

Ryan S. McGinnis, PhD

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RESEARCH INTERESTS

My research interests are primarily focused on the application of inertial sensors to the measurement and analysis of human biomechanics for clinical assessment and rehabilitation, remote health and performance monitoring, and sports training and skill assessment.

EDUCATION

University of Michigan	Ann Arbor, MI	September 2009-April 2013
PhD, MSE Mechanical Engineering		
Dissertation: Advancing Applications of IMUs in Sports Training and Biomechanics		
Chair: Noel C. Perkins, PhD		
Lafayette College	Easton, PA	September 2005-May 2009
BS Mechanical Engineering (Summa Cum Laude with Honors)		
Study Abroad at Jacobs University	Bremen, Germany	January 2007-May 2007

ACADEMIC APPOINTMENTS AND POSITIONS

Postdoctoral Research Fellow	University of Michigan	May 2013-Present
Dept. of Mechanical Engineering; School of Kinesiology		

Research Aim: Develop and validate inertial sensor based techniques for monitoring warfighter biomechanics.

- Identify and track changes in metrics indicative of warfighter biomechanical performance in response to load carriage and fatigue during:
 - a. Vertical jumping
 - b. Speed and agility assessment tasks
 - c. Up/down maneuvers
 - d. Target acquisition maneuvers
 - e. Ambulation
- Quantify warfighter rifle dynamics for skill assessment and training

Research Aim: Develop and validate inertial sensor based techniques for quantifying hip motion during common clinical tests used for diagnosis of FAI and other morphological abnormalities of the pre-arthritic hip.

- Establish the validity of clinical hip joint center identification on cadaveric specimens
- Establish the validity of clinical three-dimensional hip angle measurement on cadaveric specimens
- Investigate the influence of soft tissue on the measurement of these motions

Research Aim: Identify bio-behavioral correlates of anxiety and depression in young children within the NIMH Research Domain Criteria (RDOC) framework.

- Develop objective, inertial sensor based metrics indicative of behavioral response to potential threat, acute threat, and hedonic reward mood induction tasks.
- Aid researchers in departments of Psychology and Psychiatry with data collection protocol, interpretation of

behavioral data, and establishing the validity of metrics.

Research Aim: Develop and validate inertial sensor based techniques for quantifying flexible golf club behavior for club fitting and skill assessment.

- Develop method for accurately identifying spatial relationship between the club face and inertial sensors affixed to the shaft and head of a club
- Establish the validity of a two-sensor array for identifying shaft bending and torsion during the swing
- Establish the sensitivity of methodology to differences in shaft flexibility

Research Aim: Explore the relationships between baseball and softball windup and delivery kinematics, pitch release conditions, and pitcher skill and effectiveness.

- Identify potential windup and delivery kinematic indicators of pitcher success and injury
- Identify release condition repeatability (speed, spin, release position, etc.) in elite (D1 college level) subjects, and establish relationship to pitcher success
- Establish nominal release conditions (speed, spin rate, ball orientation, etc.) for a variety of softball pitches, including: fastball, changeup, drop, curve, and rise
- Establish relationships between pitch identification and batter skill in baseball and softball

Research Aim: Determine how running mechanics and economy, and the potential for successful running gait adaptation, are impacted by explicit individualized morphological indices.

- Examine sensitivity of habitual foot strike pattern to specific morphological and dynamic ROM indices
- Identify effect of habitual foot strike pattern, footwear type, and fatigue on mechanical and metabolic factors central to performance and/or injury
- Establish methodology for identifying optimal shoe-foot interaction based on individual specific morpho-mechanical traits

Research Aim: Improve student engagement in Introductory Dynamics and Vibrations course using inertial sensor based concept demonstrations and projects.

- Manage IMU hardware selection, acquisition, and maintenance
- Aid in experimental study design
- Develop project/in class demonstration ideas and implementation

Doctoral Student
(NSF and ME Dept. Graduate Research Fellow)
Dept. of Mechanical Engineering

University of
Michigan

September 2009-April 2013

Research Aim: Develop and validate inertial sensor based algorithms in the following applications:

- Reconstructing free-flight angular velocity data from accelerometer measurements
- Pitched baseball and softball dynamics, skill assessment, and training
- Quantifying joint reaction forces and moments
- Identifying ball joint center of rotation in a mechanical analog to the human hip joint
- Estimating athlete speed using a single, torso-mounted inertial measurement unit

Research Aim: Explore the relationship between hand path during the golf swing and club deformation.

