The Importance of Neurorehabilitation Research: Understanding Motor Control and Motor Learning to Improve Walking

Behind every step we take is an intricate sequence of muscle contractions, neural signals, and mechanical forces. For many people, walking feels automatic. However, for people with neurological conditions like stroke or Parkinson's disease, walking may become more difficult, less efficient, and something that, when combined with poor balance, puts them at greater risk for falls. Rehabilitation can help, but rehabilitation often depends on using practice to drive motor learning. Understanding how motor control and motor learning are impacted by different neurological conditions is critical for developing and delivering the most effective rehabilitation approaches. ASNR Member James Finley, PhD, leads an interdisciplinary research program that brings together principles from neuroscience, biomechanics, engineering, and exercise physiology to conduct research that will ultimately help restore mobility and independence for people living with neurological conditions.

1. Can you tell us about your position and your research program?

I am an Associate Professor in the Division of Biokinesiology and Physical Therapy at the University of Southern California (USC). I also hold an appointment in the USC Neuroscience Graduate Program and a courtesy appointment in the USC Alfred E. Mann Department of Biomedical Engineering. I direct the Locomotor Control Lab at USC, where we use a combination of experimental studies and computational models to understand how mobility is controlled in individuals with and without neuromotor impairments, such as stroke and Parkinson's disease. Currently, most of our ongoing studies focus on identifying factors that influence the energy cost of walking, balance control, and decision-making while walking.

2. What inspired you to get involved in neurorehabilitation research?

Since I was a child, I've been deeply interested in understanding how complex systems work and using this knowledge to enhance their performance. This interest initially led me to pursue a degree in mechanical engineering with the goal of working in the automotive industry. However, during my undergraduate studies, I had the unexpected opportunity to complete a summer internship at Medtronic, a medical device company based in Minneapolis. It was during my time at Medtronic that I first experienced the application of engineering analysis and design in the biomedical field, which sparked my interest in learning more about human physiology and neuroscience. During my senior year as an undergraduate, I began exploring graduate research opportunities at the intersection of engineering and neuroscience, and I became fascinated by the field of neurorehabilitation. My interest in the field crystallized during my PhD at

Northwestern University, as the labs where I worked were located within the Rehabilitation Institute of Chicago (now called the Shirley Ryan AbilityLab). As a graduate student, I appreciated the opportunity to work with and learn from leading researchers in engineering, neuroscience, and physical therapy, whose collective work continues to transform the practice of neurorehabilitation.

3. How has federal funding benefited or influenced your research/career?

It's difficult to overstate the importance of federal funding in my career. When talking about federal funding in the field of neurorehabilitation, it is understandable that our discussions often gravitate toward NIH. Like many other neurorehabilitation researchers, NIH funding has been essential for my research. However, I'd like to focus on how funding from the National Science Foundation (NSF) not only helped support the foundation of my graduate training but also continues to shape much of what I do now.

When I applied to graduate school, one of the things that drew me to Northwestern was an NSF-sponsored program known as the VaNTH Engineering Research Center. One of the goals of this center was to apply learning science research to improve methods for teaching undergraduate biomedical engineering. Once I joined the PhD program at Northwestern, I began working on a VaNTH-sponsored project called Get-a-Grip!, where we collaborated with local middle schools to teach students about the engineering design process, with the goal of having them design a prosthetic device for someone in a low-income country. My work with VaNTH was one of the most rewarding experiences from my time in graduate school, as we had the opportunity to demonstrate how math, science, and creative thinking could be applied to solve a real-world, biomedical problem.

Since then, I've been fortunate to receive several forms of support from the NSF, including a graduate research fellowship, two research grants at USC, and two grants to organize and expand access to academic research conferences. What I've always appreciated about NSF funding is that awardees are not only expected to use the funding we receive to accomplish our research objectives, but NSF also requires that our work has what's referred to as "Broader Impact". This most often involves leaving the comfort of our labs and sharing our science with the masses in some form or another. In just the past two years, I've led NSF-sponsored outreach initiatives that have included teaching data science to high school students in Los Angeles, hosting high school and undergraduate students as research assistants in my lab, and providing funding to faculty from rural universities to attend a major scientific meeting.

I think it's also important to note that a substantial portion of funding from federal research grants, regardless of the agency, is allocated to support the next generation of scientists, including undergraduate researchers, PhD students, and postdoctoral researchers. These are the individuals who, if sufficient federal funding continues to be available, will likely become some of the world's leading innovators and problem solvers in academia and industry.

4. What do people in your studies say about what it's like to be involved in your research?

There are two key types of responses that we routinely receive from participants after they participate in our studies. First, people from the community are often amazed by the technology we use to study human movement and request photos of themselves that they can share with friends and family. When you're immersed in a research environment every day, it can be difficult to appreciate how rare it is for most people to see or interact with the tools at our disposal. The second type of response we often hear is a general sense of appreciation for the interpersonal interactions our participants have with our study personnel. We have always had a very diverse team of researchers, both in terms of ethnicity and academic training, and our studies often provide a unique environment where both participants and research team members can learn about each other's life experiences.

5. What are some of the outcomes or impacts of your federally funded research that you are most proud of?

This is a tough question to answer. Although the primary goal of research is knowledge generation, I'm most proud of the impact our research has on the development of current and former trainees. Since joining USC, I've had the pleasure of training high school students and undergraduates who've gone on to pursue PhDs, as well as PhD students and postdoctoral fellows who have gone on to start their own labs or take leadership roles in industry. Federal funding has been essential to creating an environment where trainees can learn from the research we conduct, and it has provided the necessary resources for travel to conferences and other forms of professional development. Lastly, over the past three years, I have been a member of the leadership team for ReproRehab, an NIH-funded training program to help rehabilitation researchers develop data science skills. We recently surveyed our first three cohorts of trainees about their experiences in the program, and it was incredibly rewarding to hear how they utilized the skills they learned and the professional network they established during the program to advance their research careers.