Mission
The Department of Physical Therapy, Movement and Rehabilitation Sciences’ research mission is to build the evidence for best practices to maintain and improve the health and wellbeing of the local, national, and global community members.

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Highlights from 2015

The Department of Physical Therapy, Movement, and Rehabilitation Sciences had an excellent year with regard to research in 2015. The department continued to grow with new faculty and research facilities. Researchers were very productive publishing their work and submitting new grants applications to expand our current activities in upcoming years. Highlights from the 2015 calendar year include

- Over 48 peer reviewed journal publications
- Over 110 peer reviewed conference abstracts, papers, and presentations
- Over 679 citations of works by tenure-track faculty with an average H-index of 8.1
- $6.92 million in direct costs for multi-year grants submitted to external agencies
- $1.45 million in direct costs new multi-year grants awarded.
- $1.44 million in direct costs for internally & externally funded research activities
- Three new tenure-track faculty

Description of research program

At the heart of the research is the success of the department’s faculty and their resources. The department has ten tenure-track and seventeen clinical faculty devoted to the department’s research mission. The department has over 4,900 square feet of research laboratories mostly located within Robinson and Richards Hall equipped with the state of the art research equipment. Equipment include systems to measure human motion, posture and force, neurophysiology, muscle and tissue physiology, and musculoskeletal structure and include intervention systems such as rehabilitation robots and office ergonomic furniture. Other capabilities include survey and population data base resources and software.

Growth with new faculty!

The department’s research expanded with the appointment of three new members of our faculty, Drs. Danielle Levac, Gene Tunik, and Josh Stefanik.

Danielle Levac, BSc.PT, MSc, PhD  
Dr. Levac is a physical therapist and Assistant Professor in the Department of Physical Therapy, Movement and Rehabilitation Sciences at Bouvé College of Health Sciences, Northeastern University. She directs the Rehabilitation Games and Virtual Reality (ReGameVR) Laboratory. She joined the faculty in January of 2015. She received her Ph.D. in rehabilitation sciences from the McMaster University in Hamilton Ontario.

Dr. Levac’s research interests stem from her clinical practice experience as a pediatric physical therapist searching for rehabilitation strategies that effectively engage client participation and promote motor learning: namely, permanent, transferable and generalizable changes in motor skill capabilities. She is motivated by the potential of virtual reality (VR) and active video gaming systems to promote motor learning in pediatric and adult neurological populations. VR systems that motivate users to control games by means of movement and posture have been embraced within
rehabilitation and appear to challenge user’s motor skills. Although these systems incorporate key motor learning principles known to be critical for rehabilitation (such as task-oriented training and multisensory feedback), we know very little about how therapists can use this technology to promote motor learning. Resources to support the integration of VR systems into clinical practice remain scarce.

Joshua Stefanik, MSPT, PhD Joshua Stefanik is an Assistant Professor of Physical Therapy, Movement and Rehabilitation Sciences. He joined the faculty in September 2015. Prior to coming to Northeastern he was a Research Assistant Professor of Physical Therapy and Athletic Training at Boston University. He received his M.S. in Physical Therapy from Northeastern and his PhD in Anatomy and Neurobiology from Boston University School of Medicine where he also did a postdoctoral fellowship in Clinical Epidemiology. Josh’s primary research interests are in the field of knee (patellofemoral joint) osteoarthritis, knee pain and lower extremity biomechanics. His ultimate goal is to develop novel and effective rehabilitation interventions for older individuals with knee osteoarthritis.

Eugene Tunik, PhD, PT Gene Tunik is joining the college as an Associate Professor in the Department of Physical Therapy, Movement and Rehabilitation Sciences. He joined the faculty in September 2015. Prior to coming to Northeastern, he was an Associate Professor at the Department of Rehabilitation and Movement Science at Rutgers University. Gene received his B.S. in Physical Therapy from Northeastern University, his PhD in Neuroscience from Rutgers University, and completed a postdoctoral fellowship at Dartmouth. Gene’s primary research interest is in the study of brain mechanisms involved in human motor control, motor learning, and motor recovery from disease.

New grants!

Does narrative feedback enhance motor learning of a virtual balance task in children with cerebral palsy?