- Developed novel club fitting methodology
- Identified relationships between golfer-supplied reactions at the grip and shaft deflection

Research Aim: Explore the relationship between hand path during the golf swing and various swing parameters.

- Identified a clear pattern in hand path instantaneous radius of curvature across subjects
- Demonstrated relationships between hand path and swing parameters including club head speed, loading on the golfer, etc.
- Identified a hand path which maximizes club head velocity for a given kinetic input to the club

RESEARCH AND PUBLICATIONS

I. Manuscripts In Preparation

1. **McGinnis, RS**, Perkins, NC. Torso-mounted Inertial Measurement Unit for Quantifying Athlete Speed. *Journal of Sports Engineering*: In Preparation.
2. Nesbit, SM, Milanovich, M, **McGinnis, RS**. The Effects of Bat Inertial Properties on Female Softball Swing Mechanics and Bat Performance. *Journal of Sports Biomechanics*: In Preparation.

II. Peer Reviewed Journal Articles (Appeared or Submitted)

1. Whiteside, D, **McGinnis, RS**, Deneweth, JM, Zernicke, RF, Goulet, GC. Ball flight kinematics, variability and pitching success in elite baseball. *Medicine and Science in Sports and Exercise*: Submitted.
2. **McGinnis, RS**, Cain, SM, Davidson, SP, Vitali, R, Perkins, NC, McLean, SG. Quantifying the Effects of Load Carriage and Fatigue under Load on Sacral Kinematics during Countermovement Vertical Jump with Novel IMU-based Method. *IEEE Transactions on Biomedical Engineering*: Submitted.
3. **McGinnis, RS**, Cain, SM, Tao, S, Whiteside, D, Goulet, GC, Gardner, EC, Bedi, A, Perkins, NC. Validation of a Novel IMU-based Three-dimensional Hip Angle Measurement in Diagnostic Tests for Femoroacetabular Impingement. *IEEE Transactions on Biomedical Engineering*: Under Review.
4. Nesbit, SM, **McGinnis, RS**. Kinetic Constrained Golf Swing Optimization. *Journal of Sports Science and Medicine*: Under Review.
5. Hough, J, **McGinnis, RS**, Perkins, NC. Benchmarking the Accuracy of Inertial Measurement Units Part 1: Estimating Kinetic Energy. *ASME Journal of Applied Mechanics*: Under Review.
6. **McGinnis, RS**, Hough, J, Perkins, NC. Benchmarking the Accuracy of Inertial Measurement Units Part 2: Estimating Joint Reactions. *ASME Journal of Applied Mechanics*: Under Review.
7. **McGinnis, RS**, Perkins, NC. Inertial Sensor Based Method for Identifying Ball Joint Center of Rotation. *Journal of Biomechanics*: (2013) 46, 2546-2549.
8. **McGinnis, RS**, Perkins, NC. A Highly Miniaturized, Wireless Inertial Measurement Unit for Characterizing the Dynamics of Pitched Baseballs and Softballs. *Sensors*: (2012) 12, 11933-11945.
9. **McGinnis, RS**, Perkins, NC, King, KW. Reconstructing Free-flight Angular Velocity from Miniaturized Wireless Accelerometer. *ASME Journal of Applied Mechanics*: (2012) 79, 041013:1–041013:9.

