

New Program Proposal: Doctoral of Philosophy (Ph.D.) program in

- **Human Movement and Rehabilitation Sciences**
- **2 March 2018**

Executive Summary

A strong global need exists for interdisciplinary, innovative, and translational research directed towards improving quality of life and participation of all people in our communities. To meet this need, we propose a novel Doctoral of Philosophy Program in Human Movement and Rehabilitation Sciences. This new Ph.D. program will be housed in the Department of Physical Therapy, Movement, and Rehabilitation Sciences (PTMRS). It will build on the existing strengths across programs and departments within the Bouvé College of Health Sciences, including Health Sciences, Communication and Speech Disorders, Nursing, Applied Psychology, Exercise Science, Sports Performance. The program will leverage capacities and collaboration across colleges, including the College of Computer and Information Sciences, the College of Engineering, and the College of Science.

The new doctoral program will prepare graduates to conduct independent (original) basic, translational, and applied research in Human Movement and Rehabilitation Sciences. The goal is to create new knowledge about neuromotor mechanisms and methods of restoring and maximizing human functional capacity and wellbeing across the lifespan. The program will emphasize core competencies in motor control and motor learning, movement measurement and analysis, knowledge translation theory, and the use of traditional and emerging technologies. The program will be based on the integration of core skills and concepts across the multiple disciplines that are associated with human movement and rehabilitation sciences, coupled with the acquisition of research methodology, analyses, and skill, and specialization within specific areas of human movement and rehabilitation research. Graduates of the program will be able to develop researchable questions, design rigorous methodology, analyze and interpret data, and disseminate findings. In addition, graduates will enhance new knowledge base in the field of human movement and rehabilitation sciences in academic, industrial, policy and governmental settings.

1. Program Description

a. New Ph.D. Program

Aligned with the 2025 Academic Plan, we propose a novel interdisciplinary Ph.D. Program housed in the Department of Physical Therapy, Movement and Rehabilitation Sciences. The mission of the program is to advance our understanding of the neurological basis for human movement and translate this knowledge to improve healthy living for all people in all areas of life. The goals of the program are to enhance research and education around the following broad themes: neural control of movement, neuromotor learning, health and wellbeing through movement and design, human-cybernetic system interactions and neurorehabilitation of movement.

Program implementation will incorporate the multidisciplinary and multidimensional concepts of the World Health Organization's International Classification of Functioning, Disability, and Health (ICF).¹ This includes the concepts of body function and structure, activities of people, participation of people in all areas of life, and environmental factors that affect these experiences.

Building off the experiential learning embedded in Ph.D. programs with an apprentice training model, the implementation of the program will include the Department's clinical faculty such that the program has the benefit of the "in-action" expertise of the clinical and the applied community.

According to the 2017 report from the World Health Organization Rehabilitation 2030: A Call for Action², "there is a substantial and ever-increasing unmet need for rehabilitation." This need is a result of increases in non-communicable diseases and injuries across the globe resulting from advances in medicine that have led to increase survival from accidents and disease thus increasing life expectancy. Furthermore, approaches to functionality have changed as knowledge and technology have changed over time as well. As people's health and functionality changes with this new knowledge and technology, research is critical in the use of these technologies in rehabilitation.

The vision for the proposed program is to become a global leader at the interface of the fundamental study of neural control of human movement and implementation of the learned principles to advance rehabilitation sciences. Building from the department's international partners, this program will examine human movement and rehabilitation sciences from a global perspective, so that the outcomes of the program can positively impact people and societies around the world.

Graduates of the program will be capable of conducting research that contributes new knowledge about the development, identification and treatment of selected disabilities as well as mechanisms to understand movement, leading to improved health outcomes for individuals. They will be educated in current theories of knowledge translation and be trained to use the latest evidence in the field of knowledge transfer to maximally disseminate their research such that it will impact all relevant stakeholders.

¹ https://www.cdc.gov/nchs/data/icd/icfoverview_finalforwho10sept.pdf

² http://www.who.int/disabilities/care/Rehab2030MeetingReport_plain_text_version.pdf?ua=1

This new doctoral program will prepare graduates to conduct independent (original) basic, translational, and applied research in human movement and rehabilitation sciences in order to create new knowledge. The program will be based on the integration of core skills and concepts across the multiple disciplines that are associated with human movement and rehabilitation sciences, coupled with the acquisition of research skills and tools, and specialization with-in specific areas and tracks.

The program will also emphasize the development of skills for obtaining research support (e.g., research grant preparation), and for the effective dissemination of knowledge in clinical neurosciences and rehabilitation sciences (e.g., mentored experience teaching in the classroom, preparation and submission of peer-reviewed publications, etc.). Ideally, students will begin their funding trajectories as students in the program through funding mechanisms such as the National Research Service Award (NRSA). Such a program is specifically designed to facilitate the training of new scientists while providing a mechanism through which faculty mentorship of Ph.D. students can begin. A major long-term goal of the program is to play a significant role in training the future generations of clinical neuroscientists and neurorehabilitation scientists that are so critically needed at a growing number of academic and research institutions.

b. Potential for future programs

The Ph.D. program will provide future growth opportunities for the Department's academic programs. Specifically we see a future combined DPT-Ph.D. track that we will developed after the Ph.D. program is underway. The Doctoral of Physical Therapy (DPT) is an accredited clinical doctoral degree. The Department is currently revising the program's curriculum. Once these changes are completed, we will determine the specific admission procedures and curriculum requirements for a combined program. The combined DPT-Ph.D. track will provide opportunities for students to streamline and customize their educational experience. In the meantime, the Ph.D. program will be marketed to graduating DPT students. Students with a DPT degree who are accepted may have the ability to waive up to 12 elective credits if they have already taken electives as required coursework for the DPT degree and received a B or higher in each course.

