



**Wake Forest®**  
School of Medicine

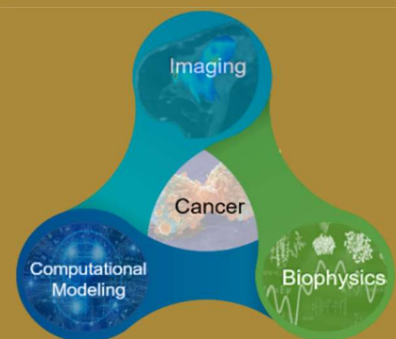
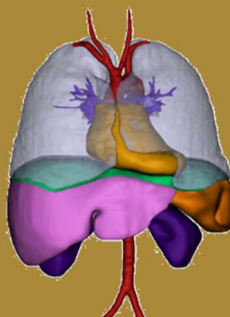
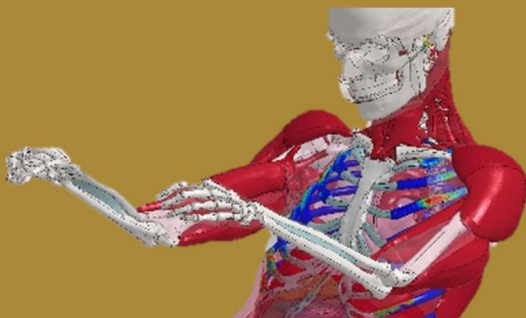
# REU Project Descriptions

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## 2022 BME Undergraduate Summer Internship Program



**25+ Projects offered for Summer of 2022!**



# 2022 REU Project Descriptions

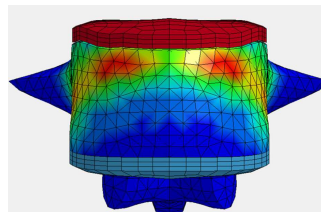
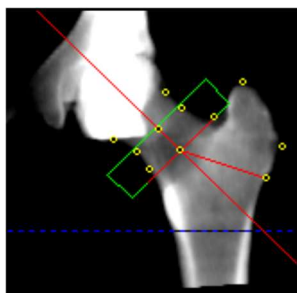
Project #	Advisor	Project Description Title
Project 1	Beavers	Effect of Weighted Vest Use or Resistance Training to Minimize Weight Loss Associated Bone Loss in Older Adults
Project 2	Brown	Additive Manufacturing for Clinical Research
Project 3	Brown	Novel Research and Medical Device Development
Project 4	Brown	Surgical Robotics and Biomechanics
Project 5	Gayzik	Characterization of Subcutaneous Pelvic Adipose Tissue for Enhancement of Human Surrogate Models
Project 6	Gayzik	Development and Validation of Brain Phantom for Therapeutic Cooling Devices
Project 7	Gayzik	Human Body Model Development for Trauma Research
Project 8	Gayzik	Underbody Blast Biomechanics
Project 9	Hall	Molecular Detection and Analysis of Trauma Bioindicators
Project 10	Nicholson	Impact of Kinematics and Ball Weight on Shoulder and Elbow Stress During Weighted Ball Drills
Project 11	Ostasiewski	Data Analysis Pipelines
Project 12	Ostasiewski	Networked Data Models
Project 13	Rahbar	Computational Fluid Dynamic (CFD) Modeling of Hemorrhage Shock
Project 14	Stitzel	Crash Injury Research and Engineering Network [CIREN]
Project 15	Stitzel	Head Impact Exposure Quantification and Mitigation in Motorsports
Project 16	Stitzel	Subconcussive Head Impact Analysis using Instrumented Mouthpiece Data
Project 17	Topaloglu	Adverse event detection using Deep Learning for Immunotherapy
Project 18	Topaloglu	Deep Learning Cancer Health Disparities
Project 19	Topaloglu	Privacy Preserved Federated Learning
Project 20	Topaloglu	Tumor Tissue Biobank
Project 21	Urban	Biomechanical Evaluation of Head Impact Exposure in Adolescent Athletes
Project 22	Weaver	Effect of High Protein Weight Loss on Older Adult Bone Health
Project 23	Weaver	Vertebral Strength and Injury Risk Following Long-Duration Spaceflight
Project 24	Weis	Image-based Biophysical Modeling to Differentiate Radiation-induced Injury from Tumor Recurrence Following Stereotactic Radiosurgery
Project 25	Whitlow	Neuroimaging and Cognitive Changes in Youth Football Players
Project 26	Willey	Prevention of skeletal complications during spaceflight: the Rodent Research-18 Mission to the International Space Station
Project 27	Zhao	Biomedical imaging of the brain tumor microenvironment

## Project 1 - Summer 2022

### Effect of Weighted Vest Use or Resistance Exercise Training to Minimize Weight Loss Associated Bone Loss in Older Adults

Osteoporosis is a significant public health problem among older adults and is exacerbated with weight loss. Identification of intervention strategies to minimize weight loss associated bone loss is needed. This NIH funded randomized controlled trial is designed to test whether weighted vest use during a 12 month weight loss intervention attenuates bone loss compared to weight loss alone, and similarly to weight loss plus resistance training (a bone-sparing strategy which is effective, but present barriers to large scale implementation) in 192 older adults with obesity.

The student will: 1) review the literature on weight loss associated bone loss and techniques for measuring bone health using computed tomography (CT), 2) form a hypothesis to test the effect of skeletal loading interventions on CT-derived bone outcome such as bone mineral density (BMD), cortical thickness, bone strength, or fracture risk measured from the hip and spine of study participants (Figure 1), and 3) experimentally test the hypothesis by applying learned CT analysis and finite element (FE) modeling techniques to collect, analyze, and draw conclusions from the resulting bone outcome data.



**Location:**

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**Kristen M. Beavers, PhD, MPH, RD**

Associate Professor, Department of Health & Exercise Science  
Wake Forest University  
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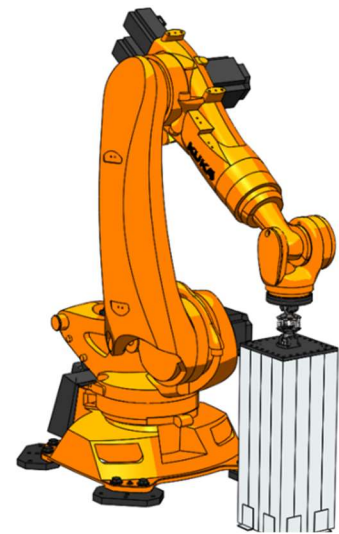
<http://hes.wfu.edu/beavers.htm>



## Project 2 - Summer 2022

### Additive Manufacturing for Clinical Research

There are several opportunities within Biomedical Engineering and through collaborations with orthopedics, neurosurgery, plastic surgery, and others for the experimental validation and exploration of surgical techniques. These procedures are intended to preserve and/or restore physiological function. Our lab conducts surgical biomechanical experiments on new and standard surgical techniques of repairs to bones, ligaments, tendons, and joints. Students selected for this research area will be heavily engaged in experimental design, fixture design, tissue handling and dissection, instrumentation, material testing, data analysis, as well as maintaining professional partnerships with clinical faculty.



