Sophia K. Tushak

PhD

Staff Consultant

Dr. Sophia K. Tushak is a biomechanical engineer at Engineering Systems Inc. (ESi) in the Minnesota office. Dr. Tushak has expertise in injury causation analysis, reconstruction, experimental design and execution, imaging and video analysis, motion capture systems, injury detection and risk, computational modeling and simulation, analysis of vehicle crash databases, statistical analysis and data science. She has experience working with human surrogates, including biological tissue, anthropomorphic test devices, and computational models of the human body. At ESi, she is building her practice in a range of injury biomechanics investigative scenarios, such as motor vehicle crashes, product and premises liability claims, slips, trips, falls, and criminal matters.

Prior to joining ESi, Dr. Tushak earned her Ph.D. in Mechanical and Aerospace Engineering at the University of Virginia. Her doctoral research at the Center for Applied Biomechanics focused on quantifying traumatic lumbar spine fracture tolerance and developing statistical tools for predicting fracture risk in frontal vehicle crash scenarios. She also has researched pediatric biomechanics, multiple event crashes, reclined occupants, pelvis fractures, bone microstructure, and advanced statistical and computational modeling. She has presented her research at domestic and international conferences and is published in peer-reviewed scientific journals and conference proceedings, including the Journal of Biomechanics, Annals of Biomedical Engineering, Traffic Injury Prevention, Enhanced Safety of Vehicles, and International Research Council on Biomechanics of Injury.

Education

PhD, Mechanical and Aerospace Engineering, University of Virginia. 2024

BS, Biomedical and Health Sciences Engineering, NC State University. 2018

Contact Information

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ESi Minnesota

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Areas of Specialization

- Computational Modeling
- Data Acquisition & Analysis
- Diagnostic Imaging
- Experimental Testing
- Human Injury Causation
- Impact Biomechanics
- Injury Risk Analysis
- Injury Tolerance & Mechanisms
- Lumbar Spine Injury
- Multiple Event Crashes
- Occupant Loading & Kinematics
- Pediatric Injuries
- Slips, Trips, Falls
- Statistical Analysis
- Videography & Motion Analysis

Positions Held

Engineering Systems Inc., Plymouth, MN

- Staff Consultant, 2025 – Present

University of Virginia, Department of Mechanical and Aerospace Engineering, Charlottesville, VA

- Research Scientist, Center for Applied Biomechanics, 2024 – 2025
- Graduate Research Assistant, Center for Applied Biomechanics, 2019 – 2024
- Teaching Assistant, Strength of Materials & Continuum Mechanics, 2020 – 2021

Comillas Pontifical University, School of Engineering, Madrid, Spain

- International Graduate Research Assistant, MoBios Laboratory, 2022

NC State University, Department of Biomedical Engineering, Raleigh, NC

- Undergraduate Research Assistant, Orthopaedic Mechanobiology Laboratory, 2016 – 2018
- Teaching Assistant, Orthopaedic Biomechanics, 2018

Children's Hospital of Philadelphia, Philadelphia, PA

- Biomechanics Intern, Center for Injury Research and Prevention, 2018

Wake Forest University, Department of Biomedical Engineering, Winston-Salem, NC

Biomechanics Intern, Center for Injury Biomechanics, 2017 – 2018

Professional Affiliations/Honors

Institute of Police Technology and Management

- Passenger Restraint Safety Systems, 2025

International Research Council on Biomechanics of Injury

- Best Presentation in Session, 2022, 2023, 2024

University of Virginia

- Mechanical and Aerospace Engineering Outstanding Graduate Research Award, 2023
- Copenhaver Charitable Trust Bicentennial Fellowship, 2022

Association for the Advancement of Automotive Medicine (AAAM)

- H. Clay Gabler Scholars Award, 2022
- Member, 2020 – Present

Institute of International Education Graduate International Research Experience Fellowship, 2020

National Science Foundation Graduate Research Fellowship, 2019 –2024

Biomedical Engineering Society (BMES), 2017 – 2019

NC State University

- Abrams Scholar, 2016 – 2018
- Biomedical Engineering Undergraduate Research Award, 2018

Children's Hospital of Philadelphia Student Research Day Best Presentation, 2018

Women in Science and Engineering (WISE), 2016 – 2018

Publications

"Does lumbar vertebra bone microstructure relate to combined loading fracture tolerance and inform fracture initiation site?" **Tushak SK**, Chernyavskiy P, Gates B, George C, Gepner BD, Kerrigan JR. Journal of Bone and Mineral Research (in review), 2025.

