

CURRICULUM VITAE

Rebekah L. Lawrence, PT, PhD
Board Certified Specialist in Orthopaedic Physical Therapy

Date: 06/30/2024

Contact Information

Program in Physical Therapy
Washington University School of Medicine
MSC 8502-66-1101
4444 Forest Park Avenue, Room 1123
St. Louis, Missouri 63108
r.lawrence@wustl.edu
(314) 286-1413

Present Position

2022-present Assistant Professor
Program in Physical Therapy
Department of Orthopaedic Surgery
Washington University School of Medicine (WUSM)

Education

2002-2006 BS, Health Science; Bradley University; Peoria, IL
2006-2008 DPT, Physical Therapy; St. Ambrose University; Davenport, IA
2009-2010 Orthopaedic Residency; St. Ambrose University; Davenport, IA
2012-2018 PhD, Rehabilitation Science; University of Minnesota; Minneapolis, MN
Thesis: Movement-Related Pathogenesis of Rotator Cuff Disease in Persons with Shoulder Pain: Effects of Decreased Scapulothoracic Upward Rotation
Advisor: Paula M. Ludewig, PT, PhD, FAPTA
2018-2022 Postdoctoral Fellowship
Bone and Joint Center, Henry Ford Health System; Detroit, MI
Concentration: Orthopaedic biomechanics

Academic Positions / Employment

2009-2012 Adjunct Instructor, Physical Therapy Program
St. Ambrose University; Davenport, IA
2010-2012 Clinical Mentor, Orthopaedic Residency Program
St. Ambrose University; Davenport, IA
2012-2018 Research Assistant, Minnesota Rehabilitation Biomechanics Laboratory
Division of Rehabilitation Science
University of Minnesota; Minneapolis, MN
2012-2014 Teaching Assistant, Division of Physical Therapy
University of Minnesota; Minneapolis, MN
2017-2022 Guest Instructor, Division of Rehabilitation Science
University of Minnesota; Minneapolis, MN

- 2018-2022 Postdoctoral Research Fellow
Bone and Joint Center, Department of Orthopaedic Surgery
Henry Ford Health System; Detroit, MI
- 2022-present Assistant Professor, Program in Physical Therapy
Washington University School of Medicine; St. Louis, MO
- 2022-present Assistant Professor, Department of Orthopaedic Surgery
Washington University School of Medicine; St. Louis, MO

Clinical Title and Responsibilities

- 2009-2012 Physical Therapist
Rock Valley Physical Therapy; Davenport, IA
- 2015-2018 Physical Therapist (PRN)
TRIA Orthopaedic Center; Bloomington, MN

Teaching Title and Responsibilities

Graduate (entry Level DPT)

- 2009-2012 Lab Assistant, Musculoskeletal Therapeutics I (DPT 620)
Physical Therapy Program, St. Ambrose University
Enrollment: 15 students
- 2009-2012 Lab Assistant, Musculoskeletal Therapeutics II (DPT 720)
Physical Therapy Program, St. Ambrose University
Enrollment: 15 students
- 2010-2012 Adjunct instructor, Physical Therapy Procedures I (DPT 560)
Physical Therapy Program, St. Ambrose University
Enrollment: 30 students
- 2011-2012 Lab assistant, Physical Agents (DPT 570)
Physical Therapy Program, St. Ambrose University
Enrollment: 15 students
- 2012-2014 Graduate teaching assistant, Musculoskeletal Therapeutics I (PT 6283)
Division of Physical Therapy, University of Minnesota
Enrollment: 50 students
Overall student rating: 97.2%-98.5%
- 2012-2014 Graduate teaching assistant, Musculoskeletal Therapeutics II (PT 6284)
Division of Physical Therapy, University of Minnesota
Enrollment: 50 students
Overall student rating: 96.5%
- 2012-2014 Graduate teaching assistant, Anatomy for Physical Therapy (PT 6058)
Division of Physical Therapy, University of Minnesota
Enrollment: 50 students
Overall student rating: 95.8%-96.9%
- 2013 Graduate teaching assistant, Neurorehabilitation (PT 6287)
Division of Physical Therapy, University of Minnesota
Enrollment: 50 students
Overall student rating: not assessed
- 2022-present Coach
Program in Physical Therapy, WUSM
Enrollment: 5 students

- 2023 Advisor, DEA III
Program in Physical Therapy, WUSM
- 2023 Discussant/Content Expert, DEA III Journal Club
Program in Physical Therapy, WUSM
Enrollment: 15-20 students
- 2024-present Content Expert/Lecturer, Module 4B - Movement and Precision Health
Program in Physical Therapy, WUSM
Enrollment: 85-90 students
Overall student rating: 4.7/5.0
- 2024-present Discussant/Content Expert, Module 8 – Practice, Health and Equity
Program in Physical Therapy, WUSM
Enrollment: 20-25 students

Graduate (PhD)

- 2017-present Guest lecturer, Advanced Biomechanics I – Kinematics (RSC 5135/8135)
Division of Rehabilitation Science, University of Minnesota
Enrollment: 8-12 students
Overall student rating: 96.0%
- 2022-present Presenter, Program Seminar
Movement Science PhD Program, WUSM
Enrollment: 5 students
- 2023-present Lecturer, Movement Science II – Biomechanics
Movement Science PhD Program, WUSM
Enrollment: 5 students

University, School of Medicine and Hospital Appointments and Committees

- 2022-present Musculoskeletal Research Center, WUSM
- 2022-present Institute of Clinical and Translational Sciences, WUSM

Professional Licensure and Certification

- 2009-2012 State of Illinois physical therapist license (#070016875)
- 2009-2013 State of Iowa physical therapist license (#004366)
- 2010-present Orthopaedic Clinical Specialist, American Board of Physical Therapy
Specialties (#22260)
- 2011 Credentialed Clinical Instructor, APTA
- 2012 Advanced Credentialed Clinical Instructor, APTA
- 2013-2022 State of Minnesota physical therapist license (#9223)
- 2022-present State of Missouri physical therapist license (#2022030812)

Honors and Awards

- 2002-2006 Dean's List, Bradley University
- 2002-2006 Dean's Scholar, Bradley University
- 2002-2006 Bradley Fellow, Bradley University
- 2008 Iowa Physical Therapy Foundation Student Scholarship
- 2012 DPT Student Appreciation Award, St. Ambrose University