Danielle Levac and Amy Lu (Bouvé College of Health Sciences and College of Arts, Media and Design) were awarded a TIER 1 Interdisciplinary Research Award for their project entitled: Does narrative feedback enhance motor learning of a virtual balance task in children with cerebral palsy? Cerebral palsy is the primary cause of childhood disability in the United States, leading to balance impairments that interfere with functional mobility and impact a child’s ability to learn new skills. The feedback provided by physical therapists during motor skill learning is important because it can help children plan movements and detect errors. Feedback should be salient and motivating to enhance adherence in abundant practice trials. However, little is known about the best ways to provide feedback to children with CP for effective motor learning. Since we know that many children are attracted to fantasy narratives, we want to know whether receiving narrative feedback might help children learn a new movement task better than regular feedback. This research project will compare the effects on retention and transfer of learning of two types of feedback provided in a virtual environment during learning of a new virtual reality (VR) balance task: narrative feedback (in the context of a story related to the VR task) and regular feedback. The goal is to establish proof of concept and lead to further research studies in this area. VR is an increasingly popular physical therapy intervention for children with CP, and our
partnership with VR game developers can translate the findings into practice to create VR games for children with CP that incorporate narrative feedback conditions.

**Predictability in Complex Object Control (Co-I, CJ Hasson, PI: Dagmar Sternad).**
Assistant Professor CJ Hasson is part of a research team examining motor learning strategy with better understanding the movement dynamics. They were awarded a 5-year R01 NIH grant this past year. Manipulation of complex objects such as transporting a cup of coffee without spilling creates complex interaction forces that humans need to predict, preempt, and compensate for. Using a virtual experimental set-up that simulates the task of “carrying a cup of coffee” and novel analysis approaches, this research aims to show that humans learn control strategies that make object dynamics predictable. This research will help gain insights into many neurological diseases that compromise manual dexterity, such as dystonia, multiple sclerosis, and apraxia, including aging. The grant is for five years.

**Planning and Updating in Frontoparietal Networks for Grasping (PI Gene Tunik)**
Associate Professor Gene Tunik brings with him an R01 funded by the NIH examining brain networks with grasping activities. A number of brain disorders caused by cortical lesions due to stroke or trauma can be explained by abnormalities in integration of sensory information and motor commands. This project uses brain imaging and non-invasive brain stimulation, combined with novel perturbations of grasping movements with robotics and virtual environments to study the roles played by frontoparietal brain areas in different stages of sensorimotor integration and to identify specific contributions of brain networks subserving goal-directed grasping. This work will advance our understanding of brain-behavior interactions as it impact clinicians and basic scientists, in line with the mission of the NIH, and direct relevance to public health.

**Identifying cases of patellofemoral joint osteoarthritis & their hip impairments**

**Rheumatology Research Foundation**
The goal of this proposal is to determine criteria that can be used to identify individuals with patellofemoral joint osteoarthritis (PFJ OA) and then, using these criteria to select patients, to quantify strength and movement patterns in subjects with PFJ OA. We will begin using data from the Clinical Assessment Study Knee (CAS-K)[3, 6, 10]. CAS-K is a prospective study of knee pain and OA in the general population in the United Kingdom and offers a unique advantage of having radiographs of the knee and information on clinical examination measures (e.g. joint crepitus, PFJ compression, tenderness around the knee joint, etc.). Additionally, to identify strength and movement impairments (potential rehabilitation targets), subjects with PFJ OA (and controls without OA) will be recruited locally from the community, physician and physical therapy clinics and other ongoing studies; our group has recently successfully completed a PFJ OA knee bracing study[24], demonstrating our ability to successfully recruit such subjects. Subjects will undergo hip muscle strength assessment and motion analysis with joint kinematic data while performing functional activities (gait, stairs, sit to stand and stand to sit). Our specific aims are to: Specific Aim 1: Determine the diagnostic utility of clinical examination findings, pain location and painful activities to identify PFJ OA Hypothesis 1: Using clinical examination findings, in additional to self-reported pain location and with activities, will better discriminate knees with primarily PFJ OA vs. primarily TFJ/No OA Specific Aim 2: Quantify hip muscle strength in subjects with PFJ OA and controls Hypothesis 2: Subjects with PFJ OA will have lower hip extensor, abductor and external rotator muscle strength compared with control subjects Specific Aim 3: Quantify trunk, pelvis and hip kinematics during functional activities in subjects with PFJ OA and controls Hypothesis 3: Subjects with PFJ OA will demonstrate higher peak ipsilateral trunk lean, contralateral pelvic drop, hip internal rotation and hip adduction during functional activities compared with control subjects.
APPENDIX