This research effort will be in the Center for Injury Biomechanics (CIB) and you will have the opportunity to work on a range of projects in the field of automobile safety, military restraints, and sports biomechanics. The CIB has two primary research facilities. The first is in the WFU School of Medicine in Winston-Salem, NC and the second is at Virginia Tech. The research at the CIB combines experimental testing, computational modeling, and case analysis to investigate human injury biomechanics.

**Location:**

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**Philip Brown, PhD**

Research Assistant Professor, Biomedical Engineering  
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<http://www.wakehealth.edu/CIB/CIB-People.htm>





## Project 3 - Summer 2022

### Novel Research and Medical Device Development

There are several opportunities within Biomedical Engineering and through collaborations with orthopedics, neurosurgery, the center for biomedical imaging, plastic surgery, and others for the development of novel medical and research devices. These include experimental fixtures, exercise/rehabilitation machines and instruments, as well as surgical tools and hardware. Students selected for this project will be heavily engaged in the design process, conceptualization, prototyping, quality assurance, and experimental evaluation of multiple concurrent device development projects.



The student will aid in research and development of novel medical devices and operation of 3D printing support. This will involve review of literature on current and future medical procedures and techniques. The student will receive training in operation of professional software and hardware tools for industry quality CAD and FEA software as well as 3D printing systems. Mechanical material testing and analysis may also be conducted.

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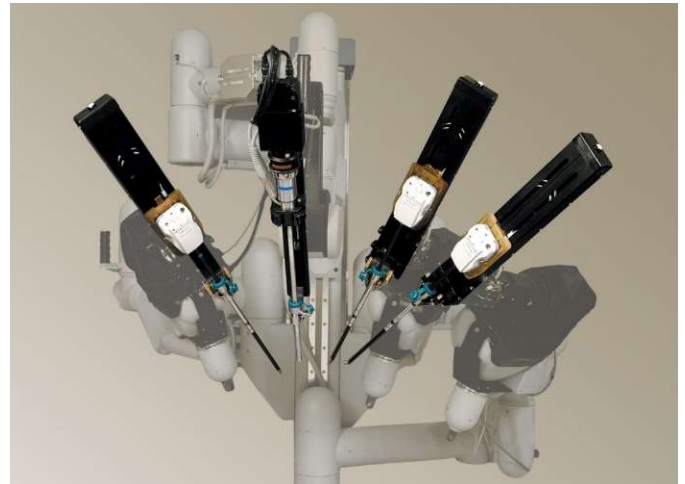


## Project 4 - Summer 2022

### Surgical Robotics and Biomechanics

Advancements in robotics, computing power, medical imaging and processing, augmented reality, artificial intelligence, motion tracking, and topology scanning are combining to increase the performance and applications of robotic surgery. The trend is driving down system cost and improving effectiveness, and prevalence in care pathways. Biomedical Engineering is fostering opportunities for collaborative research and technology development with physicians and industry partners. We have interest to investigate the following areas of surgical robotics: surgeon to robot interface, force feedback control, autonomous operations, robot tool and tissue interaction, laparoscopic tissue mechanics, surgical instrument design, visualization aids, augmented reality interfaces, training tissue surrogate development, analysis of training and surgical operation, artificial intelligence surgical aids, patient safety, operating room safety & efficiency.

The student will research one or more of these areas by reviewing current understanding and technology development through literature review. This will be followed up by a proposal of novel technology development or pilot research and experimentation. This may include hypothesis formation, experimental design, cadaveric testing, and data analysis. The student will receive training in robot control and any other relevant technical skills. Outcomes from their summer research experience will contribute to proposals for grant funding.



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**Philip Brown, PhD**

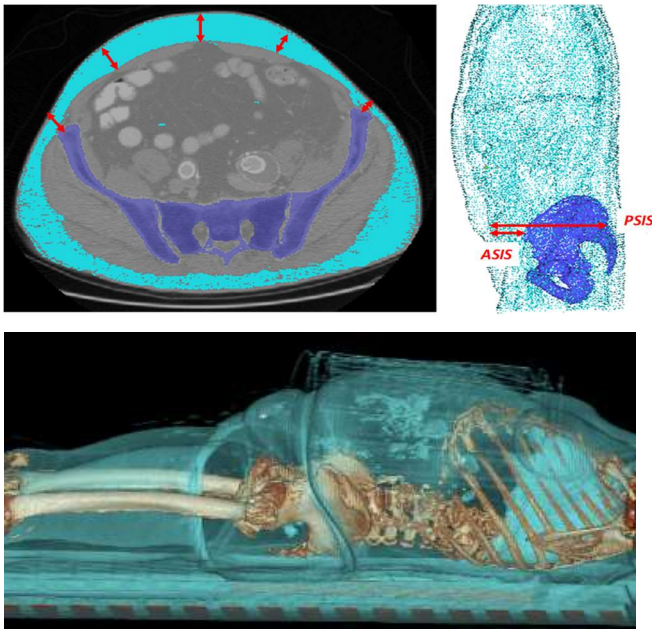
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## Project 5 - Summer 2022

### Characterization of Subcutaneous Pelvic Adipose Tissue for Enhancement of Human Surrogate Models

Occupant submarining occurs mainly in frontal motor vehicle crashes when the lap belt slides over the ASIS of the pelvis. The issue of submarining has become more urgent given the potential of highly autonomous vehicle occupants to recline more frequently or for longer durations when compared to traditional seating postures. Human body models present the unique opportunity to study the risks associated with reclined seating and would greatly benefit from studies characterizing the morphology and quality of adipose tissue in the ASIS region. This study involves analysis of subcutaneous adipose tissue (SAT) in medical imaging scans in supine and seated postures. Linear regression will be used to develop relationships between subject characteristics (BMI, sex, and age) and four quantitative measures of SAT: cross sectional area ( $CSA_{SAT}$ ), adipose tissue depth to bony prominences like the ASIS, posterior superior iliac spine (PSIS), or others ( $D_{SAT,1,2..N}$ ), fat quality ( $Q_{SAT}$  by grayscale unit), and seat belt sign location distance to ASIS (SBL).

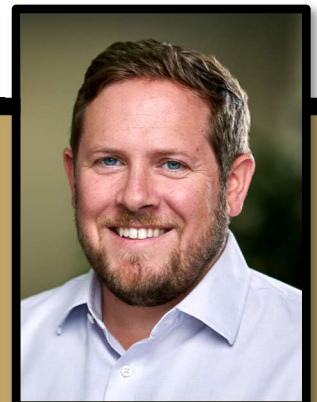


The student working on this project will be trained in collecting measurements from abdominal-pelvic CT and/or MRI medical images, and statistical analysis of data collected from human subjects.