2012	New Student Academic Merit Award, Program in Rehabilitation Science, University of Minnesota
2012-2013	Florence P. Kendall Doctoral Scholarship, Foundation for Physical Therapy
2014	Physical Therapy Preceptor of the Year, University of Minnesota Physicians' Phillips Neighborhood Clinic
2015-2017	Promotion of Doctoral Studies (PODS) II Scholarships, Foundation for Physical Therapy
2016	Young Investigator Award, International Society of Biomechanics Shoulder Technical Group
2016-2018	Ruth L. Kirschstein National Research Service Award (F31), National Institutes of Health (NIH)
2017	Emerging Leader Alumni Award; St. Ambrose University College of Health and Human Services
2018	APTA Biomechanics SIG PhD Student Travel Award
2018	Milne-Brandenburg Award for Exceptional Research by Graduate Students in the Basic Biomedical Sciences; University of Minnesota
2018	ASB Doctoral Student Presentation Award
2019	ORS Travel Grant in Orthopaedic Research Translation
2020	APTA Biomechanics SIG Postdoc Travel Award
2024	Early Career Investigator Award in Biomechanics Research, APTA Academy of Research

Editorial Responsibilities

Editorial Board

2015-present International Editorial Review Board, Journal of Orthopaedic and Sports Physical Therapy

Manuscript Reviewer

2012-present Clinical Biomechanics
2013-present Journal of Orthopaedic and Sports Physical Therapy
2013-present Physical Therapy
2015 Manual Therapy
2015-present American Journal of Sports Medicine
2015-present Journal of Shoulder and Elbow Surgery
2016-present Brazilian Journal of Physical Therapy
2017-present Journal of Orthopaedic Research
2018-present Journal of Biomechanics
2018-present Journal of Electromyography and Kinesiology
2019-present Journal of Applied Biomechanics
2020-present Gait and Posture
2021-present Orthopaedic Journal of Sports Medicine
2023-present British Journal of Sports Medicine

Abstract Reviewer

2019-present Orthopaedic Research Society Annual Meeting
2021-present American Society of Biomechanics Annual Meeting

2024-present International Shoulder Group, Biannual Meeting

National Panels, Committees, Boards

2023 Ad-hoc grant reviewer, Swiss National Science Foundation

Professional Service Contributions

Departmental

2016-2017 PhD Student Representative, Director Search Committee; Division in Physical Therapy, University of Minnesota

University

2021-2022 Member, Postdoctoral Seminar Planning Committee; Henry Ford Health System

2014-2023 Member, College of Health and Human Services Advisory Council; St. Ambrose University

Professional Societies and Organizations

American Physical Therapy Association

2006-present Member, American Physical Therapy Association

2006-2012 Member, Iowa Physical Therapy Association

2009-present Member, Academy of Orthopaedic Physical Therapy

2010-present Member, Academy of Research

2012-2018 Member, Minnesota Physical Therapy Association

2018-2022 Member, Michigan Physical Therapy Association

2022-present Member, Missouri Physical Therapy Association

International Society of Biomechanics

2013-present Member, International Society of Biomechanics

2013-present Member, Shoulder Technical Group

Other

2009-2012 Member, American Academy of Orthopaedic and Manual Physical Therapists

2015-present Member, Orthopaedic Research Society

2018-present Member, American Society of Biomechanics

Major Invited Professorships and Lectureships

Invited Presentations

1. Shoulder Impingement Revisited: Evolution in Diagnostic Understanding in PT and Orthopaedic Surgery. APTA Combined Sections Meeting; Las Vegas, NV. February 2014.
2. "Shoulder Biomechanics, the Right-Hand Rule, and Other Lessons Learned Along the Way." Physical Therapy Program, St. Ambrose University; Davenport, IA. September 2017.
3. "Biomechanics Updates Applied to the Aging Shoulder." OrthoRehab Specialists, Inc.; Minneapolis, MN. October 2017.
4. "The Effect of Decreased Scapulothoracic Upward Rotation on Subacromial Proximities." Physical Therapy Program, Wayne State University; Detroit, MI. August 2018.

5. "Investigating the Multi-Factorial Etiology of Rotator Cuff Pathology." Department of Biomedical Engineering. Wayne State University; Detroit, MI. November 2019.
6. "Mechanical Rotator Cuff Impingement: Biomechanical Considerations in Rehabilitation." Department of Physical Therapy. University of Illinois at Chicago; Chicago, IL. January 2020.
7. "From Cellular to Joint Mechanics: Evidence for the Multi-Factorial Etiology of Rotator Cuff Disease." APTA Combined Sections Meeting; Denver, CO. February 2020.
8. "Paradigm Shifts in Rotator Cuff Impingement: Implications for the Movement System." Program in Physical Therapy, Movement System Clinical Fellowship Symposium. Washington University in St. Louis; St. Louis, MO (virtual). May 2020.
9. "Evidence for the Multi-Factorial Etiology of Rotator Cuff Pathology: Implications for the Physical Therapy Profession." Program in Physical Therapy, Shirley Sahrman Lectureship. Washington University in St. Louis; St. Louis, MO (virtual). October 2020.
10. "Paradigm Shifts in Rotator Cuff Impingement: Implications for Physical Therapists." Henry Ford Rehabilitation, Henry Ford Health System. Wyandotte, MI. April 2022.
11. "Funding Your Postdoc: Preparing NIH F32 and K99/R00 Applications." Postdoc Seminar Series. Henry Ford Health System. Detroit, MI. July 2022.
12. "From the clinic to the lab: Striving to improve outcomes for individuals with shoulder pain through biomechanics research." Research in Engineering, Healthcare, and Biomechanics (REHAB). University of Wisconsin-Milwaukee (virtual). April 2023.
13. "Running a Research Lab Is Like Running a Small Business". Presenter/panelist. APTA Combined Sections Meeting; Boston, MA. February 2024.
14. "Investigating the Multifactorial Etiology of Rotator Cuff Tears". Avioli Seminar, Musculoskeletal Research Center. Washington University School of Medicine; St. Louis, MO. May 2024.
15. "Investigating the Multifactorial Etiology of Rotator Cuff Tears". Department of Mechanical and Materials Engineering. Queen's University; Kingston, ON. June 2024.

