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EDUCATION

- The University of Michigan, Ann Arbor, MI*
Ph.D. in Biomedical Engineering **May 2013**
Dissertation: "An experimental investigation of human/bicycle dynamics and rider skill in children and adults" (Advisor: Noel C. Perkins)
- The University of Michigan, Ann Arbor, MI*
M.S. in Biomedical Engineering **April 2012**
Area of Concentration: Biomechanics (Advisor: Noel C. Perkins)
- The University of Michigan, Ann Arbor, MI*
M.S. in Mechanical Engineering **April 2005**
Area of Concentration: Biomechanics (Advisor: Daniel P. Ferris)
- The Pennsylvania State University, University Park, PA*
B.S. in Mechanical Engineering **December 2002**
Honors Thesis: "Design of a novel knee simulator" (Advisor: Stephen J. Pizza)

RESEARCH EXPERIENCE

- Department of Chemical and Biomedical Engineering
West Virginia University, Morgantown, WV
Assistant Professor **8/2021 – present**
- My research is focused on using principles from inertial navigation, engineering dynamics, biomechanics, and kinesiology to develop algorithms and data collection protocols that utilize data from body-worn inertial sensors and other wearable technologies to quantify human movement and physiology in non-laboratory environments. Through the measurement of human movement in the real world, my research enables new research discoveries and the development of personalized interventions to help improve human health and performance.
- Department of Mechanical Engineering
The University of Michigan, Ann Arbor, MI
Assistant Research Scientist **12/2017 – 8/2021**
- Advanced the use of wearable inertial sensors for quantifying human movement and biomechanics across a wide range of applications, including warfighter performance, shoulder use in manual wheelchair users, arm use in breast cancer survivors, baseball pitching, walking, and running.
- Perkins Research Group*
Department of Mechanical Engineering
The University of Michigan, Ann Arbor, MI
Research Investigator (Lab director: Dr. Noel Perkins) **2/2015 – 11/2017**
- Developed and tested algorithms for quantifying athletic/warfighter performance using body-worn inertial sensors.

Human Performance Innovation Laboratory and Vibrations and Acoustics Laboratory
School of Kinesiology and Department of Mechanical Engineering
The University of Michigan, Ann Arbor, MI

Research Fellow (Lab directors: Dr. Noel Perkins and Dr. Scott McLean) **1/2013 – 2/2015**

- Developed non-invasive methods to monitor and analyze human performance and fatigue in non-laboratory environments using inertial measurement technology
- Developed a novel method to analyze human gait (walking, running, stair climbing/descending) using an array of inertial measurement units (IMUs)
- Created algorithms that can be used to assess balance, stability, and performance during a wide range of obstacle course tasks (*e.g.* balance beam, window entry, agility tests, vertical jumping)

Vibrations and Acoustics Laboratory
The University of Michigan, Ann Arbor, MI

Graduate Student Research Assistant (Advisor: Dr. Noel Perkins) **1/2009 – 12/2012**

- The completed project focused on understanding how humans stabilize a bicycle; specifically, what information is important for learning and what makes an expert different from a novice
- Developed a novel instrumented bicycle to measure the relevant human inputs to the bicycle and the bicycle response

Human Neuromechanics Laboratory
The University of Michigan, Ann Arbor, MI

Graduate Student Research Assistant (Advisor: Dr. Daniel Ferris) **1/2004 – 6/2008**

- Studied the biomechanical, physiological, and neural effects of powered exoskeletons on walking
- Designed and built a novel hypergravity simulator to investigate the role of the ankle, knee, and hip during gait
- Designed and fabricated devices used to measure human power during exercise

Center for Locomotion Studies
The Pennsylvania State University, University Park, PA

Undergraduate Research Assistant (Advisor: Dr. Stephen Piazza) **1/2002 – 12/2002**

- Designed and built a novel knee simulator
- Developed advanced machining skills using a mill and lathe
- Wrote an undergraduate thesis on the design and fabrication of the simulator, which is still used by researchers in the lab as a handbook for how to use the device

Applied Research Laboratory
The Pennsylvania State University, University Park, PA

Undergraduate Researcher **5/2001 – 8/2001**

- Set up and ran experiments to investigate flow over a nose cone using both a 48-inch wind tunnel and a 12-inch water tunnel

PUBLICATIONS IN PEER-REVIEWED JOURNALS

11. Freehill, M. T., Rose, M. J., McCollum, K. A., Agresta, C. E., **Cain, S. M.** (2023) "Game-Day Pitch and Throw Count Feasibility Using a Single Sensor to Quantify Workload in Youth Baseball Players." *The Orthopaedic Journal of Sports Medicine*. 11(3): 23259671231151450. doi: [10.1177/23259671231151450](https://doi.org/10.1177/23259671231151450)
12. Agresta, C., Freehill, M. T., Zandler, J., Giblin, G., **Cain, S. M.** (2022). "Sensor Location Matters When Estimating Player Workload for Baseball Pitching." *Sensors*, 22. <https://www.mdpi.com/1424-8220/22/22/9008>
13. Agresta C, Freehill MT, Nakamura B, Guadagnino S, **Cain SM.** (2022). "Using Sensors for Player Development: Assessing Biomechanical Factors Related to Pitch Command and Velocity." *Sensors*, 22. <https://www.mdpi.com/1424-8220/22/21/8488>

14. Potter, M. V., **Cain, S. M.**, Ojeda, L. V., Gurchiek, R. D., McGinnis, R. S., Perkins, N. C. (2022). "Evaluation of error-state Kalman filter method for estimating human lower-limb kinematics during various walking gaits." *Sensors*. <https://www.mdpi.com/1424-8220/22/21/8398>
15. Baroudi, L., Yan, X., Newman, M. W., Barton, K., **Cain, S. M.**, Shorter, K. A. (2022). "Investigating walking speed variability of young adults in the real world." *Gait & Posture*, 98, 69-77.
16. Gonzalez, S., Stegall, P., **Cain, S. M.**, Siu, H. C., Stirling, L. (2022). "Assessment of a Powered Ankle Exoskeleton on Human Stability and Balance." *Applied Ergonomics*, 103.
17. Gilley, S., Baroudi, L., Yu, M., Gainsburg, I., Reddy, N., Bradley, C., Cislo, C., Rozwadowski, M. L., Clingan, C. A., DeMoss, M. S., Churay, T., Birditt, K., Colabianchi, N., Chowdhury, M., Forger, D., Gagnier, J., Zernicke, R. F., Cunningham, J. L., **Cain, S. M.**, Tewari, M., Choi, S. W. (2022). "Risk Factors for COVID-19 in College Students Identified by Physical, Mental, and Social Health Reported During the Fall 2020 Semester: Observational Study Using the Roadmap App and Fitbit Wearable Sensors." *JMIR Mental Health*, 9. <https://mental.jmir.org/2022/2/e34645/>
18. Jahanian, O., Van Straaten, G., Goodwin, B. M., **Cain, S. M.**, Lennon, R. J., J. D., Murthy, N. S., Morrow, M. M. B. (2021). "Inertial Measurement Unit-Derived Ergonomic Metrics for Assessing Arm Use in Manual Wheelchair Users With Spinal Cord Injury: A Preliminary Report." *Topics in Spinal Cord Injury Rehabilitation*, 27(3), 12-25.
19. Goodwin BM, **Cain SM**, Van Straaten MG, Fortune E, Jahanian O, Morrow MM. "Humeral elevation workspace during daily life of adults with spinal cord injury who use a manual wheelchair compared to age and sex matched able-bodied controls." *PLoS one*. (2021) Apr 23;16(4):e0248978.
110. Goodwin BM, O Jahanian, **SM Cain**, MG Van Straaten, E Fortune, MMB Morrow. "Duration of static and dynamic periods of the upper arm during daily life of manual wheelchair users and matched able-bodied participants." *Frontiers in Sports and Active Living* 3 (2021).
111. Potter MV, **Cain SM**, Ojeda LV, Gurchiek RD, McGinnis RS, Perkins NC. "Error-state Kalman filter for lower-limb kinematic estimation: Evaluation on a 3-body model." *Plos one*. 2021 Apr 20;16(4):e0249577.
112. Davidson SP, **SM Cain**, L Ojeda, A Zaferiou, RV Vitali, L Stirling, NC Perkins. "Quantifying warfighter performance during a bounding rush (prone-sprinting-prone) maneuver." *Applied Ergonomics* 94 (2021): 103382.
113. Baroudi L, M Newman, E Jackson, K Barton, KA Shorter, **SM Cain**. "Estimating Walking Speed in the Wild." *Frontiers in Sports and Active Living* 2 (2020).
114. Jahanian O, Van Straaten MG, Goodwin BM, **Cain SM**, Lennon RJ, Barlow JD, Murthy NS, Morrow MM. "Inertial Measurement Unit-Derived Ergonomic Metrics for Assessing Arm Use in Manual Wheelchair Users With Spinal Cord Injury: A Preliminary Report." *Topics in Spinal Cord Injury Rehabilitation*. (2021);27(3):12-25.
115. Rose MJ, KA McCollum, MT Freehill, and **SM Cain**. "Quantifying throw counts and intensities throughout a season in youth baseball players: a pilot study." *Journal of Biomechanical Engineering* 143(3) (2021), 034502.
116. Schneider KJ, CN Hollenhorst, AN Valicevic, LM Niziol, M Heisler, DC Musch, **SM Cain**, PA Newman-Casey. "Impact of the Support, Educate, Empower (SEE) personalized glaucoma coaching program pilot study on eye drop instillation technique and self-efficacy." *Ophthalmology Glaucoma* (2020).
117. Payne N, R Gangwani, K Barton, AP Sample, **SM Cain**, DT Burke, PA Newman-Casey, KA Shorter. "Medication adherence and liquid level tracking system for healthcare provider feedback." *Sensors* 20(8) (2020): 2435.
118. Hallbeck MS, Law KE, Lowndes BR, Linden AR, Morrow M, Blocker RC, **Cain SM**, Degnim AC, Hieken TJ, Jakub JW, Racz JM. "Workload Differentiates Breast Surgical Procedures: NSM Associated with Higher Workload Demand than SSM." *Annals of Surgical Oncology* (2020): 1-9.
119. Potter MV, LV Ojeda, NC Perkins, **SM Cain**. "Effect of IMU design on IMU-derived stride metrics for running." *Sensors* 19(11) (2019): 2601.
120. Vitali RV, **SM Cain**, LV Ojeda, MV Potter, SP Davidson, A Mendoza, L Stirling, NC Perkins. "Body-worn IMU array reveals effects of load on performance in an outdoor obstacle course." *PLoS one* 14(3) (2019): e0214008.
121. Vitali RV, **SM Cain**, SP Davidson, NC Perkins. "Human crawling performance and technique revealed by inertial measurement units." *Journal of Biomechanics* 84 (2019): 121-128.
122. Stirling L, C Eke, **SM Cain**. "Examination of the perceived agility and balance during a reactive agility task." *PLoS one* 13.6 (2018): e0198875.

