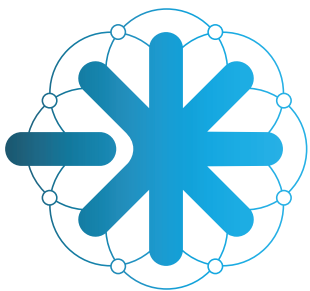
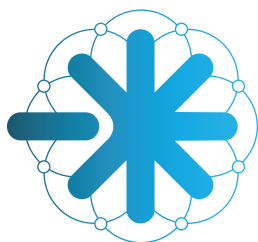




# 2023-24 ANNUAL REPORT



**Hanger Institute**  
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# A letter from our Chief Clinical Officer

Dear Friends and Colleagues,

It is my privilege to introduce the Hanger Institute for Clinical Research and Education 2023/24 Annual Report.

Our key initiatives within the Hanger Institute are designed to address and navigate a rapidly changing healthcare environment, with a focus on positively impacting the lives of those in need of life-changing orthotic and prosthetic (O&P) care. With a nation that is moving from a fee-for-service approach to one that rewards outcomes, efficiency, quality, and population health, along with a more complex regulatory environment, reimbursement challenges, and continuing uncertainty, we are leveraging our resources, expanding our networks, and contributing to our knowledge base with an unwavering commitment to advancing evidence-based O&P practice.

While for many, this is a time for anxiety, at Hanger, it is a time for continued action. The development of our scientific and evidence base has been, and will remain, one of our highest priorities. We can claim significant progress in supporting and advancing clinical research that demonstrates the true value and positive patient outcomes resulting from the care we provide as highlighted throughout this report.

I would like to acknowledge my colleagues and the individuals inside and outside of the Hanger organization who support and contribute to the Hanger Institute's work. Clinical outcomes are vital and serve as the foundation that directs our clinical decision-making, and my sincere thanks to the teams across Hanger Clinic that are dedicated to collecting patient outcomes as a basic standard of care.

At Hanger, we are committed to clinical excellence and are a patient-centered organization. This annual report is designed to demonstrate that, collectively, we have the will and the momentum to effect change and positively impact the lives of the people we are privileged to serve across our profession.

Sincerely,



**James H. Campbell, PhD**  
Senior Vice President and Chief Clinical Officer



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## Establishing Expectations Following Lower Limb Amputation

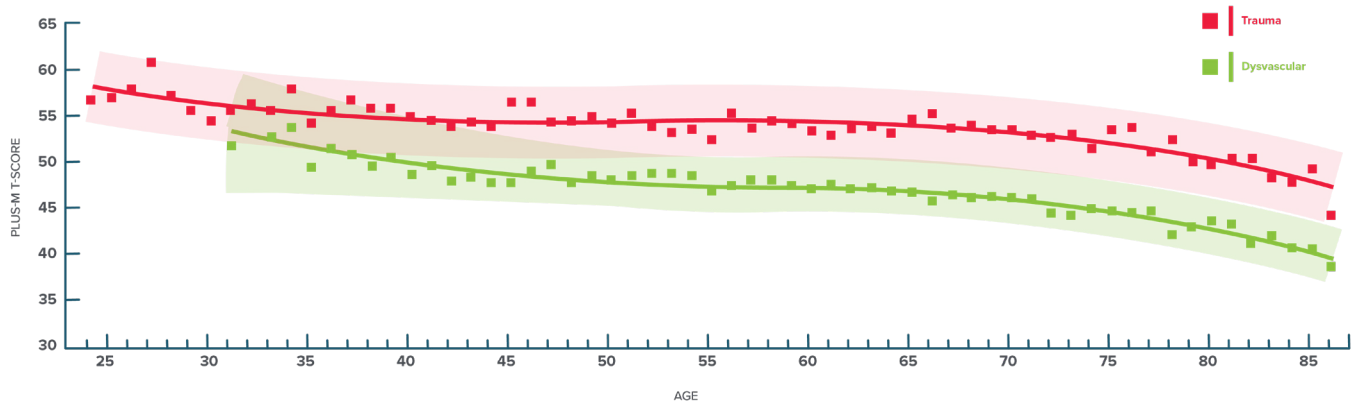
Goal setting and establishing realistic expectations after lower limb amputation are vital for patient success. To provide best-in-class care, we need to understand where our patients are today and where we see them progressing in the future. Setting challenging and achievable goals and balancing expectations are crucial for success. For our patients with lower limb amputation, mobility is often the primary goal, for good reason. Increased mobility has been linked to increased quality of life, greater satisfaction, reduced risk of injurious falls, and even higher odds of returning to work.



## Mobility Goals Based on Age, Amputation Level, and Etiology

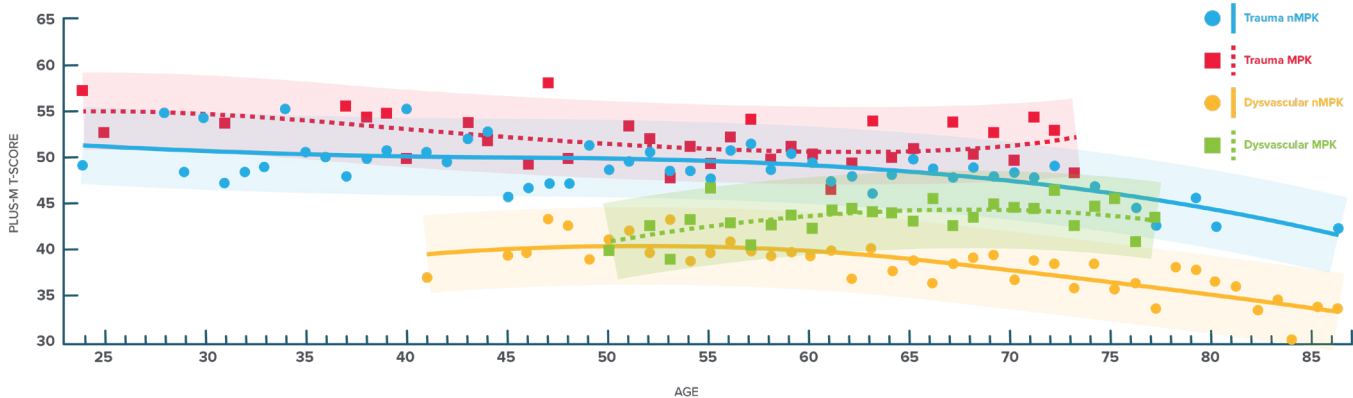
One of our recent papers, CASTLE 1 (Fylstra et al., 2023), expanded on our previous work (England et al., 2021) in this area. The study aimed to establish normative mobility scores for each year of patient age, ranging from 25 to 85 years old, following lower limb amputation. By analyzing data from just under 30,000 individual patients across various ages, amputation levels, and etiologies (trauma or diabetes/dysvascular), we have made significant progress in understanding mobility outcomes and goals. The impact of CASTLE 1 lies in its ability to use these mobility curves across patient age to predict the average mobility for a patient based on their age, amputation level, and etiology (Figure 1). With this understanding, we are better positioned to help patients set realistic mobility goals. Armed with this information, we can focus rehabilitation efforts on improving and/or maintaining mobility as the patient continues to age. In addition, we can also explore the impact of prosthetic technology on these mobility curves – for example, microprocessor knees may change the trajectory of patients’ mobility as they age (Figure 2). The next step in this research is to understand precisely what those rehabilitation recommendations look like to ensure the patient receives the best care possible.

### Trajectory of Patient Mobility Across Age for Individuals with Amputation Below-the-Knee



**Figure 1:** Patient age and etiology can impact an individual’s predicted mobility. To calculate a patient’s expected mobility, simply draw a vertical line at their age and a horizontal line at their respective etiology.