The Ph.D. program curriculum will also serve as a springboard for other degree and certificate programs in Human Movement and Rehabilitation Science. A master's of science degree option can be based upon completing the course work and a capstone project. In addition, completing the required courses can constitute completing a certificate program. Once the doctoral program has gone through the approval process and vetting, we will put forth proposals for both the MS and Certificate programs as spinoffs of the terminal degree program.

2. Program support of the college, school and university mission

In line with Northeastern University's mission articulated in the Academic Plan 2025 for lifelong learning and discovery through evolving global networks, this program will give students a skill set while immersing them in the global research community that allows them to address the multiple dimensions of the World Health Organization's International Classification of Functioning, Disability, and Health conceptual framework using multidisciplinary approaches.³ Additionally, the mission of the University to create and translate knowledge to meet global and societal needs will come to full fruition with a Ph.D. program that creates the next leaders in

³³ https://www.cdc.gov/nchs/data/icd/icfoverview_finalforwho10sept.pdf

research whose work results in applicable solutions to improving the quality of life for all people in all areas of life throughout the lifespan.

Furthermore, the proposed program aligns with Bouvé College's stated mission to train leaders in its professions. The creation of a viable and robust research doctoral of philosophy program in rehabilitation sciences will represent a major step forward for the college, and for the field that clearly needs the scientists this new program will generate.

The design of the curriculum also allows for individualization of the program for each student. Depending upon the students interests, a student can create a custom program for their specific research project and plans.

Since human movement and rehabilitation sciences is an international field, students will have many opportunities for international experiences. The program will encourage students to participate in international conferences, spend time with other research groups around the globe, and collaborate with international partners to write papers. The faculty have an established and large international network from which the students will build their global experiential education. Many of the faculty are members of international scientific communities as well as adjunct appointments at Universities outside of the United States including Ecuador, Columbia, the Netherlands, and Sweden. Dr. Iversen, for example, has faculty appointments and collaborations with the Karolinska Institute and the Department of Women's and Children's Health, Astrid Lindgren's Children's Stockholm Sweden. Another example of international networks, the Department of Physical Therapy, Movement and Rehabilitation Sciences has a long-standing relationship with Hesav Sante, Lausanne, Switzerland for annual student exchanges program.

3. Program Clientele Analysis

a. Unique Aspects and Opportunity

Northeastern is ideally suited to be a leader in this venture. The program at Northeastern will leverage our strengths: our world-renowned engineering college and nationally, the highly-ranked programs in health professions at the Bouvé College of Health Sciences, successful programs in the College of Science and College of Engineering, and unique research laboratories focused on movement analysis and their applications to human movement and epidemiology.

Further, Northeastern has strong global network connections, enabling this venture to have global impacts. The faculty leaders of this proposal have demonstrated expertise and strengths in human movement and rehabilitation sciences. In brief, Northeastern has the opportunity and capability to advance the field of human movement and rehabilitation science and translate research to develop a personalized medicine approach to neurorehabilitation research.

As Northeastern does not have a medical school/hospital affiliation, students and faculty of the program are not constrained to conduct research at a local clinical facility or to target a specific patient population, as is the case for most other clinical research programs whose research focus tends to be narrowly defined by their clinics.

This program also builds upon a critical mass and concentration of faculty in the Department whose research has a focus on human movement sciences. While each of them conducting independent research, the common themes and methods will provide for collaborative learning and opportunities for students in the program that will attract and retain students in the program.

In addition, the Department along with the University as a whole has a unique focus on technology and its uses in rehabilitation sciences. The Department has built new research laboratories utilizing state-of-the-art movement and rehabilitation methods including virtual reality, ultrasound, neuroscience, neurophysiology, robotics, and movement measurement technologies as well as building new partnerships for innovative epidemiology, intervention and teaching research (<https://bouve.northeastern.edu/physical-therapy/research/>).

b. Evidence for program demand and for ability to attract high quality students

According to the 2017 report from the World Health Organization Rehabilitation 2030: A Call for Action⁴, “there is a substantial and ever-increasing unmet need for rehabilitation.” This need is a result of increases in noncommunicable diseases and injuries across the globe resulting from advances in medicine that have led to increase survival from accidents and disease, thus increasing life expectancy.

Additionally, the American Academy of Physical Therapy has identified a critical deficit in Ph.D. trained doctors of physical therapy who are needed to address both research advances in the field and to educate the next generation of physical therapists. There is high demand for Ph.D. physical therapist in DPT programs across the country.

In the past decade several other Ph.D. programs have emerged based on the recognized need to address these new health demands and train a new-minded type of workforce: individuals who understand neuroscientific and biological principles, who have an understanding of engineering and technology, and who have a solid foundation in the scientific method and who are clinically-fluent to understand normal and pathological movement. These programs are well enrolled and at top-notch institutions. As such they attract top rated students.

c. Competition from Other Programs

There are about two dozen Ph.D. programs in Neurorehabilitation, or related disciplines in this country, and about a dozen more world-wide. The programs that have emerged are housed in some of the top-tier institutions world-wide (Northwestern University, University of Illinois-Chicago, Washington University, University of Southern California, UNC-Chapel Hill, Emory University, University of Oxford, University of Cambridge, University College London).

