



Streamline your research with **simVITRO**

SPECIALISED ROBOTIC TESTING SYSTEMS
FOR ORTHOPEDIC BIOMECHANICS RESEARCH



**Test every major joint.
Loads from 5 N to 3000 N.
Six degrees of freedom.**

DEVELOPED BY

**Cleveland Clinic
BioRobotics Laboratory**

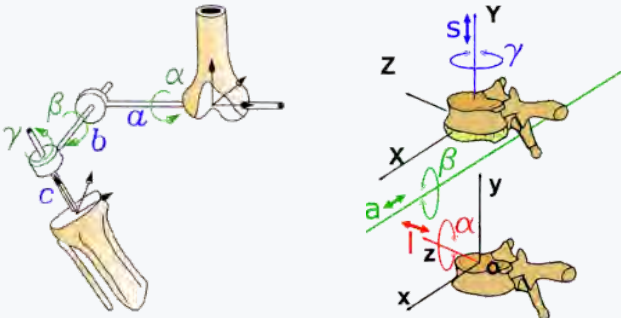
A universal musculoskeletal simulator for the testing of major joints.

simVITRO® is a hardware neutral joint testing system born out of the BioRobotics and Mechanical Testing Laboratory of Cleveland Clinic Research. The flexible merging of software and hardware components are designed to provide flexibility for end users to test in relevant joint specific modules and have the necessary software tools to support their business and/or research needs. simVITRO systems are supplied, installed and supported in your laboratory.

Force, moment, translation, and rotation control run within one controller, so a protocol can move between load controlled and position controlled phases without leaving the test. The result is a rig that follows the study design rather than a study designed around the rig.

CONTROL	JOINT MODULES	simSURROGATE	PROVENANCE
Force, position, or a hybrid of both within a single trajectory	Spine, knee, foot/ankle, hip, shoulder, elbow, wrist and more	A 3D-printed synthetic joint specimen that mimics real joint behaviour. Knee included with every system; hip, shoulder and foot available as add-ons	DEVELOPED BY Cleveland Clinic BioRobotics Laboratory

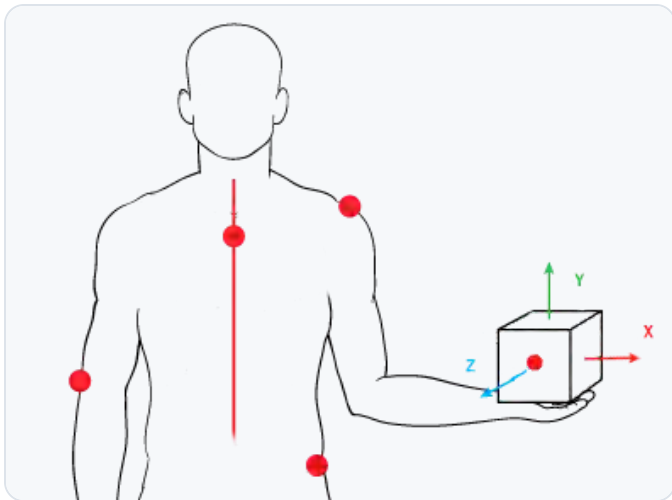
SIMVITRO USES JOINT SPECIFIC COORDINATE SYSTEMS, SUCH AS THE INTERNATIONAL SOCIETY OF BIOMECHANICS (ISB) DEFINITIONS, FOR ALL MODULES





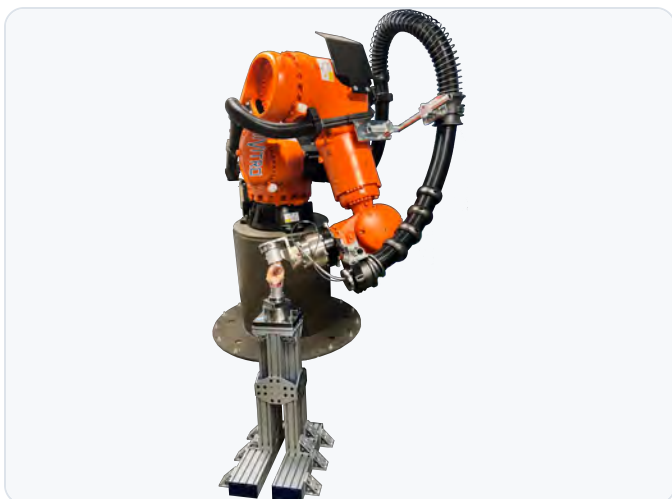
01 Streamlined research

- Less time building and validating bespoke tooling, more time answering the clinical question.
- Protocols, fixturing, and data pipelines arrive as a working system rather than a laboratory project of their own.