### Altered Trajectories Observed for Individuals with Amputation Above-the-Knee With the Use of a Microprocessor Knee (MPK)



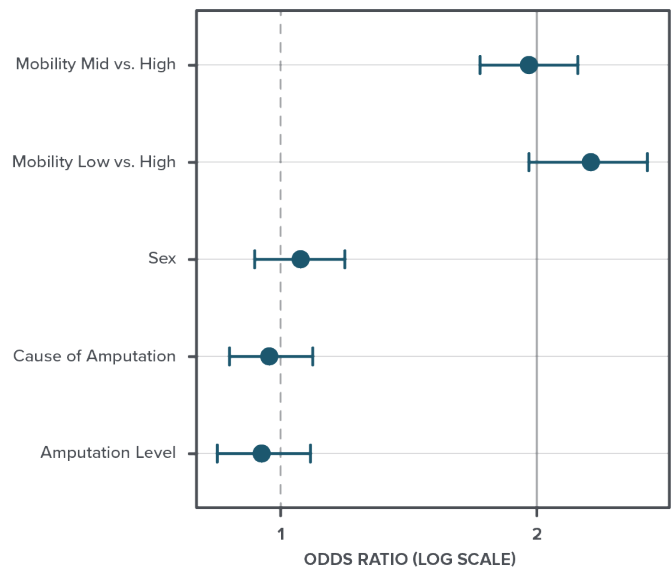
**Figure 2:** The curves in yellow and blue represent patients using a non-microprocessor knee following amputation due to dysvascular and trauma etiologies, respectively. The curves in green and red represent patients using a microprocessor knee following amputation due to dysvascular and trauma etiologies, respectively. On average, individuals with a microprocessor knee had increased mobility across all ages. In addition, microprocessor knees may even change the expected trajectory of patients as they age.



## Relationship Between Mobility and Injurious Falls

A fall resulting in an injury can significantly impact a patient's life. Injurious falls can also impose a high cost and economic burden, not only on the patient, but on the health system as a whole. Recently, we published the second paper in the SAFE-AMP series focused on exploring the relationship between mobility and injurious falls (Miller et al., 2022).

Results from this study revealed that individuals in the lowest mobility group had over twice the odds of experiencing an injurious fall compared to those in the highest mobility group (Figure 3). This finding underscores the importance of working towards increasing patient mobility – either through a change in prosthetic intervention and/or physical therapy. Increased mobility is not only an important part of overall well-being (Wurdeman et al., 2018), but it can also significantly reduce the risk of injurious falls.



### Risk of Injurious Fall Based on Mobility Level

**Figure 3:** Compared to those with high levels of prosthetic mobility, individuals with low and mid-level mobility were approximately two times more likely to experience an injurious fall. By contrast, an individual's sex, cause of amputation, and amputation level were unrelated to their risk for injurious fall.

Increased mobility is not only an important part of overall well-being, but it can also significantly reduce the risk of injurious falls.

## Falls: By the Numbers

Falls are the **leading cause of non-illness related death** for Americans over the age of 65.

Approximately **30%** of individuals over age 65 incur a fall each calendar year.

**1 in 5** falls results in serious injury such as broken bones or head injury.

Fall risk is roughly **50%** higher among individuals with lower limb amputation and even higher for those with above-the-knee amputation.

Only **25%** of elderly individuals report a return to prior levels of independence after a fall.

Vascular disease, frequently observed among individuals with lower limb amputation, increases fall risk by roughly **75%**.



## Impact of Gender, Geography, and Employment on Mobility

The GGEM Study: Gender, Geography, and EMPloyment (England et al., 2023) explored various patient attributes and how these attributes impact patient mobility. Here are some key findings:

- 1. Employment:** Patients with lower mobility were more likely to be unemployed. Previous studies have demonstrated that employment is beneficial for improving self-esteem and reducing social isolation. However, a return to work cannot be assumed as these rates following amputation are reported between 43-70%. Increasing mobility may improve an individual's odds of returning to work.
- 2. Gender:** Gender was highly associated with patient mobility, with women being less likely to ambulate. This suggests that our female patients may benefit from additional encouragement and attention in their prosthetic rehabilitation.
- 3. Geography:** Individuals living in the South reported poorer functional mobility. In contrast, individuals living in the Northeast had 30% increased odds of reporting an above-average prosthetic mobility level.

	Age < 65 Y		Age > 65 Y	
	Mobility	P	Mobility	P
<b>Employment (mean ± SD)</b>				
No	46.3 ± 10.6	<0.001	44.7 ± 11.5	<0.001
Yes	55.2 ± 10.0		52.2 ± 9.9	
<b>Gender (mean ± SD)</b>				
Female	46.1 ± 10.9		41.0 ± 11.2	
Male	50.3 ± 11.1	<0.001	46.9 ± 11.4	<0.001
<b>Region (mean ± SD)</b>				
South	48.2 ± 11.4	<0.001	43.8 ± 11.2	<0.003
Northeast	49.8 ± 11.2		45.7 ± 11.9	
West	48.9 ± 11.3		46.0 ± 11.4	
Midwest	49.7 ± 10.9		45.6 ± 11.7	

### Impacts of Employment, Gender, and Geography on Mobility

**Figure 4:** The average mobility values observed among prosthesis users according to their employment status, gender and geographic location.

These findings highlight the importance of considering gender, geography, and employment when setting patient mobility goals and adjusting accordingly. Additionally, understanding how these attributes impact mobility allows clinicians to better estimate fall risk from SAFE-AMP 2 and plan preventative intervention effectively. The better we are at establishing expectations following lower limb amputation, the better equipped we will be at providing exceptional evidence-based care.

## REFERENCES

- England, D. L., Miller, T. A., Stevens, P. M., Campbell, J. H., & Wurdeman, S. R. (2021). Normative mobility values for lower limb prosthesis users of varying age, etiology, and amputation level. *American Journal of Physical Medicine & Rehabilitation*.
- England, D. L., Miller, T. A., Stevens, P. M., Campbell, J. H., & Wurdeman, S. R. (2023). GGEM: Gender, Geography, and Employment differences based on mobility levels among lower limb prosthesis users living in the United States. *Prosthetics and Orthotics International*.
- Fylstra, B. L., England, D. L., Stevens, P. M., Campbell, J. H., & Wurdeman, S. R. (2023). Creating Adjusted Scores Targeting mobility Empowerment (CASTLE 1): Determination of normative mobility scores after lower limb amputation for each year of adulthood. *Disability and Rehabilitation*, 1-7.
- Miller, T. A., Paul, R., Forthofer, M., & Wurdeman, S. R. (2022). Reduced functional mobility is associated with a history of injurious falls in lower limb prosthesis users. *Annals of Physical and Rehabilitation Medicine*, 66(4).
- Wurdeman, S. R., Stevens, P. M., & Campbell, J. H. (2018). Mobility Analysis of Amputees (MAAT I): Quality of life and satisfaction are strongly related to mobility for patients with a lower limb prosthesis. *Prosthetics and Orthotics International*, 42(5), 498–503.







## Caring for Those Who Have Experienced an Amputation Due to Diabetes or Dysvascular Disease

Amputation due to diabetes or dysvascular disease is of increasing interest in the literature due to its increased prevalence, economic impact, and poorer health outcomes (England et al., 2022). The continued tracking and monitoring of this patient population allows for individualized interventions or changes in the patient's care plan.



## Determinants of Prosthetic Referral and Functional Mobility for Patients with Dysvascular Amputation

One of our recent manuscripts found that among a population of 255 vascular patients, nearly half of the sample was not referred to be fitted for a prosthesis (Fridling et al., 2023). Factors such as older age, more comorbid health conditions, less independence, and lack of rehabilitation referral were all associated with fewer prosthetic referrals (Figure 5). For those individuals who were fitted for a prosthesis, factors such as insurance status, postoperative rehab disposition, and cardiovascular health were associated with improved post-amputation mobility (Fridling et al., 2023).

While there may be other factors influencing prosthetic referrals that were not included in the study, the next step will be to identify evidence-based approaches to determine which patient should or should not be fitted with a prosthesis. This approach will assist patients, surgeons, and other healthcare professionals in shared decision-making regarding prosthetic referrals.

## Aggregated Observations Shared Internationally

In 2023, members of the Hanger Institute traveled to Guadalajara to share our aggregated observations from several prior publications relative to the prosthetic management of individuals with amputation due to diabetes. These included observations relative to both comorbid health and component selection and their impacts on mobility and fall risk among older individuals with diabetic or dysvascular amputation (Stevens & Wurdeman, 2023).