Research Support

Active (government)

Role: PI

Title: Investigating the Multi-factorial Etiology of Rotator Cuff Pathology in Human Subjects

Source: NIH/NIAMS (R00-AR075876)

Duration: 09/01/2022-08/31/2025

Direct costs: \$677,994

Past (government)

Role: Trainee (Co-PIs: Clohisy DR, Carlson CS)

Title: University of Minnesota Department of Orthopaedic Surgery Musculoskeletal Training Grant

Source: NIH/NIAMS (T32-AR050938)

Duration: 04/01/2014-03/31/2016

Direct costs: N/A

Role: PI

Title: Movement-related Pathogenesis of Rotator Cuff Disease in Persons with Shoulder Pain

Source: NIH/NICHD/NCMRR (F31-HD087069)

Duration: 05/01/2016-04/30/2018

Direct costs: \$85,832

Role: PI

Title: Movement-related Pathogenesis of Rotator Cuff Disease in Persons with Shoulder Pain
Source: NIH/NICHD, Loan Repayment Program (L30-HD089226)
Duration: 07/01/2016-06/30/2018
Award amount: \$65,037

Role: PI

Title: Investigating the Multi-factorial Etiology of Rotator Cuff Pathology in Human Subjects
Source: NIH/NIAMS (K99-AR075876)
Duration: 09/01/2020-08/31/2022
Direct costs: \$167,916

Role: PI

Title: Investigating the Factors Associated with Rotator Cuff Pathology and Repair Failure
Source: NIH/NIAMS, Loan Repayment Program (L30-AR079959)
Duration: 07/01/2021-06/30/2022
Award amount: \$29,918

Past (non-government)

Role: PI

Title: Movement-related Pathogenesis of Rotator Cuff Disease in Persons with Shoulder Pain
Source: University of Minnesota Department of Orthopaedic Surgery
Duration: 04/01/2015-03/31/2018
Direct costs: \$25,000

Role: PI

Source: Foundation for Physical Therapy (PODS II scholarship)
Duration: 09/01/2015-08/31/2016
Award amount: \$15,000

Role: PI

Source: Foundation for Physical Therapy (PODS II scholarship)
Duration: 09/01/2016-08/31/2017
Award amount: \$15,000

Trainee / Mentee / Sponsorship Record

Undergraduate Students

2018-2021	Alena Jalics; Biomedical and Mechanical Engineering, Wayne State University Role: Postdoc mentor for undergraduate research assistantship Outcome: 1 published manuscript, 1 national conference abstract
2020-2022	Kevin Roseni; Mechanical Engineering, Oakland University Role: Postdoc mentor for undergraduate research assistantship Outcome: 2 published manuscripts
2023-present	Lydia Nicholson; Biomedical Engineering, Washington University in St. Louis Role: Mentor for undergraduate research assistantship Outcome: 2 poster presentations
2023-present	Sarah Baldwin; Biology, Washington University in St. Louis Role: Mentor for undergraduate research assistantship Outcome: 1 poster presentation

- 2023-present Nicholas Seifried; Neuroscience, Applied and Computational Mathematics and Statistics, University of Notre Dame
Role: Mentor for undergraduate research assistantship
- 2024-present Connor Dechiro; Biology (pre-med track), Washington University in St. Louis
Role: Mentor for undergraduate research assistantship

Graduate Students (PhD)

- 2023 Erin Lee, Mechanical Engineering, Queen's University
Natural Sciences & Engineering Research Council of Canada (NSERC) Scholar
Role: Faculty mentor for visiting pre-doctoral scholar
Outcome: 1 national conference abstract, 2 international conference abstracts.
Awards: PhD student award at the 14th Conference of the International Shoulder Group
- 2023-present Stacey Chen, PT, DPT, ATC; Movement Science, WUSM
Role: Primary PhD mentor
Outcome: 1 national conference abstract, 1 international conference abstract
Awards: Promotion of Doctoral Studies (PODS) I Scholarship, Foundation for Physical Therapy

Graduate Students (Entry level DPT)

- 2023 Tessa Roberts
Role: Mentor for research assistantship
- 2023 Steven Solomon
Role: Mentor for DEI III synthesis project
Title: Effect of Real-time Biofeedback on Shoulder Kinematics and Function
- 2023-present Samantha Loudermilk
Role: Mentor for research assistantship

Qualifying Examinations and Dissertation Committees

- 2022-2024 Jeffrey Konrad, PT, PhD; Movement Science PhD Program, WUSM
Role: Oral proposal and dissertation committee member
Title: "Measurement of and Contributors to Developmental Coordination Impairment"
Outcome: Assistant professor, WUSM Program in Physical Therapy
- 2024 Christina Bourantas; Movement Science PhD Program, WUSM
Role: Qualifying examination committee member

Bibliography

Original, peer reviewed articles in refereed journals

1. **Lawrence RL**, Braman JP, LaPrade RF, Ludewig PM. Comparison of 3-dimensional shoulder complex kinematics in individuals with and without shoulder pain-Part I: Sternoclavicular, acromioclavicular, and scapulothoracic joints. Journal of Orthopaedic and Sports Physical Therapy. 2014; 44(9):636-A8. PMID: [25103135](#).
2. **Lawrence RL**, Braman JP, Staker JL, LaPrade RF, Ludewig PM. Comparison of 3-dimensional shoulder complex kinematics in individuals with and without shoulder pain-Part II: Glenohumeral joint. Journal of Orthopaedic and Sports Physical Therapy. 2014; 44(9):646-B3. PMID: [25103132](#).