10. King, KW, Hough, J, **McGinnis, RS**, Perkins, NC. A New Technology for Resolving the Dynamics of a Swinging Bat, *Journal of Sports Engineering*: (2012) 15, 41-52.
11. Nesbit, SM, **McGinnis, RS**. Biomechanical Study of the Golf Swing Using a Full Body Computer Model, *Journal of Applied Golf Research*: (2011) <http://thejagr.com/issue/issue-1-spring-2011/article/biomechanical-study-of-the-golf-swing-using-a-full-body-computer-model1>.
12. King, KW, Perkins, NC, Churchill, H, **McGinnis, RS**, Doss, R, Hickland, R. Bowling Ball Dynamics Revealed by Miniature Wireless MEMS Inertial Measurement Unit, *Journal of Sports Engineering*: (2010) 13, 95-104.
13. **McGinnis, RS**, Nesbit, SM. Golf Club Deflection Characteristics as a Function of the Swing Hub Path, *Open Sports Sciences Journal*: (2010) 3, 155-164.
14. Nesbit, SM, **McGinnis, RS**. Kinematic Analysis of the Golf Swing Hub Path and its Role in Golfer/Club Kinetic Transfers. *Journal of Sports Science and Medicine*: (2009) 8, 235 - 246.

III. Peer Reviewed Conference Articles/Abstracts

1. **McGinnis, RS**, Cain, SM, Davidson, SP, Vitali, R, McLean, SG, Perkins, NC. 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, Montreal, QC: Accepted.
2. Cain, SM, **McGinnis, RS**, Davidson, SP, Vitali, R, Perkins, NC, McLean, SG. Using Inertial Measurement Units to Quantify Gait Performance. *Dynamic Walking 2014*, June 10-13, Zurich, Switzerland.
3. Whiteside, D, **McGinnis, RS**, Deneweth, JM, Holstad, R, Martini, DN, Zernicke, RF, & Goulet, GC. Relating ball flight characteristics, variability in release location and game success in elite baseball pitchers. XIX Annual Congress of the European College of Sport Science, July 2-5, 2014, Amsterdam, Netherlands.
4. **McGinnis, RS**, Cain, SM, Davidson, SP, Vitali, R, McLean, SG, Perkins, NC. Validation of IMU-based Method for Tracking Warfighter Torso Angle during Up-down Maneuver. 7th World Congress of Biomechanics, July 6-11, Boston, MA.
5. **McGinnis, RS**, Cain, SM, Davidson, SP, Vitali, R, McLean, SG, Perkins, NC. Validation of IMU-based Method for Tracking Warfighter Motion during Jumping Maneuver. 7th World Congress of Biomechanics, July 6-11, Boston, MA.
6. Cain, SM, **McGinnis, RS**, Davidson, SP, Vitali, R, McLean, SG, Perkins, NC. 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, Boston, MA.
7. Davidson, SP, **McGinnis, RS**, Cain, SM, Vitali, R, McLean, SG, Perkins, NC. Validating Inertial Measurement Units as a Method for Determining Rifle Aiming Performance. 7th World Congress of Biomechanics, July 6-11, Boston, MA.
8. Vitali, R, **McGinnis, RS**, Cain, SM, Davidson, SP, McLean, SG, Perkins, NC. Quantifying Rifle Aiming Dynamics with an Inertial Measurement Unit. 7th World Congress of Biomechanics, July 6-11, Boston, MA.
9. Fox, A, Cain, SM, **McGinnis, RS**, Davidson, SP, Vitali, R, Perkins, NC, McLean, SG. 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, Akron, OH.
10. **McGinnis, RS**, Hough, J, Perkins, NC. Benchmarking the Accuracy of Inertial Measurement Units for Estimating Joint Reactions. Proceedings 2013 ASME International Mechanical Engineering Congress and Exposition, San Diego, CA. IMECE2013-63303. Best paper award, ASME Bioengineering Division: Biomedical and Biotechnology Engineering
11. Hough, J, **McGinnis, RS**, Perkins, NC. Benchmarking the Accuracy of Inertial Measurement Units for

Estimating Kinetic Energy. Proceedings 2013 ASME International Mechanical Engineering Congress and Exposition, San Diego, CA. IMECE2013-63300.

12. **McGinnis, RS**, Perkins, NC. Pitcher Training Aided by Instrumented Baseball. 9th Conference of the International Sports Engineering Association (ISEA), Lowell, MA. Published in Procedia Engineering: (2012) 34, 580-585.
13. **McGinnis, RS**, Perkins, NC, King, KW. Miniaturized Wireless IMU Enables Low-Cost Baseball Pitching Training Aid. 35th Annual Meeting of the American Society of Biomechanics, Long Beach, CA, August 10-13, 2011.
14. **McGinnis, RS**, Nesbit, SM. Analysis of the Swing Hub of the Golf Shot. 13th European College of Sports Science Congress, Estoril, Portugal, July 9-12, 2008.