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Description of Laboratories

Occupational Biomechanics and Ergonomics Laboratory (Jack Dennerlein)
001 Robinson Hall 1190 square feet
The Occupational Biomechanics and Ergonomics Laboratory research aims to prevent work-related musculoskeletal disorders by understanding injury mechanisms through laboratory and field studies that utilize biomechanics, neuromuscular, exposure-response, and intervention study designs and methods. Located on the ground floor of Robinson Hall, this space contains a state of the art office space for research staff and trainees and a human movement and biomechanics laboratory space, both approximately 600 square feet. The flexible design of biomechanics laboratory space allows for a range of experiments investigating thumb movements while using mobile computing technology to the ergonomics of dynamic office workstation designs. The laboratory contains equipment to measure human motion and posture, surface electromyography, and applied forces. Human motion equipment includes Northern Digital Optotrak system and Ascension Technology Mini-Bird systems. Electromyography equipment include a 12 channel Delsys and an 8 channel wireless Mega systems. Load cells to measure force include custom made force plates for computing to ATI 3-axis force-torque sensors. www.neu.edu/ergonomics

Center for Cancer Survivorship Studies (Ann Marie Flores)
406 Robinson Hall 320 square feet
The mission of the center is to describe and evaluate issues of cancer survivorship that affect physical and functional well-being and quality of life after a cancer diagnosis with special emphasis on minorities, the poor and medically underserved. The center is also devoted to the development and testing of physical therapy and technological interventions to improve physical and functional well-being and quality of life after a cancer diagnosis. The center encourages collaborative research that includes the fields of physical therapy, biostatistics, public health, epidemiology, sociology, biomedical & biomechanical engineering, psychology, nursing, oncology (surgical, medical and radiation), pharmacy sciences, cancer, and cell biology.

Neuromotor Systems Laboratory (C.J. Hasson)
426 Richards Hall 700 square feet
The goal of the Neuromotor Systems Laboratory is to understand how the nervous system learns, interacts with, and takes advantage of the properties of the musculoskeletal system and the external environment to achieve task goals. They are particularly interested in understanding how age-related changes in the neuromuscular system contribute to decrements in movement performance and stability. The laboratory’s larger room will contain an isolated experimental room and a separate office area for research staff and student activities. The experimental room will house an electromyography system (records muscle activity), a high-performance robotic arm, and high-performance computers for
modeling, simulation, and data analysis. This equipment will be used to perform human motor control and learning experiments. A separate room will house Dr. Hasson’s office and a small workshop that will be used to fabricate custom apparatuses and maintain experimental equipment. [http://www.neu.edu/neuromotorsystems/lab](http://www.neu.edu/neuromotorsystems/lab/)

**Teaching and Learning Innovation Program (Lorna Hayward)**

Dr. Hayward’s research centers on the scholarship of teaching and learning as it relates to student learning, cultural competency, professional role formation and novice to expert transitions. Dr. Hayward designs and examines educational models that involve the use of technology, standardized patient interactions, and experiential education in physical therapist students. Dr. Hayward’s research is currently supported by the Kenneth B. Schwartz Center and the Wellesley Village Church. [http://www.northeastern.edu/lornahayward](http://www.northeastern.edu/lornahayward).