With respect to the impact of comorbid health conditions on prosthetic mobility, we reviewed our findings from MAAT 2 (Wurdeman et al., 2018). Reviewing data from just under 600 patients, we observed that, despite common opinions to the contrary, the presence of most comorbid health conditions were not associated with decreased prosthetic mobility. These non-contributing health conditions included diabetes, chronic obstructive pulmonary disease (COPD), congestive heart failure, a history of heart attack, and obesity. Ultimately, only advanced age, history of a stroke, peripheral vascular disease (PVD), and anxiety/panic disorders were mildly associated with reduced prosthetic mobility. In addition, we observed that the presence of multiple comorbidities had little effect on prosthetic mobility when we adjusted for the effects of age, stroke, PVD, and anxiety/panic disorders (Figure 6).

Demographics	No prosthetic fitting (n = 101)	Fitted for prosthetic (n = 134)	p-value
Age, years	68.6	62.1	<.001
Chronic kidney disease	45 (44.6)	35 (26.1)	.042
Prior cardiovascular disease	37 (37.0)	20 (14.9)	<.001
<b>Ambulatory status</b>			
Independent	22 (21.8)	63 (47)	<.001
Assist device	51 (50.5)	58 (43.3)	
Non-ambulatory	28 (27.7)	12 (9.7)	
<b>Disposition</b>			
Home	18 (17.8)	15 (11.2)	<.001
Skilled nursing facility	76 (75.2)	78 (58.2)	
Rehab	3 (3.0)	25 (18.7)	
<b>Mortality at 1 year</b>	24 (23.8)	5 (3.7)	<.001

Data are presented as number (%).

### Characteristics of Those Individuals Fitted and Not-Fitted with Prostheses

**Figure 5:** Numbers and population percentages of those fitted and not fitted with prostheses according to the presence of chronic kidney disease or prior cardiovascular disease, ambulatory status, and discharge dwelling location.



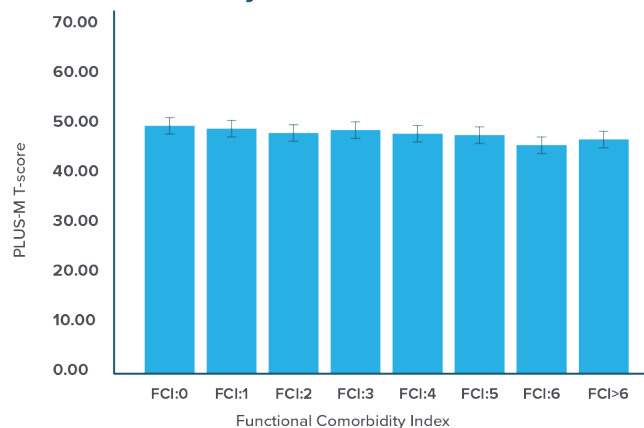
Relative to component considerations, we shared observations from the MAAT 5 study. In this effort, an analysis of 738 patients with amputation due to diabetes/dysvascular disease established that certain prosthetic foot types are associated with higher mobility levels. Specifically, patients with diabetic/dysvascular amputation fit with a microprocessor foot (MPF) or vertical shock-loading pylon type foot (L5987) had significantly higher mobility compared to other foot types. On the other hand, patients fit with a flex-walk type foot (L5981) or the flex-foot type foot (L5980) had the lowest mobility among the five ankle-foot categories (Wurdeman et al., 2019, Figure 7). These findings suggest that certain ankle-foot technologies can increase prosthetic mobility for individuals with amputation due to diabetes/dysvascular disease.

We also revisited the impacts of microprocessor knees among individuals with transfemoral amputation due to diabetes or dysvascular disease by citing the findings of our SAFE-AMP 1 manuscript where we observed that those from this population using a non-microprocessor knee were 2.5 times more likely to sustain an injurious fall than those using microprocessor technology (Wurdeman et al., 2023).

## REFERENCES

- England, D. L., Miller, T. A., Stevens, P. M., Campbell, J. H., & Wurdeman, S. R. (2022). Mobility Analysis of Amputees (MAAT 7): Normative mobility values for lower limb prosthesis users of varying age, etiology, and amputation level. *American Journal of Physical Medicine & Rehabilitation*, 101(9), 850-858.
- Fridling, J., Gontarz, B., Bozeman, P., Mather, J., Wurdeman, S. R., Murray, J., McKay, R., Sutton, T., & Gifford, E. (2023). Determinants of prosthetic referral and functional mobility following prosthesis fitting for vascular patients after major lower extremity amputation. *Journal of Vascular Surgery*, 78(4), e135-e136.
- Stevens, P. M., & Wurdeman, S. R. (2023). Influence of co-morbid health and component selection on mobility and fall risk among older diabetic/dysvascular amputees. International Society for Prosthetics & Orthotics (ISPO) 19th World Congress. Guadalajara, Mexico. April 23-27, 2023.
- Wurdeman, S. R., Stevens, P. M., & Campbell J. H. (2018). Mobility analysis of Amputees II: Comorbidities and mobility in lower limb prosthesis users. *American Journal of Physical Medicine & Rehabilitation*. November 1, 2018;97(11):782-8.
- Wurdeman, S. R., Stevens, P. M., & Campbell J. H. (2019). Mobility analysis of Amputees (MAAT 5): Impact of five common prosthetic ankle-foot categories for individuals with diabetic/dysvascular amputation. *Journal of Rehabilitation and Assistive Technologies Engineering*, 6.
- Wurdeman, S. R., Miller, T. A., Stevens, P. M., & Campbell, J. H. (2023). Stability and Falls Evaluations in AMPutees (SAFE-AMP 1): Microprocessor knee technology reduces odds of incurring an injurious fall for individuals with diabetic/dysvascular amputation. *Assistive Technology*. 35(3):205-210.

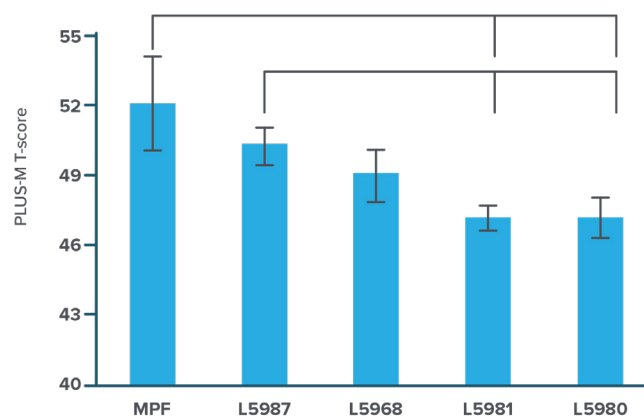
## Mobility & Comorbid Health



### Mobility and Comorbid Health

**Figure 6:** The limited impact of progressively increasing concurrent comorbid health conditions on prosthetic mobility after adjusting for the presence of known contributors including age, stroke, PVD, and anxiety/panic disorder.

## Mobility for Individuals with Diabetic/Dysvascular Amputation



### Mobility (PLUS-M T-Score) for Five Different Groups of Prosthetic Ankle-Feet (Total Sample, n=738)

**Figure 7:** Columns (from left to right) correspond to microprocessor ankle-foot (MPF), shank-foot systems with vertical shock-loading pylons (L5987), hydraulic ankle-foot systems (L5968), flex-walk ankle-foot systems (L5981), and flex-foot type ankle-foot systems (L5980). Individuals with MPFs or vertical loading pylons had significantly increased mobility compared to those with flex-walk or flex-foot systems.





## Embracing the Advances in Bone-Anchored Prosthetics

Hanger Clinic participated in the nation's first FDA-approved feasibility study on bone-anchored prosthetics (Sinclair et al., 2022). Since that time, the organization has been actively involved in the prosthetic rehabilitation of those individuals managed with FDA-approved bone-anchored prosthetic implants.