3. Sessions WC, **Lawrence RL**, Steubs JT, Braman JP, Ludewig PM. Thickness of the rotator cuff tendons at the articular margin: An anatomic cadaveric study. *Iowa Orthopaedic Journal*. 2017; 37:85-89. PMID: [28852340](#).
4. **Lawrence RL**, Schlangen DM, Schneider K.A., Schoenecker J, Senger A.L, Starr WC, Staker JL, Ellermann JM, Braman JP, Ludewig PM. Effect of glenohumeral elevation during functional reach on rotator cuff mechanical impingement. *Journal of Orthopaedic Research*. 2017; 35(10):2329-2337. PMID: [28071815](#).
5. **Lawrence RL**, Ellingson AM, Ludewig PM. Validation of single-plane fluoroscopy and 2D/3D shape-matching for quantifying shoulder complex kinematics. *Medical Engineering & Physics*. 2018; 52:69-75. PMID: [29229406](#).
6. **Lawrence RL**, Sessions WC, Jensen M, Staker JL, Eid A, Breighner R, Helwig NE, Braman JP, Ludewig PM. The effect of glenohumeral plane of elevation on supraspinatus subacromial proximity. *Journal of Biomechanics*. 2018;79:147-154. PMID: [30172354](#).
7. Akbari-Shandiz M, **Lawrence RL**, Johnson CP, Zhao KD, Ellingson AM, Ludewig PM. MRI vs CT-Based 3D-2D auto-registration accuracy for quantifying shoulder motion using biplane fluoroscopy. *Journal of Biomechanics*. 2019;82:375-380. PMID: [30385001](#).
8. **Lawrence RL**, Braman JP, Ludewig PM. The impact of decreased scapulothoracic upward rotation on subacromial proximities. *Journal of Orthopaedic and Sports Physical Therapy*. 2019;49(3):180-191. PMID: [30658048](#).
9. **Lawrence RL**, Braman JP, Keefe DF, Ludewig PM. The coupled kinematics of scapulothoracic upward rotation. *Physical Therapy*. 2020;100(2):283-294. PMID: [31696926](#).
10. Kage CC, Akbari-Shandiz M, Foltz MH, **Lawrence RL**, Brandon TL, Helwig NE, Ellingson AM. Validation of an automated shape-matching algorithm for biplane radiographic spine osteokinematics and radiostereometric analysis error quantification. *PLOS One*. 2020;15(2):e0228594. PMID: [32059007](#).
11. **Lawrence RL**, Ruder MC, Zuel R, Bey MJ. Instantaneous helical axis estimation of glenohumeral kinematics: The impact of rotator cuff pathology. *Journal of Biomechanics*. 2020;109(26):109924. PMID: [32807327](#).
12. **Lawrence RL**, Ruder MC, Moutzouros V, Makhni EC, Muh SJ, Siegal D, Soliman SC, van Holsbeeck M, Bey MJ. Ultrasound shear wave elastography and its association with rotator cuff tear characteristics. *Journal of Shoulder and Elbow Surgery International*. 2021;5(3):500-506. PMID: [34136861](#)
13. Saini G, **Lawrence RL**, Staker JL, Braman JP, Ludewig PM. Supraspinatus-to-glenoid contact occurs during standardized overhead reaching motion. *Orthopaedic Journal of Sports Medicine*. 2021;9(10), 23259671211036908. PMID: [34646898](#).
14. Ruder MC, **Lawrence RL**, Soliman SB, Zuel R, van Holsbeeck M, Bey MJ. Pre-surgical tear characteristics and estimated shear modulus as predictors of repair integrity and shoulder function one year after rotator cuff repair. *Journal of Shoulder and Elbow Surgery International*. 2021;6(1):62-69. PMID: [35141678](#).
15. **Lawrence RL**, Ruder MC, Zuel R, Jalics A, Olszewski A, Diefenbach B, Moutzouros V, Makhni EC, Muh S, Bey MJ. In vivo static retraction and dynamic elongation of rotator cuff repair tissue after surgical repair: A preliminary analysis at 3 months. *Orthopaedic Journal of Sports Medicine*. 2022;10(3):23259671221084294. PMID: [35387360](#).
16. Aliaj K, **Lawrence RL**, Foreman B, Chalmers P, Henninger H. Kinematic coupling of the glenohumeral and scapulothoracic joints generates humeral axial rotation. *Journal of Biomechanics*, 2022;136:111059. PMID: [35367838](#).

17. **Lawrence RL**, Roseni K, Bey MJ. Correspondence between scapular anatomical coordinate systems and the 3D axis of motion: a new perspective on an old challenge. *Journal of Biomechanics*, 2022;145:111385. PMID: [36403529](#).
18. **Lawrence RL**, Soliman SB, Roseni K, Zauel R, Bey MJ. In vivo evaluation of rotator cuff internal impingement during scapular plane abduction in asymptomatic individuals. *Journal of Orthopaedic Research*, 2023;41(4):718-726. PMID: [35880416](#).
19. Braudy R, Atoms B, Coghlan J, Staples M, Moga D, Tollefsrud R, **Lawrence RL**, Ludewig PM, Koehler L. Shoulder Kinematics of Axillary Web Syndrome in Women Treated for Breast Cancer. *Archives of Physical Medicine and Rehabilitation*, 2023;104(3):403-409. PMID: [36202228](#).
20. **Lawrence RL**, Veluswamy B, Dobben EA, Klochko C, Soliman SB. Predictors of infraspinatus muscle degeneration in individuals with an isolated supraspinatus tendon tear. *Skeletal Radiology*, 2023;52(4):695-703. PMID: [36195776](#).
21. **Lawrence RL**, Saini G, Staker JL, Ludewig PM. Comparison of rotator cuff to glenoid proximity based on scapulothoracic upward rotation classification. *Brazilian Journal of Physical Therapy*, 2023; 27(3):100505. PMID: [37167904](#).
22. **Lawrence RL**, Soliman SB, Dalbøge A, Lohse K, Bey MJ. Investigating the multifactorial etiology of supraspinatus tendon tears. *Journal of Orthopaedic Research*, 2024;42(3):578-587. PMID: [37814893](#).
23. **Lawrence RL**, Brown LB, Bilodeau HL, Bonath DJ, Dahn DJ, Em MA, Sarkar S, Braman JP, Ludewig PM. Effects of scapular angular deviations on potential for rotator cuff tendon mechanical compression. *Orthopaedic Journal of Sports Medicine*, 2024; 12(3):23259671231219023. PMID: [38435717](#).
24. Khandare S, **Lawrence RL**, Jalics A, Zauel R, Klocko C, Bey MJ. A novel 3D MRI-based approach for assessing supraspinatus muscle length. *Journal of Biomechanics*, in press. PMID: [38677025](#).
25. Hoshikawa K, Dominguez M, **Lawrence RL**, Jacobs PM, Yuri T, Mura N, Giambini H. Muscle compensation strategies to maintain glenohumeral stability in rotator cuff tears: a cadaveric study. *Journal of Bone and Joint Surgery*, in press. PMID: pending.