Compared to other terminal degree programs in psychology, neuroscience, bioengineering or related fields, human movement and rehabilitation has relatively few competitor programs. As these programs emerge the program at Northeastern is well situated to become a leader in the field and distinguish itself from its competitors. Northeastern will not focus on one disease or geographical region, we will link to our well-established co-op education model, and we will merge a large but currently dispersed faculty into a single mission-driven program, and we will offer Ph.D.-only and DPT-Ph.D. combined modular options.

Graduates of our program will be competitive to pursue career paths in a range of departments in academia, hospital / rehabilitation centers, and technological companies in the neurorehabilitation market sector. The rapid emergence of new programs in neurorehabilitation and clinical neuroscience (as they are typically called in international universities), and expansion of existing programs, makes a compelling case for the demand. The good news is that the global availability of such programs is still in the dozens, so the demand for programs still far exceeds the supply. This is an opportune time for Northeastern to advance the field of

⁴ http://www.who.int/disabilities/care/Rehab2030MeetingReport_plain_text_version.pdf?ua=1

neuroscience and neurorehabilitation by leveraging our unique strengths to develop a premiere experiential-based global and innovative Ph.D. training program that will stand out from the other relatively few programs.

d. Impact on other programs at Northeastern

This program will have a positive impact on other programs at Northeastern. The proposed program will introduce new research and new students into our other interdisciplinary programs, such as population science, personal health informatics, and bioengineering. The new program will complement these efforts building and expanding our existing expertise and training opportunities. In addition, the program will develop new courses with a focus on human movement and rehabilitation sciences that currently are not offered by the other colleges. Programs in bioengineering, biology, and health sciences will benefit from these courses providing the community at large with the knowledge of these courses.

4. Educational Objectives and Curriculum

a. Education Objectives

This Ph.D. program will focus on research within a highly interdisciplinary setting with an emphasis on the rigorous education of graduate students. It will operate with the support of University based research activities at the interface of rehabilitation, neuroscience, and movement sciences that span the colleges of the university. It will emphasize the importance of linking and the intersection of basic, translational, and applied research associated with human movement and rehabilitation science in order to improve the quality of life of those with neuromuscular diseases. Finally, it will emphasize the core competencies of any research program including effective communication and collaborative partnerships to complete research.

b. Admission Criteria and Process

Application Process. Application materials will include transcript(s), statement of purpose, resume/CV, three letters of reference, GRE scores, and TOEFL score for international applicants. Applications to the program will be evaluated by an Admissions Committee comprising members of the program's core faculty. The requirements for admission to and completion of the program will conform to the University Graduate Council By-laws. Applications will be accepted on a rolling basis throughout the year.

Admittance. Students will be accepted either with a bachelor's or higher degree in a technical discipline (e.g., bio engineering, biomechanics), in a biological science discipline (e.g., physiology, biology) or in a health science discipline (e.g., nursing, medicine, physical therapy, pharmacy, public health, exercise science, occupational therapy). The admissions committee will take into account students' previous academic record; however applicants will be expected to have a minimum of 3.000 undergraduate GPA, minimum total GRE percentiles of 75 percentile, and, for international applicants, a minimum TOEFL score of 105. No single part of the application file alone determines admission. Students will be accepted to start either Fall or Spring Semesters.

c. Degree Requirements

Degree requirements are listed below. Detailed procedures and forms for each of these will be created once the program has been approved. In addition, these degree requirements will be

communicated to the students via a Student Handbook again to be developed once the program has approval.

i. Credit Hour Requirements

32 Credit Hours

ii. Minimum Academic Standards and Requirements

There will be no additional standards outside of those in place for Bouvé College graduate students at Northeastern University; grades in courses submitted to satisfy, in whole or in part, the requirements for any graduate degree of advance study must yield a cumulative quality point average of 3.0 or higher. Grades for courses granted transfer credits from another institution will not be used in computing the cumulative grade point average.

iii. Requirements, as applicable, such as residency requirement, qualifying examination, comprehensive examination, proposal defense, language or tool requirements, field component, teaching, thesis or dissertation requirements. For Ph.D. programs, state the point at which doctoral students become degree candidates.

Residency requirement. The residency requirement will follow the University Graduate Council By-Law policy. A Doctor of Philosophy degree student must spend the equivalent of at least one academic year in residence at the university as a full-time graduate student. Students are required to be continually enrolled while pursuing the completion of the dissertation. Non-residency periods need to be approved by the Associate Dean of Graduate Studies.

Teaching Assistantships: Each student will be required to be the teaching assistant for at least three courses during their tenure in the program. The courses can be in courses in and outside of the department as many of our departmental courses currently require licenses DPT as instructors.

Dissertation Advising. Each student will have one primary academic advisor from the program faculty as well as a dissertation committee once a student becomes a candidate.

Qualifying Examinations. Each student must pass a qualifying exam near and upon the completion of their course work. The exam consists of two parts, a written and oral component where the student writes a research proposal and then defend the proposal through an oral presentation. The research proposal must address a research topic and question related to human movement and rehabilitation sciences approved by the examination committee. Qualifying exams must be successfully completed no later than the semester after completing the 32 credit hours.

