Friedl De Groote, Lorenzo Pitto, Antoine Falisse, Hans Kainz,
Mariska Wesseling, Sam Van Rossom, Eirini Papageorgiou,
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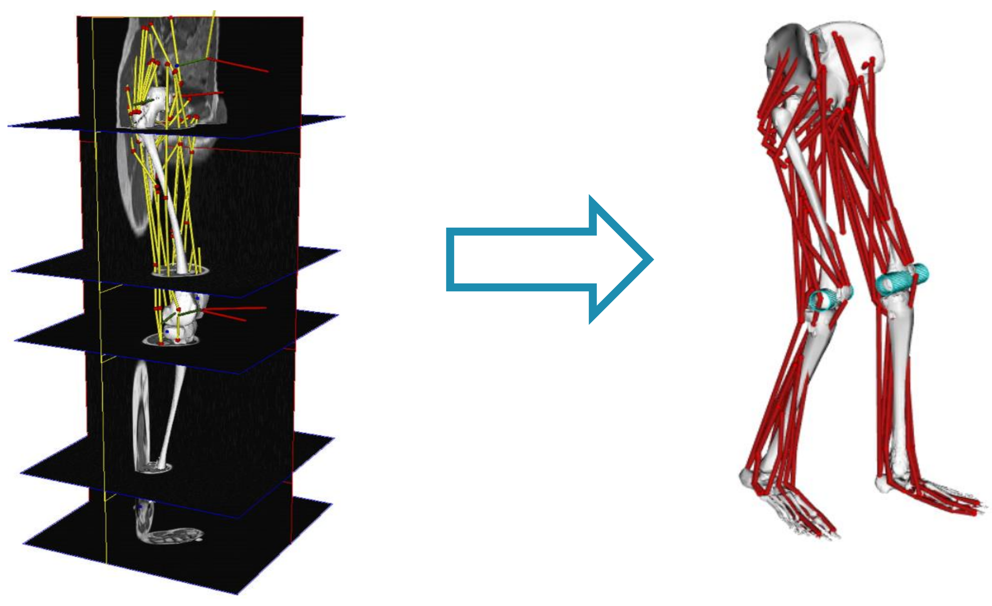
SimCP: A simulation platform to predict gait performance following orthopedic intervention in children with cerebral palsy

PERSONALIZED NEURO-MUSCULOSKELETAL MODEL

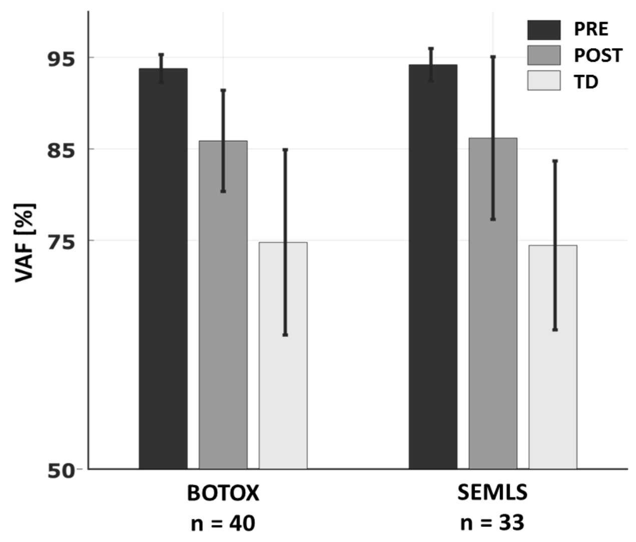
Musculoskeletal geometry

based on MRI images (Scheys et al., 2011)



Non-selective muscle control

based on muscle synergies derived from EMG during walking



Pre-intervention synergy weight vectors explain post-intervention EMG.

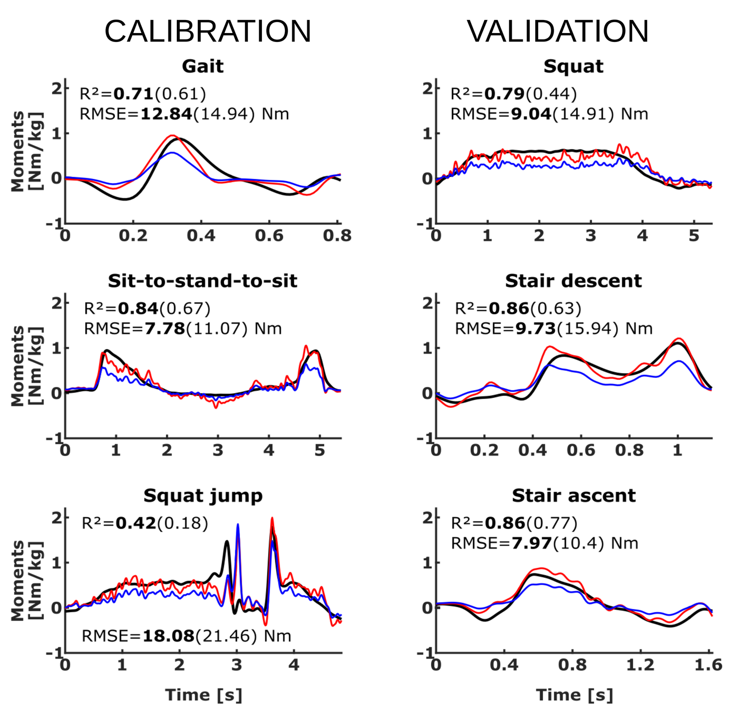
Difference in variance accounted for (VAF) between pre- and post- intervention walking EMG explained by