Reviews, Chapters and Editorials

1. Braman JP, Zhao KD, **Lawrence RL**, Harrison AK, Ludewig PM. Shoulder impingement revisited: evolution of diagnostic understanding in orthopaedic surgery and physical therapy. *Medical & Biological Engineering & Computing*. 2014; 52(3):211-219. PMID: [23572144](#).
2. Ludewig PM, **Lawrence RL**. Mechanics of the Scapula in Shoulder Function and Dysfunction. In: Kibler WB, Sciascia AD, eds. *Disorders of the Scapula and Their Role in Shoulder Injury-A Clinical Guide to Evaluation and Management*. Springer, New York, NY; 2017.
3. Wilkes T, Ebaugh D, Spinelli B, **Lawrence RL**, Ludewig PM, Kibler WB. Anatomic and Physiologic Basis for Postoperative Rehabilitation for the Shoulder. In: Green A, Hayda R eds. *Postoperative Orthopaedic Rehabilitation*. American Academy of Orthopaedic Surgeons; 2017.
4. **Lawrence RL**, Moutzouros V, Bey MJ. Asymptomatic rotator cuff tears. *JBSJ Reviews*. 2019;7(6):e9. PMID: [31246863](#).
5. **Lawrence RL**, Braman JP, Ludewig PM. Shoulder kinematics impact subacromial proximities: A review of the literature. *Brazilian Journal of Physical Therapy*. 2020, 24(3):219-230. PMID: [31377124](#).

6. **Lawrence RL**, Ludewig PM, Ward SR. An integrated approach to musculoskeletal performance, disease, and recovery. *Physical Therapy*. 2021;101(12). PMID: [34636897](#).
7. **Lawrence RL**, Zauel R, Bey MJ. Measuring 3D in-vivo shoulder kinematics using biplanar videoradiography. *Journal of Visualized Experiments*. 2021(169): 10.3791/62210. PMID: [33779606](#).

Non-refereed publications

1. Ludewig PM, **Lawrence RL**, Braman JP. What's in a name? Using movement system diagnoses vs. pathoanatomical diagnoses. *Journal of Orthopaedic and Sports Physical Therapy*. 2013;43(5):280-283. PMID: [23636096](#).
2. Ludewig PM, Kamonseki DH, Staker JL, **Lawrence RL**, Camargo PR, Braman JP. Changing our diagnostic paradigm: movement system diagnostic classification. *International Journal of Sports Physical Therapy*. 2017;12(6):884-893. PMID: [29158950](#).

Abstracts

Platform presentations

1. **Lawrence RL**, LaPrade RF, Braman JP, Ludewig PM. Differences in Shoulder Complex Motion in Subjects with and without Shoulder Pain. APTA Combined Sections Meeting; Las Vegas, NV. February 2014.
2. Bilodeau HL, Brown LB, Dahn DJ, Bonath DJ, Em M, Sarkar S, Braman JP, **Lawrence RL**, Ludewig PM. Effects of Scapular Position Changes on Rotator Cuff Tendon Mechanical Impingement Risk. 10th Conference of the International Shoulder Group; Waterloo, Ontario. July 2014.
3. **Lawrence RL**, Ludewig PM. Comparison between Methods of Calculating Shoulder Angular Displacements for Clinical Interpretation. 10th Conference of the International Shoulder Group; Waterloo, Ontario. July 2014.
4. **Lawrence RL**, Schlangen D, Schneider K, Schoenecker J, Senger A, Starr WC, Staker JL, Braman JP, Ludewig PM. The Interaction of Humeral Retroversion and Elevation on Supraspinatus Subacromial Compression during a Simulated Reaching Task. APTA Combined Sections Meeting; Anaheim, CA. February 2016.
5. Sessions WC, **Lawrence RL**, Staker JL, Ellermann JM, Braman JP, Ludewig PM. Minimal Distance Between the Supraspinatus Tendon and the Acromion During Multiplanar Humeral Elevation. Annual meeting of the Minnesota Orthopedic Society; Minneapolis, MN. May 2016.
6. **Lawrence RL**, Staker JL, Braman JP, Ludewig PM. Mechanical Internal Impingement of the Supraspinatus Tendon during a Simulated Reaching Task. 11th Conference of the International Shoulder Group; Winterthur, Switzerland. July 2016.
7. **Lawrence RL**, Schlangen D, Schneider K, Schoenecker J, Senger A, Starr WC, Staker JL, Braman JP, Ludewig PM. The Effect of Humeral Elevation and Retroversion on Supraspinatus Subacromial Compression during a Simulated Reaching Task. 11th Conference of the International Shoulder Group; Winterthur, Switzerland. July 2016.
8. **Lawrence RL**, Staker JL, Braman JP, Ludewig PM. Mechanical Internal Impingement of the Supraspinatus Tendon during Simulated Reaching. APTA Combined Sections Meeting; San Antonio, TX. February 2017.
9. Staker JL, **Lawrence RL**, Braman JP, Ludewig PM. Effects of Shoulder Elevation Plane on Rotator Cuff Subacromial Proximity. APTA Combined Sections Meeting; San Antonio, TX. February 2017.
10. Akbari-Shandiz M, **Lawrence RL**, Ellingson AM, Zhao KD, Ludewig PM. MRI vs CT-Based Shape Registration Accuracy for Quantifying Shoulder Motion Using Biplane