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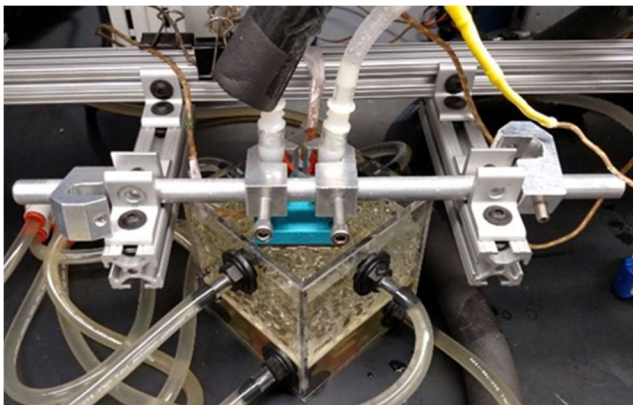


## Project 6 - Summer 2022

### Development and Validation of a Brain Phantom for Therapeutic Cooling Devices

An emerging area of interest is the study of bio-heat transfer for modeling brain therapeutics and pathology such as epilepsy. This project will focus on the study of heat transfer as it pertains to human body modeling, specifically quantifying thermal dose in the human body based on well-known bio-heat transfer experiments in the literature. The student will conduct experiments on a previously-developed brain phantom which simulates cooling therapy.

Next, using an established finite difference model, the student will calculate the predicted transient temperature response of both the phantom and of a brain, and compare those mathematical results to those from the lab experiment. In conjunction with this effort, the phantom will be improved upon in a laboratory setting in order to ensure repeatability of experiments as well as the ability to match the expected physiological response.



Lastly, the student will be tasked with developing prototypes of novel cooling devices within relevant design criteria. Understanding the context and application of such a device will be key to development.

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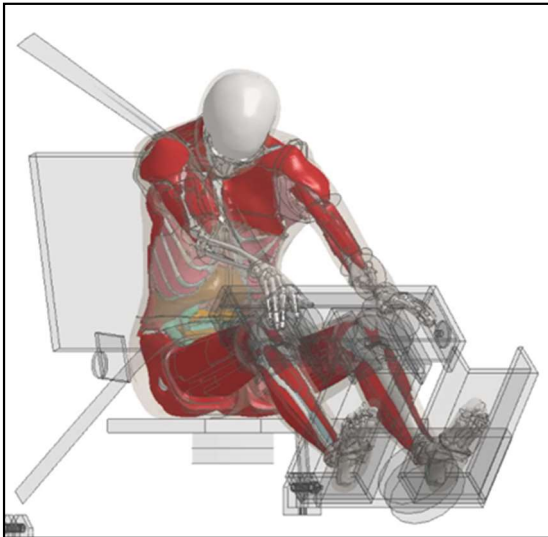




## Project 7 - Summer 2022

### Human Body Model Development for Trauma Research

Computational modeling is a growing component of injury biomechanics and trauma research. This project is a multi-center effort developing a next generation set of human body finite element (FE) models for enhanced injury prediction and prevention systems. The student will learn specific skills that are highly translatable to future graduate research experience including finite element volume meshing, high performance computing and morphometric operations such as scaling and medical image analysis. There will be a specific emphasis on applying the scientific process to these efforts. Students will review the literature in the subfield of modeling in which they are working. Computational efforts will focus on hypothesis driven activities, with simulations designed and conducted by the student to verify or refute their inquiries. These activities will be focused around model validation, studies related to injury risk predication in a given environment, or how best to scale results to match literature data from different body habitus.



This research effort will be in the Center for Injury Biomechanics (CIB) and you will have the opportunity to work on a range of projects in the field of automobile safety, military restraints, and sports biomechanics. The CIB has two primary research facilities. The first is in the WFU School of Medicine in Winston-Salem, NC and the second is at Virginia Tech. The research at the CIB combines experimental testing, computational modeling, and case analysis to investigate human injury biomechanics.

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**Scott Gayzik, PhD**

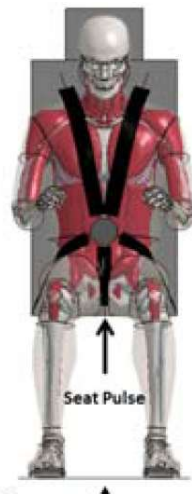
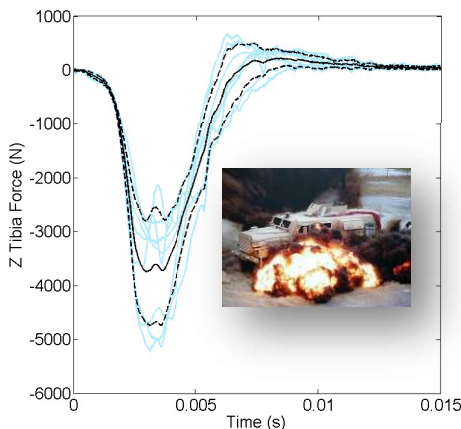
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## Project 8 - Summer 2022

### Underbody Blast Biomechanics

Underbody blast loading creates vertical accelerative loading and is a significant threat to the modern warfighter. The goal of this project is to develop a biomechanically based strategies for mitigating injury in these environments. This includes team-oriented work on the development of anthropomorphic testing devices (ATD, aka dummy) with biofidelic capabilities specific to the underbody blast environment. Additionally, human body finite element modeling in this environment will be a component of the project. Human modeling work is focused on the hypothesis that computational human body models can be used this environment to predict injury and thus be used as a novel surrogate to establish preliminary guidelines on human tolerance to severe vertical loading. Component level tests will be evaluated for statistically significant agreement with experimental trials and we will explore the suitability of a modeling approach for foundational biomechanical work in vertical loading. The student will assist in the development and execution of code to generate human injury probability curves and use of finite element models in matched trials of dummy and laboratory tests.



This research effort will be in the Center for Injury Biomechanics (CIB) and you will have the opportunity to work on a range of projects in the field of automobile safety, military restraints, and sports biomechanics. The research at the CIB combines experimental testing, computational modeling, and case analysis to investigate human injury biomechanics.