"The Effect of Varying Child Restraint System Seatback Angle on Spinal Loading of Toddler PIPER Human Body Models in Frontal Impacts" **Tushak SK**, Valdano M, Kerrigan JR, Lopez-Valdes FJ. Traffic Injury Prevention (in review), 2025.

"Development of injury risk functions incorporating repeated measures in survival analysis with multiple samples from the same subject" Kong JS, Chernyavskiy P, Hanggi C, **Tushak S**, Gepner B, Ostling M, Kerrigan J. Annals of Biomedical Engineering (in review), 2025.

"Characterization of the Lumbar Spine Dynamic Flexion Response Past its Physiological Range of Motion" **Tushak SK**, Kerrigan JR. Journal of Biomechanical Engineering (in press), 2025.

"Microstructure of the anterior iliac spine: identification of trends and relation to fracture tolerance" Hanggi C, **Tushak S**, Garman E, Gepner B, Ostling M, Kerrigan J. Journal of the Mechanical Behavior of Biomedical Materials (Article 107174), 2025.

"Human Lumbar Spine Injury Risk in Dynamic Combined Compression and Flexion Loading" **Tushak SK**, Gepner BD, Forman JL, Hallman JJ, Pipkorn B, Kerrigan JR. Annals of Biomedical Engineering, 2023.

"Failure Tolerance of the Human Lumbar Spine in Dynamic Combined Compression and Flexion Loading" **Tushak SK**, Donlon JP, Gepner BD, Chebbi A, Pipkorn B, Hallman JJ, Forman JL, Kerrigan JR. Journal of Biomechanics, 2022.

"How do novel seat positions impact usability of child restraints?" Tremoulet PD, Belwadi A, Corr B, Sarfare S, Seacrist T, **Tushak S.** TRIP, 2021.

"Comparison of injuries in multiple and single event crashes" **Tushak SK**, McMurry TL, Lee SH, Hong SH, Kerrigan JR. Traffic Injury Prevention, 2021.

"Forelimb unloading impairs glenohumeral muscle development in growing rats" **Tushak SK**, Tamburro MK, Fawcett EB, Merritt LE, Saul KR, Cole JH. Journal of Orthopedic Research (preprint), 2020.

"Responses of the scaled pediatric human body model in the rear- and forward-facing child seats in simulated frontal motor vehicle crashes" Belwadi A, Sarfare S, **Tushak S**, Maheshwari J, Menon S. Traffic Injury Prevention, 2019.

"Transporting Children in Autonomous Vehicles: An Exploratory Study" Tremoulet PD, Seacrist T, McIntosh CW, Loeb H, DiPietro A, **Tushak S.** Human Factors, 2019.

Presentations

Conference Presentations with Proceedings

"The influence of subject-specific geometric morphing and soft tissue material scaling on lumbar spine biomechanical response" **Tushak SK**, Bollapragada V, O'Cain C, Shin J, Gepner BD, Pipkorn B, Kerrigan JR. Proceedings of the International Research Council on the Biomechanics of Impact (IRCOBI), Stockholm, Sweden, 2024.

"GHBMC-Specific Injury Risk Prediction for the Lumbar Spine Considering Two Different Metrics" **Tushak SK**, Gepner BD, Pipkorn B, Kerrigan JR. Proceedings of the International Research Council on the Biomechanics of Impact (IRCOBI), Cambridge, United Kingdom, 2023.

"Evaluation of the GHBMC Lumbar Spine in Subinjurious and Injurious Loading" **Tushak SK**, Gepner BD, Pipkorn B, Kerrigan JR. Proceedings of the International Research Council on the Biomechanics of Impact (IRCOBI), Porto, Portugal, 2022.

