MyoBack: A Musculoskeletal Model of the Human Back with Integrated Exoskeleton

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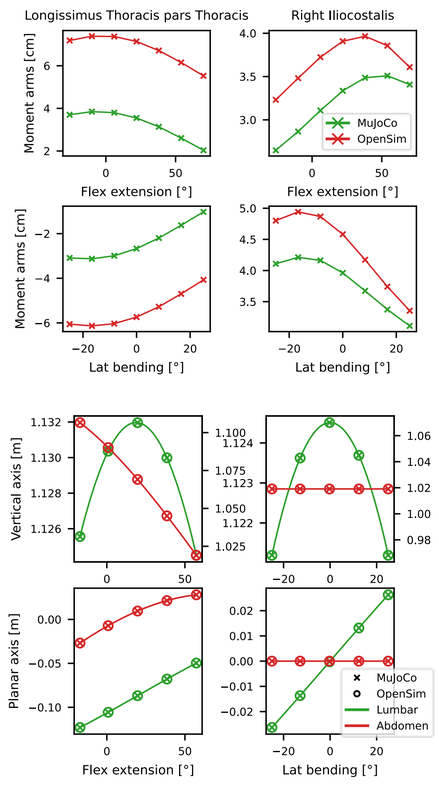
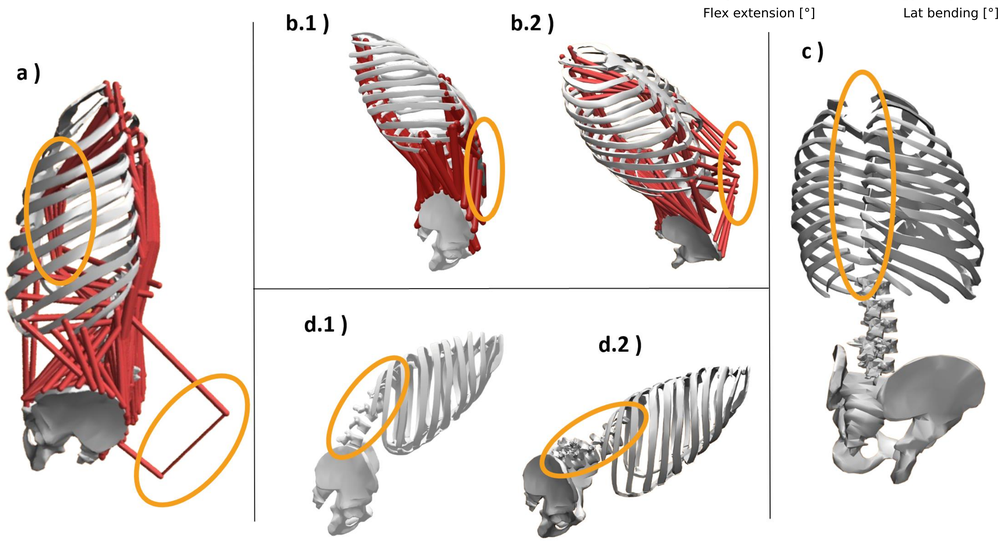
Digital Twins of Back Models are important in:

- Understanding full body motion (e.g. walking, balancing, squatting.)
- Development and testing of assistive devices
- Modeling back-related MSK disorders

Step 1: MyoBack Conversion and Finetuning

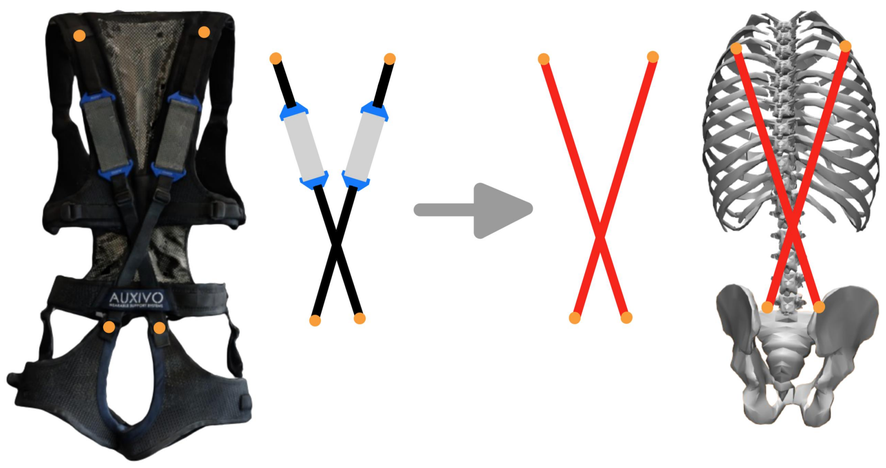
1. Selecting an available OpenSim model
2. Converting to MyoSuite compatible version using MyoConverter (Wang et al. 2022)
3. Fixing and Finetuning
   - Muscle jumping
   - Immobile abdomen
   - Non-curved spine
   - Absent thoracic vertebrae
4. Validating against OpenSim kinematic readings in:
   - Joint position at different DoFs
   - muscle moment
   - muscle force generations