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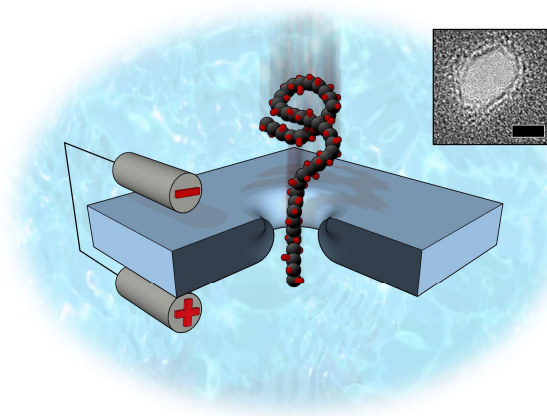


## Project 9 - Summer 2022

### Molecular Detection and Analysis of Trauma Bioindicators

Hyaluronan (or hyaluronic acid, HA) is a key linear sugar that is found in all physiological fluids and tissues, where variation in its composition can either result from or be a direct cause of disease emergence. While changes in net HA abundance in biofluids can be probed conventionally, this metric ignores a critical size-function relationship in which high- and low-molecular weight (MW) HA exhibit contrasting effects on inflammation, angiogenesis, cell motility, and more. Consequently, determination of both HA abundance *and* size distribution is essential. However, many important physiological systems contain small total amounts of HA and technologies for comprehensive assessment have critical limitations in sensitivity as well as challenges in dynamic range, cost, ease of implementation, and/or delivery of quantitative results.

In response, our laboratory has applied a molecular detection strategy using the solid-state nanopore platform, which is able to detect and size HA electrically and with tremendous sensitivity. Here, we will apply our assay to probe the HA content of plasma derived from trauma patients. As a central goal of this project, we aim to investigate HA MW as a bioindicator of outcomes for patients presenting with similar trauma severities.



The student who joins our team will learn and/or perform one or more of the following activities:

- Biochemical extraction of hyaluronan from physiological samples
- Molecular detection with the solid-state nanopore platform
- Data analysis & reporting

**Location:**

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**Adam Hall, PhD**

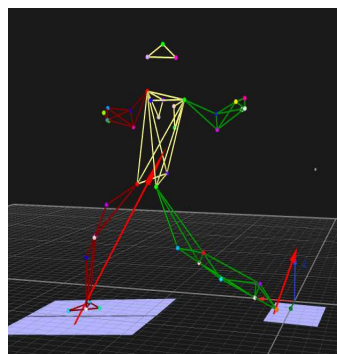
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<https://thehalllab.org>



## Project 10 - Summer 2022

### Impact of Kinematics and Ball Weight on Shoulder and Elbow Stress During Weighted Ball Drills

The safety and efficacy of weighted ball drills for the baseball pitcher are highly debated. While some research has shown that throwing weighted balls improves pitching velocity, it is unknown how the kinematics and ball weight of specific weighted ball drills directly impact stress at the shoulder and elbow. This project involves collecting 3D motion capture data of weighted ball drills to investigate the impact of player specific kinematics and ball weight on the player's arm health.



The student will: 1) review literature on weighted ball drills and pitching biomechanics, 2) collect 3D motion capture data of players performing weighted ball drills, and 3) analyze the kinematics and ball weight influence on shoulder distraction force and elbow valgus torque. The student will apply skills they learn in human subjects' research, experimental design, data collection and processing, biomechanics and human movement, and statistical analysis to better understand the impact of weighted ball drills on the health of the pitchers' arm.

**Location:**


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**Kristen Nicholson, PhD**

Assistant Professor, Orthopedic Surgery  
Wake Forest Baptist Health  
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Winston-Salem, NC 27157





# Project 11 - Summer 2022

## Data Analysis Pipelines

Beyond the essential coded data elements in Electronic Medical Records (EMRs), additional metadata and free text data provide opportunities for better patient evaluation and care, if those elements can be easily incorporated into research data warehouses. In this project textual data can be mined with advanced targeted analysis as an injected step within the larger Natural Language Processing (NLP) concept extraction process and de-identification of the text to remove Protected Health Information (PHI). The use of recurrent neural networks or machine learning methods could be explored and compared with the results achieved through standard methods and tooling to gain insight on better processing of data while ensuring quality.



The student working on this project will be trained in data analytics and supporting application programming. The student will get familiarity with national medical data standards, and ontological systems. Data characterization, cleaning, NLP, and visualization will be explored.

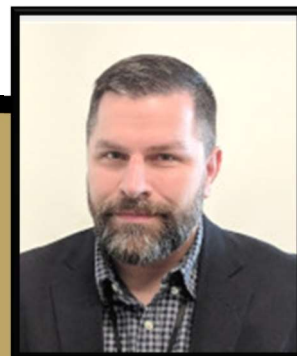
**Required skills: Python programming**

**Prior experience with databases, statistics, and machine learning is helpful.**

**Location:**  **Wake Forest®**  
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**Brian Ostasiewski**

Informatics Program Director  
Clinical and Translational Science Institute  
Center for Biomedical Informatics  
Wake Forest School of Medicine  
486 N. Patterson Ave, Suite 400  
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## Project 12 - Summer 2022

### Networked Data Models

Electronic Medical Records (EMRs) are aimed at supporting clinical practice at the point of care. These are often deeply customized and unique to the institutions in which they operate. Therefore, when conducting research with collaborators at other institutions it is often difficult to execute systematic analysis of these disparate observational databases. Common Data Models (CDMs) allow transformation of data contained within these databases into a common format as well as a common representation (terminologies, vocabularies, coding schemes), which then allows systematic analyses using a library of standard analytic routines that can be written based on the common format. The CTSI at Wake Forest leads and participates in several of these regional and national networks sharing data for basic science, retrospective studies, and clinical trial recruitment.



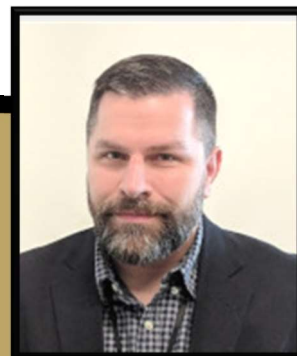
The student working on this project will be trained in data analytics and supporting application programming. The student will get familiarity with national medical data standards, ontological systems, and the full-cycle process of research from cohort identification to data extraction and analysis. Data characterization, cleaning, Natural Language Processing (NLP), and visualization will be explored.

