A Perfect Blend of Medicine and Engineering

Steven A. Gard, PhD, combines his fascination with medicine and his engineering skills in his research and career achievements.

For 2018, O&P Almanac is introducing individuals who have undertaken O&P-focused research projects. Here, you will get to know colleagues and health-care professionals who have carried out studies and gathered quantitative and/or qualitative data related to orthotics and prosthetics, and find out what it takes to become an O&P researcher.

When it comes to O&P research, the name Steven A. Gard, PhD, should come to mind. In addition to serving as the executive director of the Northwestern University Prosthetics-Orthotics Center (NUPOC) and as an associate professor in the Department of Physical Medicine & Rehabilitation at Northwestern's Feinberg School of Medicine, Gard also has duties as a research health scientist at the Jesse Brown Veterans Affairs (VA) Medical Center (VAMC) and as director at the Jesse Brown VAMC Motion Analysis Research Laboratory.

Gard has been interested in the human body and improving how it works for as long as he can remember. "I became interested in biomedical engineering when I was a senior in high school," in 1982, recalls Gard. "There was considerable coverage of a new artificial heart device in the news at that time, and I liked the idea of combining engineering with medicine. When I was an undergraduate student in college, I wanted to develop artificial organs for the body. However, I had a professor tell me at the time that I would probably never see implantable artificial organs in use during my lifetime." It was at that point that Gard shifted his focus to prostheses and orthoses.

During his graduate education, Gard was mentored by Dudley Childress, PhD, a former director of NUPOC and the Northwestern University Prosthetics Research Laboratory, who instilled in Gard an appreciation for research. Childress "is highly regarded for his work with myoelectric control in upper-limb prostheses, and he was just beginning to develop interest in lower-limb prostheses when I entered his laboratory, about 30 years ago," says Gard. He also "had an intense passion for O&P research that fostered my interest in the field." For Gard's master's project, he investigated the feasibility of using strain gauges for applications in upper-limb prostheses. "Strain gauges have many distinct advantages for use as a sensor but they typically utilize too much power for long-term application in battery-powered prostheses," he says.
"Therefore, I developed low-powered circuitry that would enable strain gauges to be used in upper-limb prostheses for extended periods of time."

When it came time to develop a doctoral research project, Gard began investigating issues pertaining to foot clearance in transfemoral prosthesis users, again under the guidance of Childress. "Additionally, though, I was fortunate to collaborate on one aspect of my research project with Jack Uellendahl, CPO, who exposed me to the clinical side of P&O," says Gard. "Jack identified a clinical question about four-bar linkage knees that I was able to tackle with my engineering skills. It was through that experience that I first recognized the value of clinical input and collaboration on addressing research problems."

Roles and Responsibilities

Over the past three decades, Gard has published many O&P papers and spoken at countless conferences on O&P-related research topics. Through the years, he has been able to count on the support of his wife of 32 years, Kristin, and his two children, Nathaniel and Chelsea.

As the current executive director at NUPOC, Gard has administrative responsibilities over both research and education, "though I tend to focus more on the research side," he says. His research responsibilities include writing and submitting grant proposals to obtain funding to support research efforts, managing research studies and personnel involved in those projects, and disseminating research findings through presentations at professional conferences and publishing in scientific journals. He also teaches classes to engineering students at Northwestern University on O&P-related topics, and teaches O&P students on the topic of "research methods." In addition, Gard advises graduate engineering students on their research projects for the master's and PhD degrees.

In his position as a research health scientist with the Jesse Brown VA Medical Center, Gard applies for and receives funding from the VA Rehabilitation Research and Development Program. "The VA has a long history for supporting prosthetics- and orthotics-related research, particularly as it relates to the needs of veterans," he says.

When he's not hard at work on one of his many research O&P projects, Gard enjoys spending time in one of his favorite activities, deer hunting. "I grew up in rural southern Missouri, so I developed a love of hunting and fishing at an early age," he says.

Wide Array of O&P Interests

Throughout his career, Gard has studied many aspects of O&P, including prosthetic feet, knees, shock-absorbing components, sockets, liners, ankle-foot orthoses, knee-ankle-foot orthoses, and reciprocating gait orthoses. "I am very interested in how these different technologies affect gait biomechanics, so I typically use quantitative gait analyses to learn more about how the functions of gait are affected," he says.