- Fluoroscopy. Annual Meeting of the American Society of Biomechanics; Boulder, CO. August 2017.
11. **Lawrence RL**, Ludewig PM. The Relationship between Glenohumeral Kinematics and Subacromial Proximities. APTA Combined Sections Meeting; New Orleans, LA. February 2018.
 12. **Lawrence RL**, Ludewig PM. The Effect of Scapulothoracic Upward Rotation on Subacromial Proximities. Annual Meeting of the American Society of Biomechanics; Rochester, MN. August 2018.
 13. Looft JM, Eid M, Fischbach J, Spracklin A, **Lawrence RL**, Ellingson AM, Braman JP, Ludewig PM. Finite Element Model of the Supraspinatus Tendon During Simulated Functional Reach. 12th Conference of the International Shoulder Group; Rochester, MN, USA. August 2018.
 14. **Lawrence RL**, Ludewig PM. The Coupled Mechanics of Scapulothoracic Upward Rotation. 12th Conference of the International Shoulder Group; Rochester, MN, USA. August 2018.
 15. Staker JL, **Lawrence RL**, Braman JP, Ludewig PM. Kinematics and Utility of Shoulder Joint Laxity Tests as Diagnostic Criteria in Multidirectional Instability. 12th Conference of the International Shoulder Group; Rochester, MN, USA. August 2018.
 16. Kage CC, Shandiz-Akbari M, Foltz MH, **Lawrence RL**, Brandon T, Twohey E, Ellingson AM. Lumbar Spine Biplane Fluoroscopy Validation via an Automated Shape-Matching Algorithm. Annual Meeting of the American Society of Biomechanics; Rochester, MN. August 2018.
 17. **Lawrence RL**, Keefe DF, Braman JP, Ludewig PM. Kinematic Mechanisms of Scapulothoracic Upward Rotation. APTA Combined Sections Meeting; Washington, DC. January 2019.
 18. Ludewig PM, Looft J, Spracklin A, Staker JL, **Lawrence RL**, Braman JP. Supraspinatus Stress and Strain across Arm Elevation. APTA Combined Sections Meeting; Washington, DC. January 2019.
 19. **Lawrence RL**, Baumer TG, Ruder M, Zael R, Mourzouros V, Bey MJ. The Relationship between 3D Glenohumeral Morphology and Rotator Cuff Pathology. Annual meeting of the Orthopaedic Research Society; Austin, TX. February 2019.
 20. Ellingson AM, Kage CC, Foltz MH, Johnson CP, **Lawrence RL**, Ludewig PM. Imaging Approaches to Quantifying Spinal Pathomechanics. XXVII Congress of the International Society of Biomechanics; Calgary, Canada. August 2019.
 21. **Lawrence RL**, Ruder MC, Bojnowski J, Moutzouros V, Bey MJ. Supraspinatus Shear Wave Speed as a Predictor of Tear Chronicity and Pre-Operative Shoulder Function. APTA Combined Sections Meeting; Denver, CO. February 2020.
 22. Ruder MC, **Lawrence RL**, Bey MJ. Running Exposure is Associated with Achilles Tendon Shear Wave Speed. Annual Meeting of the American Society of Biomechanics; virtual. August 2020.
 23. **Lawrence RL**, Ruder MC, Diefenbach BJ, Moutzouros V, Makhni EC, Muh S, Bey MJ. Rotator Cuff Repair Tissue Elongation Measured in-vivo 3 Months Following Arthroscopic Repair. APTA Combined Sections Meeting; San Antonio, TX. February 2022.
 24. Ivens R, Harris-Hayes M, **Lawrence RL**. The impact of altering scapular kinematics on the proximity between the rotator cuff footprint and the glenoid. Annual meeting of the American Society of Shoulder and Elbow Therapists; Atlanta, GA. October 2022.

25. **Lawrence RL**, Ivens R, Harris-Hayes M. The effect of Scapular Kinematics on Mechanisms of Rotator Cuff Injury: Subacromial Impingement. APTA Combined Sections Meeting; San Diego, CA. February 2023.
26. **Lawrence RL**, Ivens R, Harris-Hayes M. The effect of Scapular Kinematics on Mechanisms of Rotator Cuff Injury: Internal Impingement. APTA Combined Sections Meeting; San Diego, CA. February 2023.
27. Lee ECS, **Lawrence RL**, Rainbow M. Disentangling Allometry and Sex-Based Differences in Scapula Shape. Annual Meeting of the International Society of Biomechanics; Fukuoka, Japan. August 2023.
28. **Lawrence RL**, Dobben EA, Klochko CL, Soliman SB. The Not-So-Inferior Infraspinatus Muscle: Predictors of Infraspinatus Muscle Degeneration with an Isolated Supraspinatus Tendon Tear. Annual meeting of the Radiological Society of North America (RSNA); Chicago, IL. November 2023.
29. **Lawrence RL**, Soliman SB, Dalbøge A, Lohse KR, Bey MJ. Morphology and Occupational Exposure as Predictors of Supraspinatus Tendon Tears. APTA Combined Sections Meeting; Boston, MA. February 2024.
30. Lee ECS, Young NM, Li EY, **Lawrence RL**, Rainbow MJ. Tear-Associated Scapular Morphology Alters the Stabilizing Role of Supraspinatus. 14th Conference of the International Shoulder Group; Toronto, ON. June 2024.
31. Chen S, Lee ECS, Rainbow MJ, **Lawrence RL**. Geometric and Kinematic Accuracy of Low Dose CT Protocols for Shoulder Analysis. 14th Conference of the International Shoulder Group; Toronto, ON. June 2024.

Poster presentations

1. Schlichte BM, Farrell KP, Jones CL, **Lawrence RL**. Neurological Symptoms Status Post Arthroscopic Tenotomy of the Long Heads of the Biceps. APTA Combined Sections Meeting; San Diego, SD. January 2013.
2. Budlong MR, Butala BE, Clark RM, Dragseth JR, Ebert TR, Foelker RJ, **Lawrence RL**, Staker JL, Ludewig PM. Effects of Feedback Types on Sternoclavicular Elevation and Upper Trapezius Activation in Persons with Shoulder Pain. Spring Conference, Minnesota Chapter of the APTA; St. Paul, MN. April 2014.
3. **Lawrence RL**, LaPrade RF, Braman JP, Ludewig PM. Shoulder Complex Coupling as a Mechanism for Kinematic Differences between Symptomatic and Asymptomatic Subjects. 10th Conference of the International Shoulder Group; Waterloo, Ontario. July 2014.
4. Dragseth J, Budlong M, Butala B, Clark R, Ebert T, Foelker R, **Lawrence RL**, Staker JL, Ludewig PM. Effects of Feedback Types on Sternoclavicular Elevation and Upper Trapezius Activation in Persons with Shoulder Pain. APTA Combined Sections Meeting; Indianapolis, IN. February 2015.
5. Staker JL, **Lawrence RL**, Ludewig PM. Movement-Based Biomechanical Examination Following a Three-Year Case of Scapular Dyskinesia. APTA Combined Sections Meeting; Indianapolis, IN. February 2015.
6. Sessions WC, **Lawrence RL**, Staker JL, Ellermann JM, Braman JP, Ludewig PM. Minimal Distance Between the Supraspinatus Tendon and the Acromion During Multiplanar Humeral Elevation. Minnesota Medical Association's Annual Conference; Minneapolis, MN. September 2015.
7. **Lawrence RL**, Schlangen D, Schneider K, Schoenecker J, Senger A, Starr WC, Staker JL, Ellermann JM, Braman JP, Ludewig PM. Effects of Humeral Elevation on Supraspinatus Mechanical Impingement During a Simulated Reaching Task. University

