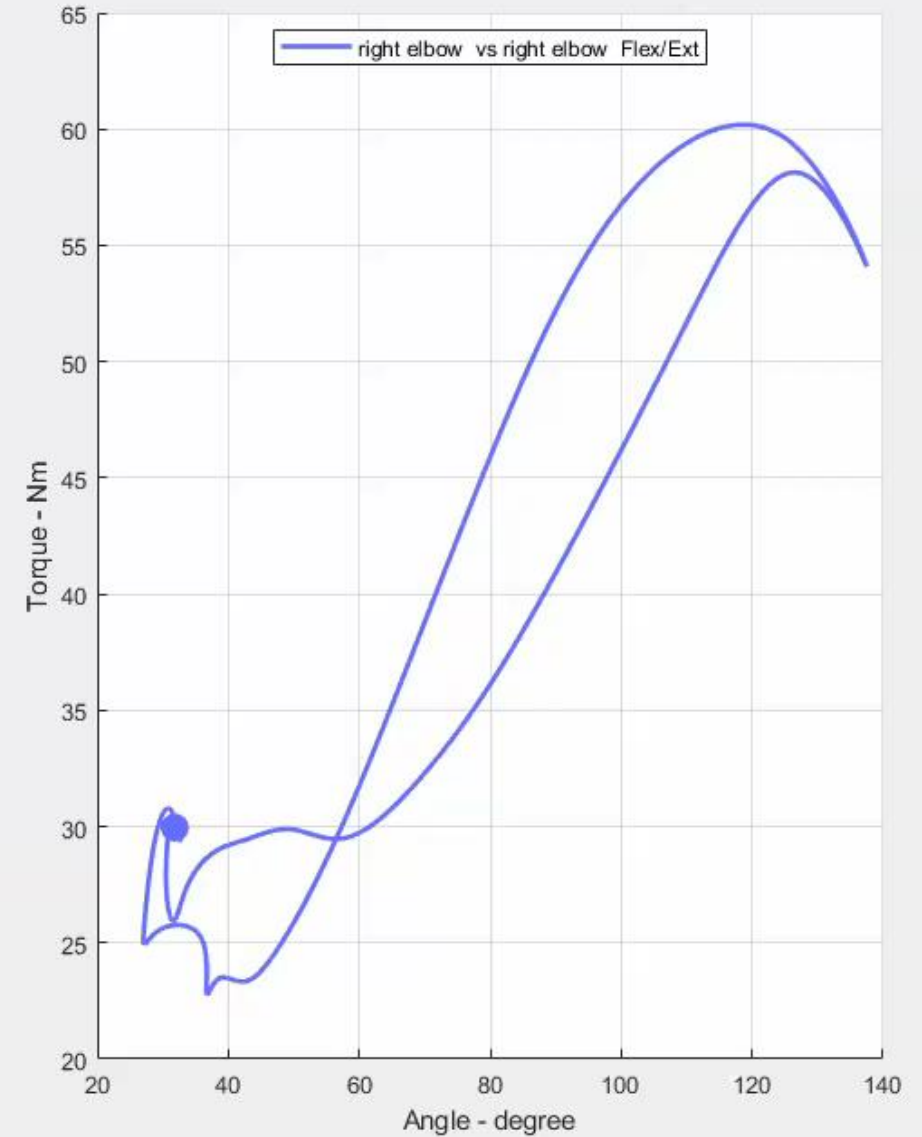
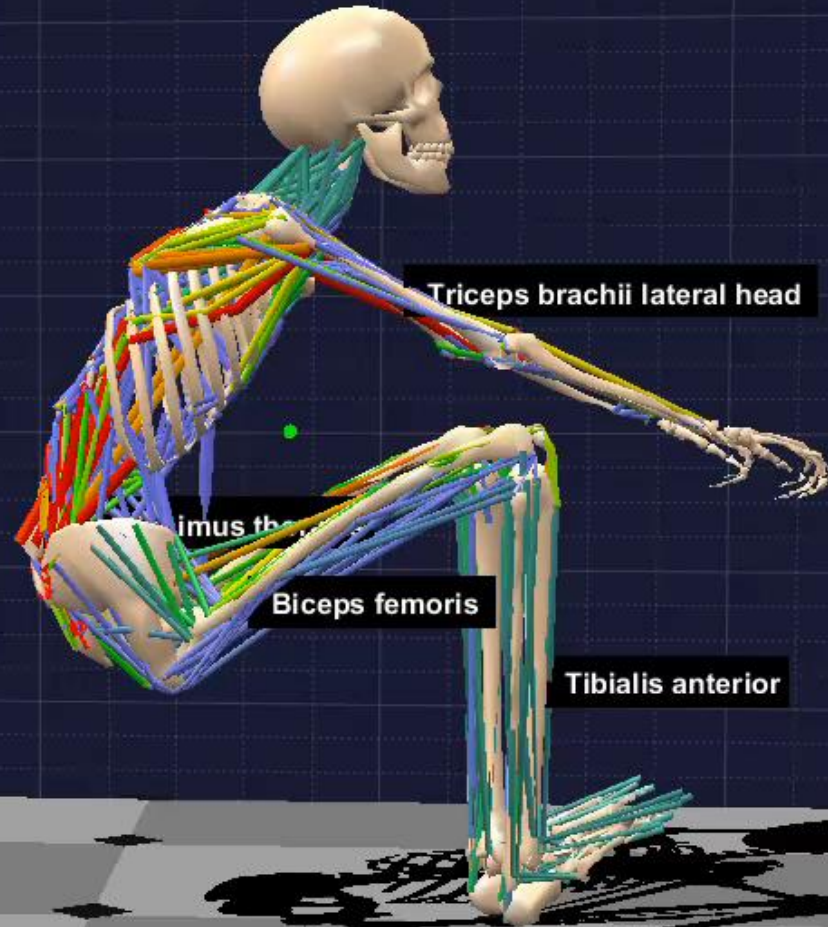
Joint contact forces

BoB calculates joint contact forces from the constraint forces and the muscle forces.



BoB output

Bivariate plots



BoB output

Kinematic and kinetic comparisons across a population.