02 Expansive capabilities

- Any joint, any load, any range of motion.
- Capacities from 5 N to 3000 N.
- One license can run multiple sized robots, so a single laboratory can hold both ends of its research programme.



03 Modular Solutions

- Hardware and software configured to the laboratory's exact need, and revised as the research direction moves.

Five systems, separated by load capacity. Each carries the same software and control stack, built on a KUKA robot with OptiTrack motion capture.



Mercury 5 5 N capacity

simVITRO Software Suite, Knee
simSURROGATE, dual range load cells,
fixturing kit, OptiTrack motion capture,
four years of technical support.



Mars 60 60 N capacity

simVITRO Software Suite, Knee
simSURROGATE, dual range load cells,
fixturing kit, OptiTrack motion capture,
four years of technical support,
fluid resistant active markers.



Neptune 160 160 N capacity

simVITRO Software Suite, Knee
simSURROGATE, dual range load cells,
fixturing kit, OptiTrack motion capture,
four years of technical support,
fluid resistant active markers.



Saturn 1600 1600 N capacity

simVITRO Software Suite, Knee
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Jupiter 3000 3000 N capacity

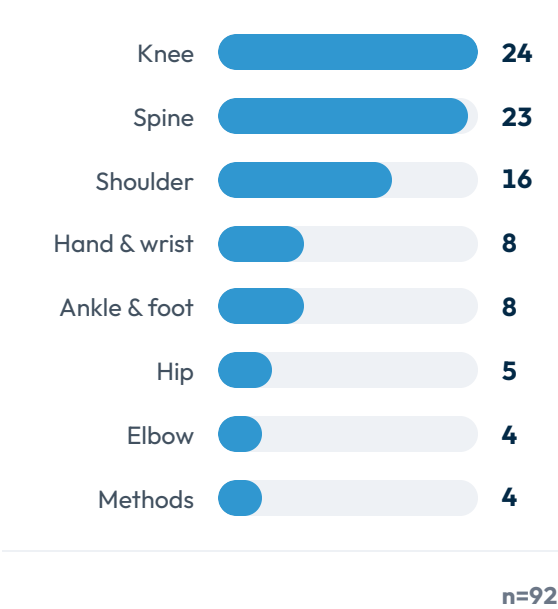
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A record written by other laboratories.

simVITRO's use is documented in more than ninety independently published biomechanics studies across eight anatomical regions, in journals including *The American Journal of Sports Medicine*, *Journal of Biomechanics*, *Journal of Biomechanical Engineering*, *The Spine Journal*, *Arthroscopy*, and *Journal of Neurosurgery: Spine*.

The platform is not certified against an existing ISO standard because the work it supports precedes one: these laboratories are establishing the methods by which future standards will be written.

PUBLISHED STUDIES BY REGION



SELECTED PUBLICATIONS

01

Colbrunn, R. W., Loss, J. G., Gillespie, C. M., Pace, E. B., & Nagle, T. F. (2024). Methodology for Robotic In Vitro Testing of the Knee. *Journal of Knee Surgery*, 37(8), 556–569.

02

Noble, L. D., Colbrunn, R. W., Lee, D. G., van den Bogert, A. J., & Davis, B. L. (2010). Design and validation of a general purpose robotic testing system for musculoskeletal applications. *Journal of Biomechanical Engineering*, 132(2), 025001.

