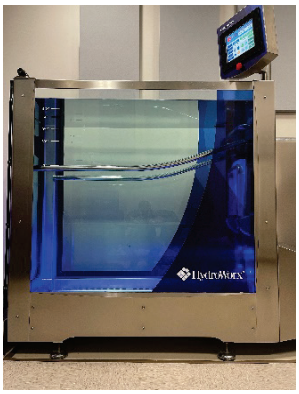
Facilities and Major Equipment

Biomechanics Research Building (BRB) at the University of Nebraska at Omaha (UNO)

The BRB is a 53,000 sq ft space dedicated solely to Biomechanics research. There are lab spaces for a variety of types of biomechanics applications, including human biomechanics (6), animal biomechanics (1), balance and strength (1), virtual reality (2), and 3D printing (1). There is also a Senior Design Studio, Machine Shop, Conference Room (7), Graduate Office, Computer Labs (2), secured IRB Closet, Evaluation Rooms (2), Consultations Rooms (2), and a teaching lab. Additionally, there are reserved parking spots for research participants and a receptionist area for welcoming people to the lab. All laboratories, offices, and equipment are housed in the controlled access Biomechanics Research Building. Faculty offices are on the second or first floor.

Laboratories at the Biomechanics Research Building (BRB)

Aquatic Therapy Lab, BRB 021



This 246 ft^2 lab is dedicated to a self-contained underwater treadmill (300 series, HydroWorx, Middletown, PA, USA) that allows subjects to sit, stand, walk, or run in an aquatic setting. This provides a buoyancy effect to offload lower limbs and drag to challenge the muscles in different rehabilitation protocols. EMG and triaxial accelerometry can be wirelessly recorded using 16 waterproof sensors (Mini Wave Waterproof, Cometa Systems, Bareggio, Italy). These sensors can transmit synchronously in humid or wet environments or asynchronously, with 8 hours of onboard data-logging, fully submerged using a custom remote controller.

CAREN Lab, BRB 027

This 1083 ft^2 lab houses the Computer Assisted Rehabilitation Environment (CAREN) (Motek, Amsterdam, Netherlands). It includes a 180-degree screen and front-mounted projectors for complete visual immersion. Kinematic and kinetic data can be collected using a 10-camera system (Vero, Vicon Motion Systems Ltd, Oxford, UK) synchronized with an instrumented split-belt treadmill (MotekForce, Motek, Amsterdam, Netherlands). Therefore, 3D motion and forces are measured can be measured. This treadmill is supported on a motion base that can translate and rotate about 6 degrees of freedom (DoF). The environment is controlled using D-Flow software and has several options for device integration.

Gait Lab, BRB 035

This 1335 ft^2 lab features seven force platforms (400600HPS, AMTI Inc., Watertown, MA, USA) and a 12-camera motion capture system (Kestral 4200, Motion Analysis Corp, Rohnert Park, CA, USA). Force plates are embedded in a modular 3x4 array for many potential configurations. False plates are used to fill in extra spaces. The walking path is in-line with double doors to BRB 027, allowing for a 49-foot walking path. In addition, a marker-less motion capture system (Theia Markerless, Kingston, ON) uses eight high-resolution video cameras (Prime Color, OptiTrack, Corvallis, OR, USA). Our new acquisition is a motion analysis system composed of ten cameras (Miqus Hybrid, Qualysis Ab, Gothenburg, Sweden) to record high-resolution digital videos compatible with Theia Markerless or infra-red (IR) marker data which is reconstructed in 3D.