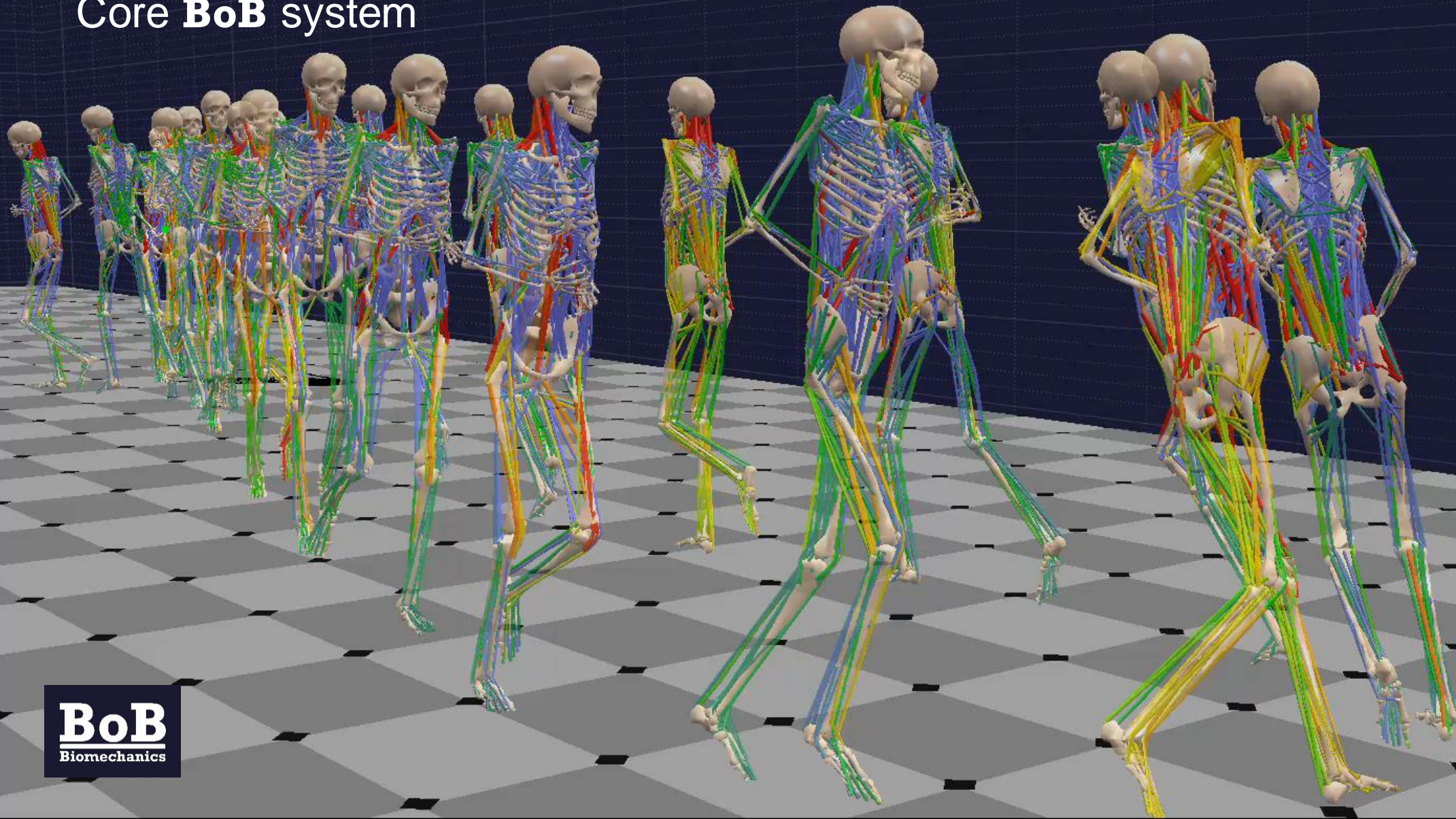
BoB variants

- **BoB/Research**
- **BoB/Ergo**
- **BoB/EMG**
- **BoB/Teaching**



BoB/Research

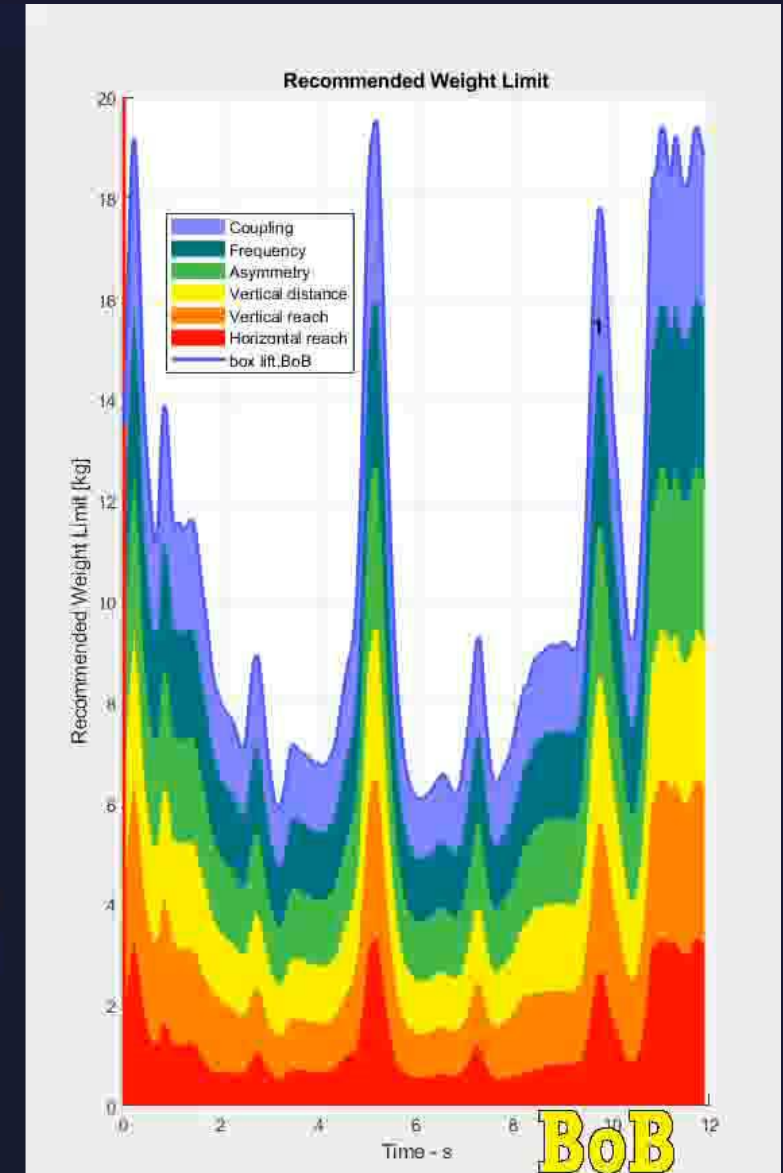
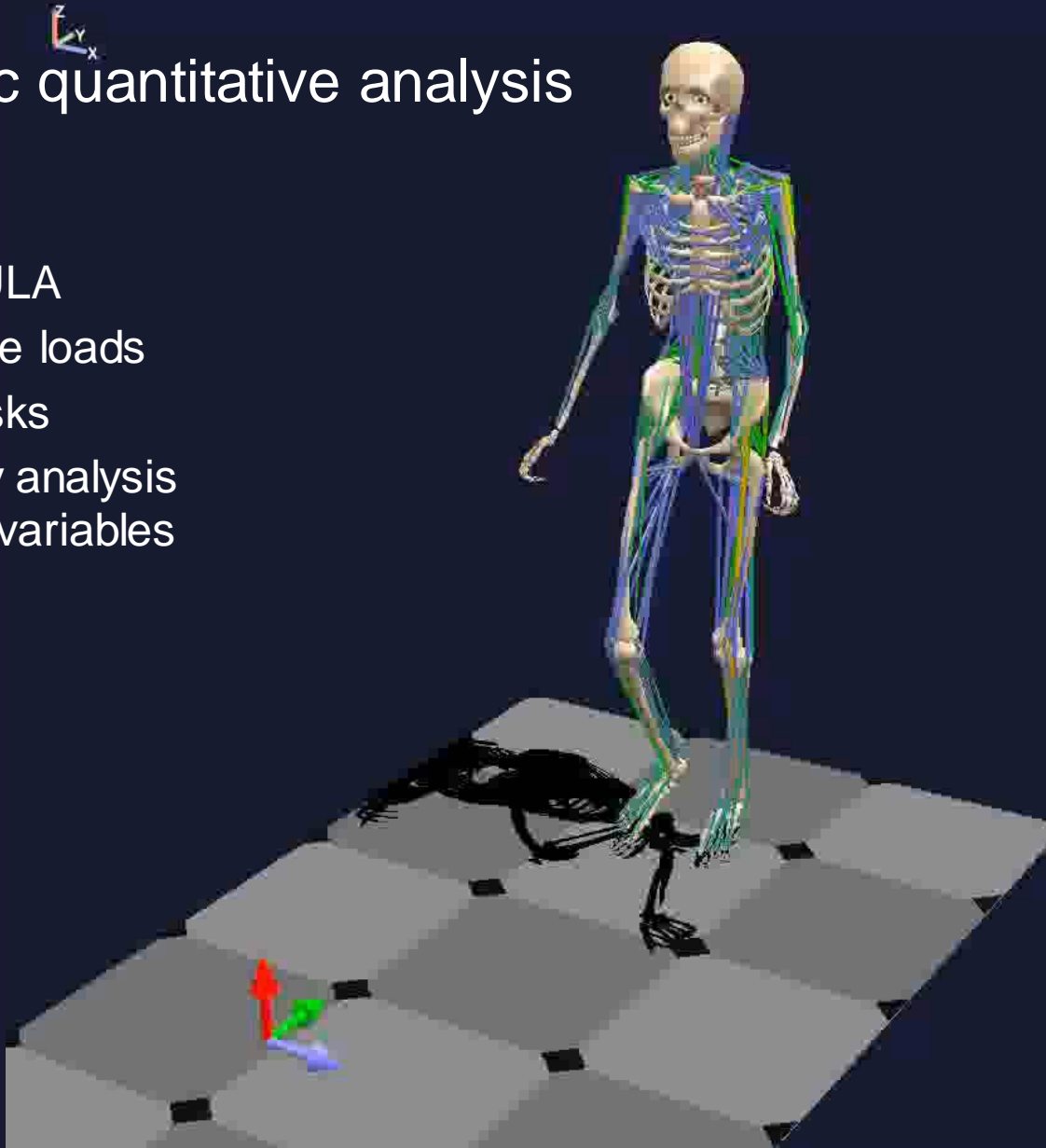
Core BoB system