123. Tammana A, C McKay, **SM Cain**, SP Davidson, RV Vitali, L Ojeda, L Stirling, NC Perkins. "Load-embedded inertial measurement unit reveals lifting performance." *Applied Ergonomics* 70 (2018): 68-76.
124. Ojeda L, A Zaferiou, **SM Cain**, RV Vitali, SP Davidson, LA Stirling, NC Perkins. "Estimating stair running performance using inertial sensors." *Sensors* 17.11 (2017): 2647.
125. Zaferiou AM, L Ojeda, **SM Cain**, RV Vitali, SP Davidson, L Stirling, NC Perkins. "Quantifying performance on an outdoor agility drill using foot-mounted inertial measurement units." *PLoS one* 12.11 (2017): e0188184.
126. Eke CU, **SM Cain**, LA Stirling. "Strategy quantification using body worn inertial sensors in a reactive agility task." *Journal of Biomechanics* 64 (2017): 219-225.
127. Vitali RV, **SM Cain**, RS McGinnis, AM Zaferiou, LV Ojeda, SP Davidson, NC Perkins. "Method for estimating three-dimensional knee rotations using two inertial measurement units: Validation with a coordinate measurement machine." *Sensors* 17.9 (2017): 1970.
128. McGinnis RS, **SM Cain**, SP Davidson, RV Vitali, SG McLean, NC Perkins. "Inertial sensor and cluster analysis for discriminating agility run technique and quantifying changes across load." *Biomedical Signal Processing and Control* 32 (2017): 150-156.
129. Davidson SP, **SM Cain**, RS McGinnis, RV Vitali, NC Perkins, SG McLean. "Quantifying warfighter performance in a target acquisition and aiming task using wireless inertial sensors." *Applied Ergonomics* 56 (2016): 27-33.
130. McGinnis RS, **SM Cain**, SP Davidson, RV Vitali, NC Perkins, SG McLean. "Quantifying the effects of load carriage and fatigue under load on sacral kinematics during countermovement vertical jump with IMU-based method." *Sports Engineering* 19.1 (2016): 21-34.
131. **Cain SM**, JA Ashton-Miller, and NC Perkins. "On the skill of balancing while riding a bicycle." *PLoS one* 11.2 (2016): e0149340.
132. **Cain SM**, RS McGinnis, SP Davidson, RV Vitali, NC Perkins, SG McLean. "Quantifying performance and effects of load carriage during a challenging balancing task using an array of wireless inertial sensors." *Gait & Posture* 43 (2016): 65-69.
133. McGinnis RS, **SM Cain**, SP Davidson, RV Vitali, SG McLean, NC Perkins. "Inertial sensor and cluster analysis for discriminating agility run technique." *IFAC-PapersOnLine* 48.20 (2015): 423-428.
134. McGinnis RS, **SM Cain**, S Tao, D Whiteside, GC Goulet, EC Gardner, A Bedi, NC Perkins. "Accuracy of femur angles estimated by IMUs during clinical procedures used to diagnose femoroacetabular impingement." *IEEE Transactions on Biomedical Engineering* 62.6 (2015): 1503-1513.
135. **Cain SM** and NC Perkins. "Comparison of experimental data to a model for bicycle steady-state turning." *Vehicle System Dynamics* 50.8 (2012): 1341-1364.
136. **Cain SM**, KE Gordon, and DP Ferris. "Locomotor adaptation to a powered ankle-foot orthosis depends on control method." *Journal of NeuroEngineering and Rehabilitation* 4.1 (2007): 48.

SUBMITTED (IN REVIEW) PUBLICATIONS IN PEER-REVIEWED JOURNALS

51. Hafer, J. F., Vitali, R. V., Gurchiek, R., Curtze, C., Shull, P., **Cain, S. M.** "Challenges and advances in the use of wearable sensors for lower extremity biomechanics." *Journal of Biomechanics* (in review)
52. Mihiy, J. A., Wagatsuma, M., **Cain, S. M.**, Hafer, J. F. "Minimizing the effect of IMU misplacement with a functional orientation method." *Gait & Posture* (in review)
53. Baroudi, L., Zernicke, R. F., Tewari, M., Carlozzi, N. E., Choi, S. W., **Cain, S. M.** "Using wear time for the analysis of consumer-grade wearables' data: a case study using Fitbit data." *JMIR* (in review)

IN PREPARATION PUBLICATIONS IN PEER-REVIEWED JOURNALS

- PP1. **Cain SM**, MMB Morrow. "Quantifying shoulder motion in the real world using wearable inertial measurement units: challenges and recommendations." (planned submission to *Journal of Biomechanics*)

CONFERENCE ABSTRACTS, PAPERS, AND PRESENTATIONS

- C1. Pinnock Branford, K., Van Straaten, M. G., Jahanian, O., Morrow, M. M. B., **Cain, S. M.** (2023) "A novel approach to quantify manual wheelchair propulsion patterns." *Annual Meeting of the American Society of Biomechanics*, Nashville, TN. (in review)