**Required skills: Programming. Prior experience with databases and statistics is helpful.**

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**Brian Ostasiewski**

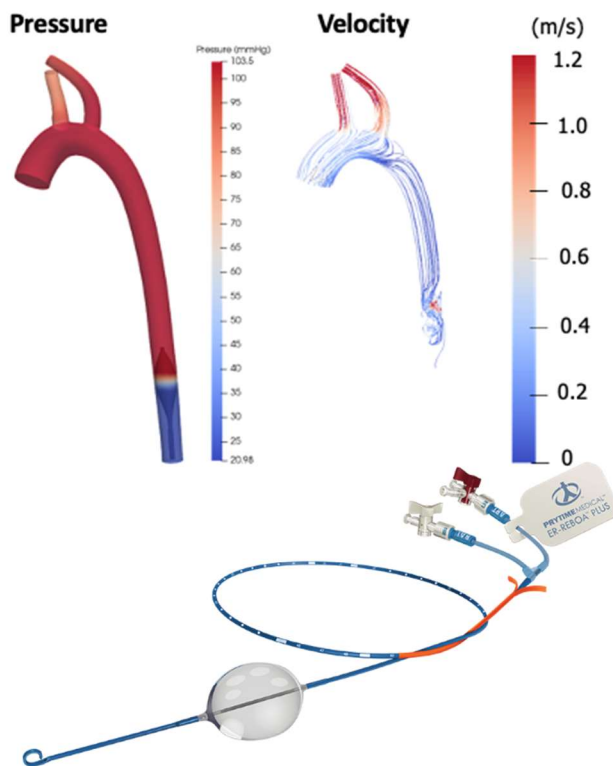
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## Project 13 - Summer 2022

### Computational Fluid Dynamic (CFD) Modeling of Hemorrhagic Shock

Non-compressible hemorrhage, referring to regions of the body that cannot be tourniquet pose a serious threat to one's survival. To address this problem, Endovascular Hemorrhage Control (EHC) devices such as REBOA have been implemented to create a partial or full occlusion of the aortofemoral artery via inflation of a balloon catheter. However, these methods are of high risk, often resulting in significant ischemic injury and vascular damage. This project exploits CFD modeling to better understand the hemodynamics during hemorrhage and EHC device usage.



The student will: 1) review literature on hemorrhagic shock, 2) design a hypothesis-driven project to evaluate the efficacy of EHC devices, and 3) apply learned CFD and FE skills to quantify key fluid mechanics properties (e.g., shear stress, blood pressure) in the aortofemoral region. This data will help inform improved designs of EHC devices, ensuring the restoration of blood pressure and fluid flow, while delivering sufficient oxygen to mitigate ischemic injury.

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Elaheh Rahbar, PhD

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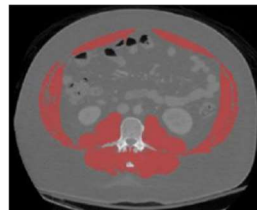
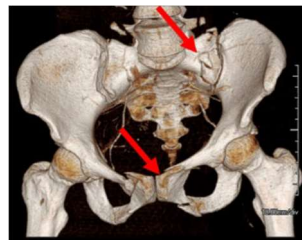
<https://school.wakehealth.edu/Research/Labs/Rahbar-Lab>



## Project 14 - Summer 2022

### Crash Injury Research and Engineering Network (CIREN)

CIREN is a research catalyst that can be used to conduct a wide range of motor vehicle trauma studies. It has been an ongoing project at WFUBMC since 2005.



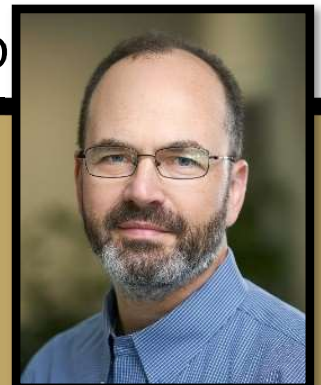
The student will: 1) conduct detailed investigations of real-world motor vehicle crashes and determine mechanism and causation of occupant injuries to improve prevention, mitigation, and treatment of motor vehicle crashes, 2) collaborate and work closely with a broad range of medical specialties, including biomedical engineers, crash investigators, radiologists, orthopedic surgeons, and trauma surgeons, and 3) conduct finite element (FE) modeling reconstructions of CIREN crashes using the simplified GHBM human body model of a simplified vehicle model providing kinematic visualizations and injury analyses to supplement our investigations.

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**Joel Stitzel, PhD**

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## Project 15 - Summer 2022

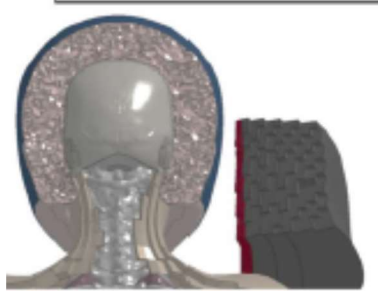
### Head Impact Exposure Quantification and Mitigation in Motorsports

The Pilot testing of individualized mouthpiece deployment in motorsports involving injury risk assessment for the optimization of safety measures

Driver FE Model

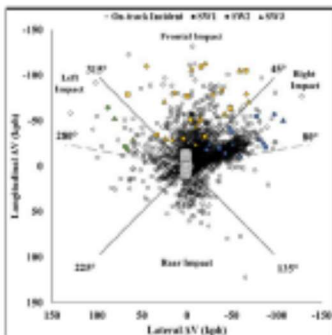


FE Simulation for  
Driver Safety Optimization



The student will: 1) conduct analysis to quantify environmental and crash head kinematics, 2) utilize finite element (FE) modeling for injury risk assessment for drivers in crash scenarios, and, 3) FE simulation to optimize safety measures and driver comfort.

Example On-Track Impacts

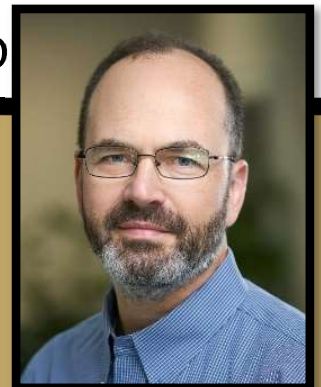


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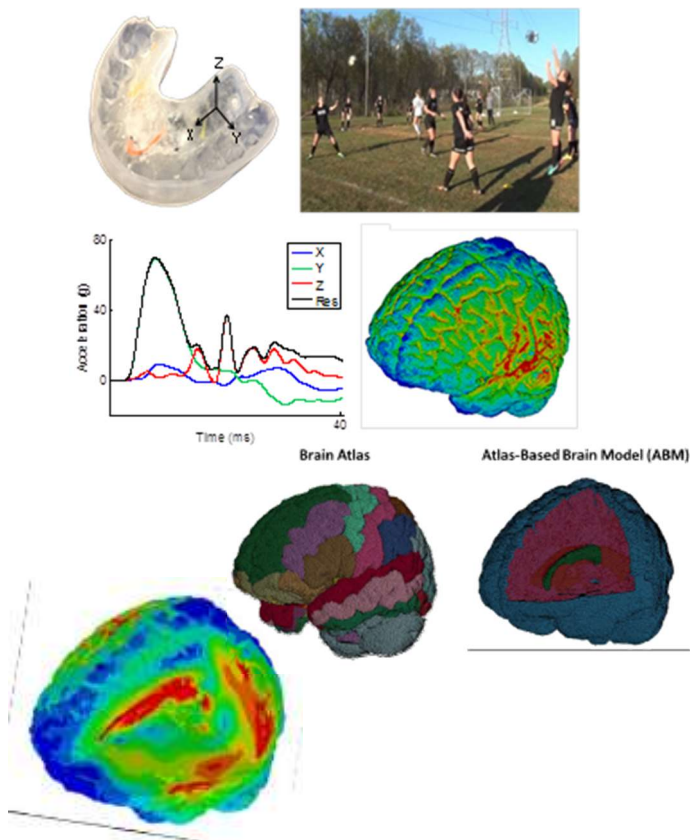
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## Project 16 - Summer 2022

### Subconcussive Head Impact Analysis using Instrumented Mouthpiece Data

Sensor technology offers researchers and consumers the ability to collect head impact data in the real-world; however, the accuracy of such sensors has been limited. This project involves development, testing, and field deployment of a novel instrumented mouthpiece in contact sports (e.g. football, gymnastics, soccer, hockey) and everyday activities (e.g. sitting, running).