BoB/Ergo

Ergonomic quantitative analysis

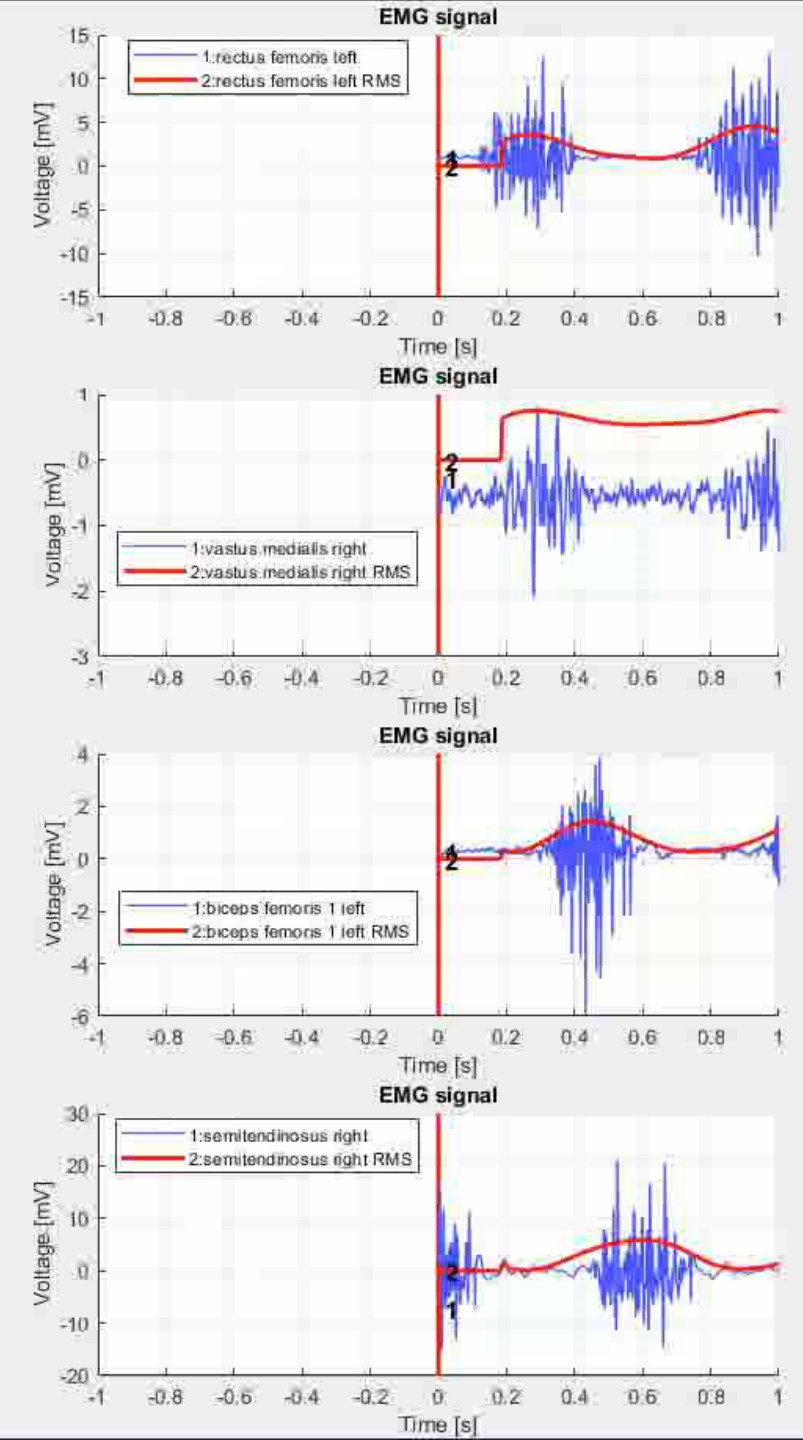
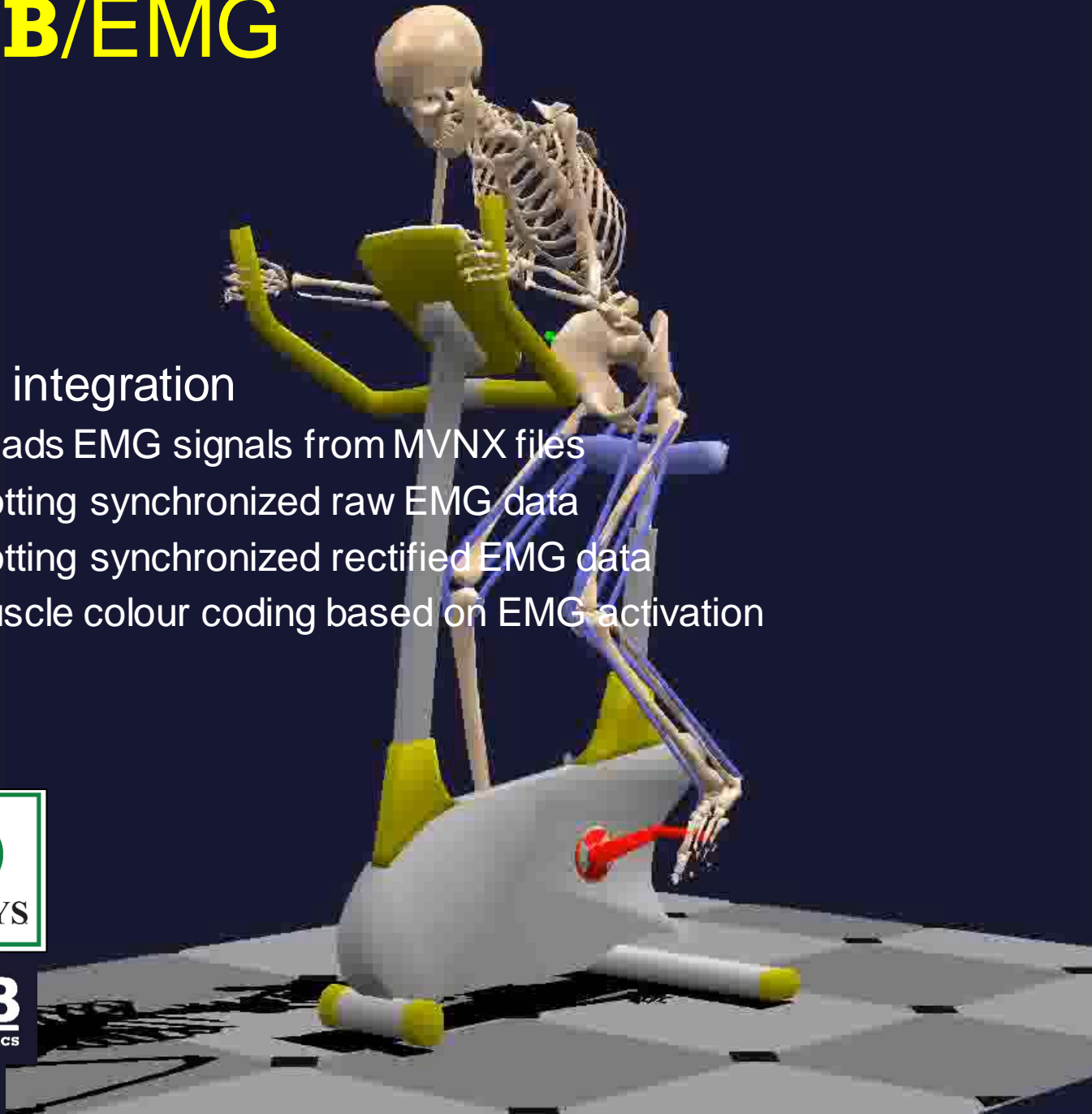
- ISO
- NIOSH
- REBA/RULA
- Cumulative loads
- Marras risks
- Sensitivity analysis to design variables