IV. Patent Submissions

1. **McGinnis, RS**, Perkins, NC, Copples, BR. IMU Array for Assessing Proper Head and Torso Posture during Physical Impact in Sport. US 61/931,767, Provisional Filed January 27, 2014.
2. **McGinnis, RS**, Perkins, NC. Athlete Speed Prediction Method Using Data from Attached Inertial Measurement Unit. US 14/224,386, Filed March 25, 2014.
3. **McGinnis, RS**, Perkins, NC. Ball Joint Center Locating Method Using Data from Attached Inertial Measurement Unit. US 61/694,790, Filed August 30, 2012. PCT/US2013/057303, Filed August 29, 2013.
4. **McGinnis, RS**, Perkins, NC. Pitcher Training Apparatus and Method Using a Ball with an Embedded Inertial Measurement Unit. US 13/570,622, Filed August 9, 2012. PCT/US2013/053556, Filed August 5, 2013.
5. Perkins, NC, King, KW, and **McGinnis, RS**. Apparatus and Methods for Employing Miniature IMU's for Deducing Forces and Moments on Bodies. US 13/236,728, Filed September 20, 2011.

V. Participation in Funded Research and Grant Submissions

1. Title: Novel Sensor Technology for Tackle Training to Reduce Brain Injury in Football
Agency: NFL, Under Armour, GE Head Health Challenge II
Role: Co-Investigator
Year Awarded: Submitted 2014
Year (Inclusive) of Project: N/A
Direct Costs: N/A
2. Title: Novel IMU Array Algorithms for Golf Club Fitting
Agency: Insight Limited
Role: Co-Investigator
Year Awarded: 2014
Year (Inclusive) of Project: 2014
Direct Costs: \$7,740
3. Title: IMU Array Algorithms and Technology for Field-based Warfighter Performance Assessment
Agency: US Department of Defense
Role: Postdoctoral Fellow
Year Awarded: 2013
Year (Inclusive) of Project: 2013-2015
Direct Costs: \$845,474
4. Title: Instrumented Baseball Bat for Bat Testing
Agency: Hillerich and Bradsby Co.
Role: Graduate Student Researcher

Year Awarded: 2012
Year (Inclusive) of Project: 2012
Direct Costs: \$9,874

5. Title: Advancing Applications of IMUs in Sports Training and Biomechanics
Agency: NSF Graduate Research Fellowship Program
Role: Principal Investigator
Year Awarded: 2010
Year (Inclusive) of Project: 2010-2013
Direct Costs: \$121,500
6. Title: Prototype Instrumented Baseball Bat for Research and Development
Agency: Rawlings/Worth
Role: Graduate Student Researcher
Year Awarded: 2010
Year (Inclusive) of Project: 2010
Direct Costs: \$24,865
7. Title: Developing an Instrumented Bowling Ball: New Capabilities for Player Training and Ball Design
Agency: Ebonite International
Role: Graduate Student Researcher
Year Awarded: 2008
Year (Inclusive) of Project: 2008-2009
Direct Costs: \$102,259

VI. Other Publications/Interviews

1. **McGinnis, RS.** (2013) Advancing Applications of IMUs in Sports Training and Biomechanics. Doctoral Dissertation. Available from the University of Michigan, Ann Arbor, MI.
2. **McGinnis, RS.** (2012). Instrumented Baseball Research. Sports Technology Pod Cast. <http://sportstechnologypodcast.com/ryanmcginnis/>.
3. **McGinnis, RS,** Perkins, NC. (2012). Pitcher Training Aided by Instrumented Baseball. Advances in Engineering. <http://advancesinengineering.com/general-engineering/pitcher-training-aided-by-instrumented-baseball/>.
4. Perkins, NC, King, KW, **McGinnis, RS,** Hough, J. (2011). A Sporting Chance. Mechanical Engineering Magazine.
5. **McGinnis, RS.** (2008). Engineering a Better Golf Swing. ME Today, 10. http://www.asme.org/NewsPublicPolicy/Newsletters/METoday/Articles/Better_Golf_Swing.cfm
6. **McGinnis, RS.** (2008). Engineering a Better Golf Swing. <http://www.lafayette.edu/news.php/view/12541>