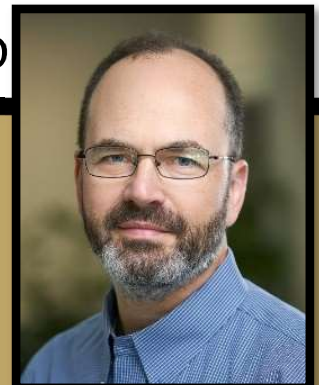
The student will: 1) review literature on head kinematics in athletic and everyday activities, and 2) work on a project to evaluate kinematic data collected from the mouthpiece. The student will apply skills they learn in human subjects' research, experimental testing, data collection and processing, statistical analysis, and FE modeling with a brain model to derive conclusions and a better understanding of head kinematics and TBI risk in sports and everyday activities.

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**Joel Stitzel, PhD**

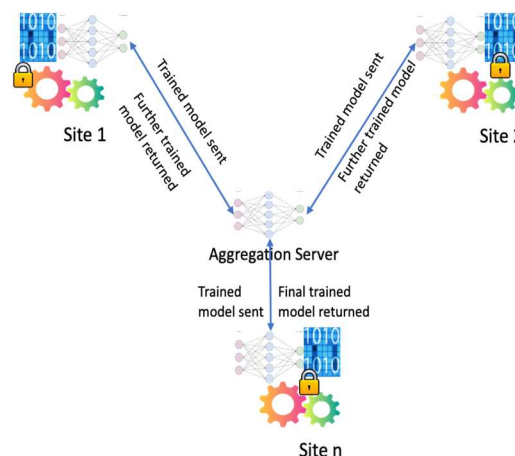
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## Project 17 - Summer 2022

### Privacy Preserved Federated Learning

Machine Learning (ML) poses an opportunity to revolutionize the healthcare industry. Issues regarding data heterogeneity, depth, and breadth are a hindrance to the generalizing ML approaches. Given the data intensive nature of model training, Federated Learning (FL) approaches may provide a novel opportunity for the future of ML applications. Despite the perceived and studied benefits, there are some challenges for wider implementation and acceptance of FL including privacy of the models that are being exchanged. We are studying use of frequency domain transformations to address the issue



**Required skills: Programming in Python, Machine Learning experience is preferred**

**Location:**

 **Wake Forest®**  
School of Medicine

**Umit Topaloglu, PhD, FAMIA**

Assoc. Director for Informatics, Comprehensive Cancer Center  
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## Project 18 - Summer 2022

### Deep Learning Cancer Health Disparities

The overall survival rate of cancer patients has been significantly improved and cancer survivors face unique challenges. Our hypothesis is that: 1) local communities where cancer survivors reside have different socioeconomic, cultural, and ethical characteristics; and 2) such community-specific features are strongly associated with the lifestyles and the access to healthcare. The goal of this project is to better understand the relations between these factors and the risks of various aging-related clinical conditions through integrative **deep learning**. This project will use graph convolutional network (GCN) models to integrate the high-resolution geographical data, HER data, and the ACS data to comprehensively investigate the correlations between community-related characteristics and the health risks; to establish the roles of community health disparity in aging-related clinical challenges among cancer survivors and pave ways to precision management and delivery of healthcare for those at risk.



**Required skills: Programming in Python**

**Location:**

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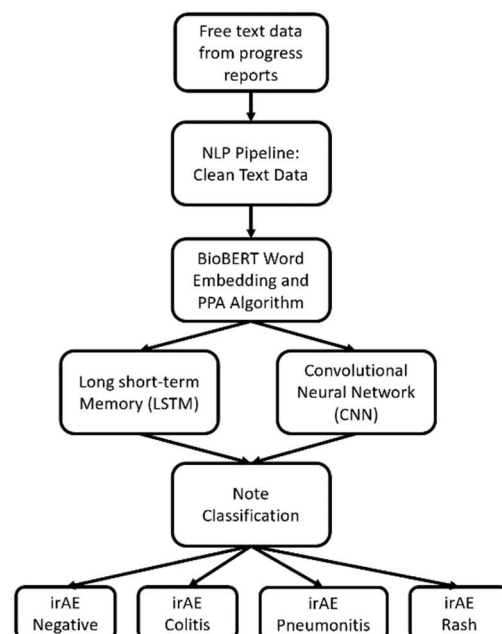


## Project 19 - Summer 2022

### Adverse event detection using Deep Learning for Immunotherapy

Immunotherapy has irrevocably altered the cancer treatment modalities and shown great promise. However, some patients experience immunotherapy related adverse events(irAEs), which could be fatal. In this project:

- We develop machine learning and natural language processing based predictive models that will classify irAEs from EHR data.
- We are working on validating and benchmarking the developed predictive models to further refine the model.



Python and machine learning experiences are needed.

**Location:**

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## Project 20 - Summer 2022

### Tumor Tissue Biobank

WFBCCC Tumor Tissue Shared Resource is in the process of migrating to a new system that involves utilizing standard terminologies to represent tissue diagnosis and histology. The process involves extracting diagnosis from Tumor Registry as well as validating what is being extracted by our Natural Language Processing Engine after parsing pathology reports. The intern is expected to work with multiple teams to help process biobank data to be completed by querying, matching, analyzing reports.



**Required skills: Programming in Python**

**Location:**

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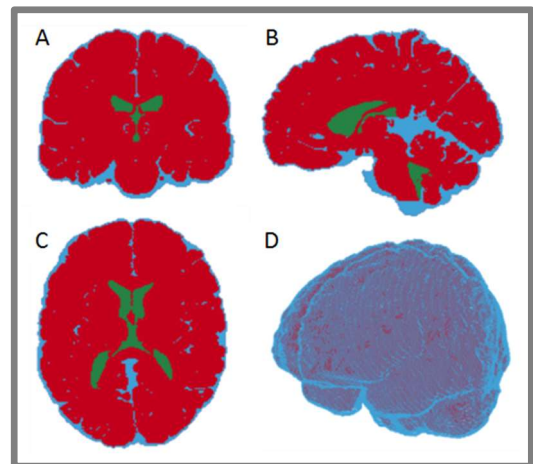


## Project 21 - Summer 2022

### Biomechanical Evaluation of Head Impact Exposure in Adolescent Athletes

Due to rising concern of head impact exposure and concussion in the 21 million children involved in team sports, this project aims to examine the biomechanical basis of sub-concussive and concussive head impact exposure in adolescent athletes instrumented with helmet-mounted and mouthpiece sensors.