- c2. Duque Urrego, D., Droste, A. P., Trenary, T. T., Sample, A. P., Burke, D. T., Brown, S. H., Newman-Casey, P. A., **Cain, S. M.** (2023) "Evaluating eye drop instillation biomechanics with an instrumented bottle." *Annual Meeting of the American Society of Biomechanics*, Nashville, TN. (in review)
- c3. Duque Urrego, D., Pinnock Branford, K., Aristizabal Pla, G., Robinson, H. M., Settle, H. A., Jochimsen, K. N., **Cain, S. M.** (2023) "IMU-based measures of stability reveal differences in balance performance between gymnasts with and without a history of sport-related concussion." *Annual Meeting of the American Society of Biomechanics*, Nashville, TN. (in review)
- c4. Pinnock Branford, K., Van Straaten, M. G., Jahanian, O., Morrow, M. M. B., **Cain, S. M.** (2023) "*The dynamics of a manual wheelchair and user during propulsion.*" Bicycle and Motorcycle Dynamics 2023, Delft, The Netherlands. (podium presentation)
- c5. Robinson, H. M., **Cain, S. M.**, Pinnock Branford, K., Duque Urrego, D., Aristizabal Pla, G., Settle, H. A., Jochimsen, K. N. "How do Division 1 collegiate gymnasts differ in balance tasks between those with and without a history of sport-related concussions?" *National Athletic Trainer's Association*. (presentation)
- c6. Van Straaten, M., Jahanian, O., Morrow, M., **Cain, S. M.** (2022). "A Qualitative Investigation of Arm Use Ergonomic Factors During Daily Activities of Manual Wheelchair Users." (12th ed., vol. 103, pp. e147). *Archives of Physical Medicine and Rehabilitation*. (poster presentation)
- c7. **Cain, S. M.**, Van Straaten, M. G., Lundell, S. M., Pinnock Branford, K., Jahanian, O., Morrow, M. M. (2022). "Can body segment angles during common manual wheelchair user movements be calculated from linear acceleration data?" *NACOB 2022*, Ottawa, Ontario, Canada. (podium presentation)
- c8. Mihiy, J. A., Wagatsuma, M., **Cain, S. M.**, Hafer, J. F. (2022). "Comparing reliability of sensor-to-segment alignment techniques." *NACOB 2022*, Ottawa, Ontario, Canada. (poster presentation)
- c9. Wagatsuma, M., Mihiy, J. A., **Cain, S. M.**, Hafer, J. F. (2022). "Comparison of in-lab and out-of-lab gait among healthy young and older adults and older adults with knee osteoarthritis." *NACOB 2022*, Ottawa, Ontario, Canada. (podium presentation)
- c10. Potter, M. V., **Cain, S. M.**, Ojeda, L. V., Gurchiek, R. D., McGinnis, R. S., Perkins, N. C. (2022). "IMU-based estimation of ankle and hip joint centers using an error-state Kalman filter." *NACOB 2022*, Ottawa, Ontario, Canada. (podium presentation)
- c11. Jahanian, O., Van Straaten, M. G., Nakum, J. B., Lundell, S. M., Pinnock Branford, K., **Cain, S. M.**, Morrow, M. M. (2022). "IMU-derived metrics of repetitive arm motion in the community environment for manual wheelchair users." *NACOB 2022*, Ottawa, Ontario, Canada. (podium presentation)
- c12. Baroudi, L., X. Y., Newman, M. W., Barton, K., **Cain, S. M.**, Shorter, K. A. (2022). "Influence of context on human walking in the real world." *NACOB 2022*, Ottawa, Ontario, Canada. (podium presentation)
- c13. Pinnock Branford, K., Kartes, J., Ingber, J., Sickmiller, L., Prine, A., Lipps, D. B., **Cain, S. M.** (2022). "Quantifying arm function after breast reconstruction with real-world reaching tasks." *NACOB 2022*, Ottawa, Ontario, Canada. (poster presentation)
- c14. Baroudi, L., Zernicke, R. F., Tewari, M., Choi, S. W., **Cain, S. M.** (2022). "Understanding compliance for consumer-grade wearables: a case study using Fitbit data." *NACOB 2022*, Ottawa, Ontario, Canada. (podium presentation)
- c15. Potter, M. V., **Cain, S. M.**, Ojeda, L. V., Gurchiek, R. D., McGinnis, R. S., Perkins, N. C. (2022). "Using OpenSim to validate and compare IMU-based kinematic estimation methods." *NACOB 2022*, Ottawa, Ontario, Canada. (podium presentation)
- c16. Baroudi L, M Newman, X Yan, K Barton, KA Shorter, **SM Cain**. "Contextualizing Walking Speed in the Real World." *Midwest ASB 2021*, Cleveland, OH, September 17-18, 2021. (podium presentation)
- c17. Jortberg J, Souther A, Guadagnino S, Freehill MT, **Cain S**, Agresta C. "Biomechanical Differences Across Levels of Command in Collegiate Baseball Pitchers." *American Physical Therapy Association Combined Sections Meeting*, Orlando, FL, February 1 – 28, 2021. (virtual)
- c18. **Cain SM**. "A Comparison of Filtering Techniques applied to Baseball Pitching Data." *44th Annual Meeting of the American Society of Biomechanics*, August 4-7, 2020, Atlanta, GA. (virtual poster presentation)
- c19. Rose MJ, KA McCollum, MT Freehill, **SM Cain**. "Using IMUs to Quantify Throw Counts and Intensities in Youth Baseball Players." *44th Annual Meeting of the American Society of Biomechanics*, August 4-7, 2020, Atlanta, GA. (virtual poster presentation)

- C20. Baroudi L, M Newman, E Jackson, K Barton, KA Shorter, **S Cain**. "Estimating Walking Speed in the Wild." *44th Annual Meeting of the American Society of Biomechanics*, August 4-7, 2020, Atlanta, GA. (virtual poster presentation)
- C21. Potter MV, **SM Cain**, LV Ojeda, NC Perkins. "IMU-based Kinematic Estimates for a Simplified Model of the Human Lower-limbs: Simulation and Experiment." *44th Annual Meeting of the American Society of Biomechanics*, August 4-7, 2020, Atlanta, GA. (virtual poster presentation)
- C22. Jahanian O, BM Goodwin, MG Van Straaten, **SM Cain**, RJ Lennon, JD Barlow, NS Murthy, MMB Morrow. "Rotator cuff tears and humeral elevation in manual wheelchair users with spinal cord injury and able-bodied controls." *44th Annual Meeting of the American Society of Biomechanics*, August 4-7, 2020, Atlanta, GA. (virtual poster presentation)
- C23. **Cain SM**, MJ Rose, KA McCollum, and MT Freehill. "Quantifying throw counts and intensities throughout a season in youth baseball players: a pilot study." *American Orthopaedic Society for Sports Medicine 2020 Annual Meeting*, July 11-14, 2020, Boston, Massachusetts.
- C24. Potter MV, **SM Cain**, LV Ojeda, NC Perkins. "IMU-Based Estimation of Walking Kinematics for 3-Body Lower-limb Model." *Dynamic Walking 2020*, May 14, 2020. (virtual poster presentation).
- C25. **Cain SM**, MJ Rose, KA McCollum, and MT Freehill. "Quantifying throw counts and intensities throughout a season in youth baseball players: a pilot study." *Orthopaedic Research Society 2020 Annual Meeting*, February 8-11, 2020, Phoenix, Arizona. (poster presentation)
- C26. **Cain SM**. "Wearable inertial sensors: powerful tools for sports science, but not without limitations and challenges." *XXVII Congress of the International Society of Biomechanics / 43rd Annual Meeting of the American Society of Biomechanics*, July 31-August 3, 2019, Calgary, Canada. (invited talk)
- C27. **Cain SM**, MMB Morrow. "Challenges and recommendations for quantifying shoulder motion using wearable inertial sensors." *XXVII Congress of the International Society of Biomechanics / 43rd Annual Meeting of the American Society of Biomechanics*, July 31-August 3, 2019, Calgary, Canada. (poster presentation)
- C28. **Cain SM**, C Agresta. "Capturing day-to-day variability in pitching mechanics with an array of wearable inertial sensors." *XXVII Congress of the International Society of Biomechanics / 43rd Annual Meeting of the American Society of Biomechanics*, July 31-August 3, 2019, Calgary, Canada. (podium presentation)
- C29. Goodwin BM, **SM Cain**, MG Van Straaten, E Fortune, MMB Morrow. "IMU-derived humeral elevation angles during daily living of manual wheelchair users and able-bodied controls." *XXVII Congress of the International Society of Biomechanics / 43rd Annual Meeting of the American Society of Biomechanics*, July 31-August 3, 2019, Calgary, Canada. (poster presentation)
- C30. Giblin G, C Agresta, **S Cain**, and R Zernicke. "Counter-movement jumping profiles by position in baseball using principal component analysis." *XXVII Congress of the International Society of Biomechanics / 43rd Annual Meeting of the American Society of Biomechanics*, July 31-August 3, 2019, Calgary, Canada. (poster presentation)
- C31. Ojeda LV, **SM Cain**, NC Perkins. "The relation of foot clearance and gait speed during stair ascent and descent." *XXVII Congress of the International Society of Biomechanics / 43rd Annual Meeting of the American Society of Biomechanics*, July 31-August 3, 2019, Calgary, Canada. (poster presentation)
- C32. Shelton AD, **S Cain**, LA DiBerardino III. "Kinematic considerations for inertial measurement units." *XXVII Congress of the International Society of Biomechanics / 43rd Annual Meeting of the American Society of Biomechanics*, July 31-August 3, 2019, Calgary, Canada. (poster presentation)
- C33. Xu Y, **SM Cain**, KA Kerber, KA Shorter. "Characterization of the Epley Maneuver using a wearable inertial sensor." *XXVII Congress of the International Society of Biomechanics / 43rd Annual Meeting of the American Society of Biomechanics*, July 31-August 3, 2019, Calgary, Canada. (poster presentation)
- C34. Goodwin BM, **SM Cain**, MG Van Straaten, E Fortune, MMB Morrow. "Inertial measurement units used to quantify arm elevation angles of manual wheelchair users and able-bodied controls throughout a typical day." *Summer Biomechanics, Bioengineering and Biotransport Conference*, June 25-28, Seven Springs, PA, USA. (podium presentation)
- C35. Shelton AD, **S Cain**, and LA DiBerardino III. "WIP: Kinematic considerations for accelerometers and inertial measurement units." *2019 Midwest Regional American Society of Biomechanics Meeting*, February 28-March 1, 2019, Dayton, OH. (poster presentation)
- C36. Meyer B, **SM Cain**, NC Perkins, RS McGinnis. "Predicting vertical ground reaction forces during jumping from wearable sensor data." *Biomedical Engineering Society Annual Meeting*, October 17-20, 2018, Atlanta, Georgia. (poster presentation)