- of Minnesota Institute of Engineering in Medicine Annual Conference; Minneapolis, MN. September 2015.
8. Schlangen D, Schneider K, Schoenecker J, Senger A, Starr WC, **Lawrence RL**, Staker JL, Braman JP, Ludewig PM. Effects of Humeral Elevation on Supraspinatus Mechanical Impingement during a Simulated Reaching Task. APTA Combined Sections Meeting; Anaheim, CA. February 2016.
 9. **Lawrence RL**, Schlangen D, Schneider K, Schoenecker J, Senger A, Starr WC, Staker JL, Ellermann JM, Braman JP, Ludewig PM. Effects of Humeral Elevation on Supraspinatus Mechanical Impingement during a Simulated Reaching Task. Annual meeting of the Orthopaedic Research Society; Orlando, FL. March 2016.
 10. Long M, **Lawrence RL**, Braman JP, Ludewig PM. Spatial Interactions Between the Supraspinatus Tendon and Coracoacromial Arch Through Three Planes and a Range of Glenohumeral Elevations. John S. Rogers Science Program, Lewis and Clark University; Portland, OR. August 2016.
 11. Braman JP, **Lawrence RL**, Staker JL, Ludewig PM. Is Impingement Dead? Concern for the Extrinsic Mechanism. Annual meeting of the American Shoulder and Elbow Surgeons (ASES); Boston, MA. October 2016.
 12. **Lawrence RL**, Ellingson AM, Ludewig PM. Single Plane Fluoroscopy for Quantifying Shoulder Complex Kinematics and Subacromial Proximities. Annual meeting of the Orthopaedic Research Society; San Diego, CA. March 2017.
 13. Kim K, **Lawrence RL**, Kyllonen N, Ludewig PM, Ellingson AM, Keefe DF. Anatomical 2D/3D Shape-Matching in Virtual Reality: A User Interface for Quantifying Joint Kinematics with Radiographic Imaging. IEEE Symposium on 3D User Interfaces (3DUI); Los Angeles, CA. March 2017.
 14. Spracklin A, **Lawrence RL**, Ludewig PM. The Effect of Axial Rotation on Shoulder Impingement. University of Minnesota Undergraduate Research Symposium; Minneapolis, MN. April 2017.
 15. Boudlali H, Akbari-Shandiz M, Kage C, Foltz M, **Lawrence RL**, Ellingson AM. Comparative Accuracy of Models Derived from CT Versus MRI for Measuring Intersegmental Cervical Spine Motion Using Biplanar Fluoroscopy. University of Minnesota Undergraduate Research Symposium; Minneapolis, MN. April 2017.
 16. Kage C, Akbari-Shandiz M, **Lawrence RL**, Boudlali H, Foltz M, Ellingson AM. Validation of Biplane Fluoroscopy for Cervical Spine Kinematics. Annual Meeting of the American Society of Biomechanics; Boulder, CO. August 2017.
 17. Looft JM, Eid M, Fischburn J, **Lawrence RL**, Ellingson AM, Ludewig PM. Stress and Strain in the Supraspinatus Tendon during a Simulated Functional Reach. Annual meeting of the Orthopaedic Research Society; New Orleans, LA. March 2018.
 18. Akbari-Shandiz M, **Lawrence RL**, Ellingson AM, Zhao KD, Ludewig PM. Validation of an Automatic 3D-2D Registration Algorithm for Quantifying Shoulder Motion Using MRI/CT Image Volume and Biplane Fluoroscopy. Annual meeting of the Orthopaedic Research Society; New Orleans, LA. March 2018.
 19. **Lawrence RL**, Sessions WC, Jensen M, Staker JL, Eid A, Breighner R, Helwig NE, Braman JP, Ludewig PM. The Effect of Glenohumeral Plane of Elevation on Supraspinatus Subacromial Proximity. University of Minnesota Supercomputing Institute Research Exhibition; Minneapolis, MN. April 2018.
 20. Kage C, Akbari-Shandiz M, **Lawrence RL**, Foltz M, Brandon T, Twohey E, Ellingson AM. Biplane Fluoroscopic Kinematic Comparison of an Automated Shape-Matching Technique vs. RSA for Cervical Spine Flexion Motion. World Congress of Biomechanics; Dublin, Ireland. July 2018.