The student will: 1) review literature focused on cumulative exposure of sub-concussive and concussive head impacts and factors influencing exposure (e.g. coaching techniques; practice and game guidelines/rules; community-based interventions; athlete age, size, experience, and position), and 2) design a hypothesis-driven experiment to examine analytically and computationally-based metrics of head impact exposure using FE modeling, on-field video analysis, biomechanical data processing, and statistical approaches learned from mentored training. The student will directly contribute to the broader research goal of reducing sub-concussive and concussive head impact exposure to improve sport safety in adolescents



**Location:**

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**Jillian Urban, PhD, MPH**

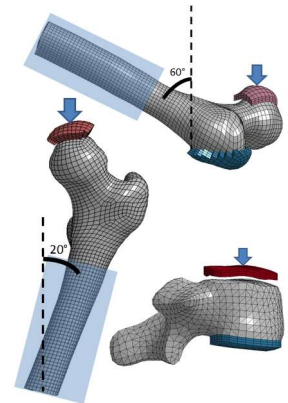
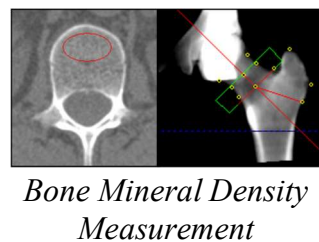
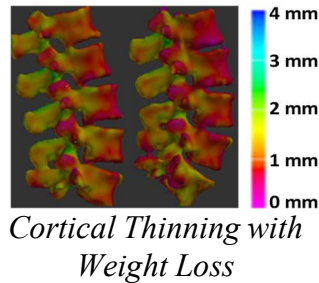
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## Project 22 - Summer 2022

### Effect of High Protein Weight Loss Diet on Older Adult Bone Health

Weight loss is controversial in older adults due to its association with bone loss and increased fracture risk. This clinical trial aims to determine whether a high protein diet during and following weight loss will reduce loss of bone mineral density, bone thickness, and bone strength and decrease fat cells in the bone marrow in older adults with obesity. CT scans of 225 older adults randomized to low vs. high protein weight loss diets will be analyzed to quantify bone health. Subject-specific finite element models created from the CT data will be used to predict femur and vertebra strength and fracture risk.



*Finite Element Modeling of  
Falls and Physiological  
Loading for Strength and  
Fracture Prediction*

The student working on this project will be trained in image segmentation, image registration, pipelines for quantifying bone quality (i.e. cortical thickness, bone mineral density), and finite element modeling and simulation. The student will form a hypothesis to test the effects of nutrition and weight loss on bone. To test the hypothesis, CT of participants will be analyzed to measure the changes that occur from baseline, 6-month, and 18-month CT scans.

**Location:**

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**Ashley Weaver, PhD**

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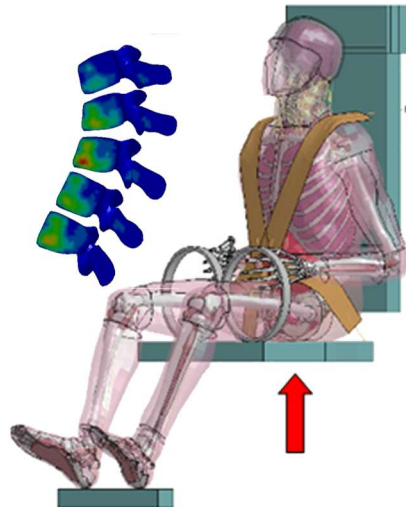


## Project 23 - Summer 2022

### Vertebral Strength and Injury Risk Following Long-Duration Spaceflight

Prolonged spaceflight can degrade the vertebrae and spinal muscles, leading to astronaut injury. This study is collecting pre- and post-flight CT and magnetic resonance imaging (MRI) scans of astronauts to quantify vertebral BMD, cortex thickness, geometry, and spinal muscle volume changes in 6-month space missions. Vertebral strength and injury risk will be quantified from simulations with a human body model altered to represent each astronaut's pre- and post-flight vertebrae and spinal muscles

The student will: 1) review literature on astronaut musculoskeletal deconditioning and form a hypothesis to test the effect of spaceflight on a bone or muscle outcome, and 2) learn image segmentation and registration, BMD and cortical thickness algorithms, and FE modeling to analyze pre- to post-flight changes in the astronauts to improve our understanding of injury risks associated with spaceflight deconditioning



**Location:**

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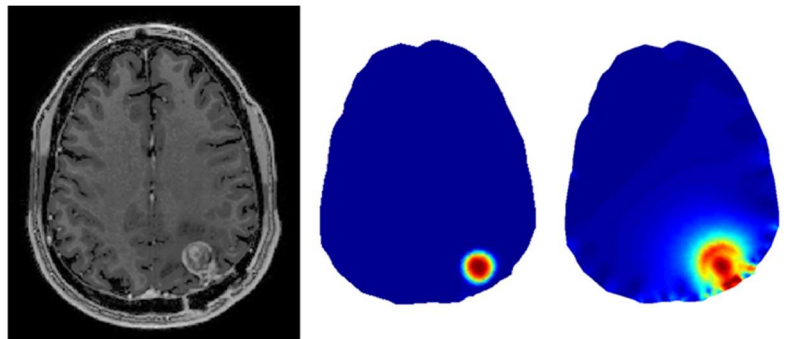


## Project 24 - Summer 2022

### Image-based Biophysical Modeling to Differentiate Radiation-induced Injury from Tumor Recurrence Following Stereotactic Radiosurgery

Patients with intracranial metastasis treated with stereotactic radiosurgery (SRS) are evaluated for local control using serial MR imaging. Lesions can often be seen during these follow-up imaging sessions with expanding areas of contrast enhancement and surrounding tissue abnormality. Determining the underlying pathology of the lesion presents enormous clinical challenges as tumor recurrence and radiation-induced injury appear radiographically similar. Lesions are often classified as indeterminate and monitored with additional and costly serial follow-up imaging, at the risk of letting a potential recurrent tumor progress. New methods are desperately needed to guide therapeutic intervention decision-making in this important patient group. This project investigates the development of computational modeling methods that are driven by clinical imaging data. As the underlying physiology of the two conditions is fundamentally different, biophysical models may allow parameterization of lesion properties as a model-based biomarker to determine post-SRS enhancing lesion etiology, reducing costs due to unnecessary imaging or missed diagnosis.