- C37. **Cain SM**, E Fortune, M Van Straaten, MM Morrow. "Quantifying the shoulder workspace of wheelchair users and able-bodied controls using IMUs." *42nd Annual Meeting of the American Society of Biomechanics*. August 8-11, 2018, Rochester, MN. (poster presentation)
- C38. **Cain SM**, RV Vitali, MV Potter, SP Davidson, L Ojeda, LA Stirling, NC Perkins. "Activity recognition for a military-style obstacle course using body-worn IMUs." *42nd Annual Meeting of the American Society of Biomechanics*. August 8-11, 2018, Rochester, MN. (podium presentation)
- C39. Potter MV, LV Ojeda, NC Perkins, **SM Cain**. "Effect of foot-mounted IMU design on IMU-estimated running gait accuracy." *42nd Annual Meeting of the American Society of Biomechanics*. August 8-11, 2018, Rochester, MN. (podium presentation)
- C40. Vitali RV, **SM Cain**, MV Potter, L Ojeda, S Davidson, A Mendoza, L Stirling, NC Perkins. "Load effects on performance for example obstacles in an outdoor course." *42nd Annual Meeting of the American Society of Biomechanics*. August 8-11, 2018, Rochester, MN. (podium presentation)
- C41. Wathen R, C Hancock, R Vitali, **S Cain**, N Perkins, L Ojeda. "Utilizing inertial sensors to evaluate human walking during a long outdoor march." *42nd Annual Meeting of the American Society of Biomechanics*. August 8-11, 2018, Rochester, MN. (poster presentation)
- C42. **Cain SM**, MM Morrow. "Using inertial sensors to estimate the angle of arm elevation and the plane of arm elevation of manual wheelchair users in the real world." *8th World Congress of Biomechanics*, July 8-12, 2018, Dublin, Ireland. (podium presentation)
- C43. Hooke AW, E Fortune, **SM Cain**, MG Van Straaten, MM Morrow. "Cumulative exposure of upper extremity kinetics and kinematics in manual wheelchair users in their free-living environments." *8th World Congress of Biomechanics*, July 8-12, 2018, Dublin, Ireland. (poster presentation)
- C44. Fortune E, B Cloud, S Madansingh, A Ducrey, **SM Cain**, D Murphree, K Aminian, K Zhao, M Morrow. "Inertial sensor-based measurements of shoulder elevation angles during propulsion and non-propulsion activity in manual wheelchair users in their free-living environments." *8th World Congress of Biomechanics*, July 8-12, 2018, Dublin, Ireland. (poster presentation)
- C45. **Cain SM**, E Fortune, M Van Straaten, MM Morrow. "Quantifying the shoulder movement of manual wheelchair users in the real world using inertial measurement units." *41st Annual Meeting of the American Society of Biomechanics*. August 8-11, 2017, Boulder, CO. (podium presentation)
- C46. **Cain SM**, MV Potter, L Ojeda, NC Perkins. "Accurate and robust gait event detection using foot-mounted inertial measurement units." *41st Annual Meeting of the American Society of Biomechanics*. August 8-11, 2017, Boulder, CO. (poster presentation)
- C47. Ojeda L, A Zaferiou, **SM Cain**, N Perkins. "Using inertial sensors for assessing performance during stair running." *41st Annual Meeting of the American Society of Biomechanics*. August 8-11, 2017, Boulder, CO. (podium presentation)
- C48. Potter MV, **SM Cain**, L Ojeda, NC Perkins. "Influence of accelerometer range on accuracy of foot-mounted IMU based running velocity estimation." *41st Annual Meeting of the American Society of Biomechanics*. August 8-11, 2017, Boulder, CO. (poster presentation)
- C49. Vitali R, **S Cain**, L Stirling, N Perkins. "Assessing performance correlations among tasks in a challenging obstacle course." *41st Annual Meeting of the American Society of Biomechanics*. August 8-11, 2017, Boulder, CO. (poster presentation)
- C50. **Cain SM**, E Fortune, M Van Straaten, MM Morrow. "Quantifying the shoulder movement of manual wheelchair users in the real world using an array of inertial sensors." *5th International Conference on Ambulatory Monitoring of Physical Activity and Movement*. June 21-23, 2017, Bethesda, MD. (poster presentation)
- C51. Morrow M, **SM Cain**, A Hooke, E Fortune, C Jayaraman, J Sosnoff, M Van Straaten. "Shoulder overuse injury in manual wheelchair users: quantification of shoulder function in the real-world." *American Spinal Injury Association 2017 Annual Scientific Meeting*. April 26-29, 2017, Albuquerque, NM. (poster presentation)
- C52. **Cain SM**. "Measurement of bicycle and rider kinematics during real-world cycling using a wireless array of inertial sensors." *Bicycle and Motorcycle Dynamics 2016*, September 21-23, 2016, Milwaukee, WI. (podium presentation)
- C53. **Cain SM**, L Ojeda, RV Vitali, SP Davidson, AM Zaferiou, NC Perkins. "A standard approach for using inertial measurement units (IMUs) to accurately measure human movement outside of the lab." *American Society of Biomechanics Annual Meeting*. August 2-5, 2016, Raleigh, NC. (poster presentation)

- C54. Davidson SP, **SM Cain**, L Ojeda, AM Zaferiou, RV Vitali, NC Perkins. "Analysis of a drop landing task using inertial measurement units." *American Society of Biomechanics Annual Meeting*. August 2-5, 2016, Raleigh, NC. (poster presentation)
- C55. Ojeda L, AM Zaferiou, **SM Cain**, RV Vitali, SP Davidson, NC Perkins. "Development of performance metrics using inertial sensors during stair running ascent." *American Society of Biomechanics Annual Meeting*. August 2-5, 2016, Raleigh, NC. (poster presentation)
- C56. Vitali RV, SP Davidson, **SM Cain**, AM Zaferiou, L Ojeda, NC Perkins. "Method for calculating three-dimensional knee rotations using two inertial measurement units." *American Society of Biomechanics Annual Meeting*. August 2-5, 2016, Raleigh, NC. (poster presentation)
- C57. Zaferiou AM, L Ojeda, **SM Cain**, RV Vitali, SP Davidson, NC Perkins. "Using inertial measurement units mounted on the feet to define performance metrics for an outdoor agility drill." *American Society of Biomechanics Annual Meeting*. August 2-5, 2016, Raleigh, NC. (poster presentation)
- C58. Vitali RV, **SM Cain**, SP Davidson, AM Zaferiou, L Ojeda, NC Perkins. "Method for calculating three-dimensional knee rotations using two inertial measurement units." *Dynamic Walking 2016*. June 4-7, 2016, Holly, MI.
- C59. McGinnis RS, **SM Cain**, SP Davidson, RV Vitali SG McLean, NC Perkins. "Inertial sensor and cluster analysis for discriminating agility run technique." *9th IFAC Symposium on Biological and Medical Systems*, August 31 – September 2, 2015, Berlin, Germany. (Co-author, podium presentation)
- C60. **Cain SM**, RS McGinnis, SP Davidson, RV Vitali, NC Perkins, SG McLean. "Quantifying performance and effects of load carriage during completion of a window obstacle using an array of wireless inertial sensors." *American Society of Biomechanics Annual Meeting*. August 5-8, 2015, Columbus, Ohio. (podium presentation)
- C61. Davidson SP, **SM Cain**, RS McGinnis, RV Vitali, NC Perkins, SG McLean. "Quantifying Warfighter Performance during a Prone-Running-Prone Movement Task Using Wireless Inertial Sensors." *American Society of Biomechanics Annual Meeting*. August 5-8, 2015, Columbus, Ohio. (poster presentation)
- C62. McLean SG, **SM Cain**, RS McGinnis, SP Davidson, RV Vitali, NC Perkins. "Quantifying field-based warfighter performance via a body-worn array of wireless inertial sensors." *American Society of Biomechanics Annual Meeting*. August 5-8, 2015, Columbus, Ohio. (Co-author, invited talk)
- C63. McGinnis RS, **SM Cain**, SP Davidson, RV Vitali, SG McLean, NC Perkins. "Wearable Inertial Sensor for Agility Run Performance Assessment." *ASME IDETC/CIE 2015*, August 2-5, 2015, Boston, MA.
- C64. **Cain SM**, RS McGinnis, SP Davidson, RV Vitali, SG McLean, NC Perkins. "Quantifying Performance and Effects of Load Carriage during a Challenging Balancing Task using an Array of Wireless Inertial Measurement Units." *International Society of Biomechanics*. July 12-16, 2015, Glasgow, Scotland. (poster presentation)
- C65. Davidson SP, RS McGinnis, RV Vitali, **SM Cain**, NC Perkins, SG McLean. "Validating Inertial Measurement Units as a Method for Determining Rifle Aiming Performance." *International Society of Biomechanics*. July 12-16, 2015, Glasgow, Scotland. (poster presentation)
- C66. McGinnis RS, **SM Cain**, SP Davidson, RV Vitali, SG McLean, NC Perkins. "Validation of Complementary Filter Based IMU Data Fusion for Tracking Torso Angle and Rifle Orientation." *2014 ASME International Mechanical Engineering Congress and Exposition*, November 14-20, 2014, Montreal, QC. (Co-author, podium presentation)
- C67. Fox A, S Davidson, R McGinnis, **S Cain**, N Saunders, S McLean (2014). "Exploring the use of wireless inertial measurement units for biomechanical analysis of side-step cutting manoeuvres." *2014 Australian Conference of Science and Medicine in Sport*, October 15-18, 2014, Canberra, Australian Capital Territory, Australia. (Co-author, podium presentation)
- C68. **Cain SM**, RS McGinnis, SP Davidson, RV Vitali, SG McLean, NC Perkins. "An IMU-based method for quantifying gait: algorithm development and comparisons to motion capture and instrumented treadmill data." *7th World Congress of Biomechanics*, July 6-11, 2014, Boston, MA. (poster presentation)
- C69. Davidson SP, RS McGinnis, **SM Cain**, RV Vitali, SG McLean, NC Perkins. "Validating Inertial Measurement Units as a Method for Determining Rifle Aiming Performance." *7th World Congress of Biomechanics*, July 6-11, 2014, Boston, MA. (Co-author, poster presentation)
- C70. McGinnis RS, **SM Cain**, SP Davidson, RV Vitali, SG McLean, NC Perkins. "Validation of IMU-based Method for Tracking Warfighter Torso Angle during Up-down Maneuver." *7th World Congress of Biomechanics*, July 6-11, 2014, Boston, MA. (Co-author, poster presentation)

