

# Christian R. D'Andrea

PhD Candidate, Drexel University · Philadelphia, PA · [crd73@drexel.edu](mailto:crd73@drexel.edu) · [dandrea.sh](https://dandrea.sh)

## RESEARCH FOCUS

---

Computational methods for fast, person-specific biomechanical simulation, including inverse analysis, neural network finite element solver surrogates, and human–device and human–robot interaction for general and medical applications

## DEMONSTRATIONS AND SOFTWARE

---

- [Humanoid + Finite Element Model Real-Time Interaction \(code\)](#): real-time inference of hyperelastic cylinder mesh deformation from humanoid robot actions
- [GaitDynamics with Shoes On: Real-Time High-Resolution Simulation of Foot Pressure \(code\)](#): real-time inference of shoe sole deformation and pressure under prescribed gait

## EDUCATION

---

### PhD in Biomedical Engineering

Aug. 2026 (expected)

Drexel University, Philadelphia, PA

Working Dissertation Title: *Patient-Specific Finite Element Modeling of Pediatric Scoliosis Correction with Growth Modulation*

Thesis Advisor: Sriram Balasubramanian, PhD

### B.S. and M.S. in Biomedical Engineering

Aug. 2020

Drexel University, Philadelphia, PA

Thesis Title: *Prediction of Anterior Vertebral Body Tethering Outcomes with Patient-Specific Finite Element Modeling*

Thesis Advisor: Sriram Balasubramanian, PhD

## RESEARCH EXPERIENCE

---

### Biomechanical Simulations of Pediatric Scoliosis Progression and Correction

2018–Present

Thesis Advisor: Sriram Balasubramanian, PhD

- Created an image-based growing-spine FE model with region-specific stress-modulated vertebral growth to simulate scoliosis progression and implant-driven correction, using HyperMesh and LS-DYNA
- Developed a pipeline to morph spine FE models to patient/animal-specific geometry using X-ray/CT landmark points with dual-kriging in MATLAB, while developing deep-learning-based methods for automated landmark point placement
- Built an orchestration framework to execute parameterized spine simulations in parallel on SLURM computing clusters using Python, including PyVista for visualization
- Implemented Bayesian optimization- and quasi-random sampling-based calibration frameworks to calibrate model parameters to X-ray- or CT-acquired 3D data and validate modeling approaches in Python
- Applied the simulation and calibration frameworks to prediction of human idiopathic scoliosis correction with vertebral body tethering in 20 patients with up to 5-year follow-up, generally within clinical measurement uncertainty, in collaboration with Children’s Hospital of Philadelphia, and to 16-week porcine scoliosis induction with a novel tether-based implant in collaboration with the University of Pennsylvania School of Veterinary Medicine

### Real-Time Biomechanics of Intervertebral Disc and Spine Deformation

Mar. 2026–Present

Collaborators: Michael Sacks, PhD, Ben Thomas, and Kenneth Meyer, University of Texas at Austin

- Trained an unsupervised neural-network finite element model to predict intervertebral disc displacement fields across the range of disc geometries found in the adult human spine by minimizing total potential energy rather than training on conventional solver solutions, using JAX/Equinox and JIT-compiled training/evaluation kernels
- Benchmarked 49 architecture and hyperparameter configurations across six-degree-of-freedom loading, achieving median nodal displacement error of 0.02 mm (0.2% of disc height) on loading cases reported from *in vitro* testing relative to the corresponding conventional finite element solves
- Designed gradient-driven and derivative-free inverse analyses to calibrate annulus fibrosus material parameters, including synthetic inverse tests against corresponding finite element solutions with loading based on *in vitro* testing moments and direct calibration against range-of-motion targets
- Extending these methods from single intervertebral discs toward spine-level range-of-motion simulation