The student will gain experience with medical image processing (segmentation, registration) and biophysical finite element modeling based on MRI data. The student will develop and deploy computational analysis pipelines and contribute to the development of computational model-based image analysis methodologies to guide interventional therapy for cancer patients.



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## Project 25 - Summer 2022

### Neuroimaging and Cognitive Changes in Youth Football Players

Sports-related head impacts are common and involve significant forces that can result in mild to severe traumatic brain injury (TBI). Football has the highest incidence of sports-related TBI and limited data is available for the effects of repetitive head impact exposure for the millions of participants in youth and adolescent football leagues (8-18 years old) during this time of rapid brain development. We obtain functional/structural magnetic resonance imaging (MRI), magnetoencephalography (MEG), and cognitive measures, as well as detailed biomechanical head impact data from sensors embedded within the helmets of youth and adolescent athletes to determine the effects of repetitive subconcussive head impact exposure, and the true incidence of cognitive and objective imaging changes. The student selected will perform literature review focused on changes in the brain measurable from imaging and cognitive testing that are associated with cumulative head impact exposure and subconcussive head impacts.

The student will: 1) review literature on impact-induced changes in the brain that are measurable with neuroimaging and cognitive testing, and 2) develop a hypothesis-driven project to correlate neuroimaging measures, cognitive testing, and biomechanical head impact data in youth football players. The student will be trained in multimodal imaging acquisition and analysis (diffusion tensor imaging, functional MRI, arterial spin label imaging, susceptibility weighted imaging, magnetoencephalography), cognitive testing, biomechanical instrumentation (helmet-mounted accelerometers), and statistical analysis. They will apply these skills in their project to analyze youth football data to identify neuroimaging and cognitive biomarkers that are sensitive to cumulative subconcussive head impact exposure in youth football.

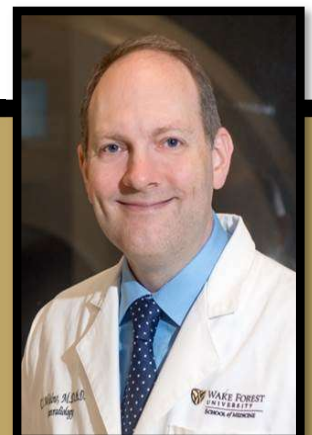
**Location:**



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**Christopher T. Whitlow, MD, PhD, MHA**

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Director, CTSI Translational Imaging Program  
Director, Combined MD/PhD Program  
Departments of Radiology and Biomedical Engineering  
Clinical and Translational Sciences Institute (CTSI)  
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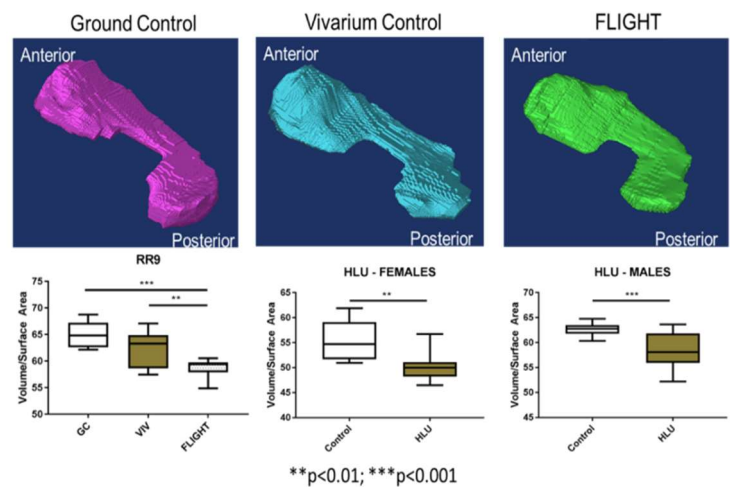


## Project 26 - Summer 2022

### The Rodent Research-18 Mission to the International Space Station: Prevention of Skeletal Complications

Loss of bone, cartilage, and muscle during periods of microgravity in space serves as a challenge to astronaut health during and after the mission. Our previous spaceflight data (from the International Space Station and Space Shuttle) identified damage to soft (cartilage, menisci) and hard (bone) joint tissues. Our group is again part of a team of investigators examining spaceflight affects on musculoskeletal health. Our team is examining will characterize the role of mitochondria in regulating oxidative stress-induced musculoskeletal damage, and will also determine the extent to which an antioxidant metalloporphyrin (MnTnBuOE-2-PyP5+), and a return to weight-bearing, protects against spaceflight environment-induced damage to bone and joint tissues.

Our upcoming mission will send mice to the International Space Station in December, 2021. While a group of mice will return in January to examine damage/protection of skeletal tissues, another group will return and be permitted to reload joints normally until June-July, 2021. The REU student will perform microCT analysis to measure degraded/preserved hindlimb bone architecture as strength changes/preservation via finite element modeling. The student will also perform contrast-enhanced microCT analysis to measure cartilage and meniscal degradation in the knee, and then assist with histology for biomarkers of joint damage. Outcome of these data will identify if a novel, well-tolerated antioxidant can serve to protect musculoskeletal health in astronauts during long-duration missions.



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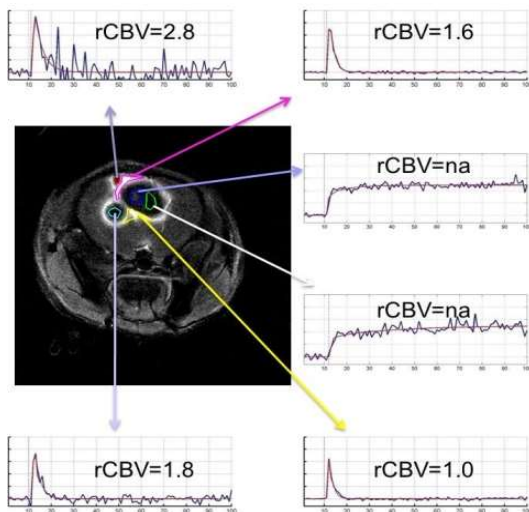




## Project 27 - Summer 2022

### Biomedical imaging of the brain tumor microenvironment

Malignant brain tumors that are characterized by profound angiogenesis and intratumoral hypoxia and necrosis are highly resistant to conventional multimodal therapies. Delivery of therapeutic agents to the brain tumor remains a major challenge partially due to the blood brain barrier (BBB). The BBB in brain tumor is known to be heterogeneously disrupted with tumor growth. Non-invasive MRI provides not only anatomic images, but also information about vascular function in brain tumors.



The student will: 1) review literature on cancer imaging and brain tumor pathophysiology, 2) learn post imaging processing skills with MatLab. The student will apply skills they learn in imaging segmentation of brain tumors in small animals and mathematic models-based quantitative imaging analysis of vascular perfusion and permeability parameters.

**Location:**  **Wake Forest®**  
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**Dawen Zhao, MD, PhD**

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