An exam committee will evaluate the students' performance for both the written and oral components of the qualifying exam. The committee shall consist of at least three faculty related to the specific topics from the dissertation proposal. Two of the faculty shall be members of the program's core or interdisciplinary affiliated faculty. The exam committee must be approved by the program director and the Bouvé College Associate Dean of Graduate Studies at least 60 days prior to the oral exam date.

The exam committee will make a recommendation based on the students' performance of pass, conditional pass (e.g. complete a literature review, take additional courses, etc.) or fail.

Degree Candidacy. A student is considered a Ph.D. degree candidate upon meeting these conditions:

- Completion of curriculum requirements with a minimum GPA of 3.000 overall (no-pass failed allowed),
- Successful completion of the qualifying (written and oral) examinations, and
- Selection and approval of a Dissertation Committee

It is expected that a student transitions to candidate within 2 years of initiating the program.

Dissertation: Each candidate then must successfully complete and defend a dissertation. The written dissertation must follow the requirements of the University Graduate Council. The dissertation shall contain three manuscripts prepared for submission to peer reviewed journals. The student shall defend the dissertation in a public seminar with the dissertation committee.

The Dissertation Committee will consist of at least 3 members in accordance with the University Policies for such committees. One of the members must be a clinical faculty member affiliated with the program. The other faculty should be a member of the core or affiliated interdisciplinary faculty. The dissertation committee must be approved by the program director and the Bouvé College Associate Dean of Graduate Studies. Selection and approval of the committee shall occur within 30 days of completing the qualification exams.

The doctoral candidates must meet with the dissertation committee once every six months and submit one page progress reports approved by the committee to the associate dean of graduate studies for his/her approval within 30 days of completed such meetings.

d. Learning Outcomes (graduate degrees)

Graduates of the program will be capable of leading and performing independent, new research projects related to human movement and rehabilitation sciences. It is expected that graduates will be well-prepared to enter into a number of post-doctoral career paths including: industrial research positions, government consultants, post-doctoral or junior faculty positions in academic institutions in either technology programs or schools of health science, public health, or medicine.

e. Curriculum Requirements

The curriculum requirements consist a core set of classes for all students to have core competencies in human movement and rehabilitation sciences as well as have completed a set of electives defining specific track for each individual student. All students will have exposure to basic, translational and applied research training, since these are considered hallmarks of the program. The curriculum will incorporate global concepts for human movement and rehabilitation sciences. Specifically the curriculum will include the multidisciplinary and multidimensional concepts of the World Health Organization's International Classification of Functioning, Disability, and Health (ICF)

At the end of the first year of study, students must submit a final plan for their individualized track. This track must be approved by the program head and submitted to the Bouvé College Associate Dean of Graduate Studies.

The current plan calls for students to be full-time in the program for a minimum of the first two years (six semesters including two summers).

i. Required and Elective Courses

Students must complete 32 credit hours of courses. These courses must be taken for a grade and cannot be taken pass/fail. These courses must include the required courses. Elective courses will be determined on a case by case methods with individual plans for each student and approved by the student's primary advisor final plan of courses needs to be submitted to the program director and the associate dean of graduate studies within the first 12 months.

Required Courses:

We expect each student in the program to have core knowledge and skills addressing the common issues for human movement and rehabilitation sciences as well as research methods. These are reflected in the core courses in

- Biostatistics: PHTH 5210 Biostatistics in Public Health (3 SH).
- PTXXXX (New) Core Concepts in Rehabilitation Science and Research: 3-SH
- PTXXXX (NEW) Measurement and Analysis of Human movement and Bioinstrumentation. (4 SH)
- PTXXXX (NEW) Emerging Technologies in Rehabilitation The course will cover emerging technologies that have relevance to rehabilitation of individuals with disorders of movement. (4 SH)
- PTXXXX (New) Interdisciplinary Seminar in Rehabilitation Science (Pass/Fail)

Electives

Electives will be agreed upon for case by case for each student in consultation with their primary advisor. A final program will need to be submitted to the program director and the associate dean of graduate studies. In addition students must obtain the permission of the instructor or meet the course prerequisites or in some cases both. Potential electives include:

- HLTH 5450: Research Methods in Health Care Research (3 + 1 Recitation)
- PT 5133. Kinesiology. 3 Hours.
- BIOE 5320. Advanced Biomedical Measurements and Instrumentation. 4 Hours.
- BIOE 5810. Design of Biomedical Instrumentation. 4 Hours.
- BIOE 5235. Biomedical Imaging. 4 Hours.
- BIOE 7300. Special Topics in Biomechanics. 4 Hours.
- PT 5410. Functional Human Neuroanatomy. 4 Hours.
- PT 5138. Neuroscience. 4 Hours.
- PT 5150. Motor Control, Development, and Learning. 4 Hours.
- PT 5209. Neurological Rehabilitation 1. 4 Hours.
- PT 5600. Ergonomics and the Work Environment. 3 Hours.
- PT 6221. Neurological Rehabilitation 2. 4 Hours
- ME 5250. Robot Mechanics and Control. 4 Hours.
- ME 5659. Control Systems Engineering. 4 Hours.
- ME 5665. Musculoskeletal Biomechanics. 4 Hours.
- ME 7247. Advanced Control Engineering. 4 Hours.
- EECE 5644. Introduction to Machine Learning and Pattern Recognition.
- EECE 5664. Biomedical Signal Processing. 4 Hours.
- EECE7200 Linear System Analysis, 4 Hours