**Rehabilitation Games & Virtual Reality (ReGame VR) Laboratory (Danielle Levac)**

402 Robinson Hall 500 Square Feet

The ReGameVR lab focuses on promoting the sustainable, evidence-based integration of virtual reality (VR) and active video gaming systems into rehabilitation. We explore how VR-based therapy can improve motor learning, balance, functional mobility and participation in children and adults with neuromotor impairments. We evaluate motor learning paradigms in virtual environments to understand how task practice conditions impact motor learning processes and outcomes. Our mission is to produce clinically-relevant, high-quality evidence in the field of virtual rehabilitation. A key goal is to partner with clinicians to create user-friendly knowledge translation resources that facilitate the integration of VR and active video gaming into clinical practice. Specifically, we conduct research to: Understand how VR systems can exploit key motor learning principles known to be critical for rehabilitation (such as motivation, task-oriented training and multisensory feedback) and create transfer-oriented practice conditions. Evaluate motor learning research paradigms in virtual environments to explore how differing task practice conditions impact motor learning outcomes. Develop and evaluate the effectiveness of VR systems and active video games that promote motor learning and functional recovery from neurological impairments. Create knowledge translation resources for therapists interested in integrating VR and gaming systems into clinical practice. [http://www.northeastern.edu/regamevr/](http://www.northeastern.edu/regamevr/)

**Rehabilitation and Epidemiology Trainee Program (Maura D. Iversen)**

The mission of the Rehabilitation and Clinical Epidemiology Trainee Program is to provide students with exposure to clinical translational research in the area of rehabilitation sciences. A central focus of our research is the design, evaluation and implementation of behavioral and rehabilitation interventions to improve health outcomes in persons with arthritis. Specific areas of expertise include studies of persons with rheumatoid arthritis, systemic lupus erythematosus, spinal stenosis and osteoporosis. Dr. Iversen’s work is has been funded by the National
Institutes of Health, the Research & Education Foundation, Foundation for Physical Therapy, the Arthritis Foundation and Farnsworth Foundation.

Lab for Movement Neuroscience (Gene Tunik)
404 Robinson 400 Square Feet
Research in this lab is geared toward understanding the neural processes that govern perception and action in health and disease. A central goal is to translate these principles of neuroscience toward improving delivery of rehabilitative therapies for patients with disordered movement. A number of approaches are used to probe these issues, including functional magnetic resonance imaging, transcranial magnetic stimulation, psychophysics and kinematics analyses, and patient-based paradigms. http://www.northeastern.edu/tuniklab/

Neurophysiology Laboratory (Robert Sikes)
Mugar Hall 300 Square Feet
The Neurophysiology Laboratory of the Department of Physical Therapy explores the role of limbic system brain structures in pain and stress. The lab conducts pre-clinical electrophysiological experiments using animal models of cutaneous and visceral pain. This facility is one of very few that records simultaneous neuron activity at multiple levels of the pain transmission network and is part of a multidiscipline collaboration with labs at Northeastern and Boston University Medical School which conduct the brain imaging and behavior testing of these animals. The lab is located in 319 Mugar Building which provides close proximity to the animal facilities and brain imaging center. With 300 sq-ft the lab has adequate space for neurophysiological recording in small animals, surgical procedures, histological processing, light microscopy and preliminary data analysis. The lab is equipped with state of art neurophysiological recording, stereotaxic micropositioning, stimulus control and physiological monitoring systems. For histology there is a Nikon Optiphot microscope and a microtome for tissue preparation. There are multiple computer systems including a server that provides access for remote data analysis. Additional equipment includes a fume- hood, flammable storage cabinet, refrigerator and drying oven.

Musculoskeletal Epidemiology and Biomechanics Laboratory (Joshua Stefanik)
404 Robinson Hall, 600 Square Feet
The goal of the Musculoskeletal Epidemiology and Biomechanics Laboratory is to better understand risk factors, mechanisms and pathomechanics related to lower extremity musculoskeletal disorders, especially knee osteoarthritis (OA). The ultimate goal of the laboratory is to provide evidence for and to design rehabilitation treatments for knee OA. Studies in the laboratory include projects within large epidemiologic studies of knee OA (e.g.,
The Multicenter Osteoarthritis Study and The Osteoarthritis Initiative). Additionally, to better understand how older individuals with knee OA move, three-dimensional motion analysis studies are performed in collaboration with the NU Action Laboratory.