One of his most significant studies involved investigating the effects of prosthetic ankle units on bilateral lower-limb amputees. "Up until that time, there were no published studies reporting quantitative gait data on that particular population, much less looking at the effects of different prosthetic interventions," Gard recalls. "We recruited 19 bilateral transtibial and four bilateral transfemoral prosthesis users to participate, and ended up publishing several papers on normative gait data for this population, differences in gait characteristics when delineated by amputation etiology, and the effects of prosthetic ankle motion on gait biomechanics."

Gard also has focused some of his research on the topic of shock absorption during ambulation. "I began by investigating the effects of shock-absorbing pylons (SAPs) in transtibial amputees, a study that we published in 2003. Unfortunately, we really didn't observe much effect during gait when subjects walked with and without the SAPs, but that finding was pretty consistent with those of others performing similar studies at the time," he says. He found the lack of an observed response to be "intriguing, suggesting that something else may be going on with subjects while walking with SAPs."

A few years ago, Gard and his team followed up on this topic and conducted a similar study with transtibial amputees, "but we reduced the stiffness of the SAP considerably, with the thought that we would induce considerable shock absorption," he says. "However, the gait data still failed to indicate a biomechanical response. Therefore, we performed impact testing with research subjects by dropping them onto a force plate and measuring peak forces generated under their prosthesis. Surprisingly, there were no differences in the peak forces when the stiffness of the SAP was varied. Eventually, we figured out that the primary shock absorption was occurring in the soft tissues at the residual limb/prosthetic socket interface, a finding that we reported in one of the publications on the study."

At the moment, Gard is continuing to look at shock absorption in the gait of prosthesis users. "I have some new ideas for providing shock absorption through improved mechanism designs that I would like to pursue, but first I have to get the grant funding to conduct the study," he says.

Gard also is looking at how to best distribute prosthetic stiffness between the ankle and foot keel in transtibial amputees in order to optimize both standing and walking performance.

Gard's team recently received a grant from AOPA to investigate the effects of a hydraulic foot-ankle component on standing and walking in K-2-level..."
ambulators, which has not been previously investigated, he says. “At NUPOC, we tend to focus on clinically relevant problems that are commonly identified and observed by both practitioners and P&O users, so continued communication and collaboration with prosthetists and orthotists is essential,” he says.

**Power of Partnerships**

Much of the work Gard does is funded by grants through such agencies as the VA; the National Institute on Disability, Independent Living, and Rehabilitation Research; the National Institutes of Health; and the Department of Defense. “We also apply for smaller grants through AOPA and the Orthotic and Prosthetic Education and Research Foundation,” he says. In addition, some of his studies are supported by industry, notably O&P manufacturers. “We have good working relationships with many O&P manufacturers on previous and current research projects,” Gard says. When partnering with manufacturers, “I think we often share similar concerns about product efficacy and approach the research with a number of common questions.” Gard’s team sometimes partners with companies on research proposals “that can be mutually beneficial to everyone involved. “Even if we don’t formally partner with manufacturers, we may end up utilizing their products for our investigations,” he says. “In those cases, we still work to establish good relationships with the companies and rely on their expertise to facilitate our research. I like to think that manufacturers rely on laboratories like ours to provide the O&P field with objective assessments of their products and help them refine and improve upon their current technologies.”

**Looking Forward**

As the O&P profession marches ahead with ever-advancing technologies, Gard continues to enjoy all aspects of his work, and says he particularly enjoys working with young people on their research projects. “I have mentored many master’s and PhD students in biomedical engineering, and recently I have had the privilege of advising a number of MPO students on their capstone projects,” he says. “It’s thrilling to interact with these individuals and share new discoveries with them.” Gard notes the importance of training future and current practitioners to be better consumers of research, even if they don’t intend to conduct research full time. “As researchers, we have a responsibility to translate new knowledge about research findings to practitioners in a palatable form, through both presentations at conferences and publications in scientific journals that are geared specifically to the P&O professional.”

Looking to the future, Gard believes the most pressing questions in the field relate to the interface between a prosthesis or orthosis and the user. “Solutions to these problems will involve the development and evaluation of new technologies, such as subchial transfemoral sockets; the improved manufacture of these custom interfaces, such as using 3-D printers; or the evaluation of completely new types of suspension systems, such as osseointegration. There is a lot of good research that needs to be conducted in these areas to substantially advance the field.”

Gard also emphasizes the importance of O&P research in providing scientific evidence to support clinical decision making and to justify reimbursement by third-party payors. “Through our research studies, we aim to fill many of the gaps that currently exist in the scientific knowledge base,” he says. “I sincerely hope that this type of evidence can be used to optimize fitting procedures and justify the prescription of prosthetic and orthotic devices in order to provide individuals with the highest quality of life possible.”

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