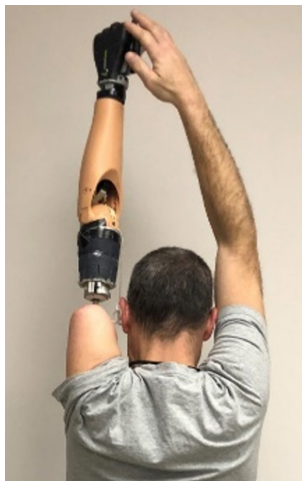
## Institute Support of Conferences Focused on Bone-Anchored Prosthetics

In addition to oversight of the clinical management of bone-anchored prostheses across the country, the Hanger Institute was recently invited to present at the Global Consensus Conference on Osseointegration in Charlotte, North Carolina as one of three invited presenters on the topic of *The 3 R's: Research, Regulatory and Reimbursement* (Churchill et al., 2023). As the nation's largest civilian provider of FDA-approved, bone-anchored prosthetic rehabilitation, this allowed us to share our observations on regulatory and reimbursement trends in this space.

Associates of the Institute were also invited to participate and present at the Bionic Reconstruction Conference (BReCON), with the stated focus of "The Future of Integrated Upper Limb Surgical and Prosthetic Innovation." This included participation in the meeting's Osseointegration Panel (Potter et al., 2023) and co-presentation of a session on Prosthetic and Therapy Perspective on Pain (Crerar & Stevens, 2023).

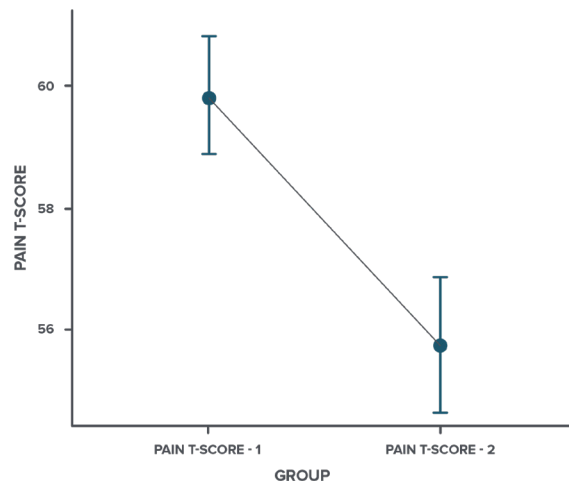
The former allowed us to comment on our early experiences in managing individuals with transhumeral bone-anchored prosthetic implants performed under Compassionate Use Exemptions from the FDA (Figure 8). The latter allowed us to share recent data on the strong correlation between pain interference and well-being among patients with upper limb amputation, as well as the observed reduction in pain interference when such patients are fit with their first prosthesis (Figure 9).

Hanger Clinic is the nation's largest civilian provider of FDA-approved, bone-anchored prosthetic rehabilitation solutions.



### Early Bone-Anchored Transhumeral Fitting

**Figure 8:** With direct attachment of the prosthesis to the implant, users are able to experience an unprecedented gain in their range of motion with their device.



### Pain Interference Values Before and After Receipt of an Upper Limb Prosthesis

**Figure 9:** Aggregated data suggests that the receipt of an individual's first upper limb prosthesis is associated with a meaningful reduction in pain interference values (59.8± 8.5 to 55.7±9.6).

### REFERENCES

- Sinclair, S., Beck, J. P., Webster, J., Agarwal, J., Gillespie, B., & Stevens, P. (2022). The first FDA approved early feasibility study of a novel percutaneous bone anchored prosthesis for transfemoral amputees: A prospective 1-year follow-up cohort study. *Archives of Physical Medicine and Rehabilitation*, 103(11), 2092-2104.
- Churchill, C., Stevens, P. M., & Wenke, J. C. (2023 Nov). The 3 R's: Research, regulatory, and reimbursement. Global consensus conference on osseointegration. Charlotte, NC.
- Potter, B. K., Fabbri, N., Nordstrum, M., Souza, J., Stevens, P. M., & Monroe, B. (2023 Nov). The future of integrated upper limb surgical & prosthetic innovation: Osseointegration panel. Bionic Reconstruction Conference (BReCON). New York City, NY.
- Crerar, E. & Stevens, P. M. (2023 Nov). Prosthetic and therapy perspectives on pain. Bionic Reconstruction Conference (BReCON). New York City, NY.





## Enhancing Outcomes Experienced by Users of Upper Limb Prostheses

Several years ago, the Hanger Institute began collecting outcome measures on their patients with upper limb amputation and limb deficiency to help inform best practices in their prosthetic rehabilitation. While well-being was identified as the primary measure of interest, additional measures included activity and participation, upper extremity function, and pain interference. Additional research has been collected on usage patterns using both accelerometry and patient-reported outcomes. Collectively, these efforts have allowed us to better appreciate these important considerations within this population.



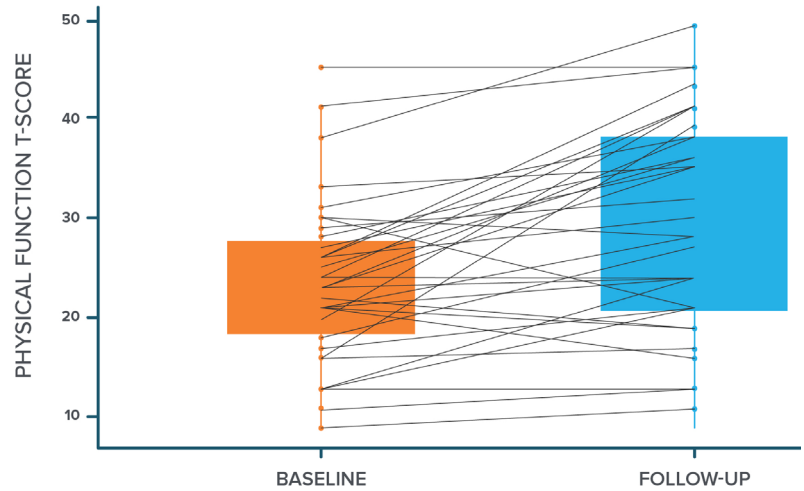
## Measuring Bimanual Function

To properly measure a patient’s success, the right instruments must be selected to measure the outcomes associated with that success. The PROMIS-UE Physical Function 9-item short form is a validated measure of nine bimanual tasks that include activities of daily living (ADLs), such as eating with a fork and knife, opening and closing a zipper, buttoning a shirt, and tying a knot or a bow (England et al., 2021). However, until recently, the sensitivity of the instrument in assessing function following the delivery of an upper extremity prosthesis had not been reported. Members of the Hanger Institute performed retrospective analyses of the clinical utility of the PROMIS-UE Physical Function before and after the receipt of an individual’s first prosthesis.

In a pilot sample of 34 individuals reported upon at the AAOP Annual Meeting and Scientific Symposium, subjects showed significant improvement in the PROMIS-9 UE scores between pre-prosthetic (23.6 ± 8.20) intervention and post-prosthetic intervention (29.71 ± 10.5) (Figure 10). These findings demonstrate responsiveness to the PROMIS-9 UE instrument in detecting changes after receipt of a patient’s first prosthesis (England et al., 2023).

## Contributors to Well-Being

With well-being selected as our primary outcome of interest for individuals who have experienced an upper limb amputation, recent analyses have attempted to better define the elements that appear to have the greatest influence on this factor. Using patient responses from the custom PROMIS-UE 9-item short form described above, the PROMIS Abilities to Participate in Social Roles and Activities (APSRA), the Trinity Amputation and Prosthesis Experience Scale (TAPES), and a question from PROMIS Pain Interference (PI), the Institute has confirmed that the constructs with the greatest relationship to well-being appear to be activity and participation levels, bimanual upper limb function, prosthesis satisfaction, and reduced pain interference (Figure 11).



Improved Physical Function with the Receipt of an Upper Limb Prosthesis

**Figure 10:** Baseline and follow-up physical function scores for individuals receiving their first upper limb prosthesis.

Construct	Measure	Individual Correlation
Activity and Participation Levels	PROMIS APSRA	0.577
Bimanual Physical Function	PROMIS-9 UE	0.489
Prosthesis Satisfaction	TAPES-R	0.456
Pain Interference	PROMIS PI	0.422

Significant Predictors of Well-Being Following Upper Limb Amputation

**Figure 11:** Several constructs were found to be moderately correlated to well-being among individuals with upper limb amputations. (APSRA: Ability to Participate in Social Roles and Activities; TAPES-R: Trinity Amputation and Prosthesis Experience Scale-Revised; PI: Pain Interference question PAININ9).