- BIOL 5601. Multidisciplinary Approaches in Motor Control. 4 Hours.
- PHTH 6210. Applied Regression Analysis. 3 Hours.
- PHTH 6440. Advanced Methods in Biostatistics. 3 Hours.
- EXSC5210: Physical Activity and Exercise: Prescription, Measurement and Testing

Table: Course Pattern for Full Time Student*

Year	Fall	Spring	Summer
1	PHTH 5210 Biostatistics 3SH PTXX Core Concepts 3SH PTXX Seminar 1 SH Electives totaling 3 SH	PTXX Measurement & Analysis 4SH PTXX Seminar 1 SH Electives totaling 4SH	Experiential Learning Opportunities
2	PTXX New Technology 4 SH PTXX Seminar 1 SH Electives totaling 4 SH	Electives totaling 8 SH PTXX Seminar 1 SH Written and Oral Qualifying Exam	Research
3+	PTXX Seminar 1 SH Research	PTXX Seminar 1 SH Research	

*The number of credit hours in this table is greater than 32 required for the program. This table includes the pass/fail courses as well as non-graded research credits to allow students to be registered at 9 SH per semester (full time status) that do not count towards the curriculum requirements.

Experiential learning opportunities during in the curriculum will be working in research groups either here in the department or with our global academic and industrial partners. These include internship with say MicroSoft or Oculus or working with our academic partners in Switzerland, Sweden, and the Netherlands. These experiences will be shared with other students in discussion during the PT Research Seminar Course.

ii. New Courses

For the PhD program we will develop three new courses and one seminar course. We expect these courses to attract students from outside the PhD program including graduate students from our department, from other graduate programs such as the exercise science MS program in Bouvé as well as students from the College of Engineering and the College of Science.

- PTXXXX *Core Concepts in Rehabilitation Science and Research*. : This course will provide a foundation for students to discuss in depth the role that theories play in the development of research questions, determination of methods and application of knowledge in rehabilitation science. Students will develop the skills to critically evaluate theories used in human movement and rehabilitation science and to become familiar with examples of macro and micro theories currently in use. The course contains a knowledge transfer focus, providing students with the opportunity to become exposed to how theory might be used in undertaking knowledge translation (KT) related to their research efforts (4 credits)
- PTXXXX *Measurement and Analysis of Human movement and Bioinstrumentation*. In this course, students will learn how to measure kinematics, kinetics, and muscle activity using bioinstrumentation includes 3D motion capture system, force plates, and electromyography. Students will learn signal conditioning and processing techniques and

how to compute physiological variables such as joint angles, joint torques, ground reaction force, center of pressure, and center of mass. Topics will also include programming skills in LabView and MATLAB. This course can easily be organized into modules to meet the new teaching models in the University (4 SH)

- PTXXXX *Emerging Technologies in Rehabilitation*. The course will cover emerging technologies that have relevance to rehabilitation of individuals with disorders of movement. The emerging technologies that will be covered in this course will include those that are used in clinical research, as well as in therapeutic applications. The course will be divided into a dozen or so modules each covering a specific topic. These topics include (1) Electroencephalography (EGG), (2) Functional Magnetic Resonance Imaging (fMRI), (3) Electromyography (EMG), (4) Virtual Reality and Gaming, (5) Robotics, (6) Neuroprosthetics, (7) Transcranial Brain Stimulation (TMS), (8) Transcranial Electrical Stimulation (TES), (9) Functional Electrical Stimulation (FES), (10) Electrical Muscle Stimulation, (11) Paired Associative Stimulation (PAS) and (12) Ultrasound imaging. In each module, students will be exposed to the following content: (a) applications of the technology, (b) historical perspective on how the technology evolved, (c) how the technology works, (d) existing variants of the technology, (e) strengths, limitations / gaps, and future directions for this technology. For each module, efforts will be made to include hands-on labs to expose the students to the content. This course can easily be organized into modules to meet the new teaching models in the University (4 SH)
- PTXXXX *Interdisciplinary Seminar in Rehabilitation Science*. Students must enroll every semester for 1 credit until they start the dissertation phase of the program (approximately 6 semesters). This seminar will include faculty seminars (1 per month) and work in progress by current doctoral students 2 per month, and an external researcher (1 per month). Doctoral student presentations can include summaries and discussion from their experiential learning internships with partnering organizations.

f. Program Assessment

i. Learning Objectives

Graduates of the program will be capable of leading and performing independent, new research projects related to rehabilitation and movement sciences. It is expected that graduates will be well-prepared to enter into a number of post-doctoral career paths including: industrial research positions, government consultants, post-doctoral or junior faculty positions in academic institutions in either technology programs or schools of health science, public health, or medicine.

ii. Other than GPA, what data/evidence is used to determine that graduates have achieved the stated outcomes for the degree? Who interprets the evidence? What is the process for interpretation?

The Dissertation Committee will provide the primary evaluation that the candidate has achieved the non-course work requirements of the degree. As stated above the committee will consist of at least 3 members and the dissertation committee must be approved by the program director and the Bouvé College Associate Dean of Graduate Studies

The doctoral candidates must meet with the dissertation committee once every six months and submit one page progress reports approved by the committee within 30 days of completed such meetings and the associate dean will keep track of the progress of these students.

iii. Describe how assessment results will be utilized to improve on the program's effectiveness.