**Laboratory for Locomotion Research (Sheng-Che Yan)**

**460 Richards Hall, 750 Square Feet**

The goals of Laboratory for Locomotion Research are to: (a) understand how the central nervous system achieves sensorimotor control during gait; (b) develop and test gait rehabilitation programs for patients with sensorimotor control problems. The lab is located in the 4th floor of the university’s Richards Hall and has a total space of 600 ft². A separate office (150 ft²) is adjacent to the lab that will be served as an examination room for healthy and patient subjects. The lab will be equipped with state of the art equipment and software for gait analysis.
Publications

Books


Book Chapters


Peer Reviewed Journal Articles


    [http://journals.lww.com/pedpt/pages/default.aspx](http://journals.lww.com/pedpt/pages/default.aspx)


29. Ragavan VK; Greenwood KC; Bibi KW. "The functional status score for the intensive care unit (FSS-ICU) scale: Is it reliable in the intensive care unit? Can it be used to determine discharge placement?". Journal of Acute Care Physical Therapy/ Lippincott/Williams and Williams.


42. Von Heideken J, Kiami S, Iversen MD. A Prospective, Randomized Controlled Trial to Evaluate the Effect of Smart Glasses on Vestibular Examination Skills. *BMJ Innovations* [http://innovations.bmj.com/content/early/2016/03/30/bmjinnov-2015-000094.abstract](http://innovations.bmj.com/content/early/2016/03/30/bmjinnov-2015-000094.abstract)


**Conference Papers**


Conferences Abstracts and Presentations

International

5. Flores AM, Nelson J, Stephenson RG, Robinson K, Blot WJ. Lymphedema signs, symptoms, self-reported diagnosis and referral to physical therapy among African American and low-income breast cancer survivors (abstract # 1704). European Cancer Congress, Vienna, Austria. Sept. 2015
12. Levac, D. E., 23rd Cochrane Colloquium, "Scoping reviews versus systematic reviews: Results from a scoping review of scoping reviews.,” Cochrane, Vienna, Austria. (October 3, 2015).

National


and the physiological parameters of neurons in the lateral anterior hypothalamus of the male hamster," Society for Neuroscience, Chicago, IL. (October 19, 2015).


43. Tunik, E. (Author), Yarossi, M. (Presenter), Wei, Y. (Other), Adamovich, S. (Other), Meeting of the Society for Neuroscience, "Comparison of TMS elicited and voluntary synergies of the human hand," Society for Neuroscience, Chicago, IL. (October 17, 2015).


Local/Regional


20. Nolan, D. C. (Presenter), The ACL: Where Have We Been and Where are We Now? A Comprehensive Approach to the Care of the ACL Injured Patient, "Return to Sport
Considerations Following ACL Reconstruction," MGH / Northeastern University, Boston, MA. (June 13, 2015).


At Northeastern:


16. Nolan, D. C. (Presenter), Asnis, P. (Presenter), The ACL: Where Have We Been and Where are We Now? A Comprehensive Approach to the Care of the ACL Injured Patient, "Anterior Cruciate Ligament Rehabilitation: How Fast Can We Go?," MGH / Northeastern University, Boston, MA. (June 13, 2015).


On-Line / Webinars


REPORTS


## Grants Submitted in 2015 ($6.92 million requested)

<table>
<thead>
<tr>
<th>Agency</th>
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<th>Status</th>
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<td>NIH</td>
<td>Moving On: A pilot project of early intervention targeting impairments and self-efficacy for pre-operative breast cancer survivors</td>
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<td>Rheumatology Research Foundation</td>
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<td>NIH</td>
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<td>Mass Technology Transfer</td>
<td>The Virtually-interfaced Robotic Ankle and Balance Trainer (vi-RABT)</td>
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<td>CP International Research</td>
<td>Motor skill learning in virtual versus physical environments for children with cerebral palsy</td>
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<td>CP International Research</td>
<td>Development and evaluation of motivating virtual environments for motor skill learning in children and youth with cerebral palsy</td>
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## Funded Grants Active in 2015 direct costs $1,441,223

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<td>NEU</td>
<td>Does Narrative Feedback Enhance Motor Learning of a Virtual Balance Task in Children with Cerebral Palsy?</td>
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<td>Alpha Foundation</td>
<td>Whole body vibration exposure and injury prevention of heavy equipment operators in coal mines</td>
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<td>Evaluate the Effect of Multitouch Interaction on the Musculoskeletal System</td>
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