Notably, other variables did not seem to influence well-being in this population. This included hours of daily prosthesis use, time since amputation, age, and gender (Stevens et al., 2023).

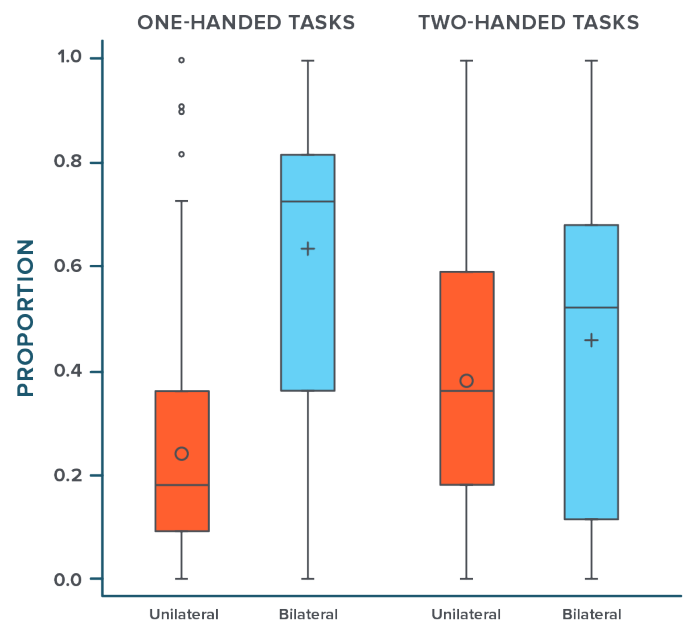
### Prosthesis Usage Patterns

In collaboration with partners at the University of Missouri, the Hanger Institute previously reported upon the insights gained from the use of accelerometers on forearms and upper arms of individuals with unilateral, acquired amputation. This included the notable finding that while isolated unimanual engagement of the prosthesis is uncommon, bilateral engagement with the sound upper limb is quite common, and observed an average of four hours daily (Frey et al., 2022). These observations were supplemented with additional data at the 50th Annual Meeting and Scientific Symposium of the American Academy of Orthotists and Prosthetists (Stevens et al., 2023).

This abstract confirmed the average daily bimanual engagement of four hours among a larger cohort of individuals with acquired unilateral amputation. It also presented new data on the distinct prosthesis usage patterns observed among individuals with unilateral congenital upper limb deficiencies and acquired bilateral amputations.

The measured usage patterns in this study effort align well with self-reported usage patterns observed in a separate collaboration between members of the Hanger Institute and researchers from the Providence Rhode VA Medical Center, Northwestern University, Brown University, and Boston University (Resnik et al., 2023). In this separate collaboration, individuals with unilateral and bilateral amputations were asked to report whether or not they used their prostheses to accomplish a number of one- and two-handed tasks.

Data from this exercise confirmed that patients with unilateral upper limb amputation are more likely to engage their prostheses during bimanual tasks. By contrast, individuals with bilateral upper limb amputation were more likely to report engaging their prostheses to complete unimanual tasks (Figure 12).



Proportion of Common Tasks Completed with Prostheses

**Figure 12:** The average number of items from lists of both one- and two-handed tasks that individuals with unilateral and bilateral upper limb amputations report completing with their prostheses. Those with unilateral amputation are more likely to use their prostheses in two-handed tasks, while those with bilateral amputations reported engaging their prostheses to complete a greater percentage of one-handed tasks.





## Aggregated Observations Shared Internationally

Members of the Hanger Institute were recently invited to share our aggregated findings in the realm of optimizing well-being during rehabilitation following upper limb amputation (Stevens & Wurdeman, 2023). This allowed us to share our observations on well-being, activity and participation levels, bimanual function, prosthesis satisfaction, and usage patterns with attendees from across the globe with an eye toward future collaborations and discussions on the next steps in our upper limb prosthetic research portfolio.

### REFERENCES

- England, D. L., Miller, T. A., Stevens, P. M., Campbell, J. H., & Wurdeman, S. R. (2021). Assessment of a nine-item patient-reported outcomes measurement information system upper extremity instrument among individuals with upper limb amputation. *American Journal of Physical Medicine & Rehabilitation*, 100(2), 130-137.
- England, D. L., Stevens, P. M., Todd, A., Mandacina, S., & Wurdeman, S. R. (2021 March). PROMIS-UE Physical Function demonstrates good clinical utility for patients following upper limb prosthesis intervention. Thranhardt Lecture: American Academy of Orthotists & Prosthetists (AAOP) 49th Academy Annual Meeting & Scientific Symposium. Nashville, TN.
- Frey, S., Motawar, B., Buchanan, K., Kaufman, C., Stevens, P. M., Cirstea, C., & Morrow, S. (2022). Greater and more natural use of the upper limbs during everyday life by former amputees versus prosthesis users. *Neurorehabilitation and Neural Repair*, 36(3), 227-238.
- Resnik, L., Borgia, M., Heinemann, A. W., Stevens, P. M., Clark, M. A., & Ni, P. (2023). The upper extremity functional scale for prosthesis users (UEFS-P): subscales for one and two-handed tasks. *Disability and Rehabilitation*, 45(22), 3768-3778.
- Stevens, P. M. & Wurdeman, S. R. (2023 April). Factors associated with elevated well-being in Individuals with upper limb amputation. International Society for Prosthetics & Orthotics (ISPO) 19th World Congress. Guadalajara, Mexico.
- Stevens, P. M., England, D. L., Todd, A. E., Mandacina, S., & Wurdeman, S. R. (2023). Activity and participation, bimanual function, and prosthesis satisfaction are strong predictors of general well-being among upper limb prosthesis users. *Archives of Rehabilitation Research and Clinical Translation*, 5(2), 100264.
- Stevens, P. M., Motawar, B., Davis-Stober, C., Buchanan, K., & Frey, S. (2024 March). Movement patterns and prosthesis use with transradial amputation: Pilot insights of bilateral limb loss and congenital limb deficiency. American Academy of Orthotists and Prosthetists (AAOP) 50th Annual Meeting and Scientific Symposium. Chicago, IL.





## Quantifying Mobility Constraints and Validating New Technologies Among Users of Lower Limb Orthoses

Recognizing the value and impact of a validated patient-reported outcome for users of lower limb prostheses, the Hanger Institute has spent the last several years collaborating with the University of Washington to produce a similar measure for users of lower limb orthoses. We anticipate that the resulting instrument will help us inform and optimize the clinical outcomes observed in this population.



## International Collaboration Auditing Existing Outcomes Instruments

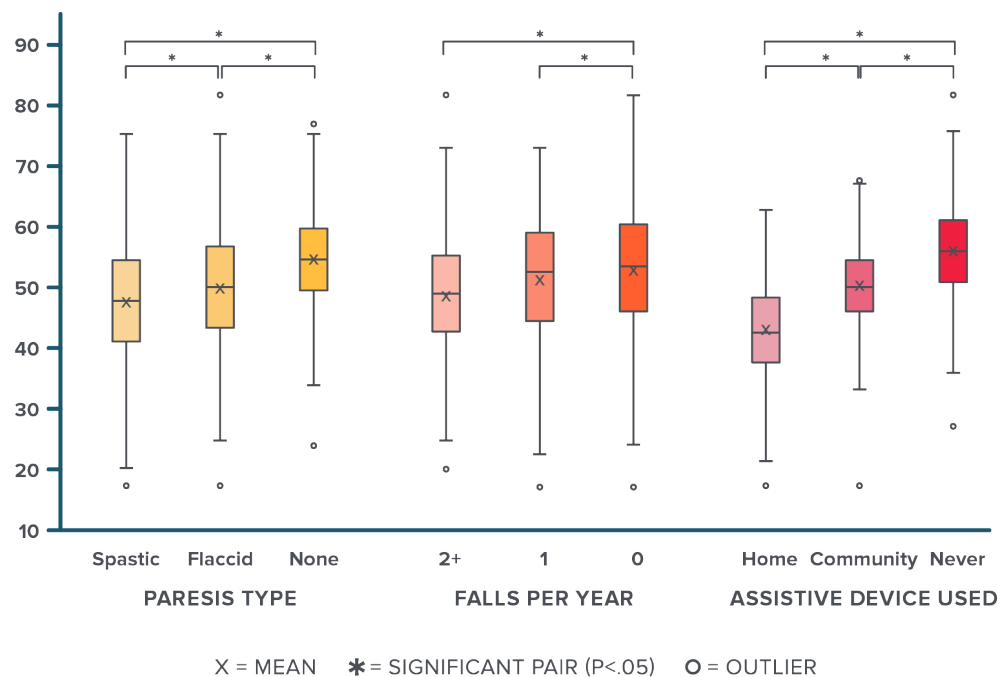
The Hanger Institute recently collaborated with Jonkoping University in Jonkoping, Sweden, to perform a systematic review of currently available outcome measures with respect to evaluating the effects of lower limb orthotic interventions for individuals who have had a stroke (Ramstrand & Stevens, 2023).