Program faculty will meet regularly to discuss results and outcomes of student's final projects, dissertations, manuscripts and exams. Data to be consider include the following. Program administrators will maintain a database of student postgraduate placement, academic, industry, or government, publications, grant funding and employment. Publication venues will provide a means to assess the quality of the program, as well as the research projects. External research funding and incoming student quality will be used to measure program strength. In addition, graduates will be asked for feedback concerning their training and program preparation. Both faculty and student surveys will be utilized to collect anonymous feedback in conjunction with teaching evaluations. Results from these feedback systems will be reviewed by all active faculty and through a democratic process, recommended changes will be incorporated into the program. The success of the program will be based on student placements post completion and qualitative reviews of the educational experience collected.

iv. Timeline for assessment

We will employ a continuous improvement approach to evaluating the program through regular meetings of the core faculty and larger systematic reviews every 5 years (length of a Ph.D. cohort). Program faculty will meet regularly to discuss results and outcomes of student's final projects, dissertations, manuscripts, and exams. Program administrators will maintain a database of student postgraduate academic placements, publications, grant funding, and employment.

v. Tracking of Program Graduates

Working with the alumni association we will track the careers of graduates to document their success in pursuing careers in workplace health and safety. In addition, Program administrators will maintain a database of student postgraduate placement, academic, industry, or government, publications, grant funding and employment. We will document these in the program's annual report.

g. Program accreditation or adherence to licensing standards

The Commission on Accreditation in Physical Therapy Education (CAPTE) grants specialized accreditation status to qualified entry-level education programs for physical therapists and physical therapist assistants. As part of their process they examine the quality of the PhD program on the training for the DPT students.

5. Resources

- a. Assess the faculty strength and expertise currently available to the program and identify any additional faculty resources needed to produce a strong program known for excellence.

A strength of this PhD proposal is the faculty in the Department Physical Therapy, Movement, and Rehabilitation Sciences. A critical mass of faculty in the area of human movement and rehabilitation science exists in the department. Since 2012, the research faculty

and external funding in this area has grown substantially with appointments at the assistant, associate, and full professor levels. These faculty have made and impact on the field through their research and teaching and this impact has been recognized by governmental and non-governmental funding agencies.

The faculty also represent the many disciplines required for the interdisciplinary program. The disciplines represented by the degrees of our tenure-track faculty include engineering, epidemiology, neuroscience, kinesiology, exercise science, anatomy, biology, physiology, education, public health, rehabilitation science, and neurobiology. Our clinical faculty have expertise in orthopaedic, musculoskeletal systems, neurology, cardiovascular, and sport performance as well as anatomy and industrial psychology.

- b. **Faculty Strength and Expertise:** List the current tenured and tenure-track Northeastern faculty who are expected to teach as core faculty in the new program and briefly describe their major accomplishments in research, scholarship, or creative activity in the area of the program. If additional tenure-track faculty will be needed by the program, note whether they will be added by reallocation within the college or by requested new tenure-track lines, and when any new faculty are expected to be hired. If the program relies on non-tenure-track and part-time instructors for required courses, project what proportion of courses in the new program will be taught by tenure-track faculty, by full-time non-tenure-track faculty, and by part-time faculty. What will be the desired academic or professional qualifications of the program's non-tenure-track faculty? Identify any additional non-tenure-track faculty resources needed by the proposed program.

Core Faculty Department of Physical Therapy, Movement, and Rehabilitation Sciences:

Tenure Track:

- Jack Dennerlein, Ph.D., Professor – Occupational Ergonomics and Safety. Dr. Dennerlein is the director of the Occupational Biomechanics and Ergonomics Laboratory (<http://www.northeastern.edu/ergonomics/>). Trained as an engineer, Dr. Dennerlein's research examines the physical design of work and tools as well as examining the effects of other conditions of work including psychosocial and organizational factors on worker safety and health. (<https://bouve.northeastern.edu/directory/jack-dennerlein/>)
- CJ Hasson, Ph.D., Assistant Professor. Dr. Hasson is the director of the Neuromotor Systems Laboratory at Northeastern University (<http://nuweb.neu.edu/cjhasson/>). His research aims to understand how the complex interactions between the musculoskeletal and central nervous systems affect movement control and learning in humans. To achieve this understanding, Dr. Hasson uses a combination of techniques from neurophysiology, musculoskeletal modeling, and robotics to noninvasively manipulate neuromuscular dynamics in living humans. (<https://bouve.northeastern.edu/directory/christopher-hasson/>)
- Lorna Hayward, EdD, PT, MPH, Associate Professor. Dr. Hayward has won multiple grants and written close to 40 articles on her work. Her current research projects involve examining the use of innovative student assessment strategies, such as student

pedagogical teams, and community based participatory research to understand the impact of international service-learning efforts on the community partner.