- C71. McGinnis RS, **SM Cain**, SP Davidson, RV Vitali, SG McLean, NC Perkins. "Validation of IMU-based Method for Tracking Warfighter Motion during Jumping Maneuver." *7th World Congress of Biomechanics*, July 6-11, 2014, Boston, MA. (Co-author, poster presentation)
- C72. Vitali RV, RS McGinnis, **SM Cain**, SP Davidson, SG McLean, NC Perkins. "Quantifying Rifle Aiming Dynamics with an Inertial Measurement Unit." *7th World Congress of Biomechanics*, July 6-11, 2014, Boston, MA. (Co-author, poster presentation)
- C73. **Cain SM**, RS McGinnis, SP Davidson, RV Vitali, NC Perkins, SG McLean. "Using Inertial Measurement Units to Quantify Gait Performance." *Dynamic Walking 2014*, June 10-13, 2014, Zurich, Switzerland. (poster and podium presentation)
- C74. Fox A, **SM Cain**, RS McGinnis, SP Davidson, RV Vitali, NC Perkins, SG McLean. "Ability of body worn inertial measurement units to detect changes in performance during a loaded step-up task." *American Society of Biomechanics 2014 Midwest Regional Meeting*, March 4-5, 2014, Akron, OH. (Co-author, podium presentation)
- C75. **Cain SM**, JA Ashton-Miller, and NC Perkins. "Skilled bicyclists attain better balance performance while using less steer effort than novice bicyclists." *Bicycle and Motorcycle Dynamics 2013*, November 10-13, 2013, Narashino, Japan. (podium presentation)
- C76. **Cain SM**, JA Ashton-Miller, and NC Perkins. "Measurement of human/bicycle balancing dynamics and rider skill." *Proceedings of the 37th Annual Meeting of the American Society of Biomechanics*, September 4-7, 2013, Omaha, NE. (poster presentation)
- C77. Davidson SP, **SM Cain**, GC Goulet, NC Perkins, SG McLean. "Fatigue effects on intersegmental accelerations during high-impact landings: piloting performance predictors." *Proceedings of the 37th Annual Meeting of the American Society of Biomechanics*, September 4-7, 2013, Omaha, NE. (poster presentation)
- C78. **Cain SM**, DA Ulrich, and NC Perkins. "Using measured bicycle kinematics to quantify increased skill as a rider learns to ride a bicycle." *2012 ASME Dynamic Systems and Control Conference and 2012 Motion & Vibration Conference*, October 17-19, 2012, Ft. Lauderdale, FL. (podium presentation)
- C79. **Cain SM**, DA Ulrich, and NC Perkins. "Quantifying increased skill using measured bicycle kinematics as riders learn to ride bicycles." *Proceedings of the 36th Annual Meeting of the American Society of Biomechanics*, August 15-18, 2012, Gainesville, FL. (podium presentation)
- C80. **Cain SM** and NC Perkins. "Human stabilization of a bicycle on rollers." *Proceedings of the 35th Annual Meeting of the American Society of Biomechanics*, August 10-13, 2011, Long Beach, CA. (poster presentation)
- C81. **Cain SM** and NC Perkins. "Comparison of a bicycle steady-state turning model to experimental data." *Bicycle and Motorcycle Dynamics 2010*, October 20-22, 2010, Delft, The Netherlands. (podium presentation)
- C82. **Cain SM** and NC Perkins. "Steady-state handling characteristics of a bicycle." *Proceedings of the 34th annual meeting of the American Society of Biomechanics*, August 18-21, 2010, Providence, RI. (poster presentation)
- C83. **Cain SM** and DP Ferris. "Walking in simulated hyper-gravity." *Proceedings of the 31st Annual Meeting of the American Society of Biomechanics*, August 22-25, 2007, Palo Alto, CA. (podium presentation)
- C84. **Cain SM**, KE Gordon, and DP Ferris. "Locomotor adaptation to a powered ankle-foot orthosis: comparison of footswitch control versus soleus proportional myoelectric control." *5th World Congress of Biomechanics*, July 29 – August 4, 2006, Munich, Germany. (podium presentation)
- C85. **Cain SM**, KE Gordon, and DP Ferris. "Motor adaptation to a powered ankle-foot orthosis under foot switch control." *ISB XXth Congress - ASB 29th Annual Meeting*, July 31 - August 5, 2005, Cleveland, OH. (poster presentation)

OTHER ARTICLES

- **Cain SM**, "How to ride a bike." *The Michigan Engineer*, Fall 2016, pp. 14.
 - **Cain SM** (2016). "The mysterious biomechanics of riding – and balancing – a bicycle." *The Conversation*. <https://theconversation.com/the-mysterious-biomechanics-of-riding-and-balancing-a-bicycle-55093>.
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MEDIA COVERAGE OF RESEARCH

- Furbee B (2022). "Statler College Professor Sets Sights on Improving Eye Drop Medication Adherence." *Statler College Media Hub*. <https://media.statler.wvu.edu/news/2022/12/08/statler-college-professor-sets-sights-on-improving-eye-drop-medication-adherence>.
- Merino D (2022). "Winning the Tour de France requires subtle physics, young muscles and an obscene amount of calories – 3 essential reads." *The Conversation*. <https://theconversation.com/winning-the-tour-de-france-requires-subtle-physics-young-muscles-and-an-obscene-amount-of-calories-3-essential-reads-186088>.
- Urban K (2019). "Major League Baseball Grant Funds Study of Pitch Counts, Throwing Injuries." *MHealth Lab*. <https://labblog.uofmhealth.org/body-work/major-league-baseball-grant-funds-study-of-pitch-counts-throwing-injuries>.
- Interviewed by Cynthia Canty on "Stateside," a radio program, about my partnership with the Detroit Tigers (2019). Interview available at: <https://www.michiganradio.org/post/stateside-fishtown-flooding-delay-mental-health-system-changes-detroit-s-digital-divide>.
- Piazza A (2019). "A New Era in Sports." *Michigan Research*. <https://research.umich.edu/news-issues/michigan-research/new-era-sports>.
- Interviewed by Evgeniy Shishkin for his podcast "The Verge of Discovery" (2016). Episode 39, entitled "Biomechanics of Riding and Balancing a Bicycle with Dr. Stephen Cain." Available at: <https://www.stitcher.com/podcast/evgeniy-shishkin/verge-of-discovery/e/44070636>.
- Ingraham C (2016). "How to ride a bike the right way, using science." *The Washington Post*. <https://www.washingtonpost.com/news/wonk/wp/2016/03/03/how-to-ride-a-bike-the-right-way-using-science/>.
- Marshall A (2016). "The (Still) Mysterious Physics of Riding a Bike." *CityLab*. <https://www.citylab.com/transportation/2016/02/the-still-mysterious-physics-of-riding-a-bike/471249/>.