This effort, commissioned by the American Academy of Orthotists and Prosthetists, observed that while some existing performance measures could detect functional differences between walking with or without an ankle-foot orthosis, most of the reviewed measures were not sensitive enough to distinguish between two types of orthoses.

### Development of the Orthotic Patient-Reported Outcomes-Mobility (OPRO-M)

This observation supported the Institute’s subsequent collaboration with the University of Washington to develop a patient-reported outcome measure that was designed specifically for those individuals that utilize a lower limb orthosis. The result of this effort was the development and validation of the Orthotic Patient-Reported Outcomes – Mobility (OPRO-M) (Balkman et al., 2023).

This represents the first successful attempt to create an assessment tool that can discern the differences observed in mobility among individuals with different types of lower limb paralysis, different fall histories, and different reliance on lower limb assistive devices (Figure 13). The collaborative efforts continued as the Institute enrolled over 100 subjects to assess the validity of the instrument against existing assessment tools, including both performance and self-report instruments (Balkman et al., 2024).



Mobility Values Observed Among Lower Limb Orthosis Users by Paresis, Fall History, and Reliance on Assistive Devices

**Figure 13:** The added sensitivity of the OPRO-M is suggested by the differences in mean mobility levels observed between those with different types of lower limb paresis, those with differing fall histories over the preceding year, and those reporting the use of different assistive devices.



The final phase of this collaboration is underway as additional subjects are being recruited to access the instrument’s longitudinal sensitivity, or the ability of the measure to detect differences in performance between those observed with no orthosis, replacement with a similar orthosis, or replacement with a new type of orthosis.

### Validating the Benefits of Microprocessor Control for Knee-Ankle-Foot Orthosis (KAFO) Users

Outcome measures were critical in a recent prospective study on the efficacy of microprocessor-regulated knee-ankle-foot-orthoses (MPKAFOs). Hanger Clinic played a prominent role in the recruitment and execution of a recent analysis of this technology, ultimately observing the impact of MPKAFOs in improving balance, reducing falls, increasing walking speed, reducing pain, and increasing physical function in appropriately selected individuals (Figure 14) (Ruetz et al., 2023). These findings have proven pivotal in justifying the appropriate provision of this emerging technology for suitable patients.

Outcome	Traditional KAFO	Microprocessor KAFO	p-value
<b>Berg Balance Scale</b>	38.8 ± 8.9	42.4 ± 8.9	<0.00001
<b>Balance Confidence</b>	52.8 ± 18.7	64.7 ± 17.7	0.00011
<b>Falls</b>	5.0 ± 18.9	1.1 ± 3.3	0.00047
<b>Fear of Falls, Indoor</b>	3.2 ± 2.7	1.9 ± 2.3	0.00059
<b>Fear of Falls, Outdoor</b>	5.3 ± 2.9	4.1 ± 2.8	0.0078
<b>Dynamic Gait Index</b>	13.6 ± 2.9	15.9 ± 3.2	<0.00001

#### Benefits Associated with the Use of Microprocessor KAFOs

**Figure 14:** Significant benefits associated with the use of microprocessor KAFOs include improvements in the Berg Balance Scale and Balance Confidence, reductions in falls, a fear of both indoor and outdoor falls, and improvements in the Dynamic Gait Index.

#### REFERENCES

- Ramstrand, N., & Stevens, P. M. (2022 June). Clinical outcome measures to evaluate the effects of orthotic management post-stroke: a systematic review. *Disability and Rehabilitation*. 44(13):3019-38.
- Balkman, G. S., Bamer, A. M., Stevens, P. M., Weber, E. L., Morgan, S. J., Salem, R., Amtmann, D., & Hafner, B. J. (2023). Development and initial validation of the Orthotic Patient-Reported Outcomes—Mobility (OPRO-M): An item bank for evaluating mobility of people who use lower-limb orthoses. *Plos one*. 18(11).
- Balkman, G. S., Bamer, A. M., Stevens, P. M., Weber, E.L., Salem, R., Morgan, S. J., & Hafner, B. J. (2024 March). Reliability and validity of the Orthotic Patient-Reported Outcomes – Mobility (OPRO-M) short forms in lower limb orthosis users. American Academy of Orthotists and Prosthetists (AAOP) 50th Annual Meeting and Scientific Symposium. Chicago, IL.
- Ruetz, A., DiBello, T., Toelle, C., Hemmen, B., Wening, J., Weber, E., Braatz, F., Winkler, T., Steinfeldt, F., Umari, M., & Rupp, R., Kluge, S., Krebs, A., & Wurdeman, S. R. (2023). A microprocessor stance and swing control orthosis improves balance, risk of falling, mobility, function, and quality of life of individuals dependent on a knee-ankle-foot orthosis for ambulation. *Disability and Rehabilitation*. 1-14.





## Translating Knowledge to the Broader Rehabilitation Community

As we continue to develop as clinicians and healthcare providers, we believe that education is key in ensuring our clinicians and partners have current information to facilitate the best care for the patients we serve.



# Hanger Institute's 2023-24 Conference Participation

The Institute has collaborated with a number of professional education conferences to share our research findings with our physician, therapist, orthotist, and prosthetist colleagues. This included international participation at the 19th World Congress of the International Society for Prosthetics and Orthotics.



## American Academy of Orthotists and Prosthetists (AAOP) 50th Annual Meeting and Scientific Symposium

Chicago, IL | March 6-9, 2024

- Reliability and Validity of the Orthotic Patient-Reported Outcomes – Mobility (OPRO-M) Short Forms in Lower Limb Orthosis Users (Balkman, G. S., Bamer, A. M., Stevens, P. M., Weber, E. L., Salem, R., Morgan, S. J., & Hafner, B. J.)
- Movement Patterns and Prosthesis Use with Transradial Amputation: Pilot Insights of Bilateral Limb Loss and Congenital Limb Deficiency (Stevens, P. M., Motowar, B., David-Stober, C., Buchanen, K., & Frey, S.)
- Translating Outcomes That Matter Most to Individuals Living with O&P to Shared Decision-Making in the Practice Setting (Wilson, L., Gutin, M., Castleberry, T. J., Gress, E., Asatkar, S., Tahir, P., & Wurdeman, S. R.)
- Individuals in Warmer Climate Regions Do Not Report Worse Socket Comfort (Castleberry TJ, England DL, Fylstra BL, Wurdeman SR)
- Response Probabilities of PLUS-M Scores for Individuals with Lower Limb Amputation (Fylstra BL, Saenz S, Hafner BJ, Wurdeman SR)
- Successful Implementation and Utilization of PROMIS (Patient Reported Outcomes Measurement Information System) in Clinical O&P Care (Castleberry, T. J., England, D. L., Fylstra, B. L., & Wurdeman, S. R.)



## Bionic Reconstruction Conference (BReCON): The Future of Integrated Upper Limb Surgical & Prosthetic Innovation

New York City, NY | Nov 30-Dec 1, 2023

- Prosthetic and Therapy Perspectives on Pain (Crerar, E. & Stevens, P. M.)
- Osseointegration Panel (Potter, B. K., Fabbri, N., Nordstrum, M., Souza, J., Stevens, P. M., & Monroe, B.)