## PUBLICATIONS

---

### PUBLISHED

1. **D'Andrea, C. R.**, Orbach, M. R., Norceide, D. J., Boyes, M. S., Moore, A. C., Jordan, J., Schaer, T. P., Singh, A., Cahill, P. J., Vresilovic, E. J., Snyder, B. D., and Balasubramanian, S. “Stress-Relaxation and Failure Properties of Spinal Ligaments in Pigs With and Without Scoliosis-Like Deformity.” *ASME Journal of Biomechanical Engineering*. November 2025; 147(11): 111008.
2. **D'Andrea, C. R.**, Samdani, A. F., and Balasubramanian, S. Patient-specific finite element modeling of scoliotic curve progression using region-specific stress-modulated vertebral growth. *Spine Deformity* 11, 525–534 (2023).
3. Balasubramanian, S., **D'Andrea, C. R.**, Viraraghavan, G., and Cahill, P. J. “Development of a Finite Element Model of the Pediatric Thoracic and Lumbar Spine, Ribcage, and Pelvis With Orthotropic Region-Specific Vertebral Growth.” *ASME Journal of Biomechanical Engineering*. October 2022; 144(10): 101007.
4. **D'Andrea, C. R.**, Alfraihat, A., Singh, A., Anari, J. B., Cahill, P. J., Schaer, T. P., Snyder, B. D., Elliott, D. M., and Balasubramanian, S. “Part 2. Review and meta-analysis of studies on modulation of longitudinal bone growth and growth plate activity: A micro-scale perspective.” *Journal of Orthopaedic Research*. 2021; 39: 919–928.
5. **D'Andrea, C. R.**, Alfraihat, A., Singh, A., Anari, J. B., Cahill, P. J., Schaer, T. P., Snyder, B. D., Elliott, D. M., and Balasubramanian, S. “Part 1. Review and meta-analysis of studies on modulation of longitudinal bone growth and growth plate activity: A macro-scale perspective.” *Journal of Orthopaedic Research*. 2021; 39: 907–918.

### MANUSCRIPTS

- Additional manuscripts under review or in preparation on scoliosis biomechanics and patient-specific finite element modeling

## CONFERENCE PRESENTATIONS

---

### ORAL PRESENTATIONS

1. **D'Andrea, C. R.**, Viraraghavan, G., Cahill, P. J., and Balasubramanian, S. “Anterior Vertebral Body Tethering Outcome Prediction with Patient-Specific Finite Element Models: Preliminary Retrospective Validation with 20 Pediatric Scoliosis Patients.” Northeast Bioengineering Conference (NEBEC), Philadelphia, Pennsylvania, USA, 2026.
2. **D'Andrea, C. R.**, Orbach, M. R., Fusco, A., Vresilovic, E. J., Snyder, B. D., Schaer, T. P., Cahill, P. J., and Balasubramanian, S. “Scoliosis Induction in the Juvenile Porcine Spine Using a Growth-Modulating Posterior Tether: Finite Element Model Development and Calibration.” Northeast Bioengineering Conference (NEBEC), Philadelphia, Pennsylvania, USA, 2026.
3. Lifat, A. S., **D'Andrea, C. R.**, and Balasubramanian, S. “Hierarchical Deep Learning Approach for Automated Vertebral Landmark Detection in Frontal and Lateral Chest Radiographs.” Northeast Bioengineering Conference (NEBEC), Philadelphia, Pennsylvania, USA, 2026. Presented by A. S. Lifat.
4. **D'Andrea, C. R.**, Cahill, P. J., and Balasubramanian, S. “Anterior Vertebral Body Tethering Outcome Prediction with Patient-Specific Finite Element Models: Preliminary Retrospective Validation with 20 Pediatric Scoliosis Patients.” Philadelphia Spine Research Society Symposium, Newark, Delaware, USA, 2025.
5. **D'Andrea, C. R.**, Cahill, P. J., and Balasubramanian, S. “An (Increasingly) Automated Framework for Simulation of Adolescent Idiopathic Scoliosis Curve Progression and Correction with Anterior Vertebral Body Tethering.” Philadelphia Spine Research Society Symposium, Philadelphia, Pennsylvania, USA, 2023.
6. **D'Andrea, C. R.**, Viraraghavan, G., and Balasubramanian, S. “Finite Element Modeling of Scoliosis Correction and Growth after Vertebral Body Tethering.” Philadelphia Spine Research Society Symposium, Philadelphia, Pennsylvania, USA, 2020. *Best Student Presentation Award*
7. **D'Andrea, C. R.**, Viraraghavan, G., and Balasubramanian, S. “Finite Element Simulation of Scoliosis Correction with Vertebral Body Tethering and Growth.” Orthopaedic Research Society Annual Meeting, Phoenix, Arizona, USA, 2020.