INVITED TALKS

- Invited speaker for the Graduate Seminar Series, Swanson School of Engineering, Department of Mechanical and Materials Science, January 30, 2020. Title of talk: "Biomechanics in the real world: enabling new research discoveries and personalized interventions with wearable sensor technology."
- Invited speaker for a symposium entitled "Challenges and resolutions in human motion monitoring with wearables," at the XXVII Congress of the International Society of Biomechanics / 43rd Annual Meeting of the American Society of Biomechanics, July 31-August 3, 2019, Calgary, Canada. Title of talk: "Wearable inertial sensors: powerful tools for sports science, but not without limitations and challenges."
- Invited speaker for the Human and Evolutionary Biology Invited Speaker Series, Dana and David Dornsife College of Letters, Arts and Sciences, University of Southern California, April 10, 2019. Title of talk: "Biomechanics in the real world: enabling new research discoveries and personalized interventions with wearable sensor technology."
- Invited speaker for a symposium entitled "How new technologies, methods, and data are shaping the future of biomechanics research," at 42nd Annual Meeting of the American Society of Biomechanics, August 8-11, 2018, Rochester, MN. Title of talk: "Quantifying biomechanics in the real world."

SPONSORED RESEARCH PROJECTS

Quantifying and understanding glaucoma eye drop medication instillation and adherence (NIH R01)

Co-PI (PIs: Dr. SM Cain, Dr. PA Newman-Casey)

7/2022 –3/2026

- There is a critical need to monitor glaucoma medication use, quantify whether the drop gets into the eye, communicate usage data to the patient's healthcare team, and build personalized strategies to counsel patients on how to best use their eye drop medications without placing a large technology burden on the patient. In this project we aim to: quantify the human movement factors that influence eye drop instillation success among older adults, create a microelectronics sensing platform and algorithms that are capable of quantifying eye drop instillation and environmental factors optimized for use by the

target population, and test the sensor platform in the laboratory and at home for initial efficacy, usability and feasibility.

- Award Amount: \$2,376,974
- Amount to Stephen M Cain: \$381,746

Exploring gait patterns in the real world: Towards an understanding of the impact of daily gait mechanics on musculoskeletal health (NIH R21)

Co-I (PI: Dr. Jocelyn Hafer, University of Delaware)

4/2022 – 3/2024

- This project will develop, validate, and disseminate novel methods that will enable clinical gait researchers to quantify and assess gait biomechanics in real-world settings in order to more readily identify, predict, and prevent gait impairment.
- Award amount: \$434,761
- Amount to Stephen M Cain: \$69,522

Why do we fail? A biomechanical assessment of eye drop instillation (Research to Prevent Blindness)

Co-I (PI: Dr. PA Newman-Casey, University of Michigan)

1/2022 –12/2023

- The aims of the project are to: 1) Collect and analyze motion data during eye drop instillation to define the quantitative kinematic features of patient eyedrop techniques, 2) Evaluate whether standardized eye drop coaching changes technique and probability of successful instillation, and 3) Create an Eye Drop Adherence Monitoring System.
- Award Amount: \$300,000
- Amount to Stephen M Cain: \$70,165

Natural history of shoulder pathology in wheelchair users (NIH R01 Renewal)

Co-I (PI: Dr. Melissa Morrow, University of Texas Medical Branch)

9/2021 – 6/2026

- The aims of this renewal are: 1) Track the progression of rotator cuff tendinopathy, partial tears and pain worsening in manual wheelchair users compared to controls to quantify the effect of age, sex, spinal cord injury lesion level, and time since spinal cord injury, 2) Determine the association between daily arm use (posture, repetitive movement, and recovery) of manual wheelchair users compared to controls in rotator cuff pathology progression and pain worsening, and 3) Evaluate the risk of comorbidities and medication use in rotator cuff pathology and pain onset.
- Award amount: \$2,585,040
- Amount to Stephen M Cain: \$302,229

Enhancing Mechanisms of Human Resilience for Student Success and Well-Being (University of Michigan Biosciences Initiative)

Co-I (PIs: M Tewari, JL Cunningham, M Chowdhury, K Birditt)

10/2020 – 9/2023

- The aims of the project are to: 1) Establish a system for collecting detailed, high time-resolution measurements of multiple physiological and psychological resilience factors in undergraduate students before, during, and after acute stress events (e.g., graded class presentations, job/internship interviews), 2) Develop a scalable mobile app platform to deliver and test resilience-enhancing interventions in a way that can ultimately allow micro-randomized trials of multiple interventions with varied timing, and 3) Perform a pilot phase study of the mobile intervention platform to enhance student resilience to acute stressors, while performing detailed objective physiologic (i.e., with wearable sensors) and subjective (i.e., with EMA and surveys) tracking.
- Award amount: \$855,000.00
- Effort: 10% (year 1), 8% (year 2), 1% (year 3)

Quantifying outcomes after prepectoral implant-based breast reconstruction (American Cancer Society)

Co-I (PI: David Lipps, University of Michigan)

9/2021 – 8/2024

- The aims of the project are to: 1) Identify how variations in surgical approaches to immediate implant breast reconstruction impact the

neuromuscular control of the shoulder, 2) Examine how variations in surgical approaches to immediate implant breast reconstruction alter upper extremity function during everyday life, and 3) Determine how variations in surgical approaches to immediate implant breast reconstruction impact cumulative medical costs.

- Award amount: \$786,546.00
- Amount to Stephen M Cain: \$57,432

Understanding cardiac health through innovative wearable sensing (University of Michigan Precision Health Initiative)

Co-PI (PIs: AK Shorter, K Barton, M Newman, SM Cain)

1/2019 – 12/2021

- The objective of our project is to provide a detailed picture of a person's physical conditioning to enhance our ability to identify and manage frailty in at-risk populations prior to cardiac surgery. A key enabler in achieving this objective lies in the development of a multi-timescale and intelligent wearable sensor system that will provide a multitude of biomechanical and physiological measurements combined with contextual and environmental information from short- term, midterm, and long-term persistent monitoring timescales.
- Award amount: \$300,000.00
- Effort: 8% Full-time

Sensor technology and complex analytics to assess, monitor, and predict injury in elite baseball pitchers (University of Michigan Exercise and Sport Science Initiative)

Principal Investigator

6/2018 – 10/2020

- The objective of this study is to characterize pitching patterns over loading cycles in order to identify aspects of mechanics that correlate to player fatigue and injury risk factors that can feasibly be monitored in real-world settings using wearable sensors.
- Award amount: \$99,751.28
- Effort: 12% Full-time

Redefining youth pitch count with throw count and intensity determination: a pilot study (Major League Baseball)

Co-PI (PIs: Dr. Michael Freehill, Dr. Stephen Cain)

1/2019 – 12/2019

- The primary purpose of this study is to develop a methodology to capture in-game total throw count and estimate the intensity of each throw accrued by adolescent (competitive) pitchers over 12 months. The secondary purpose of this study is to explore the extent to which total throw count or number of high-intensity throws influence structural changes about the elbow joint (measured via clinical tests and imaging).
- Award amount: \$31,826
- Effort: 10% Full-time

Biomechanics assessments (Detroit Tigers, Inc.)

Principal Investigator

1/2019 – 12/2019

- The deliverables for this project are: 1) individualized orthopaedic and running assessment qualitative reports for selected athletes, 2) individualized reports including high-resolution/high-speed video and biomechanical (numerical) summaries of on-field pitching mechanics across pitch types for selected pitchers, and 3) output of performance metrics for fundamental movement testing (i.e., jumping and sprinting).
- Award amount: \$75,400
- Effort: 25% Full-time

Biomechanics assessments (Detroit Tigers, Inc.)