## Global Consensus Conference on Osseointegration

Charlotte, NC | Nov 3-4, 2023

- The 3 R's: Research, Regulatory, and Reimbursement (Churchill, C., Stevens, P. M., & Wenke, J. C.)



## American Congress of Rehabilitation Medicine (ACRM) 100th Annual Conference

Atlanta, GA | Oct 30-Nov 2, 2023

- Factors Associated with Elevated Well-Being in Individuals with Upper Limb Amputation (O'Brien, E. & Fylstra, B. L.)
- Caring for the Lower Limb Amputee: Post-op to Prosthesis Receipt to Rehabilitation and Beyond (O'Brien, E. & Fylstra, B. L.)



## American Orthotic and Prosthetic Association (AOPA) 2023 National Assembly

Indianapolis, IN | Sept 6-9, 2023

- Microprocessor Stance and Swing Control Orthosis for Patients Dependent on a Knee-Ankle-Foot Orthosis for Walking: A Randomized, Controlled Crossover Trial (Kannenberg, A. & Wurdeman, S. R.)



## Clinical Orthopaedic Society's 11th Annual Meeting Scientific Program

New Orleans, LA | Sept 7-9, 2023

- Current Advances in Amputee Care for the Practicing Orthopedist: Pathway to Well-Being Following Amputation (Stevens, P. M.)



## Continuing Education Course: Amputee Coalition National Conference

Orlando, FL | Aug 1-5, 2023

- Pathway to Well-Being Following Amputation: Considerations for Upper & Lower Limb Patients (Ramcharran, E., Fylstra, B. L., Meints, J., & Stevens, P. M.)



## International Society for Prosthetics & Orthotics (ISPO) 19th World Congress

Guadalajara, Mexico | April 23-27, 2023



- Factors Associated with Elevated Well-Being in Individuals with Upper Limb Amputation (Stevens, P. M. & Wurdeman, S. R.)
- Influence of Co-Morbid Health and Component Selection on Mobility and Fall Risk Among Older Diabetic/Dysvascular Amputees (Stevens, P. M. & Wurdeman, S. R.)
- Orthotic Patient-Reported Outcomes – Mobility (OPRO-M): An Item Response Theory Based Outcome Measure for Assessing Mobility in Lower Limb Orthosis Users (Balkman, G., Stevens, P. M., Weber, E., Bamer, A., Salem, R., Morgan, S., & Hafner, B.)

## American Academy of Orthotists & Prosthetists (AAOP) 49th Academy Annual Meeting & Scientific Symposium

Nashville, TN | March 1-4, 2023



- Recently Released Clinical Practice Guidelines on Rehabilitation Following Upper Limb Amputation (Stevens, P. M. & Webster, J.)
- Well-Being, Bimanual Upper Limb Function, Activity & Participation and Prosthesis Satisfaction are Strongly Correlated Among Individuals with Upper Limb Loss (Stevens, P. M., Todd, A., Mandacina, S., England, D., & Wurdeman, S. R.)
- Self-Reported Prosthetic Use: Implications On Prosthetic Design and Training (Stevens, P. M., Borgia, M., Heinemann, A. W., Ni, P., & Resnik, L.)
- Lifetime Mobility Values Following Lower Limb Loss (Fylstra, B. L., England, D. L., Stevens, P. M., Campbell, J. H., & Wurdeman, S. R.)
- Initial Construct Validity of the Orthotic Patient-Reported Outcomes – Mobility (OPRO-M) Item Bank for Assessing Mobility of Lower Limb Orthosis Users (Balkman, G., Bamer, A., Stevens, P. M., Weber, E., Salem, R., Morgan, S., & Hafner, B.)
- PROMIS-UE Physical Function Demonstrates Good Clinical Utility for Patients Following Upper Limb Prosthesis Intervention (England, D. L., Stevens, P. M., Todd, A., Mandacina, S., & Wurdeman, S. R.)







## Professional Education: A Year in Review

Education serves as the cornerstone for translating new evidence-based treatment options to our partners in care, including our rehabilitation partners, our orthotic and prosthetic (O&P) colleagues, and others invested in the care of the patient populations we serve.

Through the Institute’s collaboration with the Hanger Professional Education team, we deliver timely, relevant, and practical education to the rehabilitation community every year. Our education covers topics ranging from the latest prosthetic rehabilitation research to pediatric education and training, ensuring that our partners are equipped with the latest advancements and best practices in patient care.



In 2023, we offered a multitude of programming to support our national and local educational efforts. Through the **Hanger Institute’s National Virtual Classroom series**, we hosted “The Pathway to Well-Being Following Upper Limb Amputation,” featuring upper limb experts who discussed the recent evidence along with case studies on prosthetic design and rehabilitation techniques aimed at restoring meaningful bimanual function and well-being through an individualized patient care approach.





Additionally, **Hanger’s Educating Partners in Care (E.P.I.C.) track**, embedded within Hanger’s national conference, Hanger LIVE, hosted its 2nd annual offering. This growing community of physical and occupational therapists, O&P experts, and patients participated in an immersive education and networking experience focused on the unique care needs of limb loss patients.

Feedback from this event underscores the importance of multidisciplinary collaboration and communication in achieving successful outcomes for prosthetic users. Participants highlighted the significance of early collaboration with prosthetists and the profound impact of hearing firsthand accounts from patients sharing their experiences. The event fosters a deeper understanding of patient needs and promotes holistic approaches to care.

“ I really appreciated the concrete, evidence-based treatment ideas and patient experiences [shared] by our patient models.”  
-ATTENDEE

“ I felt the group gait analysis and transfer training was very beneficial for me to be able to apply to my treatment with this patient population.”  
-ATTENDEE



In 2023, in collaboration with two of the top limb loss patient events around the country, we hosted inaugural medical professional education sessions to further communicate the importance of our multidisciplinary approach to care:



At **Hanger Clinic’s EmpowerFest** in Salt Lake City, the session “Navigating the Limb Loss Care Journey: A Comprehensive Prosthetic Rehabilitation Approach for Therapists,” provided therapists with a case study-based learning approach that included open discussions for collaboration among patients and their rehabilitation partners.



At the **Amputee Coalition’s National Conference** in Orlando, the session “Pathway to Well-Being Following Amputation: Considerations for Upper and Lower Limb Patients,” reexamined conventional assumptions about prosthetic mobility in specific patient groups based on recent Institute research findings while also discussing strategies to enhance prosthetic mobility within those groups.

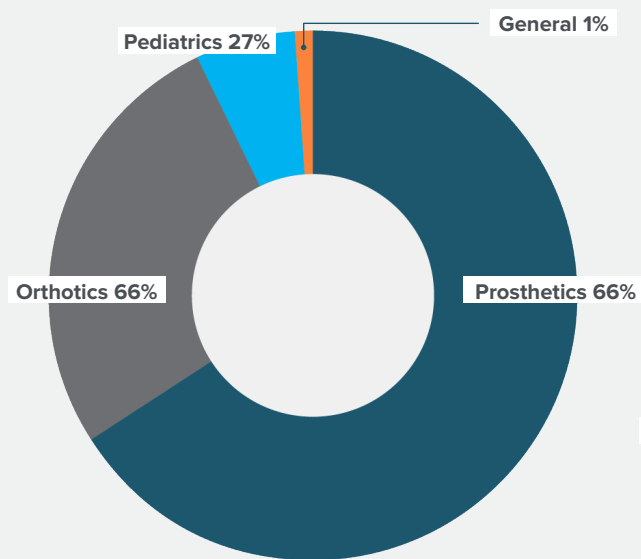


## Expanding Our Reach

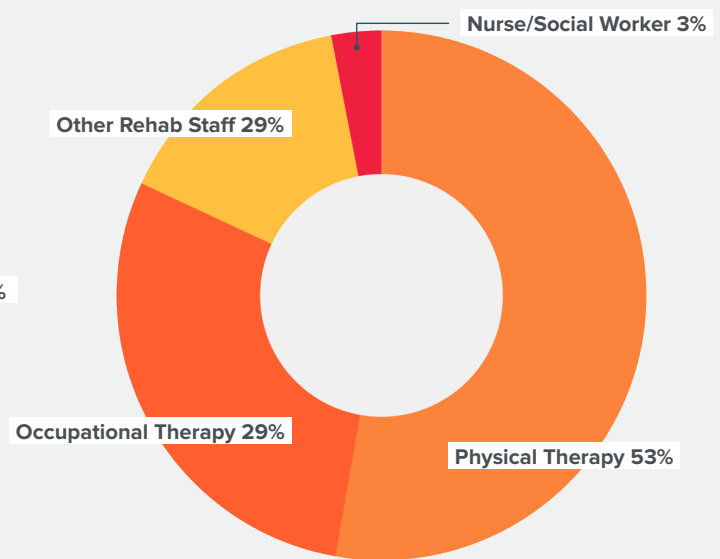
In addition to our national educational efforts, the Hanger Institute and Professional Education team leads the development of our nationwide CE Program that is offered and delivered in partnership with our Hanger Clinic field team around the country. This unique program helps expand access to the exceptional expertise of our clinicians everywhere. Every year, Hanger Clinic clinicians educate thousands of partners locally through this program, ultimately improving access to the patients they care for.

