NC State Centennial Campus Lab Tours
August 2 2016
The Movement Biomechanics Lab (MoBL) investigates biomechanical function of the upper limb with specific interest in peripheral nerve injury, rotator cuff injury, and aging. Our goal is to evaluate and improve clinical outcomes for rehabilitation of upper limb function by combining computational simulations and experimental approaches.

**Musculoskeletal Modeling**

Our research entails detailed *in vivo* experimental measurements of upper limb muscle anatomy and function to create high fidelity graphical upper limb musculoskeletal models for kinematic and dynamic analyses. These models incorporate mathematical representations of upper limb joint kinematics, muscle force-generating capacity, intersegmental dynamics, and neuromuscular control.

**Brachial Plexus Birth Palsy**

We are interested in traumatic neurological injury to the brachial plexus that occurs at birth, resulting in paralysis of upper limb muscles and permanent postural and osseous deformities of the developing shoulder. We use computational simulations to analyze biomechanical consequences of surgical treatment choices. Our current research focuses on determining metabolic, vascular, and structural changes to bone following brachial plexus birth palsy and exploring effects of muscle-bone interactions on developing bone, using an integrated musculoskeletal and finite element modeling approach to examine osseous changes.

**Rotator Cuff Injury**

Rotator cuff tears lead to strength loss, limited range of motion, and decreased functional ability, and are extremely common in older adults. We analyze kinematic and muscular compensation during activities of daily living and isometric strength tasks in older adults with rotator cuff impairment using individualized models of healthy and injured adults. Using MR imaging, we quantify structural changes, including atrophy and intramuscular fat clustering.

**Aging**

Aging leads to muscular changes such as sarcopenia and strength declines, which can often lead to disability. We use MR imaging and functional strength testing to provide insight to the extent of these losses in the upper limb, and their effects on movement and compensatory strategies. Additionally, we work with animal models to study the effects of aging on shoulder bone, muscle, and tendon.
Neuromechanics Lab

Director: Dr. Xiaogang Hu

The Neuromechanics Lab focuses on the control and neuromechanical properties of the upper extremity after a central or a peripheral injury, such as a stroke or an amputation. Specifically, we focus on the following three research topics, regarding the upper extremity neuromuscular system: the neural aspect, the mechanical aspect, and the applied aspect with a focus on rehabilitation.

Visitors will experience the techniques that we use to address problems in upper extremity neuromuscular control:

**Quantify muscle activation patterns** in healthy and pathological conditions using high-density electromyogram recordings: We quantify the spatial distribution of muscle activation across muscles groups and across compartments of a muscle, through voluntary or reflex activation.

**Capture single motor unit activation** through decomposition of electromyogram signals: We can extraction action potential distribution from single motor units, including the energy distribution, and action potential propagation properties. The motor unit discharge and recruitment properties at a wide range of muscle activation levels can also be derived.
The Translational Orthopaedic Research Lab (TORL) aims to develop tissue engineering and regenerative medicine solutions for musculoskeletal soft tissue injuries through the replication of native tissue form and function. The lab approaches this objective by characterizing tissue geometry, mechanical function, and cellular and biochemical composition of native musculoskeletal soft tissues in knees using pre-clinical animal models. The characterization of these parameters is accomplished using high resolution MRI, traditional biochemical and histological techniques, and 6 degree-of-freedom universal force sensing robotics.

Force sensing robotics can be used to measure the functional behavior individual tissues during simulated whole-joint movements, and can be used to perform tests under either kinetic or kinematic controls.

By performing clinically relevant loading tests on intact joints, a healthy kinematic path can be calculated. By performing this kinematic path with serial dissections, the individual contributions of each tissue is measured. Plotting paired translations and forces as in the figure to the left shows the functional contributions of each tissue. Here both bundles of the ACL resist anterior tibial translation, while other tissues in the knee provide resistance to posterior translation.
The overall goal of the OML is to improve current strategies for treating and preventing bone loss with aging, disease, and injury. We integrate biomechanics with molecular biology techniques to study how different factors like mechanical environment, vascular supply, and chemical and neural signaling influence bone health at various levels, from the whole bone down to the cells that remodel bone tissue. Our goal is to develop creative, new therapies for treating or even preventing bone loss with aging (osteoporosis) and disease (stroke, diabetes) to prevent fracture and speed rehabilitation.