21. Staker JL, **Lawrence RL**, Ellingson AM, Haglund SN, Braman JP, Ludewig PM. Comparison of Dynamic Joint Kinematics During Shoulder Elevation in Healthy Controls and Individuals Diagnosed with Multidirectional Instability. Annual Meeting of the American Society of Biomechanics; Rochester, MN. August 2018.
22. Kage C, Akbari-Shandiz M, Foltz MH, **Lawrence RL**, Brandon T, Twohey E, Ellingson AM. Cervical Spine Biplane Fluoroscopy: Automated Shape-Matching Algorithm Validation. Annual Meeting of the American Society of Biomechanics; Rochester, MN. August 2018.
23. Staker JL, **Lawrence RL**, Ellingson AM, Haglund S, Braman JP, Ludewig PM. Comparison of Dynamic Joint Kinematics during Shoulder Elevation in Healthy Controls and Individuals Diagnosed with Multidirectional Instability. APTA Combined Sections Meeting; Washington, DC. January 2019.
24. **Lawrence RL**, Braman JP, Ludewig PM. The Effect of Decreased Scapulothoracic Upward Rotation on Subacromial Proximities. APTA Combined Sections Meeting; Washington, DC. January 2019.
25. Saini G, Spracklin AL, **Lawrence RL**, Ludewig PM. The Effect of Axial Rotation on Shoulder Subacromial Contact and Compression. APTA Combined Sections Meeting; Washington, DC. January 2019.
26. Ruder MC, **Lawrence RL**, Baumer TG, Zael R, Bey MJ. The Effect of Region of Interest Definition and Data Fidelity on Mean Shear Wave Speed. Annual meeting of the Orthopaedic Research Society; Austin, TX. February 2019.
27. Ruder MC, **Lawrence RL**, Baumer TG, Zael R, Bey MJ. The Effect of Region of Interest Definition and Data Fidelity on Mean Shear Wave Speed. Henry Ford Health System Research Symposium; Detroit, MI. May 2019.
28. Ruder MC, **Lawrence RL**, Zael R, Bey MJ. Preliminary Comparison of Activity Levels between Rotator Cuff Repair Patients and Control Subjects. Annual Meeting of the American Society of Biomechanics; virtual. August 2020.
29. **Lawrence RL**, Ruder MC, Zael R, Jalics A, Olszewski A, Tchernychouk V, Moutzouros V, Makhni EC, Muh SJ, Bey MJ. Rotator Cuff Repair Tissue Elongation at 3 Months Following Arthroscopic Repair. Annual meeting of the Orthopaedic Research Society; virtual. February 2021.
30. **Lawrence RL**, Staker JL, Farrell KP, Soliman SB. Diagnostic Accuracy of Clinical Special Tests for Detecting Asymptomatic Rotator Cuff Tears. APTA Combined Sections Meeting; San Antonio, TX. February 2022.
31. **Lawrence RL**, Nicholson L, Lee ECS, Napier K, Zmistowski B, Rainbow MJ. Geometric Accuracy of Low Dose CT Scans for Shoulder Musculoskeletal Modeling. Annual meeting of the Orthopaedic Research Society; Long Beach, CA. February 2024.
32. Nicholson L, Lee ECS, Napier K, Zmistowski B, Rainbow MJ, **Lawrence RL**. Geometric Accuracy of Low Dose CT Protocols for Musculoskeletal Shoulder Modeling. Washington University Undergraduate Research Symposium; St. Louis, MO. April 2024.
33. Baldwin S, **Lawrence RL**. Developing Procedures for Reconstructing Fast and Accurate 3D Anatomical Models from CT. Washington University Undergraduate Research Symposium; St. Louis, MO. April 2024.
34. Chen S, Lee ECS, Rainbow MJ, **Lawrence RL**. Accuracy of low dose CT scanning for shoulder morphology and motion analysis. Annual meeting of the American Society of Biomechanics; Madison, WI. August 2024 (accepted).

Software

1. **Lawrence RL.** KinematicsToolbox: A Comprehensive Software Package for Analyzing and Visualizing Radiographic Motion Capture Data. <https://doi.org/10.7936/6RXS-103624>.
2. **Lawrence RL.** DICOMToolbox: A GUI-based program for viewing, cleaning, and interacting with DICOM images. <https://doi.org/10.7936/6RXS-103642>.
3. **Lawrence RL, Harris-Hayes M.** Visual Kinetics: A tool for teaching and learning basic mechanical concepts relevant to biomedical applications.

Continuing Education Instruction

1. An Evidence-Based Approach to the Examination, Assessment, and Treatment of the Knee. Continuing Education Course. Rock Valley Physical Therapy; Moline, IL. January 2010.
2. A Case-Based Approach to the Upper Quadrant. Continuing Education Course. Program in Physical Therapy, St. Ambrose University; Davenport, IA. March 2010.
3. A Case-Based Approach to the Lower Quadrant. Continuing Education Course. Program in Physical Therapy, St. Ambrose University. St. Ambrose University; Davenport, IA. March 2011.
4. Manual Therapy I: Differentiation and Intervention in Musculoskeletal Practice. Continuing Education Course. Program in Physical Therapy, St. Ambrose University; Davenport, IA. January 2013.
5. The Aging Shoulder. Continuing Education Course. Minnesota Physical Therapy Association; Minneapolis, MN. November 2014.
6. Integration of Biomechanics and Movement Classification in the Shoulder Region. Continuing Education Course. Sanford Health; Fargo, ND. October 2015.
7. Integration of Biomechanics and Movement System Classification in Diagnosis & Treatment for Shoulder Pain & Dysfunction. Continuing Education Course. University of Minnesota; Minneapolis, MN. September 2016.
8. Integration of Biomechanics and Movement System Classification in Diagnosis & Treatment for Shoulder Pain & Dysfunction. Continuing Education Course. St. Ambrose University; Davenport, IA. October 2016.
9. The Effect of Altered Scapular Kinematics on Mechanisms of Rotator Cuff Injury. Nexus Motion; virtual. June 2023.

Community Service

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| 2002-2006 | Volunteer, Loaves and Fish Ministry, First United Methods Church; Peoria, IL. |
| 2003-present | Volunteer donor, American Red Cross Blood Services. |
| 2004 | Volunteer, Easter Seals Timber Point Outdoor; Bloomington, IL. |
| 2007 | Volunteer, Quad Cities Special Olympics; Davenport, IA. |
| 2011 | Volunteer, John Deere Classic PGA Tournament; Silvis, IL. |
| 2010-2012 | Participant, Bike MS, Fundraiser for The National Multiple Sclerosis Society. |
| 2011-2012 | Volunteer physical therapy consultant; Rock Ridge High School Athletics; Rockridge, IL. |
| 2013-2016 | Volunteer physical therapy preceptor, Phillips Neighborhood Clinic; Minneapolis, MN. |
| 2013-2018 | Volunteer, Hennepin Avenue United Methodist Church Community Meals Program; Minneapolis, MN. |

2022-present Volunteer, Forest Park Forever; St. Louis, MO.
2022-present Participant, Susan G. Komen 3-Day, Fundraiser for breast cancer research.
2023-present Faculty volunteer, National Biomechanics Day outreach program, WUSM.
2023 Faculty liaison, Physical Therapy Day of Service; Washington University.
2024-present Volunteer, Operation Change STL; St. Louis, MO.
2024 Panelist, Junior Jumpstart; Washington University.