"A Method for Defining Failure Tolerance of the Lumbar Spine in Combined Loading" **Tushak SK**, Richardson RE, Pipkorn B, Hallman JJ, Gepner BD, Forman JL, Kerrigan JK. Proceedings of the International Research Council on the Biomechanics of Impact (IRCOBI), Munich, Germany, 2020.

"Responses of the scaled infant human body model in simulated frontal motor vehicle crashes" **Tushak SK**, Maheshwari J, Belwadi A. Proceedings of the International Technical Conference on the Enhanced Safety of Vehicles (ESV), Eindhoven, Netherlands, 2019.

"Use of Finite Element Human Body Models in a Standardized Evaluation Protocol for Pedestrian Safety Assessment" Decker W, Koya B, **Tushak S**, Shin J, Choi HY, Pak W, Untaroiu A, Gayzik FS. Conference Proceedings of Human Modeling and Simulation, Berlin, Germany, 2018.

"Development of a Rat Forelimb Unloading Model to Understand Mechanical Influences on Postnatal Shoulder Development" **Tushak SK***, Tamburro MK*, Saul KR, Cole JH. Proceedings of the National Conference of Undergraduate Research (co–first authors), 2018.

Additional Conference Presentations and Abstracts

"Biomechanical Considerations for Homicides Involving Vehicles" **Tushak SK**, Loyd AM. Crash Reconstruction Seminar, Minnesota Public Defenders, Alexandria, Minnesota, 2025.

"Stiffness and biomechanical response of the human lumbar spine until injury: investigation of factors that may cause variation and creation of benchmarks for surrogate evaluation" **Tushak SK,** Kerrigan JR. 51st NHTSA Workshop on Human Subjects for Biomechanical Research, Ann Arbor, Michigan, 2023.

“The Influence of Subject-Specific Lumbar Spine Geometry and Bone Properties on Injury-Related Biomechanical Measurements” **Tushak SK**, Bollapragada V, O’Cain C, Shin J, Gepner BD, Pipkorn B, Kerrigan JR. 67th Annual Scientific Conference of the Association for the Advancement of Automotive Medicine (AAAM), Indianapolis, Indiana (Keynote Speaker), 2023.

“Which anatomical parameters affect lumbar spine response in combined loading?” **Tushak SK**, Gepner BD, Kerrigan JR. 50th NHTSA Workshop on Human Subjects for Biomechanical Research, Denver, Colorado, 2022.

“Injury Risk Function for the Lumbar Spine in Combined Compression and Flexion” **Tushak SK**, Gepner BD, Forman JL, Hallman JJ, Pipkorn B, Kerrigan JK. 65th Annual Scientific Conference of the Association for the Advancement of Automotive Medicine (AAAM), Virtual, 2021.

“Comparison of injuries in multiple and single event crashes” **Tushak SK**, McMurry TL, Lee SH, Hong SH, Kerrigan JR. 64th Annual Scientific Conference of the Association for the Advancement of Automotive Medicine (AAAM), Virtual, 2020.

“Glenohumeral Joint Development in Neonatal Rats Experiencing Forelimb Unloading” **Tushak SK***, Tamburro MK*, Fawcett EB, Dixit NN, Saul KR, Cole JH. State of North Carolina Undergraduate Research and Creativity Symposium, Raleigh, North Carolina (co–first authors), 2018.

“The Development of PIPER 18MO Child Human Body Model and Its Response to Frontal Vehicle Impacts” **Tushak SK**, Maheshwari J, Belwadi A. Biomedical Engineering Society Annual Meeting, Atlanta, Georgia, 2018.

“Application of PIPER Software to Adjust Spinal Position of Human Body Models in Military Relevant Postures” **Tushak SK**, Aira JR, Gayzik FS. Biomedical Engineering Society Annual Meeting, Phoenix, Arizona, 2017.

“Contributions of mechanical unloading to neonatal brachial plexus injury in rats” **Tushak SK**, McCormick CM, Saul KR, Cole JH. National Conference on Undergraduate Research, Memphis, Tennessee, 2017.