<https://bouve.northeastern.edu/directory/lorna-hayward/>

- Charles Hillman, Ph.D., Professor, Department of Psychology and Department of Physical Therapy, Movement and Rehabilitation Sciences. Dr. Hillman directs the new Center for Cognitive and Brain Health, which has the mission of understanding the role of health behaviors on brain and cognition to maximize health and well-being, and promote the effective functioning of individuals across the lifespan
<http://www.northeastern.edu/cos/faculty/charles-hillman/>
- Maura Iversen, PT, DPT, SD, MPH, FNAP, FAPTA Professor and Associate Dean. Dr. Iversen's research includes the evaluation of the efficacy and effectiveness of non-pharmacologic interventions for persons with arthritis; understanding behavioral and social factors influencing adherence to pharmacologic and non-pharmacologic interventions in rheumatic conditions; and application of medical simulation to team health care .<https://bouve.northeastern.edu/directory/maura-iversen/>
- Danielle Levac, Ph.D., MSc, PT. Assistant Professor. Dr. Levac is the Director of the Rehabilitation Games and Virtual Reality Laboratory (<http://www.northeastern.edu/regamevrlab/>). Her research evaluates motor learning paradigms in virtual environments to understand how task practice conditions impact motor learning processes and outcomes. Dr. Levac's research program focuses on promoting the sustainable, evidence-based integration of virtual reality (VR) and active video gaming systems into rehabilitation.
<https://bouve.northeastern.edu/directory/danielle-levac/>
- Robert Sikes, Ph.D., Associate Professor. Dr. Sikes research the neurophysiology of the cingulate cortex; in particular, the role of cingulate cortex in pain sensation. His research has investigated pathways through which pain information is transmitted and are currently contrasting the effects of somatic and visceral noxious stimulation on cingulate neuron activity. <https://bouve.northeastern.edu/directory/robert-sikes/>
- Eugene Tunik, Ph.D., PT. Associate Professor and Associate Dean, Dr. Tunik's research mission is to advance knowledge of human neural control of movement and leverage this information to improve motor function for those with neurological impairment (<http://www.northeastern.edu/tuniklab/>). The goals include to study the neural processes that govern perception and action in health and disease, translate principles of neuroscience into practical interventions for individuals with motor impairment, and advance techniques for studying human motor neurophysiology
<https://bouve.northeastern.edu/directory/eugene-tunik/>
- Sheng-Che Yen, Ph.D., PT. Assistant Professor. Dr. Sheng-Che Yen's research goals are to understand the sensorimotor control of healthy and pathological gait and to advance the effectiveness of gait rehabilitation in patients with neuromuscular disorders. He is also interested in large dataset analysis to determine the effectiveness of therapeutic outcomes. (<https://bouve.northeastern.edu/directory/sheng-che-yen>)
- TBD: A search is underway to hire a faculty member with tenure on entry and a mature research program. The faculty will be at the Associate or Full Professor level. The area of expertise is to be in a field related to the proposed Ph.D. program. This faculty member will also serve as Research Director in the department and will therefore have strong administrative and educational ties to the Ph.D. program.

- TBD: A search is underway to hire a second faculty member with tenure on entry and a mature research program. The faculty will be at the Associate or Full Professor level. The area of expertise is to be in a field related to the proposed Ph.D. program.

Non-Tenure Track

A strength of our department is our clinical (non-tenure track) faculty who provide much of the applied and “in action” knowledge of Neuromotor and Rehabilitation Sciences. We propose that they participate in the program through serving on Ph.D. student dissertation committees as well as chair and be the primary advisory for the program’s doctoral students. These faculty include:

- Debbie Bangs, PT, DPT Assistant Clinical Professor and Academic Clinical Coordinator
Clinical Education Musculoskeletal Disorders
- Christopher Cesario, PT, DPT, MBA. Assistant Clinical Professor and Director of Clinical Education; ACL prevention and clinical education
- Stephen Clark, PT, DPT, MS, ATC, CSCS Assistant Clinical Professor; Sports Medicine: managing the injured athlete from initial injury through return to play; interdisciplinary care of student-athletes; management of athletic hip injuries; concussion care
- Marie Corkery, PT, DPT, MHS, FAAOMPT. Associate Clinical professor; Prevention and treatment of lower back pain, Manual therapy interventions for the spine and extremities
- Leslie Day, Ph.D., CSCS. Associate Clinical Professor Human Anatomy and Physiology
- Pamela Donlan, PT, DPT, EdD, Assistant Clinical Professor; Neurorehabilitation, investigating best practices in PT education, and exploring the psychosocial aspects of long-term disease and disability on patients and caregivers
- Diane Fitzpatrick, PT, DPT, MS, GCS, CEEAA. Clinical Professor; Geriatric Clinical Specialist, American Board of Physical Therapy Specialties Geriatrics and Aging
- Eric Folmar, PT, DPT, OCS, CKTP. Assistant Clinical Professor; Director, Transitional DPT Program; Orthopedic Clinical Specialist, American Board of Physical Therapy Specialties; Certified Kinesiotaping Practitioner; Orthopedic and sports Medicine; Biomechanics.
- Ann Golub-Victor, PT, MPH, DPT. Clinical Professor and Interim Associate Chair; Pediatric Physical Therapy, Developmental Disabilities, Service-Learning
- Kristin Curry Greenwood, PT, DPT, EdD, MS, GCS. Associate Clinical Professor and Interim Chair; Geriatric Clinical Specialist, American Board of Physical Therapy Specialties ;Preparation of Doctor of Physical Therapist Students for Acute Care Entry Level Practice, Simulation Education, Interprofessional Education and Practice
- Mary Hickey, PT, DPT, MHP. Associate Clinical Professor; Back pain related to back pack use in children. Evidence based practice in orthopedics, Use of standardized patients as a teaching methodology.
- Sheri Miami, PT, DPT, MS, NCS Assistant Clinical Professor, Neurological Clinical Specialist, American Board of Physical Therapy Specialties; Teaching and Learning Scholarship, Balance Assessment and Falls Prevention
- Sonya Larrieux Ph.D., MA, PT, C/NDT, Associate Clinical Professor, Director, Doctor of Physical Therapy Graduate Affairs. Diversity & equity issues related to health care, Workforce development in health care, Developmental disabilities