- age → larger difference for younger children;
- pre-intervention control → larger difference if pre-intervention synergy weight vectors explain less of the variance of reference (typically developing children, TD) EMG.

Muscle-tendon properties

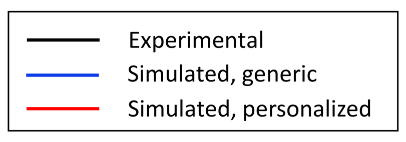
parameter estimation based on EMG, kinematics, kinetics collected during functional movements

(Falisse et al., 2017)



Suitable calibration sets to estimate Hill model parameters of knee actuators.

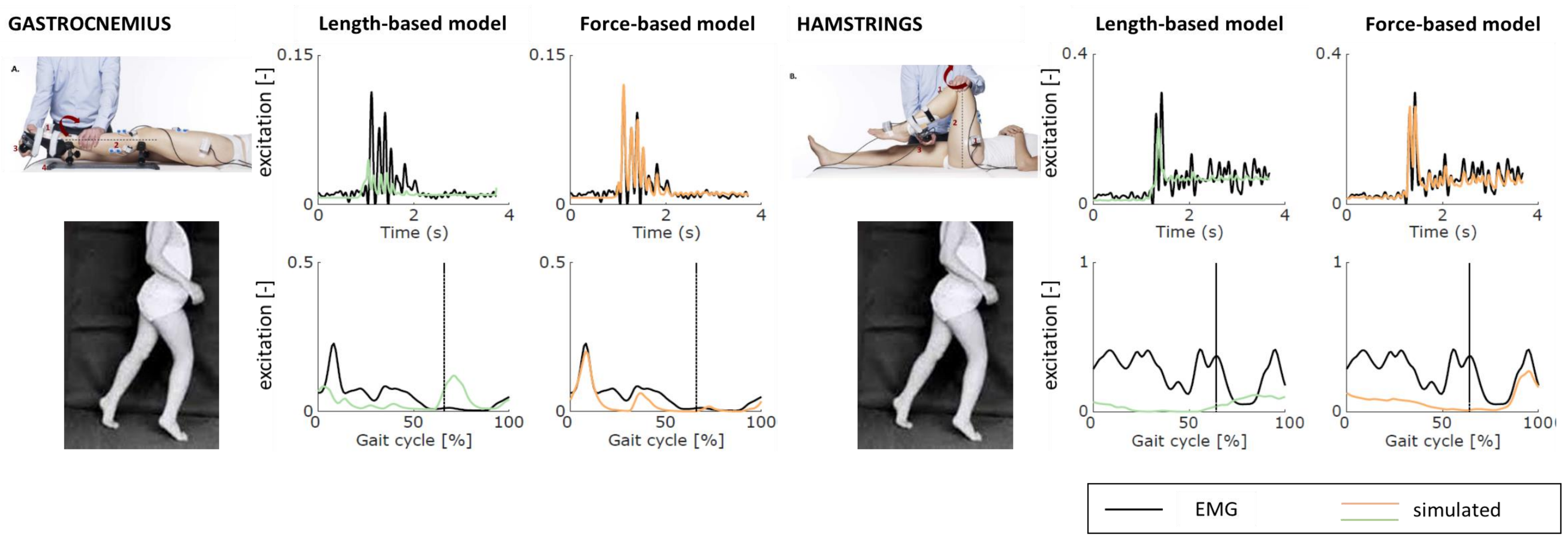
Gait	Squat	Stair descent	Stair ascent	Sit-to-stand-to-sit	Squat jump
x				x	x
x	x			x	x
x			x	x	x
x	x	x	x	x	
x	x	x		x	x
x	x		x	x	x
x		x	x	x	x



Spasticity

(Falisse et al., in review)