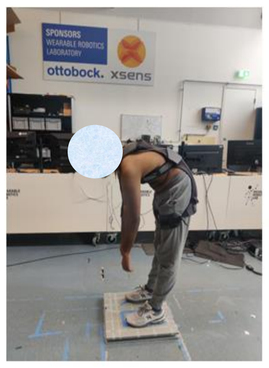
Step 2: Creating a digital Twin of Auxivo ExoSuit

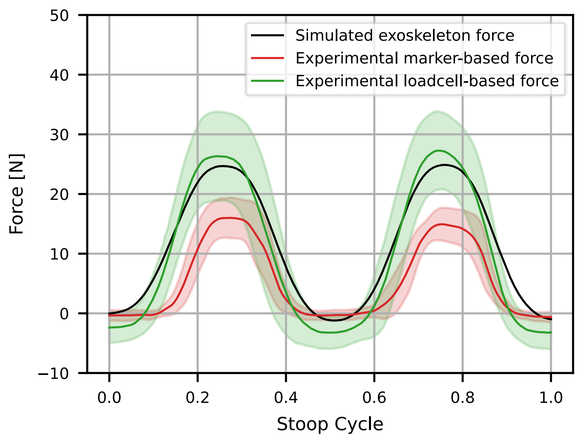
1. Modeling elastic bands as tendon in MuJoCo
   - K_{Auxivo} = F/ΔL = 1527.5N/m
   - K_{MuJoCo} = 526.4N/m due to different length
2. Deciding Attachment Point:
   - the level of the 5th thoracic rib
   - the posterior superior iliac spine
3. Creating wrapping object (cylinder)

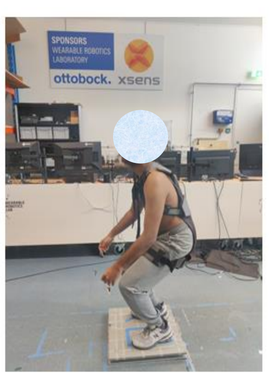


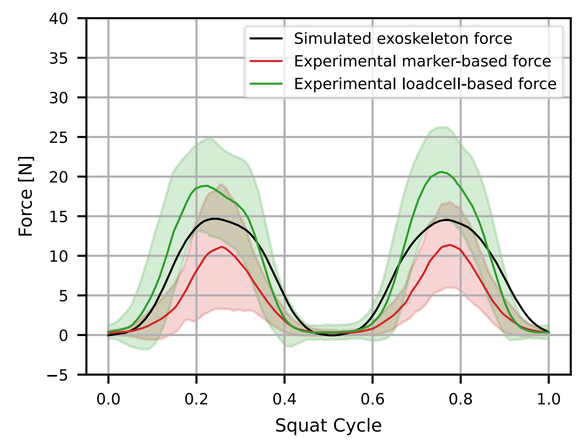
Step 3: Validation against Human Experiment

- 9 participants (height in cm: 173.8 ± 11.1, weight in kg: 73.4 ± 16.5, age in years: 23.5 ± 1.4)









Step 4: Reinforcement Learning and MyoBack

- Compatible with Gymnasium RL framework
- Significant reduction in metabolic cost using Exosuit
- Stoop at four different flex-extension angles

Looking Beyond

- Integration with lower limb MSK model
- Coordination with active Back Exoskeleton
- Understanding and modeling of *Lower Back Pain (LBP)* and other MSK disorder

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We acknowledge the funding from MITACS and NSERC Discovery to support this research. The contribution of Angela Zhu and Anto Catanzaro in their work in reinforcement learning control of MyoBack. The human experimental study was approved by the University of Twente's ethical review board (Ref. number: 240424).

Open Source and Fully Available @myo_sim and @MyoSuite!

Repo Available!