Investigating Changes in Bone-Vascular Interactions during Stroke Rehabilitation:
Stroke is the second-most common cause of disability worldwide and the most common cause of disability in North Carolina, the 'belt buckle' of America’s stroke belt. Ischemic stroke patients experience drastic losses in bone mineral density during the acute recovery period resulting in a 2-4 fold increase in fracture risk within a year of stroke. Although bed rest and limb disuse may account for some bone loss, stroke may cause blood supply changes to the bone as well. Exercise during the acute recovery period is known to increase blood perfusion in the brain, but the impact of ischemic stroke and exercise on blood perfusion in bone remains unexplored.

We use a mouse stroke model to investigate changes in osteovascular health during acute recovery. We determine the effectiveness of mechanical stimulation, such as exercise and neuromuscular stimulation, in maintaining osteovascular health by examining structural, biochemical, and functional changes in bone and vasculature. Our findings will elucidate the effects of stroke on the vascular system within bone and the potential benefit of physical and pharmaceutical rehabilitation interventions to the osteovascular system in human stroke survivors.

Website: https://www.bme.ncsu.edu/labs/colelab/index.html
The Advanced Wound Healing (AWH) lab uses materials that mimic the mechanical properties of cells and tissues to 1) better understand biological processes involved in wound repair and 2) design materials that interact with the natural wound healing process to stop bleeding and decrease scar formation after injury.

Participants will visit the AWH lab where they will observe material synthesis systems and material characterization tools. One material characterization tool that will be on display is an atomic force microscope, which is used to characterize mechanical properties of materials, tissue, and cells.
Tissue Engineering and Regenerative Medicine Laboratory

Director: Dr. Donald O. Freytes

Our laboratory is made up of the following concepts:

TISSUE SPECIFIC EXTRACELLULAR MATRICES

Extracellular matrices (ECM) provide structural and biochemical support to surrounding cells. We can use tissue specific ECM to generate biomaterials that will support tissue specific cell growth and healing.

INDUCED PLURIPOTENT STEM CELLS (iPSCs)

iPSCs are a type of stem cell that can be generated from adult cells. They hold great promise in the field of regenerative medicine, as they are able to grow indefinitely and can be differentiated into every cell type in the body. Our laboratory differentiates stem cells into multiple cell types such as cardiomyocytes and monocytes.

BIOENGINEERED MUSCLE TISSUES

We can create muscle-like tissues using pluripotent stem cells to study muscle disease and implant-host tissue interactions.

MIMICKING HOST TISSUE RESPONSE

To study the interactions between potential repair cells and the host tissue in vitro, we use macrophages (which are important players during wound healing) to model wound healing on a dish. This allows us to test different designs before proceeding to pre-clinical testing.

COLLABORATIONS

University of Puerto Rico – Mayagüez  Drexel University  Columbia University

Albert Einstein School of Medicine  New York University  University of Maryland - Baltimore

New York Stem Cell Foundation  UNC Stem Cell Core Facility
Our mission is to improve the quality of life of patients with physical disabilities. The devices we design are smart robots that sense various information about the environment and the user’s neural commands, especially electromyographic (EMG) signals. The sensor information is then interpreted by novel control algorithms to make decisions toward a number of critical prosthesis operating tasks. Here we highlight several of our ongoing projects that focus on investigating and improving the interaction between humans, machines, and the environment.

Algorithms that automatically tune prosthesis control parameters: Sensor information from the prosthesis and user are interpreted by fuzzy logic or reinforced machine learning algorithms to know how to tune prosthesis control parameters under various dynamic conditions to improve the user’s gait.

Neuromuscular dynamics of transtibial amputees: Subjects attempt to achieve wide ranges of co-contraction between ankle dorsiflexors and plantarflexors, and hit targets on a computer screen, toward enabling EMG-driven volitional control of powered ankle prostheses.

MG pattern recognition during real-world upper limb tasks: Subjects with transradial amputation are trained by an occupational therapist for several weeks before testing their ability to perform real-world tasks, such as pouring from a can, hammering a nail, and zipping a jacket.