BoB/EMG

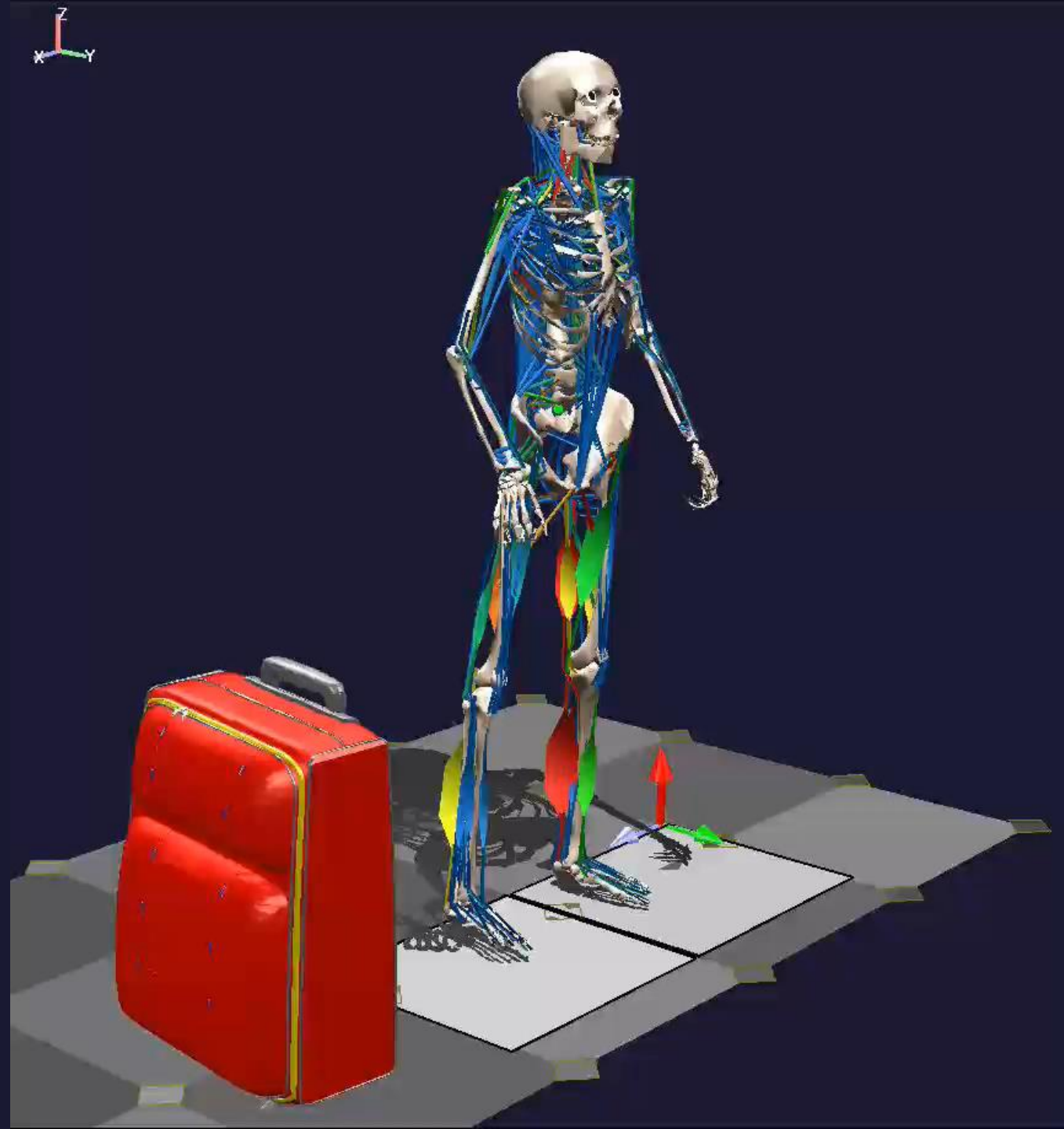
EMG integration

- Reads EMG signals from MVNX files
- Plotting synchronized raw EMG data
- Plotting synchronized rectified EMG data
- Muscle colour coding based on EMG activation



