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Biomechanics of human movement – The Legacy & the Future!

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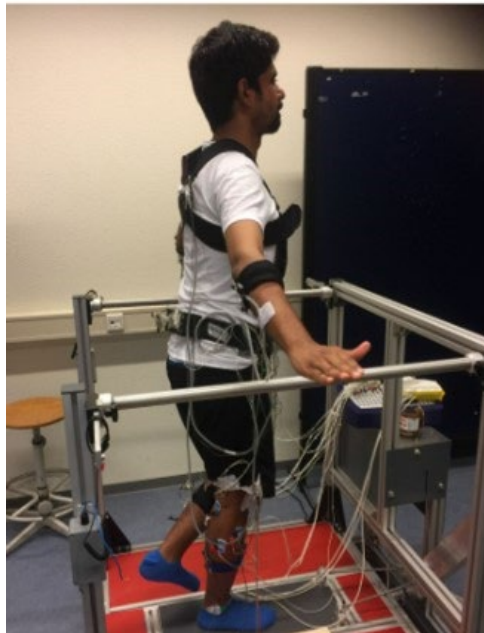


Research Topic, Question & Contents

- **Research topic** -> Biomechanics of movement in humans
- **Research question** -> Can we move towards simple smartphone-based videos in biomechanics instead of lab-based expensive Motion Capture (Mo-Cap) systems?
- **Part 1**: Past research (the legacy)
- **Part 2**: Current research (also the future)
- **Part 3**: Pictures of simulation results

The Problem (legacy)

- Traditionally biomechanical experiments are costly, time-taking, requires specific expertise and done (mostly) within labs
- Movement dynamics rarely measured in clinical settings/outside lab
- Data collection, processing & generating dynamic musculoskeletal simulations takes several days
- Inertial Measurement Units (IMUs) and marker less, video-based Mo-cap systems are current alternatives

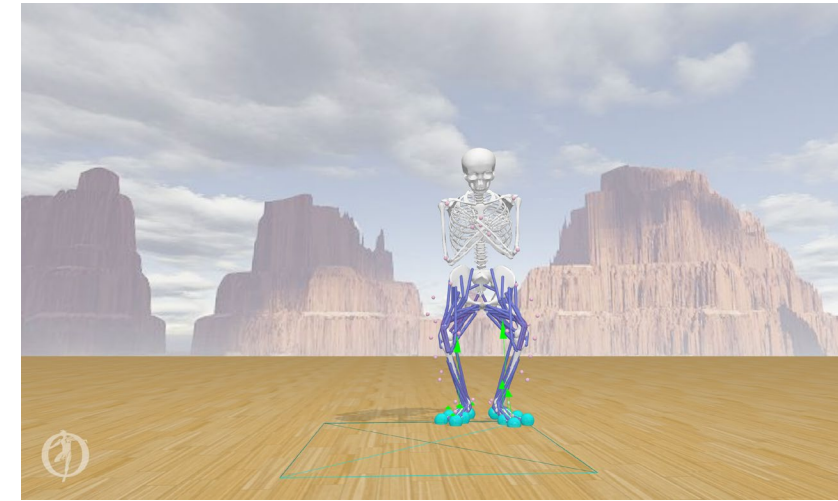


Videos with AI (the future)

The screenshot displays the OpenCap software interface. At the top left is the OpenCap logo. The top navigation bar includes links for 'RECONNECT PHONE', 'FIND ON GITHUB', and 'LOGOUT'. On the left side, there is a sidebar with a 'Trial name' field, a 'START RECORDING' button, a list of trials (SBurpees, STennis, STennisL, SPushups1, SBurpees1, SPushupsReverse), a 'Show removed trials' checkbox, and several session management buttons: 'NEW SESSION, SAME SETUP', 'NEW SESSION', 'SHARE SESSION PUBLICLY', 'DOWNLOAD DATA', 'ANALYSIS DASHBOARD', and 'BACK TO SESSION LIST'. The main area features a 3D skeleton model on a blue and white checkered floor. On the right, a video player shows a person performing a physical activity in a laboratory setting. The video player includes a progress bar, a time display of 10.89 seconds, and playback controls (play, pause, stop, next, previous) with speed options (0.1x, 0.25x, 0.5x, 0.75x, 1x, 2x).

- Video-based (markerless) kinematics & kinetics
- Based on Deep learning (LSTM) models

Muscle-driven simulations



Above figures show biomechanics of various human movements, like a jump (left), squat (center) and a sit-to-stand motion (right). These are simulation results after the video data is analyzed (see the previous slide).

The red colored muscles in the hips & lower limbs show which muscles are activated during the movement and the green arrows show the vertical ground reaction forces that are applied back at the body during the movement from the ground. These forces are equal and opposite to the forces exerted by the body on the ground (according to Newton's 3rd., law of motion in Physics).

References

- Uhlich SD *, Falisse A *, Kidziński Ł *, Muccini J, Ko M, Chaudhari AS, et al. (2023) OpenCap: Human movement dynamics from smartphone videos. PLoS Comput Biol 19(10): e1011462.
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- Delp SL, Anderson FC, Arnold AS, Loan P, Habib A, John CT, Guendelman E, Thelen DG. OpenSim: open-source software to create and analyze dynamic simulations of movement. IEEE Trans Biomed Eng. 2007 Nov;54(11):1940-50. doi: 10.1109/TBME.2007.901024. PMID: 18018689.