

BIOM9541 Mechanics of the Human Body - Individual Project Proposal

Background: A strong, firm leg and posterior are not only sought-after for aesthetics but also important indicators of lower-body fitness and overall well-being (MyaCare 2021). The goblet squat is a front-loaded squat variation in which the weight is held against the chest, emphasizing quadriceps activation while also engaging the core and upper back to maintain an upright torso (Collins et al. 2021). Understanding how squat depth and load influence muscle recruitment and joint work may help identify the most effective variations for strength, hypertrophy, and lower-body function.

Aim: To investigate how different squat depths and external loads during goblet squats affect lower-limb joint work, and optionally muscle activation to help identify the most effective variations for building strength and glute development.

Hypothesis: It is expected that increasing squat depth and load will increase lower-limb joint work and, if measured, muscle activation of the quadriceps, glutes, and hamstrings, but the relationship may not be linear, and different muscles may reach peak activation at different depths.

Methods:

- Measure the subject's anthropometrics (mass, height, inter-ASIS distance, etc.)
- Calibrate the Vicon system, zero the force plate, and perform initial IR camera setup
- Place 16 lower-body markers and record standing static calibration data (.trc, .c3d, photos)
- Perform goblet squats with varying depths (knee flexion) and loads:
 - **Depths:** shallow (0°–90°), medium (90°–110°), deep/full (110°–135°) (Straub et al. 2024)
 - **Loads:** dumbbell 2.5 kg, 5 kg, 7.5 kg
 - Maintain upright torso and pause 1–2 s at bottom for consistency
 - Record 5 trials continuously per variation, perform 1 trial record previously to verify
- Process data in Nexus (gap filling, export .trc/.c3d/CSV files) for analysis of joint angles, joint power, and (optional) muscle recruitment
- Perform OpenSim analysis: scaling, inverse kinematics, inverse dynamics, & generate joint kinematics and kinetics for analysis
- Optional: Calculate individual muscle activations with OpenSim's static optimization

Results: Static .trc and .c3d files are used for model scaling, dynamic .trc and .c3d files for inverse kinematics (IK), inverse dynamics (ID), and static optimization (SO), while force plate .csv data provide ground reaction forces for ID.

References:

MyaCare 2021, *The link between leg strength, healthy aging and longevity*, MyaCare, accessed 26 October 2020, <<https://myacare.com/blog/the-link-between-leg-strength-healthy-aging-and-longevity>>.

Collins, KS, Klawitter, LA, Waldera, RW, Mahoney, SJ & Christensen, BK 2021, 'Differences in muscle activity and kinetics between the goblet squat and landmine squat in men and women', *Journal of Strength and Conditioning Research*, vol. 35, no. 10, pp. 2661-2668, doi: 10.1519/JSC.0000000000004094.

Straub, RK & Powers, CM 2024, 'A biomechanical review of the squat exercise: implications for clinical practice', *International Journal of Sports Physical Therapy*, vol. 19, no. 4, pp. 490-501, doi: 10.26603/001c.94600.