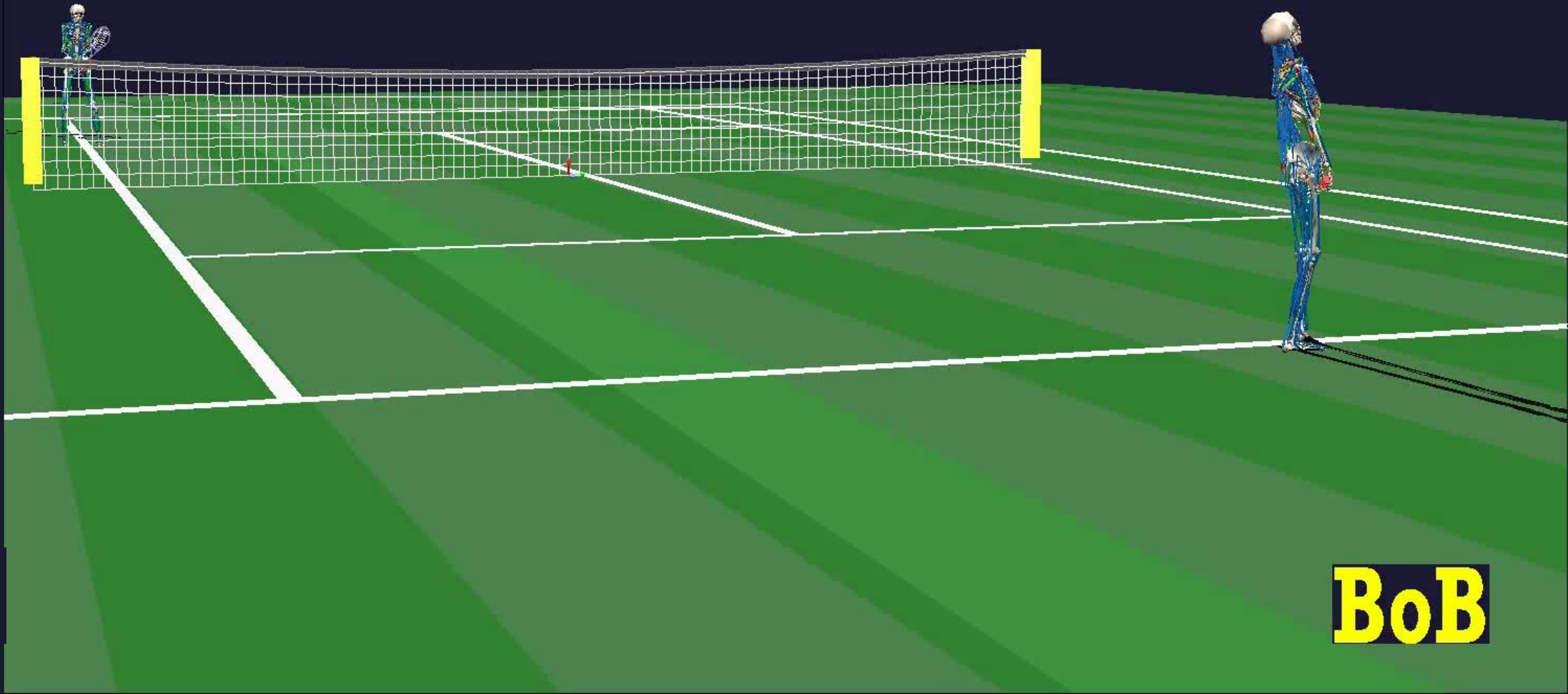
BoB/Teaching

- **BoB/Teaching** is designed for teaching biomechanics.
- **BoB/Teaching** contains pre-loaded motion examples.
- **BoB/Teaching** also contains students' worksheets.



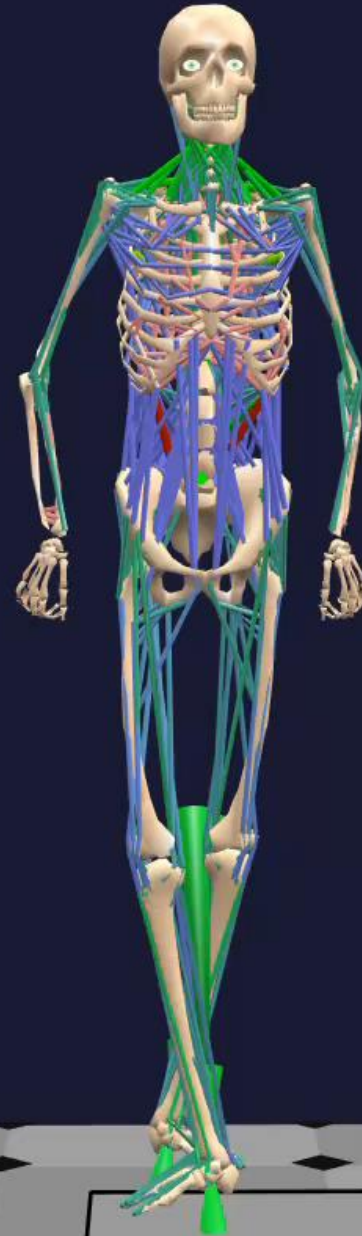
BoB applications

BoB is used to analyse sporting behaviour for technique optimization, technique comparison and injury reduction.