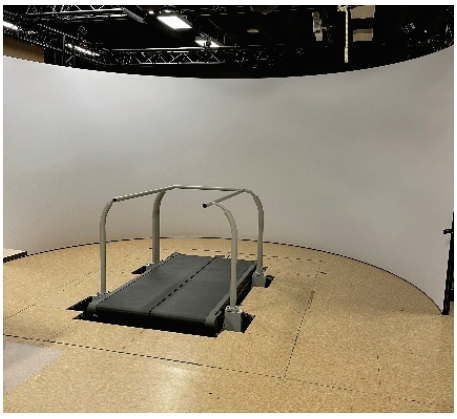
This lab space also features a computerized robotic dynamometer (Humac Norm, CSMi, Stoughton, MA, USA) to measure muscle strength and fatigue during various exercises. The device has multiple attachments for testing lower and upper limb motion across 22 standard test and exercise patterns. The adjustable chair allows for comfortable prone and supine exercise testing. It is made for easy rotational, positional, and inclination adjustments.

Insect Lab, BRB 037

This 158 ft^2 lab is used for insect and small animal biomechanics. The room has dedicated climate control and an adjoining preparation and storage space. Insect movement is recorded in a custom-made containment area using one TS5 and two IL5 high-speed digital cameras (Fastec, San Diego, CA, USA). These cameras can be used to record HD color or monochrome images. The TS5 can capture 2560 x 1440 images at 359 fps. The IL5 can capture similar images while connected to a computer. Both models can collect images over 1000 fps and be mounted on a tripod or used as a handheld. This lab also has eight high-resolution video cameras (Prime Color, OptiTrack, Corvallis, OR, USA) to record small vertebrate movements.

GRAIL Lab, BRB 103

The VR Lab is a 1,462 ft^2 space featuring a Gait Real-time Analysis Interactive Lab (GRAIL) (Motek, Amsterdam, Netherlands). It has 14 cameras for 3D motion tracking, a high-definition video (Vero/Bonita, Vicon, Oxford, UK), and an instrumented treadmill (Fully Instrumented Treadmill, Bertec Corp., Columbus, OH, USA). The treadmill is a split-belt design with tracks for the left and right legs. Forces are measured with six DoF force platforms under each belt and six separate DoF sensors for both handrails. It includes a 180-degree screen and front-mounted projectors for complete visual immersion. The system consists of an A/D board and mechanical relay box (Phidgets Inc, Calgary, Canada) to interface the GRAIL with other systems.



Portable equipment in this lab includes two actuator units and four different end effectors (Humotech, Pittsburgh, PA, USA). These effectors have an ankle prosthesis, two ankle exoskeletons, a hip exoskeleton, and a harness. The system can integrate data from our instrumented treadmills and wired EMG systems into the effector's control algorithms.

Main Gait Lab, BRB 116

This 2,535 ft^2 lab features 20 cameras for 3-D motion capture (Raptor/Kestrel 4200, Motion Analysis Corporation, Rohnert Park, CA, USA) and a 60 ft walkway with fall-arrest support. There are eight embedded force platforms (400600HPS/600900BP, AMTI, Watertown, MA, USA) and a tandem-belt instrumented treadmill (Force-Sensing Tandem Treadmill, AMTI, Watertown, MA, USA) with 6 DoF force measurement capabilities. A dedicated 16-sensor EMG system (Trigno Avanti, Delsys Incorporated, Boston, MA, USA) is integrated into this space. It also has two 4K cameras (LUMIX BGH1 Cinema 4K, Panasonic, Moriguchi, Osaka, Japan) positioned to record sagittal and frontal plane video.

This lab also includes a treadmill that measures foot pressure (KinTread Pressure Treadmill, Noraxon U.S.A. Inc., Scottsdale, AZ, USA) to analyze force and pressure distribution during standing, walking, and running. A 20-camera motion capture system (Qualisys, Göteborg, Sweden) is also housed in this lab, being ten marker-based (Oqus 500), two high-speed cameras (Miqus), and eight others able to record both markers and high-speed videos (Miqus Hybrid). This camera system is dedicated to sports biomechanics and includes the manufacturer's gait, golf, and baseball analysis modules.

