

2023 MUSE Application Cover Page

Email:

Tenure Status:

Number of years at TCNJ:

Department of Biomedical Engineering

Title of Project

Effects of Radiation Exposure During Pregnancy on Bone Health

Student Collaborators

(Junior Biomedical Engineering Major):

(Junior Biomedical Engineering Major):

Requested Budget: \$11,950.00

IACUC or IRB Approval: None Required

Date of Most Recent MUSE Award:

I. Intellectual Merit: One of NASA's long range goals is to send humans to Mars. However, once humans leave Earth's protective magnetic field, we are at risk of exposure to ionizing radiation. Ionizing radiation is emitted from our own Sun, as well as other cosmic sources such as stars. Ionizing radiation is dangerous to human health because this high energy radiation can pass through our body and deposit its energy into our tissues and cells. This causes DNA damage in cells, which can lead to many negative health effects such as cancer. Exposure to ionizing radiation is also known to have negative effects on bone health.

Over the past several years, my lab has investigated how different types and doses of radiation affect bone strength, and we were recently funded by NASA to study the effects of simulated space radiation on bone health and strength. In the past two years, we also started a new study investigating the bone strength changes during late term pregnancy in rats. ***The goal of the MUSE research combines these two areas of my research to evaluate the effects of radiation exposure during pregnancy.*** This work is part of a NASA Space Biology Grant with my collaborator _____, who has already completed the study and has the bone tissues ready for microCT scanning and biomechanical analyses. ***The proposed study will be the first to study the combined effects of radiation exposure during pregnancy.*** The effects of radiation exposure could have increased risks since there is elevated maternal bone metabolic activity during pregnancy to provide the minerals necessary for the developing fetuses' skeleton.

For the summer MUSE period, the specific goals are to work with the MUSE students to perform both mechanical experimentation (3-point bending & femoral neck testing) and quantitative image analysis using microCT scans on the bone specimens from these mice, who were exposed to low dose ionizing radiation during pregnancy (as well as sham controls). Thus, the study is designed to look at the bone health changes during pregnancy as well as the combined effects of pregnancy and radiation exposure on maternal health.

The mechanical experimentation breaks these bone specimens in a controlled manner to understand whole bone strength changes. Quantitative Image Analysis of the high resolution microCT scans of the bone provide specific bone microstructural health metrics, such as bone volume, density, connectivity, and porosity, which are indicators of overall bone health and strength. The proposed work is important for gaining a comprehensive picture of how pregnancy and exposure to radiation both affects bone health. Understanding how both bone microstructural and material properties are altered during exposure to radiation during pregnancy provides valuable information about the risks bone health once humans leave Earth's protective magnetic field and procreate on Mars.

The knowledge gained from the proposed work is not only important for helping astronauts during long duration space travel, but can also benefit people on Earth as well, such as pregnant women who are exposed to ionizing radiation during clinical diagnostic imaging (i.e. X-Rays, CT Scans). The expected outcomes by the end of the summer are for both students are to collect and analyze the data from their respective experiments and submit abstracts to present their projects at the BMES national conference. Both students are also interested in continuing working on this project to perform additional analyses (i.e. microindentation and Finite Element Modeling) on these bones during the academic year through the BME Department's Research Track. The students will later serve as co-authors on the journal manuscript submitted to Journal of Biomechanics for this novel pregnancy and radiation study. These tangible outcomes will make them both highly competitive when for the next stage of their careers. Depending on our findings, data generated will serve as preliminary data and motivation for future grant proposal submissions to NASA to identify pathways for countermeasure development or the NIH for Women's Health.

II. Role of Students and Mentor: This is my ____ year at TCNJ and I have mentored ____ TCNJ research students. Of these students, ____ were awarded NJ Space Grant Consortium Summer Fellowships, and ____ students who participated in MUSE presented their summer research projects at the Biomedical Engineering Society (BMES) Annual Meeting. Three of the students were first authors on published peer-reviewed conference papers presented at the IEEE EMBS Meetings in ____ and _____. Two are co-authors on a published peer-reviewed journal publication, and one is first author on a peer-review journal publication. ***My mentoring philosophy is geared at providing a comprehensive and rewarding experience for the mentee that allows the student to learn something new, while advancing their career and growing as a scientist/engineer.*** Throughout the mentoring experience, the student will have contributed to the research, gained confidence and independence, as well as developed important skills for a career in research or engineering practice.

Throughout the summer, I will work alongside my research students to teach them the laboratory skills and techniques needed to complete the research projects. As the summer progresses, I give the students more autonomy and independence to build confidence in their research abilities. There will be formal weekly group meetings where we will discuss their progress on the research, as well as weekly individual meetings. This is also a time where I can provide additional training and mentorship on how to have successful careers in research. I will also check in with the students individually and give them an opportunity to communicate any questions or concerns that may have encountered during the research experience.

Two students are requested because of large scope of the proposed project, which has 80 animal subjects that require both biomechanical testing and computational image analysis. Both of these experiments require significant time and effort as outlined in Table 1. I have already met with both students to explain the research project as well as my expectations for the projects. _____ (Junior BME) will be responsible for the biomechanical testing aspect of these bone specimens. _____ (Junior BME) will be responsible Image Processing and Quantitative Analysis of the bone scans. Both students have begun working in my lab to gain background knowledge on their respective projects so they can hit the ground running this summer.

Table 1: Tentative Timeline of Work for Each Student

Weeks 1-2	Specimen Preparation and 3-Point Bending	Image Processing of Bone Scans (3D Alignment & Segmentation)
Weeks 2-3	Embedding Bone Specimens	Develop Image Analysis Codes
Weeks 3-5	Femoral Neck Bone Strength Testing	Quantitative Image Analysis of Bone MicroCT Image Scans
Weeks 6-7	Analyze Data, Statistical Analysis, Interpretation of Findings	Analyze Data, Statistical Analysis, Interpretation of Findings
Weeks 7-8	Prepare Abstracts and Final Report	Prepare Abstracts and Final Report

III. Broader Impacts: This is my ____ year at TCNJ and having two research students through MUSE will generate valuable knowledge about the effects of radiation during pregnancy on maternal bone health. The findings from this study can also be used as preliminary data to motivate follow-up grant proposals as research in the field of Women's Health is growing. These projects will give students an opportunity to contribute new knowledge to the bone research community, while also gaining valuable research skills and experiences to propel them towards a successful career. In addition, both students are female, which are underrepresented in the field of engineering. And one of the students (_____) is _____ (_____), which is underrepresented at the College as well as the School of Engineering.