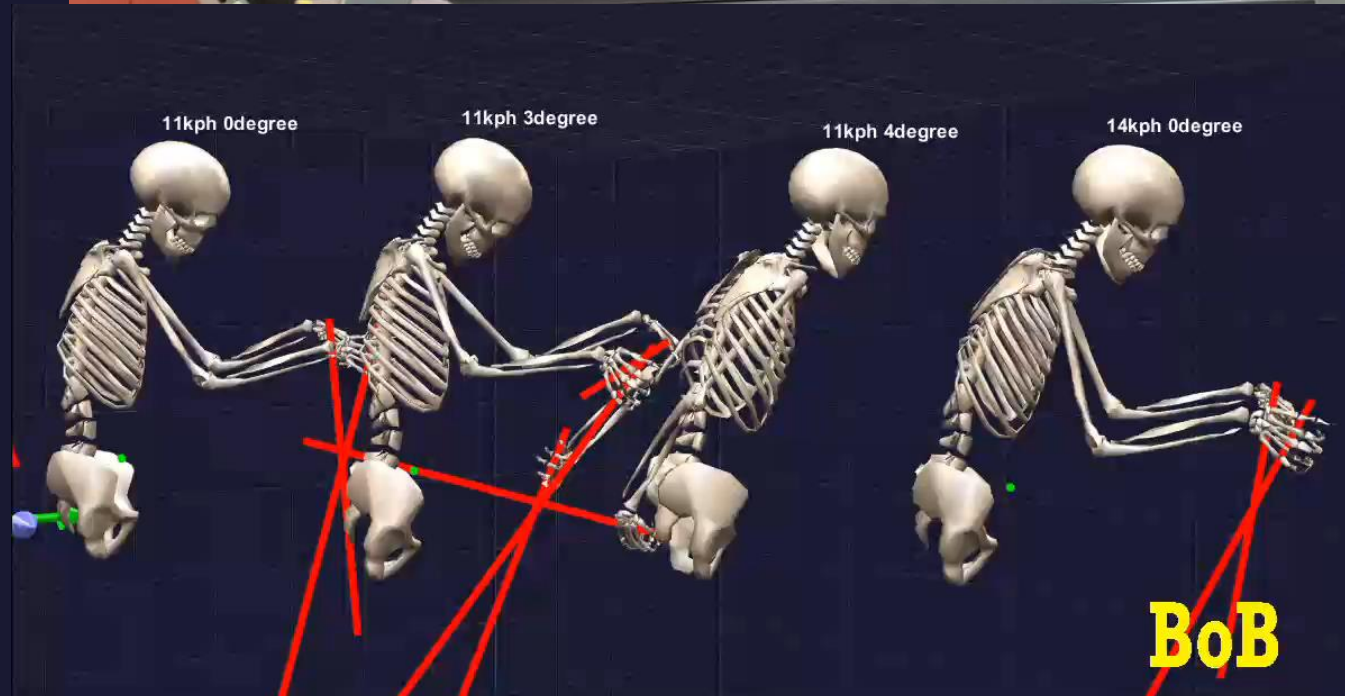
BoB applications

Reducing Irish dance injuries



BoB applications

Analysis of Paralympian athletes

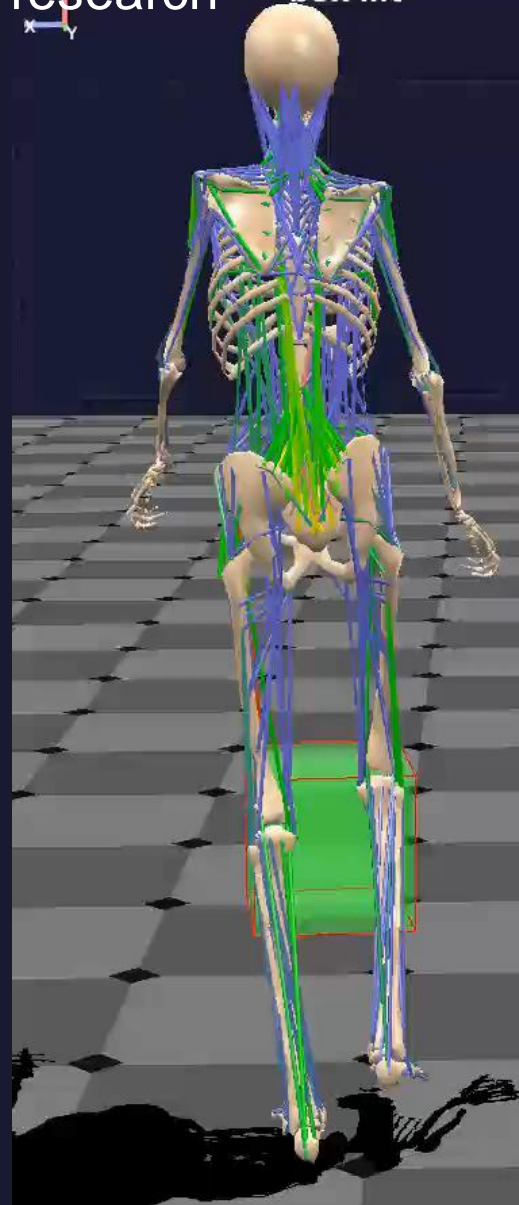


BoB applications

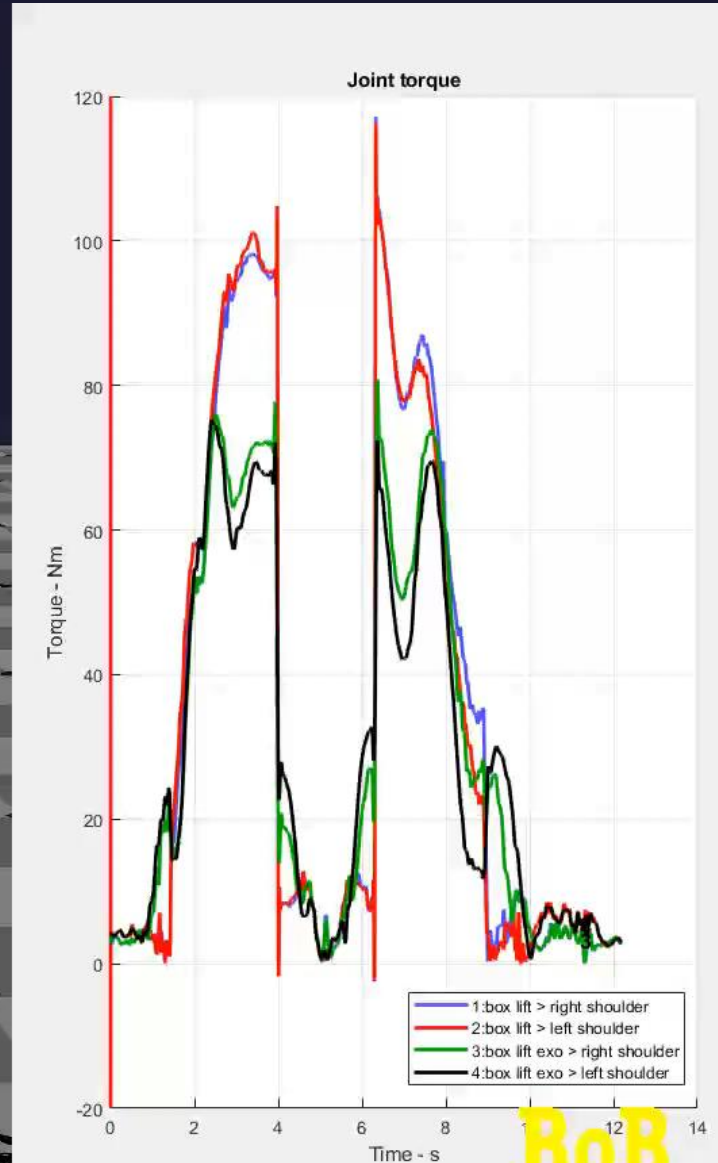
Exo-skeleton research



box lift

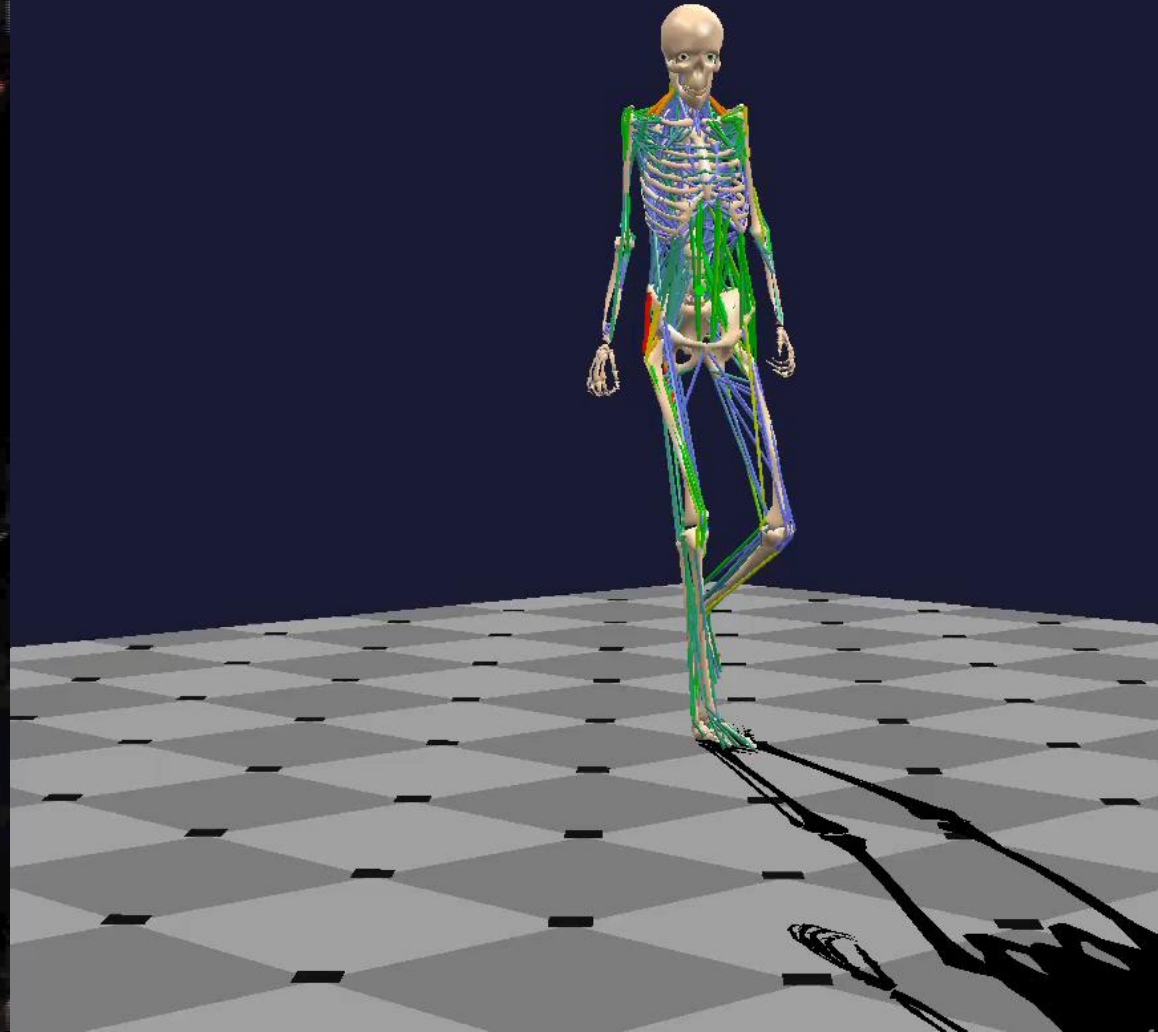


box lift exo



BoB applications

Car seat design



BoB applications