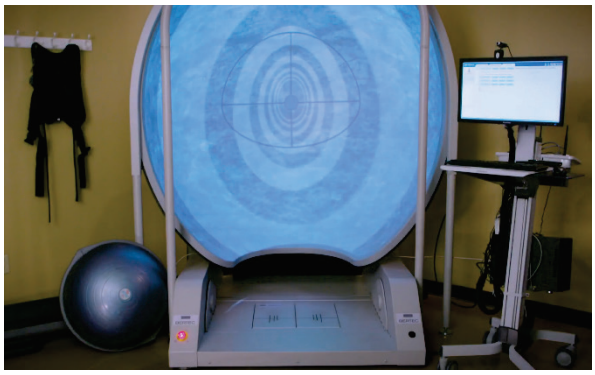
Portable equipment used primarily in this lab includes:

A 4 ft by 20 ft instrumented walkway (Zeno Electronic Walkway, ZenoMetrics LLC, Peekskill, NY, USA) that measures spatial and temporal characteristics of walking without any on-body instrumentation.

A stairway with three integrated platforms and handrails for force measurement (Instrumented Stairs, Bertec, Columbus, OH, USA) that can be readily integrated with motion capture systems to allow four continuous steps during stair ascent and descent. This system is mounted on adjustable casters that enable it to be moved and can be raised to fix it in place.

An imaging ultrasound (LS 128 CEXT, Telemed, Milan, Italy) can be used to image muscle activity in real-time during gait or other activities. It can also be synchronized with any of our motion capture systems.

Balance and Strength Lab, BRB 123



The Balance and Strength Lab (548 ft^2) primarily features two independent systems:

1) A device that objectively assesses balance control and postural stability under dynamic test conditions through computerized dynamic posturography and immersive virtual environments (CDP/IVR, Bertec, Columbus, OH, USA). The unit provides assessment and retraining capabilities on a static or dynamic support surface and in a stable or dynamic visual environment. The immersive virtual environment can be changed using real-time adjustable parameters. The device features assessment and treatment protocols and the ability to create custom protocols. A unique feature of the unit is its low step-up profile, which provides easy access for patients with balance problems.

2) A computerized robotic dynamometer (System 4, Biodex, Shirley, NY, USA) can measure strength and fatigue during various exercises. It has multiple attachments to accommodate activities involving the limbs and torso. The integrated chair allows several testing positions, rotation, and inclination adjustments.

Brain Imaging Lab, BRB 129

This 178 ft^2 space houses equipment used for noise-sensitive brain imaging and features an airlock and concrete walls for noise cancellation. The 24 Channel Optical Topography System (ETG-4000, Hitachi Medical Systems, Tokyo, Japan) is an FDA-approved device that enables imaging of the cerebral cortex during sitting or standing using infrared technology. This lab houses two electroencephalograms (EEG). One is a 128-channel system (System 400, Electrical Geodesics Inc., Eugene, OR, USA). The system is integrated with E-Prime software (Psychology Software Tools, Sharpsburg, PA, USA) and peripheral sensors, including EKG, oximeter, airflow sensors, and polygraph. It is installed on a wooden desk with casters for electrical isolation and portability. The other EEG system is ANT Neuro (eego mylab, ANT Neuro, Hengelo, Netherlands). Both measure the electrical activity in the brain. It uses a net of 130 electrodes wrapped around the scalp and face.

Portable equipment used primarily in this lab includes:

A functional Near-InfraRed Spectroscopy (fNIRS) (NIRSport 2, NIRx, Berlin, Germany) measures hemodynamic responses to neuro activation via oxy-, deoxy-, and total hemoglobin changes in the cerebral cortex.

Academic Teaching Lab, BRB 158

This 294 ft^2 lab features an 8-camera motion capture system (T160, Vicon Motion Systems, Oxford, UK). This space is also equipped with an 8-camera motion capture system (Impulse X2, PhaseSpace, San Leandro, CA, USA) with up to a 960 Hz capture rate. It is integrated with four strain gauge force platforms (OR6-7-OP Force Platform, AMTI, Watertown, MA, USA). This space is used primarily for the education of undergraduate and graduate students.