### POSTER PRESENTATIONS

1. **D'Andrea, C. R.**, Orbach, M. R., Cahill, P. J., Schaer, T. P., and Balasubramanian, S. “Simulated Scoliosis Induction in Tethered Porcine Spine Finite Element Models.” Philadelphia Spine Research Society Symposium, Newark, Delaware, USA, 2025. *2nd Place Poster Award*
2. Orbach, M. R., **D'Andrea, C. R.**, Schaer, T. P., Cahill, P. J., and Balasubramanian, S. “A Robust Method for Automated Landmark Detection and Measurements on Spine Surface Models.” Biomedical Engineering Society

Annual Meeting, Baltimore, Maryland, USA, 2024.

3. **D’Andrea, C. R.**, Orbach, M. R., Norceide, D. J., Moore, A. C., Newman, H. R., Elliott, D. M., Schaer, T. P., Cahill, P. J., Sinder, B. P., Snyder, B. D., and Balasubramanian, S. “Viscoelastic and Failure Properties of Spinal Ligaments in Yorkshire Piglets with Induced Scoliosis.” Biomedical Engineering Society Annual Meeting, Baltimore, Maryland, USA, 2024.
4. **D’Andrea, C. R.**, Watson, E. K., Orbach, M. R., Boyes, M. S., Sinder, B. P., Newman, H. R., Vresilovic, E. J., Elliott, D. M., Snyder, B. D., Schaer, T. P., Cahill, P. J., and Balasubramanian, S. “Simulated Scoliosis Induction in a Tethered Porcine Spine Finite Element Model.” Philadelphia Spine Research Society Symposium, Skytop, Pennsylvania, USA, 2024.
5. **D’Andrea, C. R.**, Cahill, P. J., and Balasubramanian, S. “Determination of Stress-Growth Relationship in Immature Porcine Vertebrae using Finite Element Modeling.” Philadelphia Spine Research Society Symposium, Philadelphia, Pennsylvania, USA, 2023.
6. **D’Andrea, C. R.**, Orbach, M. R., Norceide, D. J., Moore, A. C., Newman, H. R., Elliott, D. M., Schaer, T. P., Cahill, P. J., Sinder, B. P., Snyder, B. D., and Balasubramanian, S. “Viscoelastic and Failure Properties of Spinal Ligaments in Yorkshire Piglets with Induced Scoliosis.” Philadelphia Spine Research Society Symposium, Philadelphia, Pennsylvania, USA, 2023.
7. **D’Andrea, C. R.**, Samdani, A. F., and Balasubramanian, S. “Patient-Specific Finite Element Modeling of Scoliotic Curve Progression using Region-Specific Stress-Modulated Vertebral Growth.” Philadelphia Spine Research Society Symposium, Skytop, Pennsylvania, USA, 2022.
8. **D’Andrea, C. R.**, Cahill, P. J., and Balasubramanian, S. “Determination of Stress-Growth Relationship in Immature Porcine Vertebrae using Finite Element Modeling.” Philadelphia Spine Research Society Symposium, Skytop, Pennsylvania, USA, 2022.
9. **D’Andrea, C. R.**, Samdani, A. F., and Balasubramanian, S. “Patient-Specific Finite Element Modeling of Scoliotic Curve Progression using Region-Specific Stress-Modulated Vertebral Growth.” Biomedical Engineering Society Annual Meeting, San Antonio, Texas, USA, 2022.
10. **D’Andrea, C. R.**, Samdani, A. F., and Balasubramanian, S. “Integration of Skeletal Maturity in Patient-Specific Finite Element Model Simulations of Adolescent Idiopathic Scoliosis Curve Progression.” World Congress of Biomechanics, Taipei, Taiwan, 2022.
11. **D’Andrea, C. R.**, Samdani, A. F., and Balasubramanian, S. “Integration of Skeletal Maturity in Patient-specific Finite Element Model Simulations of Adolescent Idiopathic Scoliosis Curve Progression.” Orthopaedic Research Society Annual Meeting, Tampa, Florida, USA, 2022.
12. **D’Andrea, C. R.**, Viraraghavan, G., and Balasubramanian, S. “Finite Element Model of Region-specific Pediatric Spine Growth.” Orthopaedic Research Society Annual Meeting, Phoenix, Arizona, USA, 2020.
13. **D’Andrea, C. R.**, Singh, A., and Balasubramanian, S. “Finite Element Model of the Neonatal Brachial Plexus and Spinal Cord.” Summer Biomechanics, Bioengineering, and Biotransport Conference Annual Meeting, Seven Springs, Pennsylvania, USA, 2019.
14. Viraraghavan, G., **D’Andrea, C. R.**, Samdani, A. F., and Balasubramanian, S. “Anterior Vertebral Body Tether Simulations using an Adolescent Idiopathic Scoliosis Patient-Specific Finite Element Model.” Biomedical Engineering Society Annual Meeting, Philadelphia, Pennsylvania, USA, 2019.
15. **D’Andrea, C. R.**, Singh, A., and Balasubramanian, S. “Finite Element Model of the Neonatal Brachial Plexus and Spinal Cord.” Biomedical Engineering Society Annual Meeting, Philadelphia, Pennsylvania, USA, 2019.
16. **D’Andrea, C. R.**, Viraraghavan, G., and Balasubramanian, S. “Finite Element Simulation of Scoliosis Correction with Vertebral Body Tethering and Growth.” Philadelphia Spine Research Society Symposium, Skytop, Pennsylvania, USA, 2019.
17. **D’Andrea, C. R.**, Viraraghavan, G., and Balasubramanian, S. “Finite Element Model of Region-Specific Pediatric Spine Growth.” Philadelphia Spine Research Society Symposium, Skytop, Pennsylvania, USA, 2019.