Co-Investigator (PI: Dr. Cristine Agresta, Kinesiology)

2/2018 – 10/2018

- The objective of this project is to provide high-level biomechanical assessments of sport-specific movements and relate findings to potential for injury risk or performance optimization in selected players.
- Award amount: \$30,883.00

- Effort: 10% Full-time

Assessment of self-generated arm use following surgical intervention for brachial plexus injuries (Blue Cross Blue Shield of Michigan Foundation)

Investigator (PI: Dr. Susan Brown, Kinesiology)

8/2016 – 6/2019

- The purpose of this study is to quantify self-generated arm use in patients with brachial plexus injuries using novel, commercially-available body-worn sensor technology.
- Award amount: \$74,565.00
- Effort: 15% Full-time 1/2019-6/2019

Natural history of shoulder pathology in wheelchair users (NIH 5R01HD084423)

Co-Investigator (PI: Dr. Melissa Morrow, Mayo Clinic)

6/2016 – 5/2020

- Develop best practices for the use of an array of wireless IMUs for quantifying shoulder movement/angles and upper arm elevation angles relative to gravity and the torso.
- Develop the computational algorithms that will use the output of the wireless IMUs (accelerations, angular velocities, magnetic field, and quaternions) to calculate upper arm elevation angles and Euler angles describing the orientation of the upper arm relative to the torso.
- Assist with the design and data analysis of any validation tests needed to demonstrate that IMU-derived metrics are accurate compared to the same metrics derived via motion capture.
- Effort: 10-20% Full-time

An automated measurement system for warfighter performance quantification in naturalistic settings (US Army Natick Soldier Research, Development, and Engineering Center; contract number W911QY-15-C-0053)

Co-Investigator (PIs: Dr. Noel Perkins and Dr. Leia Stirling)

9/2015 – 1/2020

- Develop procedures and algorithms to use data from an array of wireless IMUs to quantify human athletic performance and performance degradation on a wide range of military-style obstacles.
- Map raw IMU data to performance metrics that correspond to measures of strength, agility, speed, coordination, and balance.
- Develop a software graphical interface to allow non-experts to analyze data.
- Develop an automated data parsing algorithm to parse raw IMU data into segments that define each obstacle within a given course.
- Evaluate the sensitivity of IMU-derived performance metrics to realistic variations in warfighter equipment conditions.
- Award amount: \$2,630,044.00

Development of algorithms for quantifying athletic performance (inMotion, LLC)

Principal Investigator

11/2015 – 2/2016

- Accurately quantify five specific lower body extremity actions: 1) gait (walking/jogging/running/sidestepping in a forward, backward, or sideways direction), 2) jumping (or leaping/lurching) 3) burst (explosive acceleration, which may include a turn or cutting maneuver), 4) heel pivot and 5) toe pivot.
- Develop algorithms capable of calculating meaningful performance metrics for each of the five actions above, utilizing a single foot-mounted IMU.
- Award amount: \$18,184.00 over 3 months
- Effort: 50% Full-time

Calibration of Trace IMUs (Alpine Replay, Inc.)

Principal Investigator

6/2015

- Calibrate the IMUs embedded in two of Alpine Relay's Trace action sports trackers (9DOF IMU and GPS).
- Award amount: \$800.00 over 1 month

IMU Array Technology and Algorithms for Field-Based Warfighter Performance Assessment (US Army Natick Soldier Research, Development and Engineering Center; contract number W911QY-13-C-001)

Research Fellow (PIs: Dr. Noel Perkins and Dr. Scott McLean)

1/2013 – 4/2015

- Develop procedures and algorithms to use data from an array of wireless IMUs to quantify human athletic performance and performance degradation on a wide range of military-style obstacles.
- Award amount: \$855,375.00
- Effort: 100% Full-time

RESEARCH PROPOSALS IN REVIEW OR PREPARATION

INTELLECTUAL PROPERTY

- IP1. Newman-Casey PA, **SM Cain**, A Sample, D Burke, S Brown. "Eye drop adherence monitoring system and method." US. Provisional Patent Application. Filed October 25, 2021.
- IP2. Freehill MT, **SM Cain**, J Casciano, MJ Ferlic. "Grip profile sensing and assessment." U.S. Patent Application. Filed May 22, 2020. Serial No. PCT/US20/34206
- IP3. **Cain SM**, J Casciano, M Freehill. "Grip profile sensing and assessment." U.S. Provisional Patent Application. Filed May 24, 2019. Serial No. 62/852,726
- IP4. **Cain SM**, J Casciano, M Freehill. "An instrumented baseball for measuring grip forces." University of Michigan Invention Disclosure. Submitted March 4, 2019. OTT #2019-315.
- IP5. **Cain SM**. "Measurement of bicycle and rider kinematics using an array of inertial measurement units." U.S. Provisional Patent Application. Filed September 18, 2017. Serial No. 62/559,770.
- IP6. **Cain SM**. "Measurement of bicycle and rider kinematics using an array of inertial measurement units." University of Michigan Invention Disclosure. Submitted on September 26, 2016. OTT #7230.
- IP7. Perkins NC, RS McGinnis, SG McLean, **SM Cain**, SP Davidson, RV Vitali. "Wearable sensor for assessing jump performance." University of Michigan Invention Disclosure. Submitted September 5, 2014. OTT #6389.

HONORS, AWARDS, AND FELLOWSHIPS

- National Science Foundation Graduate Research Fellowship (2003)
- Selected to participate in University of Michigan CRLT Postdoctoral Short-Course on College Teaching in Science and Engineering (Fall 2013)
- Selected to participate in University of Michigan CRLT Preparing Future Faculty Seminar (May 2011)
- University of Michigan Rackham Graduate School International Travel Grant (2006 and 2010)
- University of Michigan Mechanical Engineering departmental graduate student fellowship (2003)

TEACHING EXPERIENCE

West Virginia University, Morgantown, WV

Assistant Professor

August 2021 – present

- Courses Taught
 - BMEG 350 (Biomedical Engineering Laboratory). Fall 2022, 25% co-instructor. Designed a new biomechanics experiment and content.
 - BMEG 420 (Biomedical Instrumentation). Fall 2022. Re-designed entire course.
 - BMEG 236 (Quantitative Human Physiology). Spring 2022. Lab course. Created 3 new experiments.
 - BMEG 455/456 (Biomedical Senior Design 1 and 2). Fall 2021 – current. Co-instructor. Serve as a mentor and client to design teams.
 - CHE 796 (Graduate Seminar). Co-instructor of department graduate seminar.
- Graduate students
 - Daniel Duque Urrego (August 2022 – present). Quantifying eye drop instillation biomechanics.
 - Gerard Aristizabal Pla (August 2022 – present). Biomechanics of running and walking captured by foot-mounted inertial sensors.
 - Kathylee Pinnock Branford (August 2021 – present). Quantifying human biomechanics in the real-world.
 - Diversity Travel Award to attend NACOB 2022.

- Loubna Baroudi, University of Michigan graduate research assistant (co-advisor, January 2019 – present). Understanding cardiac health through innovative wearable sensing.
 - Diversity travel grant to attend Dynamic Walking 2022.
- Undergraduate students
 - Jake Kelemen (January 2022 – December 2022). West Virginia University Research Apprenticeship Program (RAP).
 - Ethan Hicks (Summer 2022). West Virginia University Summer Undergraduate Research Program (SURE).
 - Poster was runner-up in the Physical Sciences and Engineering at Summer Undergraduate Research Symposium.
 - Tanner Davis (Summer 2022). West Virginia University Summer Undergraduate Research Program (SURE).
 - Seth Mizia (Summer 2022). Summer research.
 - Vanessa Ferro (Summer 2022). Summer research.
 - Lorn Wolfe (Summer 2022). Summer research.
 - Manan Parikh (Spring 2022). West Virginia University Research Apprenticeship Program (RAP).

The University of Michigan, Ann Arbor, MI

Assistant Research Scientist / Research Investigator / Research Fellow Jan. 2013 – Aug. 2021

- Assisted Dr. Noel Perkins in advising and developing projects for other undergraduate students, graduate students, and research fellows in the lab:
 - Hannah Heberle-Rose, Undergraduate research assistant (May 2017 – August 2017, January 2018 – April 2018): An automated measurement system for warfighter performance quantification in naturalistic settings.
 - Maya Makhlof, Undergraduate research assistant (September 2017 – December 2017): An automated measurement system for warfighter performance quantification in naturalistic settings.
 - Michael Potter, Graduate research assistant (May 2016 – Present): An automated measurement system for warfighter performance quantification in naturalistic settings.
 - Rachel Vitali, Undergraduate research assistant/graduate research assistant (May 2013 – August 2019): IMU array technology and algorithms for field-based warfighter performance assessment and an automated measurement system for warfighter performance quantification in naturalistic settings.
 - Aditya Tammana, Undergraduate research assistant (April 2016 – April 2017): An automated measurement system for warfighter performance quantification in naturalistic settings.
 - Joshua Scharf, Undergraduate research assistant (August 2016 – April 2017): An automated measurement system for warfighter performance quantification in naturalistic settings.
 - Antonia Zaferiou, Research Fellow/Visiting Scholar (September 2015 – September 2016): IMU array technology and algorithms for field-based warfighter performance assessment and an automated measurement system for warfighter performance quantification in naturalistic settings.
 - Cody McCay, Undergraduate research assistant (October 2015 – May 2016): IMU array technology and algorithms for field-based warfighter performance assessment.
 - David Moody, UROP student (September 2014-March 2015): Analysis of helmet fit using an array of wireless inertial measurement units.
 - Caleb Kline, ME 450 project (Winter 2014): Identification of human gait and stair climbing based on data collected by an array of wireless inertial measurement units.
 - Sui Tao, ME 590 (Winter 2013): Measurement of three-dimensional hip angle using a single inertial measurement unit.
- Co-advisor of Loubna Baroudi, Graduate research assistant (January 2019 – August 2021): Understanding cardiac health through innovative wearable sensing.
- Advisor of Michael Rose, Undergraduate research assistant (May 2019 – August 2020): Sensor technology and complex analytics to assess, monitor, and predict injury in elite baseball pitchers; Redefining youth pitch count with throw count and intensity determination: a pilot study. Michael developed algorithms to identify throws and quantify throw intensities.