Computer Lab, BRB 245

This area contains 24 computers that are available for processing data. Applications that are the computers in these labs include:

- Cortex (Motion Analysis Corporation, Rohnert Park, CA, USA)
- D-Flow (Motek, Amsterdam, Netherlands)
- G*Power (Uni Kiel, Germany)
- MATLAB (MathWorks, Natick, MA, USA)
- Nexus (Vicon, Oxford, UK)
- Qualisys Track Manager (Qualisys, Göteborg, Sweden)
- ResearchIR (FLIR, Wilsonville, OR, USA)
- SPSS (IBM, Armonk, NY, USA)
- Visual3D (C-Motion, Germantown, MD, USA)

Portable Equipment Closet, BRB127

The Biomechanics Research Building houses numerous pieces of equipment used in multiple labs that are not assigned to any particular space.

Metabolics

1) A metabolic cart (TrueOne 2400 Metabolic Measurement System, ParvoMedics, Sandy, UT, USA) is used to measure intrapulmonary gas exchange analysis during stationary studies, such as running on a treadmill or pedaling on a stationary bicycle. It can provide an accurate measure of pulmonary gas exchange, i.e., VO2, VCO2, Ventilation, energy expenditure, etc.

2) We have two portable metabolic carts (Cosmed K5, Cosmed USA Inc., Chicago, IL, USA). It can provide breath-by-breath analysis and can be used in non-stationary studies.

Electromyography (EMG)

Two EMG systems (Trigno Avanti, Delsys Incorporated, Boston, MA, USA) have 18 Trigno wireless sensors that can be freely paired with installed software on desktops, laptops, and mobile devices. Each Avanti sensor includes one EMG channel and (IMU) system, totalizing ten channels per sensor. Data from these sensors can be recorded through Delsys EMGWorks software with motion capture systems or synchronized with an additional Delsys Trigger Module. In addition, a 16-sensor Noraxon Ultium EMG system (Noraxon U.S.A. Inc., Scottsdale, AZ, USA) is available, which can be integrated with the Noraxon treadmill and IMUs using MR3 software.

Eyetracking

A head-mounted eye tracker (Glasses 2, Tobii, Stockholm, Sweden) samples gaze data at 100 Hz. It simultaneously records video from a front-mounted camera and has interchangeable corrective lenses. It can both send and receive event signals.

Inertial Motion Capture

This system is a markerless technology based on IMUs to record movement and estimate joint angles. They can be used inside and outside the lab and be synchronized with other equipment systems using TTL signals. Currently, four complete systems are available: two XSENS Awinda (Enschede, Netherlands), one APDM Opal (Portland, OR, USA), and one Noraxon Ultium (Noraxon U.S.A. Inc., Scottsdale, AZ, USA).

Software

Various applications are available for analysis and design:

- **ActiLife** (Actigraph, Pensacola, FL, USA)
- **Arduino IDE** (Android Studio (Mountain View, CA, USA)
- **Autodesk Suite** (Autodesk, Inc., San Rafael, CA, USA)
- **Cortex** (Motion Analysis Corporation, Rohnert Park, CA, USA)
- **D-Flow** (Motek, Amsterdam, Netherlands)
- **EMGWorks** (Delsys Incorporated, Boston, MA, USA)
- **EMG & motion tools** (Cometa srl., Bareggio, Italy)
- **LabVIEW** (National Instruments, Austin, TX, USA)
- **MATLAB** (MathWorks, Natick, MA, USA)
- **MR3** (Noraxon, Scottsdale, AZ, USA)
- **MVN** (Xsens, Enshede, Netherlands)
- **Nexus** (Vicon, Oxford, UK)
- **Prism** (GraphPad Software, San Diego, CA, USA)
- **Qualisys Track Manager** (Qualisys, Göteborg, Sweden)
- **SolidWorks** (Dassault Systems, Vélizy-Villacoublay, France)
- **SPSS** (IBM, Armonk, NY, USA)
- **Unity** (Unity Technologies, San Francisco, CA)
- **Visual3D** (C-Motion, Germantown, MD, USA)