- Alycia Markowski, PT, DPT, MPhtyS (manipulative), FAAOMPT, OCS. Associate Clinical Professor, Orthopedic Clinical Specialist, American Board of Physical Therapy Specialties; Rehabilitation of musculoskeletal disorders and pain.
- Jessical Maxwell, PT, DPT, Ph.D., OCS. Associate Clinical Professor, Orthopedic Clinical Specialist, American Board of Physical Therapy Specialties; Functional and participation-level outcomes of knee osteoarthritis and knee replacement
- Lauren Murphy, Ph.D.. Assistant Clinical Professor; Safety climate, which is defined as workers' perception of organizational policies, procedures, and practices regarding safety
- Matthew Nippins, PT, DPT, CCS. Assistant Clinical Professor, Cardiopulmonary Clinical Specialist, American Board of Physical Therapy Specialties Cystic Fibrosis
- David Nolan, PT, DPT, MS, OCS, SCS, CSCS. Associate Clinical Professor and Director of Sports Physical Therapy Residency Orthopedic rehabilitation, Orthopedic and Sports Clinical Specialist, American Board of Physical Therapy Specialties; Sports related injury of the upper and lower quarter, Gait and running biomechanics, Balance and proprioception in musculoskeletal injury
- Susan Ventura, PT, MEd, Ph.D.. Associate Clinical Professor; Improving the quality of life of people with disabilities and their caregivers through advocacy, education, and scholarship.
- Maureen Watkins, PT, DPT, OCS, MBA, LMT Assistant Clinical Professor, Orthopedic Clinical Specialist, American Board of Physical Therapy Specialties; Scholarship of teaching and learning of Real time Ultrasound Imaging, Injury Prevention/ Role of Wellness in physical therapy and Education of the female athlete

Interdisciplinary Faculty: Core collaborators

Each of the core faculty members have partnerships with faculty in the other colleges at Northeastern. The relationships include co-mentoring graduate students to co-principal investigators on grant applications. These faculty members include members from the College of Engineering, the College of Science, the College of Computer and Information Sciences.

- Dagmar Sternad, Ph.D., Professor, Department of Biology, Electrical and Computer Engineering, and Physics <http://www.northeastern.edu/cos/faculty/dagmar-sternad/>
- Casper Hartevelde, Ph.D., Assistant Professor, Game Designing Program <https://camd.northeastern.edu/gamedesign/people/casper-hartevelde/>
- Sarah Ostadabbas, Ph.D., Assistant Professor, Department of Electrical and Computer Engineering <http://www.ece.neu.edu/people/ostadabbas-sarah>
- Emily Zimmerman, Ph.D., Assistant Professor, Department of Communication Sciences and Disorders <https://bouve.northeastern.edu/directory/emily-zimmerman/>
- Sandra Shefelbine, Ph.D., Associate Professor, Department of Mechanical and Industrial Engineering <http://www.mie.neu.edu/people/shefelbine-sandra>

There are many other faculty at Northeastern who have research projects related to human movement and rehabilitation sciences. We have listed their names here.

Affiliated faculty

- Peter Bex, Ph.D., Professor, Department of Psychology
<http://www.northeastern.edu/cos/faculty/peter-bex/>
- Dana Brooks, Ph.D., Professor, Electrical and Computer Engineering
<http://www.ece.neu.edu/people/brooks-dana>
- Deniz Erdogmus, Ph.D., Professor, Department of Electrical and Computer Engineering
<http://www.ece.neu.edu/people/erdogmus-deniz>
- Matthew Goodwin, Ph.D., Associate Professor, Department of Health Sciences
<https://bouve.northeastern.edu/directory/matthew-goodwin/>
- Holly Jimison, Ph.D., Professor of the Practice, School of Nursing/CCIS
<https://bouve.northeastern.edu/directory/holly-jimison/>
- Amy Lu, Ph.D., Assistant Professor, Department of Health Sciences/Communication Studies
<https://bouve.northeastern.edu/directory/amy-lu/>
- James Monaghan, Ph.D., Assistant Professor, Department of Biology
<http://www.northeastern.edu/cos/faculty/james-monaghan/>
- Taskin Padir, Ph.D., Associate Professor, Department of Electrical and Computer Engineering
<http://www.ece.neu.edu/people/padir-taskin>
- Misha Pavel, Ph.D., Professor of the Practice, School of Nursing/CCIS
<https://bouve.northeastern.edu/directory/3325/>

Both the interdisciplinary and faculty members have been invited to participate in the program as student mentors and all have agreed. All faculty within Bouvé will have an opportunity to review and comment on the proposal.

c. Space Needs

Students and candidates will require a central area with desks and computers. In addition, we will leverage the existing resources that are available at Northeastern University (individual PI lab space, lab equipment, current graduate level courses offered by the Department in kinesiology, motor control, assistive technology, neurorehabilitation, neuro-science, functional neuroanatomy, disability studies, etc), as well as at collaborating departments such as bioengineering.

d. Library Resources

Additional subscriptions will be requested.

6. Budget ---

To Be Submitted to the Dean's and Provost's office separately.