New multi-joint control algorithms for upper limb prostheses: We are exploring new techniques, such as musculoskeletal model simulation and Kalman filter models, for enabling continuous multi-joint prosthesis motion.

Understanding the biomechanics and neuromotor control of movement in our able-bodied and impaired subjects is critical for studying human-machine interactions.

We welcome collaboration with you!

Website: nrel.bme.unc.edu
Current Research in the PoWeR lab seeks to discover physiological principles underpinning locomotion performance and apply them to develop lower-limb robotic devices capable of improving both healthy and impaired human locomotion (e.g., for elite athletes, aging baby-boomers, post-stroke community ambulators).

By focusing on the human side of the human-machine interface, we have begun to create a roadmap for the design of lower-limb robotic exoskeletons that are truly symbiotic—that is, wearable devices that work seamlessly in concert with the underlying physiological systems to facilitate the emergence of augmented human locomotion performance.

We are particularly interested in the mechanics and control of compliant muscle-tendon units (e.g., ankle plantarflexors). We use simple mathematical models to explore how elastic mechanisms can be exploited to allow for economical force production and optimal mechanical energy transfer during both steady and unsteady cyclic movements, particularly in the context of mechanical assistance from wearable robots (e.g., exoskeletons). We test model predictions experimentally in (1) human Achilles' tendon-triceps surae in vivo during walking, running and hopping using B-mode ultrasound imaging and (2) biological muscle-tendons in vitro (bullfrog) and in situ(rat) during simulated locomotion using sonomicrometry and real-time emulation of dynamical systems through 'smart' ergometer interfaces.
One of the goals of our laboratory is to further understanding of the sensorimotor control of the hand so that restoration of function following neuromuscular injury can be improved. Toward that end we have been exploring hand neuromechanics, especially in regard to the mapping of musculotendon forces into fingertip motion.

Biomechanical studies with cadaveric tissue provide information about tissue structure, such as the material properties of the extensor mechanism which transmits forces from multiple tendons to the finger segments.

In vivo experiments permit measurement of muscle activation patterns during force and movement generation through electromyographic recordings with intramuscular or surface electrodes.

Finally, computer and finite element models allow quantitative analysis of the impact of different digit parameters on desired movement.
CREATING A HEART FOR CENTENNIAL CAMPUS
Named the nation’s top research park in 2007, NC State’s Centennial Campus is a nexus of collaboration between students, faculty, researchers, and corporate, governmental, and institutional partners. In the past 25 years, it has grown into a powerful engine of growth for the state and the nation. The Hunt Library became Centennial Campus’ intellectual and social center with its opening on January 2, 2013.

AN ICONIC BUILDING THAT SAYS “THIS IS NC STATE IN THE 21ST CENTURY”
The Hunt Library is a signature building that embodies NC State’s strengths in engineering, design, technology, and science, and captures the spirit of the NCSU Libraries as NC State’s competitive advantage.

DEFINING THE RESEARCH LIBRARY OF THE FUTURE
With world-class research collections stored in the bookBot automated book delivery system instead of traditional shelving, the vast majority of the Hunt Library is dedicated to a variety of technology-rich learning and collaborative spaces. The Hunt Library is designed to enable experimentation, support innovative projects and partnerships, and showcase university research and scholarship.

NARROWING THE SEATING GAP
Before the Hunt Library opened, the NCSU Libraries could seat fewer than 5% of our students—far short of the University of North Carolina system standard of 20%. The Hunt Library almost doubles the number of library study seats, bringing NC State nearer to that standard.

IMMERSING NC STATE IN THE LATEST TECHNOLOGIES
The NCSU Libraries has long been a bold technology incubator for NC State, making it easy for students and faculty to immerse themselves in the technologies driving our economy. The Hunt Library builds upon that tradition, giving the university an iconic space filled with technology-enabled furniture; high-definition video walls; 3D computing, printing, and visualization tools; and videoconferencing and telepresence facilities.

INSPIRING GREAT WORK WITH BOLD, ADVENTUROUS SPACES
The library is the heart of the university, a creative, inviting place that enables students, faculty, and researchers to achieve their highest goals. The Hunt Library is a stunning, memorable building where people are inspired to breathe life into the aspirations of a great university.