Emergency services training and protocols

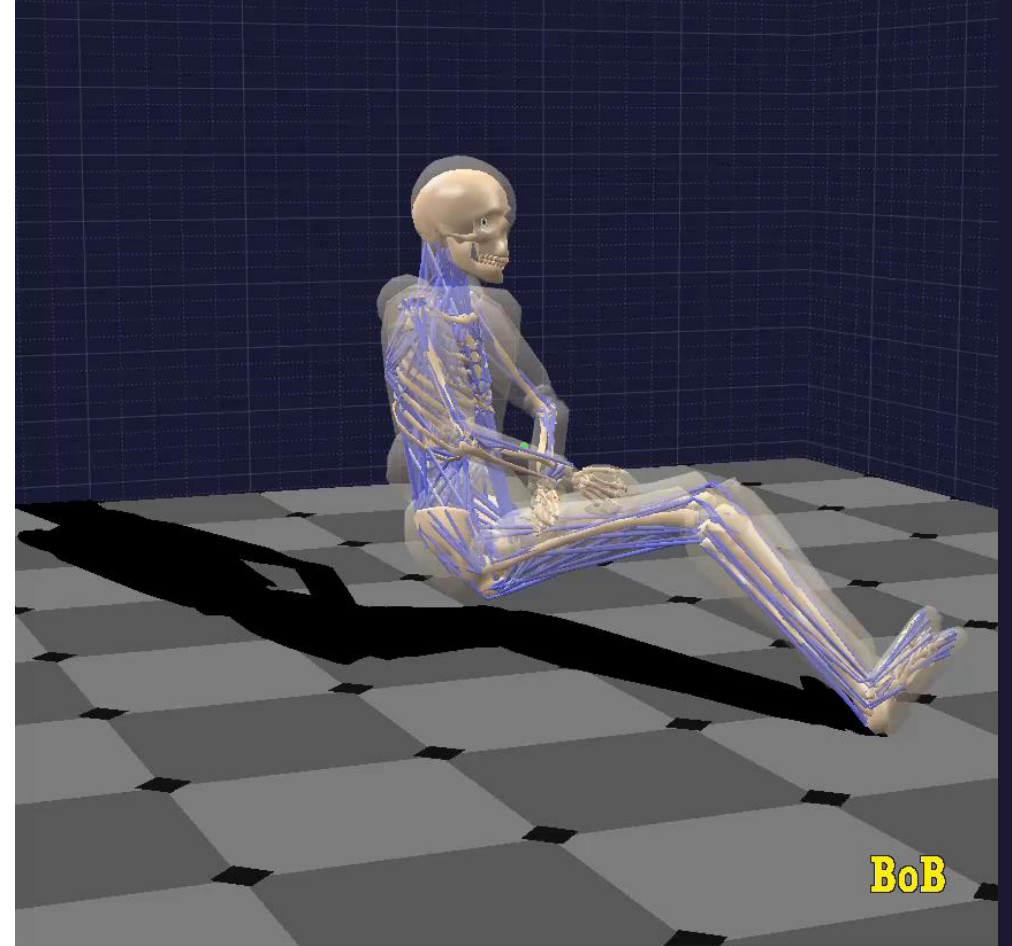
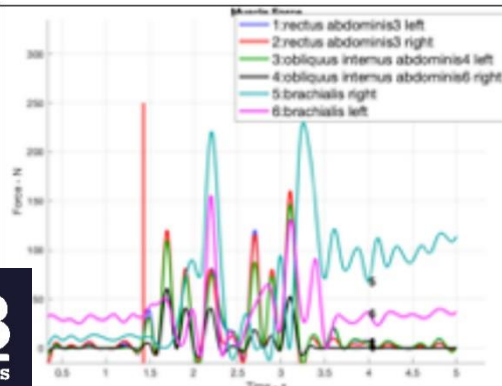
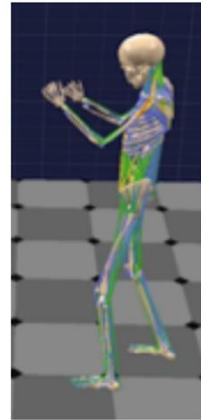
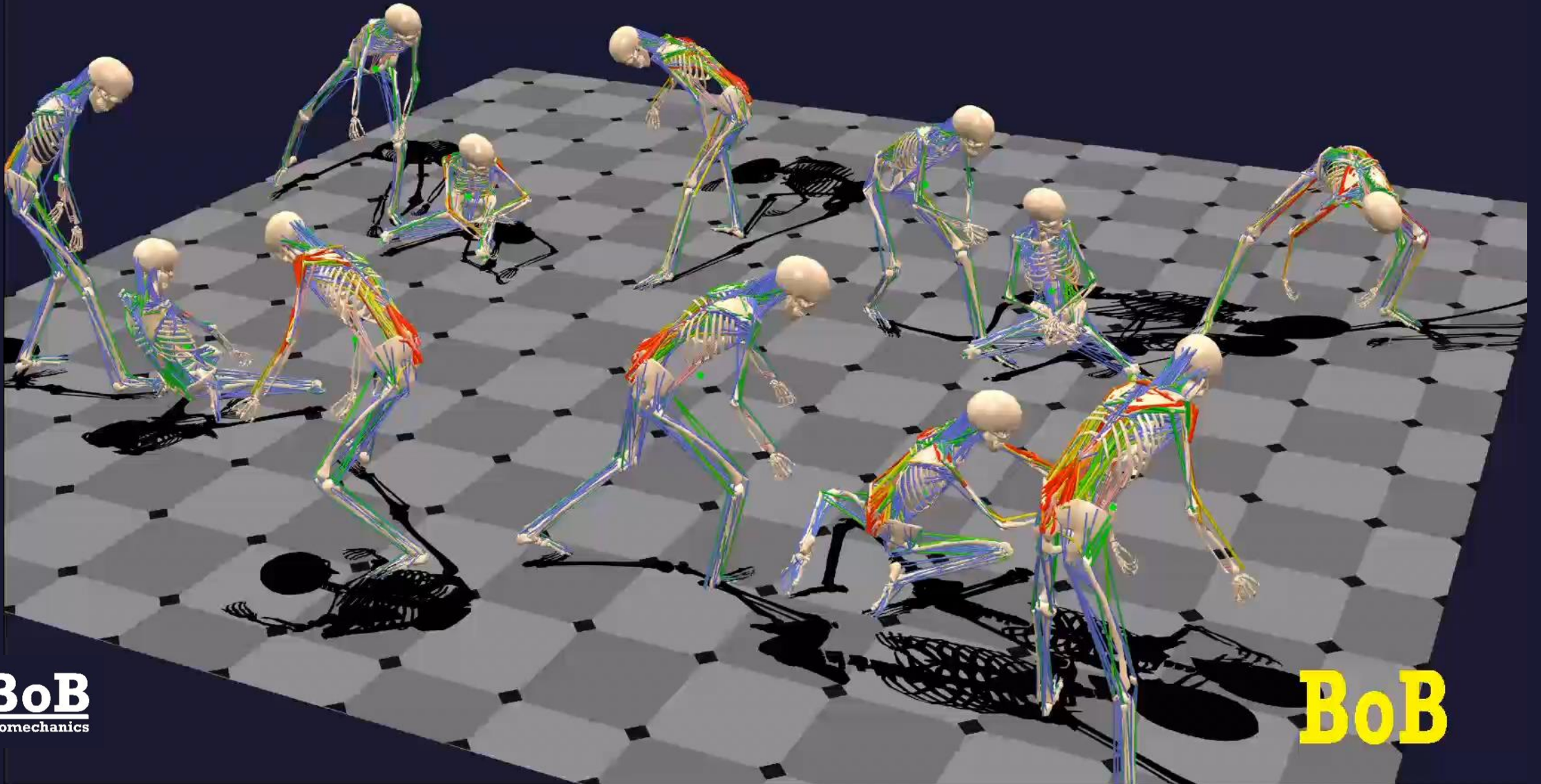


Figura 7-5. Análisis dinámico en los músculos abdominal, oblicuo y braquial (inferior izquierda) junto a su representación (inferior derecha) en el tiempo 1,4s marcado con una línea roja en las gráficas

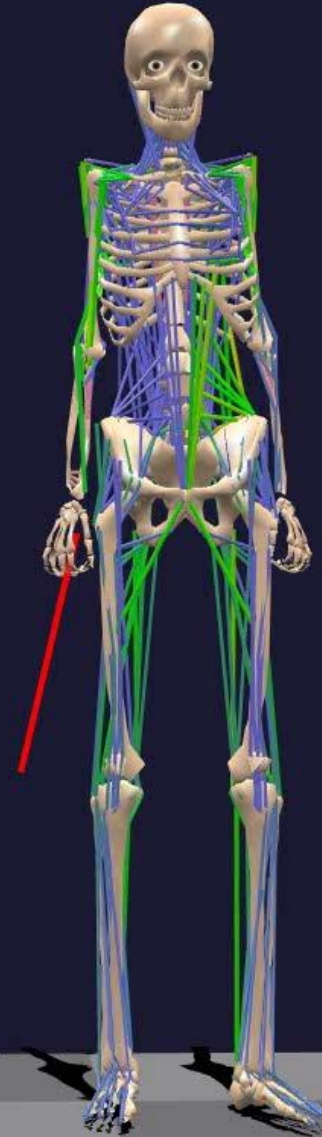
BoB applications

Formula 1 pit stop optimisation.



Summary

- 1) **BoB** introduces a human model into the MATLAB environment.
- 2) **BoB** is a biomechanical toolbox for MATLAB.
- 3) **BoB** makes extensive use of MATLAB's built-in mathematical analysis functions and graphics.
- 4) For more information on **BoB** and to download a trial version, visit our website:
BoB-Biomechanics.com



BoB