- Supervisor of Grayson Obey, Undergraduate research assistant (June 2019 – Nov 2019): Design and manufacturing of a baseball instrumented to measure pressure distributions for different pitch types; project in collaboration with Dr. Michael Freehill, Orthopaedic Surgery, Sports Medicine, University of Michigan.
- Supervisor of Nicholas Chan, Undergraduate research assistant (Nov 2018 – May 2019): Quantifying real-world upper-limb activity via patient-initiated movement after nerve reconstruction for upper brachial plexus injury; project in collaboration with Dr. Susan Brown, School of Kinesiology, University of Michigan.
- Supervisor of Jacob Casciano, Undergraduate research assistant (June 2018 – May 2019): Design and manufacturing of a baseball instrumented to measure pressure distributions for different pitch types; project in collaboration with Dr. Michael Freehill, Orthopaedic Surgery, Sports Medicine, University of Michigan.
- Supervisor of Scott Vanden Heuvel, Undergraduate research assistant (May 2018 – August 2018): Natural history of shoulder pathology in wheelchair users. Scott helped collect pilot data and helped troubleshoot a mechanical motion capture device for the shoulder.
- Co-supervisor (with Dr. K. Alex Shorter) of Yaqing Xu, Graduate research assistant (October 2017 – August 2021). Yaqing is working on developing an intelligent sensor suite and algorithms for evaluating human gait and health in non-laboratory environments.
- Co-supervisor Joseph Mazingo, a pre-doctoral student at the Mayo Clinic Graduate School of Biomedical Sciences (February 2017 – June 2018). I helped Joseph implement inertial sensors in his work to quantify shoulder kinematics using biplane fluoroscopy. Joseph's advisor at the Mayo Clinic was Dr. Kristin Zhao.
- Co-supervisor of Amélie Ducrey (April 2017 – August 2017) during the completion of her Master project in bioengineering entitled, "Shoulder motion of manual wheelchair users in the free-living environment," carried out in the Kern Center for the Science of Health Care Delivery at Mayo Clinic, Rochester, MN, USA. Other supervisors were Dr. Melissa Morrow and Dr. Emma Fortune at Mayo Clinic. Amelie was a student at the Ecole Polytechnique Federale de Lausanne (EPFL) School of Life Sciences, under the direction of Professor Kamiar Aminian.

Engineering Teaching Consultant

**Fall 2010 – Winter
2012**

- Acted as a consultant and teaching mentor to Graduate Student Instructors (GSIs) in the College of Engineering
- Facilitated teaching workshops and participated in the Engineering Graduate Student Instructor Teacher Training

Graduate Student Instructor

**Fall 2009 – Winter
2010**

Biomedical Engineering 499 – Biomedical Engineering Design

- Project manager for 3 out of the 5 teams
- Worked with the other course instructors to grade presentations, grade reports, discuss course issues and problems, assess team progress, and to help develop a more effective course

Graduate Student Instructor

Winter 2010

Biomedical Engineering 450 – Biomedical Engineering Design

- Acted as a project manager for 1 of the 7 teams

Graduate Student Instructor

Winter 2009

Biomedical Engineering 450 – Biomedical Engineering Design

- Acted as a project manager for 3 of the 10 teams

Graduate Student Instructor

**Fall 2006, 2007,
2008, and Winter
2007**

Movement Science 110 - Biological and Behavioral Bases of Human Movement

- Primary instructor for biomechanics module, taught lecture three times per week
- Developed course curriculum; created and prepared all lectures, assignments, and exams
- Created novel ways of teaching advanced biomechanical concepts (looking at real-world data, student presentations, and hands-on activities)

Graduate Student Instructor

Winter 2008

Movement Science 330 – Biomechanics of Human Movement

- Discussion section instructor; created, prepared, and graded all homework assignments

Instructional Aide

Winter 2006

Movement Science 330 – Biomechanics of Human Movement

- Assisted the Graduate Student Instructor with the laboratory portion of the course, including teaching concepts and assisted students during experiments

TEACHER TRAINING

The University of Michigan, Ann Arbor, MI

- Postdoctoral Short-Course on College Teaching in Science and Engineering (Fall 2013)
- Preparing Future Faculty Seminar (May 2011)
- Center for Research on Learning and Teaching (CRLT) training workshops
 - Consulting with GSIs (2010)
 - Office hour practice teaching training (2010)
 - Running practice teaching sessions (2010)
 - Observing classes and conducting midterm student feedback (2010)
- Engineering Graduate Student Instructor Teacher Training (2009)
- ENGR 580 – Teaching Engineering (2008)

FACILITATED TEACHER TRAINING

- Center for Research on Learning and Teaching in Engineering Workshop: *Are They "Getting It"? Low-Stakes Ways to Assess Student Learning* (September 2011)
- Graduate Student Instructor Teaching Orientation: *Grading Issues* (September 2011)
- Engineering Graduate Student Instructor Teacher Training Concurrent Session: *Grading Issues* (September 2011 and January 2012)
- Engineering Graduate Student Instructor Teacher Training Concurrent Session: *Teaching Problem Solving* (January 2011 and September 2011)
- Engineering Graduate Student Instructor Teacher Training Concurrent Session: *Leading a Discussion or Lab* (January 2011)

UNIVERSITY AND DEPARTMENT SERVICE

- Co-leader of department graduate seminar (Fall 2022 – Spring 2023)
- Department of Chemical and Biomedical Engineering Graduate Committee member
- Faculty Search Committee, Tenure-Track Biomedical Engineering (Fall 2022 – present)
- Faculty Search Committee, Teaching-Track Biomedical Engineering (Fall 2022 – present)
- Faculty Search Committee, Tenure-Track Biomedical Engineering (Fall 2021)

PROFESSIONAL SERVICE

- Co-organizer (with Jocelyn Hafer) of conference symposium at NACOB 2022, entitled "Challenges and advances in the use of wearable sensors for lower extremity biomechanics."
- NASA grant reviewer
- Advisory board member for Pac-12 Student-Athlete Health and Well-Being Initiative Grant entitled 'Overuse Injuries/Injury Prevention: Integration of Biomechanics-based Informatics for Prevention of Stress Fractures' (PI: Dr. Michael Hahn; Co-PIs: Dr. Scott Delp, Dr. Rodger Kram, Dr. Alena Grabowski, Dr. Jill McNitt-Gray, Dr. Lorraine Turcotte, Dr. Brent Liu, Dr. Kormelia Kulig)
- Organized and developed a tutorial entitled 'Using IMUs for quantifying human biomechanics' at the 2017 American Society of Biomechanics meeting in Boulder, CO
- Co-organizer (with Dr. Jill McNitt-Gray) of an informal discussion among ASB members on the use of wearable sensors in biomechanics research at the 2017 American Society of Biomechanics meeting
- Co-chair of "Wearable Sensors" session at the 2017 American Society of Biomechanics meeting
- Reviewer of abstracts for the 2017 American Society of Biomechanics meeting in Boulder, CO
- Co-organizer (with Dr. Jill McNitt-Gray and Dr. Irene Davis) of an informal roundtable discussion among ASB members on the use of wearable sensors in biomechanics research at the 2016 American Society of Biomechanics meeting in Raleigh, NC
- Reviewer for Vehicle System Dynamics

- Reviewer for ASME (2012 Dynamic Systems and Control Conference and 2013 American Control Conference)
- Co-organizer and co-chair of 'The Future of Bicycle and Motorcycle Dynamics and Control' special session at the 2012 ASME Dynamic Systems and Control Conference, Ft. Lauderdale, FL
- Co-organizer of 'Single Track Vehicle Dynamics and Control' invited session at the 2012 ASME Dynamic Systems and Control Conference, Ft. Lauderdale, FL
- Reviewer for IEEE Transactions on Control Systems Technology
- Reviewer for Journal of Applied Biomechanics
- Reviewer for Transactions on Neural Systems & Rehabilitation Engineering
- Reviewer for Human Movement Science
- Reviewer for Sensors
- Reviewer for Technologies
- Reviewer for Journal of Biomechanics
- Reviewer for Gait and Posture
- Reviewer for PLoS one
- Reviewer for Journal of Applied Ergonomics
- Reviewer for Journal of Motor Behavior

PROFESSIONAL SOCIETY MEMBERSHIPS

- American Society of Biomechanics (ASB)
- American Society of Mechanical Engineers (ASME)
- International Society of Biomechanics (ISB)