VII. Other Research Related Activities

- Reviewer for:
 - Journal of Sports Engineering
 - IEEE Transactions on Neural Systems & Rehabilitation Engineering
 - IEEE Transactions on Biomedical Engineering
 - 2013, 2014 ASME IMECE

TEACHING AND MENTORSHIP EXPERIENCE

I. Teaching Experience

- Supplemental Student Instructor for Nature of Engineering Materials (ES231, Lafayette College)

II. Teaching Interests

- Introductory Courses:
 - Introduction to Dynamics
 - Introduction to Biomechanics
 - Instrumentation and Data Acquisition
 - Human Locomotion
 - Technical Writing for Engineers
- Advanced/Graduate Courses:
 - Intermediate Dynamics
 - Advanced Dynamics
 - Human Movement Analysis
 - Laboratory Methods in Human Movement Analysis

III. Mentorship

- Graduate students:
 1. Jessandra Hough, Mechanical Engineering, PhD Student
 2. Sui Tao, Mechanical Engineering, Masters Student
 3. Gu Eon Kang, Kinesiology, PhD Student
- Undergraduate students:
 1. Peter Curran, Mechanical Engineering
 2. Brian Yost, Mechanical Engineering
 3. Jessandra Hough, Mechanical Engineering (SROP – Summer Research Opportunity Program)
 4. Ramiro Pinon, Mechanical Engineering (SROP)
 5. Katie Gessler, Mechanical Engineering (SROP)
 6. Rachel Vitali, Mechanical Engineering

IV. Other Teaching Related Experiences

- Completed University of Michigan Teaching Engineering Course:
 - Topics included educational philosophies, educational objectives, learning styles, collaborative and active learning, creativity, testing and grading, ABET requirements, gender and racial sensitivity issues.
- Guest Lecturer in Introduction to Dynamics and Vibrations (ME240, University of Michigan)

INDUSTRY EXPERIENCE

Research and Development Consultant

iTrainer Golf
Insight Ltd.

July 2012-Present

Position Description: Responsible for the development and validation of computational algorithms which utilize data from an inertial measurement unit to quantify the motion of dynamical systems.

Specific Projects:

- Development of the latest generation iTrainer golf swing analysis system (www.insight-sports.com)
- Establishing the validity and sensitivity of the iTrainer golf swing analysis system
- Development of a wireless, non-invasive method for monitoring cruise ship terminal pier deformation during docking
- Finalizing computational algorithms for an inertial sensor based bowler skill assessment and training tool

Research and Development Consultant

Louisville Slugger

February-December 2012

Position Description: Responsible for the development and validation of an inertial sensor based baseball and softball bat fitting system.

Specific Projects:

- Development of an in-house inertial sensor based research tool for quantifying metrics important for baseball bat fitting
- Experimental design support for use of the swing measurement tool in bat fitting

Research and Development Consultant

Ebonite
International

July-October 2012

Position Description: Responsible for updating existing inertial sensor based bowler analysis tool for use with the latest generation inertial sensors.

Specific Projects:

- Update in house bowler analysis software to utilize latest generation inertial sensor hardware.

ACADEMIC HONORS

Best Paper Award, Biomedical and Biotechnology Engineering, Dynamics and Control in
Biomechanical Systems, ASME IMECE 2013
Benchmarking the Accuracy of Inertial Measurement Units for Estimating Joint Reactions

November 2013

Ivor K. McIvor Award
(excellence in research and scholarship in applied mechanics, University of Michigan)

March 2013

NSF Graduate Research Fellow

May 2010-April 2013

Mechanical Engineering Department Graduate Research Fellow

Sept. 2009-May 2010

Carl Jr. and Deborah Anderson Mechanical Engineering Prize (Lafayette College)

April 2009

Sigma Xi (National Research Honor Society)

April 2009

Tau Beta Pi (National Engineering Honor Society)

October 2008

Lafayette EXCEL Scholar

May 2008

ACHA Division 2 Hockey Academic Award

2007-2009