## FELLOWSHIPS, GRANTS, AND AWARDS

---

- Research and Engineering for Pediatrics by Interdisciplinary Collaboration Leveraging Education and Partnerships (R-EPIC LEAP) for Pediatric Healthcare Fellow, Graduate Assistance in Areas of National Need (GAANN), 2021–2025.
- Dragon Impact Grant, awarded May 2026, \$10,000.
- Teaching Assistant Excellence Award, May 2026.

## TECHNICAL SKILLS

---

**Simulation:** LS-DYNA, HyperMesh/HyperWorks, ANSYS, FEniCSx, JAX-FEM

**Scientific Computing and ML:** Python, JAX, PyTorch, MATLAB, R

**Visualization and Apps:** PyVista, three.js, p5.js, React, Vite, Astro (JavaScript), Hugo (Go), FastAPI

## TEACHING EXPERIENCE

---

**Teaching Assistant · Drexel University School of Biomedical Engineering, Science, and Health Systems** *Sept. 2021–March 2026*

- Instructed Biomechanics I and II labs (BMES 441, 442, 641, and 642), including foot pressure mapping, gait analysis using marker-based motion capture data, EMG, and EKG analysis, biomechanical testing of bone and ligaments, and finite element modeling of biomechanical systems.

**Adjunct Instructor · Widener University School of Engineering** *Sept. 2021–May 2022*

- Instructed a Biomedical Engineering Laboratory course, including an introduction to MATLAB programming and analysis of gait, EMG, and EKG data.

## MENTORING

---

- Mentored 2 PhD students, 4 master's students, 4 senior design teams, and 4 high-school trainees in spine finite element modeling, CT/X-ray segmentation, biomechanics data analysis, and model development.
- Supported student projects on maternal pelvis and fetal brachial plexus finite element modeling, soft scoliosis brace design, manual and deep-learning-based vertebral segmentation, and patient-specific spine finite element modeling.

## EMPLOYMENT

---

**Research and Development Engineering Co-op · DePuy Synthes Companies** *Sept. 2017–Apr. 2018*

- Designed custom surgical instrumentation and modified existing instrumentation to meet surgeon requests using CAD tools.
- Ensured surgical instrumentation compliance with FDA regulations and drafted corresponding 510(k) reports.

**Research and Development Engineering Co-op · Halo Labs Inc.** *Sept. 2016–Apr. 2017*

- Designed, assembled, and calibrated mechanical, electronic, and optical components of Aura, a subvisible particle analysis system for characterization of biologic drugs.

## PROFESSIONAL SERVICE

---

- Reviewer, *Annals of Biomedical Engineering*.
- Member, Patient Research Advisory Committee, [Setting Scoliosis Straight Foundation](#), 2025–Present.

## PROFESSIONAL SOCIETIES

---

- Biomedical Engineering Society (BMES), 2020–2022.
- Orthopaedic Research Society (ORS), 2020–2023.