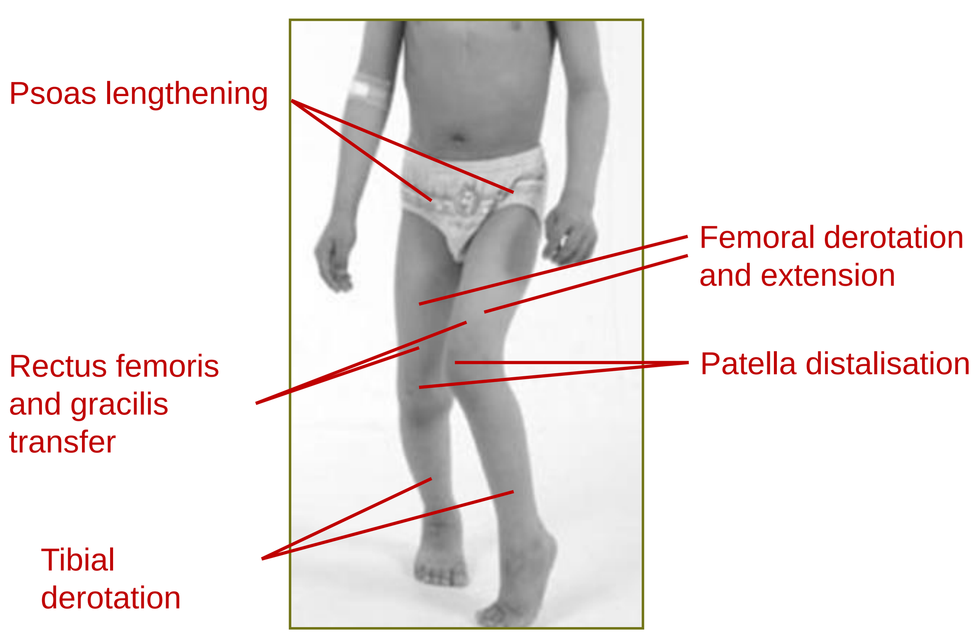
parameter estimation based on instrumented spasticity assessment (ISA)



A spasticity model based on feedback from force-related variables (muscle force and derivative of force) but not muscle length-related variables (muscle length, velocity, acceleration) explains muscle activity during passive stretches (ISA) and walking.

PREDICTION OF POST-INTERVENTION GAIT PERFORMANCE: A CASE STUDY

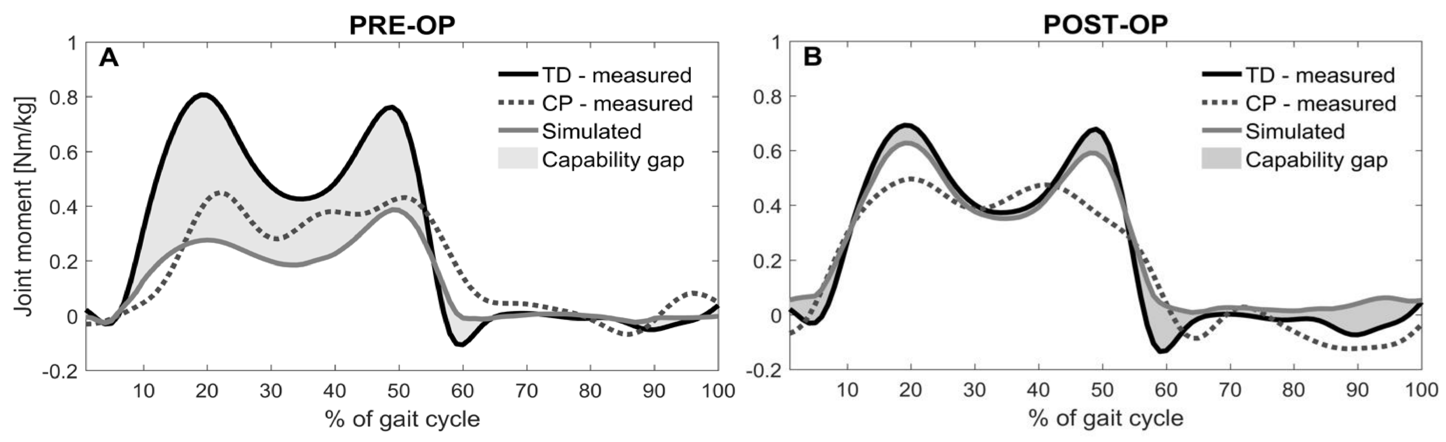
Virtual surgery on personalized neuro-musculoskeletal model



Computation of capability gap

= joint torques needed for normal walking
- joint torques model (patient) can generate

Method: synergy-constrained static optimization.



Evaluation

The simulated capability gap was smaller post-surgery (average over all joints 0.14±0.06 Nm/kg versus 0.10±0.03 Nm/kg), in agreement with closer-to-normal kinetics post-surgery (average over all joints 0.28±0.18Nm/kg versus 0.17±0.10Nm/kg).

Future work:

- more cases;
- predict gait pattern.