03

Chokhandre, S., Neumann, E. E., Nagle, T. F., Colbrunn, R. W., Flask, C. A., Colak, C., Halloran, J., & Erdemir, A. (2021). Specimen specific imaging and joint mechanical testing data for next generation virtual knees. *Data in Brief*, 35, 106824.

04

Nagle, T. F., Erdemir, A., & Colbrunn, R. W. (2021). A generalized framework for determination of functional musculoskeletal joint coordinate systems. *Journal of Biomechanics*, 127, 110664.

05

DePhillipo, N. N., Moatshe, G., Brady, A., Chahla, J., Aman, Z. S., Dornan, G. J., Nakama, G. Y., Engebretsen, L., & LaPrade, R. F. (2018). Effect of Meniscocapsular and Meniscotibial Lesions in ACL-Deficient and ACL-Reconstructed Knees: A Biomechanical Study. *Am J Sports Med*, 46(10), 2422–2431.

06

Murata, Y., Fukase, N., Brady, A. W., Douglass, B. W., Bryniarski, A. R., Dornan, G. J., Utsunomiya, H., Uchida, S., & Philippon, M. J. (2022). Biomechanical Evaluation of 4 Suture Techniques for Hip Capsular Closure. *Orthop J Sports Med*, 10(6), 23259671221089946.

07

Bokshan, S. L., DeFroda, S. F., Gil, J. A., Badida, R., Crisco, J. J., & Owens, B. D. (2019). The 6-O'clock Anchor Increases Labral Repair Strength in a Biomechanical Shoulder Instability Model. *Arthroscopy*, 35(10), 2795–2800.

08

Conway, J. C., Oliver, R. A., Wang, T., Wills, D. J., Herbert, J., Buckland, T., Walsh, W. R., & Gibson, I. R. (2021). The efficacy of a nanosynthetic bone graft substitute as a bone graft extender in rabbit posterolateral fusion. *Spine J*, 21(11), 1925–1937.

09

Nagle, T. F., Loss, J. G., & Colbrunn, R. W. (2025). A Functional-Aggregate Method for Repeatable Determination of Vertebral Coordinate Systems. *ASME J Biomech Eng*, 147(9), 091006.

“simVITRO gives you 6 degrees of freedom. It tells you everything about the mechanical environment you want to know.”

Professor Bill Walsh, PhD. Director, Surgical & Orthopaedic Research Laboratories, University of New South Wales

UNIVERSITY OF NEW SOUTH WALES

From testing to device development

UNSW's Surgical & Orthopaedic Research Laboratory bought simVITRO in 2014, having previously assumed a robot would be too expensive, too complicated, and too cumbersome for the lab. The laboratory has since published continuously with the system, and two medical devices developed on it are coming to market.

Professor Walsh attributes that to setup speed, “whether you are a simple user, like me, or a power user, you can set up the robot and generate data within minutes”, which let the lab iteratively design implants rather than only test them.

“I would not be using a robot if simVITRO didn't exist. The path to commercialisation would have therefore been more arduous.”

NC STATE / WISCONSIN / DELAWARE

One platform across a career

Dr. Stephanie Cone has used simVITRO from graduate work at North Carolina State University, through a postdoctoral fellowship at the University of Wisconsin, to her own laboratory at the University of Delaware, studying ACL and meniscus injury in small and large animal models.

Studying complex changes in function within unique populations, she reports that simVITRO offers “the flexibility to perform detailed mechanical testing in the context of physiologically relevant functional demands” with individual joint modules that let applicable tests be run quickly.

“This is a great tool to invest in if you are interested in ramping up biomechanical testing quickly with assistance in all of the technical aspects.”

EARLY ADOPTER LABORATORY, NINE YEARS OF USE

Adopted simVITRO in 2015, moving off a KUKA robot running custom in-house software. Over a dozen studies have followed in top-tier journals including *AJSM*, with shoulder, hip, and ankle protocols added alongside motion capture, graft-force load cells, and contact pressure sensors.

Specifying a system for a grant application?

Most simVITRO installations begin twelve to twenty-four months before the equipment arrives, at the point a research programme is being costed. Tell us what you're testing and we'll spec the system. simVITRO systems are supplied, installed and supported in your laboratory.

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