## Field Team Program Statistics

### Course Topic Breakdown



### Attendee Demographics



As we look towards the future, education remains a cornerstone of our commitment to advancing patient care and empowering our rehabilitation partners. Through ongoing collaboration, innovative programming, and a dedication to the highest standard of care, we will continue to equip healthcare professionals with the knowledge and skills needed to deliver exceptional care to the orthotic and prosthetic patient population. Together, we will shape a brighter future for those we serve, fostering improved mobility and function, independence, and well-being.

### REFERENCES

- Fylstra, B., Meints, J., Stevens, P. M., & Ramcharran, E. (2023 Aug). Pathway to Well-Being Following Amputation: Considerations for Upper and Lower Limb Patients. Amputee Coalition National Conference.





## Hanger Clinic O&P Residency Program

Since 1996, the Hanger Clinic O&P Residency Program has been the gold standard and pillar of excellence in clinical education, having trained more than 875 O&P residents. Our investment in the next generation of clinical experts is unparalleled, ensuring that patients across the country have access to care delivered with empathy and expertise for years to come.

The Hanger Clinic O&P Residency Program helps prepare new graduates for competent, autonomous clinical practice in the field of O&P. We utilize a comprehensive, gradual experiential model within a broad-based professional and academic environment conducive to the education and training of tomorrow's industry leaders.





We count on our residents to continue our storied tradition by offering a comprehensive, state-of-the-art, patient-oriented training environment that focuses on the development of new clinicians in the most efficient and effective manner possible. We provide elevated education and requirements above and beyond the standards of our resident credentialing board NCOPE. Residents are required to perform advanced activities, including viewing surgeries and participating in advanced evaluation clinics for our patients.

Residents also participate in our mock exam process that is held three times per year. Both prosthetic and orthotic board-eligible clinicians attend, where they participate in mock situations to prepare them for their board exams. This process results in Hanger Clinic residents passing the board exam at levels higher than industry averages.

The Hanger Clinic O&P Residency Program has a management structure that allows continuous check-in by national and regional leaders (resident liaisons). Each year, Hanger Clinic trains approximately 150 residents as they move through the 12-month or 18-month options of training, most of whom stay with the organization to continue their professional development.

## In 2023, Hanger Clinic hired 74 new residents.

For training, 47 residents selected the 12-month option and 27 selected the 18-month combined option.





## Who We Are: Meet the Institute Teams

The Hanger Institute is fortunate to have access to a number of motivated and talented professionals. These include internal Associates who oversee its day-to-day operations and Hanger Affiliates who support a number of Institute initiatives in addition to their primary responsibilities within Hanger Clinic and other segments of Hanger, Inc. In addition, the Institute is engaged in a number of research collaborations with Academic Partners as well as research and development projects with Industry Collaborators.



# Leadership & Associates

The core faculty of the Hanger Institute is comprised of a team of dedicated professionals in their disciplines of clinical care, research, and education.



**James Campbell, PhD**  
SVP & Chief Clinical Officer



**Phil Stevens, MEd, CPO/FAAOP**  
Vice President of Clinical Affairs



**Shane Wurdeman, PhD, CP, FAAOP (D)**  
Vice President of Scientific Affairs



**Siya Asatkar**  
Research Assistant



**Kathleen Carroll, MS, MSPO, CPO, FAAOP**  
Outcomes Program Specialist



**Todd Castleberry, PhD**  
Research Scientist



**Megan Chamis, MSPO, CO**  
Clinical Specialist Pediatrics



**Patsy Diaz Delgado, MS**  
Research Assistant



**Tom DiBello, L/CO, FAAOP**  
Director, Clinical & Scientific Affairs



**Dwiesha England, MSEng**  
Research Associate



**Bretta Fylstra, PhD**  
Post-Doctoral Researcher



**Liliana Komraus, MS**  
Senior Manager,  
Professional Education



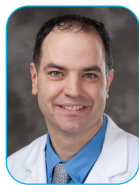
**Molly McCoy, CPO**  
Clinical Documentation  
Specialist



**Erin O'Brien, CPO, FAAOP**  
Clinician & Clinical  
Education Specialist



**Shannon O'Shea, CPO**  
Area Clinic Manager & National  
Clinical Specialist, Pediatrics



**Matthew Parente, MS, PT, CPO, FAAOP**  
Clinical Education Specialist



**Vahness Swilley**  
Director of  
Operations



**Chris Toelle, CO**  
Clinical Specialist  
Orthotics



**Doug Reber, L/CO**  
Director, Education &  
National Residency



**Eric Weber, CPO, FAAOP**  
Clinician & Clinical  
Research Associate



## External Advisory Board

To provide guidance around our mission to explore, expand, and facilitate opportunities that help advance leading-edge research, evidence-based care, and quality education in O&P, the Hanger Institute formed an external Advisory Board composed of highly respected, experienced members of the healthcare community.



**Biykem Bozkurt, MD, PhD**

**Director**, Winters Center for Heart Failure Research  
**Associate Director**, Cardiovascular Research Institute  
*Baylor College of Medicine | Houston, TX*



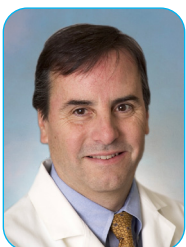
**Judith M. Burnfield, PhD, PT**

**Director**, Institute for Rehabilitation Science and Engineering  
**Director**, Movement and Neurosciences Center  
**Clifton Chair**, Physical Therapy and Movement Sciences  
*Madonna Rehabilitation Hospitals | Lincoln, NE*



**Catrine Tudor-Locke, PhD, FACS, FNAK**

**Dean**, College of Health and Human Services  
**Professor**, College of Health and Human Services  
*University of North Carolina*  
Charlotte, NC



**Douglas Smith, MD**

**Professor Emeritus**, Department of Orthopaedic Surgery  
*University of Washington | Seattle, WA*  
**Professor**, Department of Physical Medicine and Rehabilitation  
*Uniformed Services University of the Health Sciences and the Henry Jackson*  
*Foundation for the Advancement of Military Medicine | Bethesda, MD*





# Academic Partners

Collaborative research remains a core activity of the Hanger Institute, with team members pursuing patient-centered research questions across a broad spectrum of patient populations and interests. Several of our partners in such efforts include:

**Department of Medicine**

*University of California San Francisco*

**Department of Physical Medicine and Rehabilitation**

*Northwestern University*

**Department of Physical Medicine and Rehabilitation**

*Mayo Clinic*

**Department of Physical Therapy**

*Virginia Commonwealth University*

**Department of Physical Therapy and Rehabilitation Science**

*The University of Iowa*

**Department of Rehabilitation Medicine**

*University of Washington*

**School of Biological and Health Systems Engineering**

*Arizona State University*

**Walker Department of Mechanical Engineering**

*The University of Texas at Austin*

# External Grant Funding

As the Hanger Institute and its collaborators continue to pursue our diverse and ongoing research efforts, we acknowledge and thank the associated funding mechanisms and sources that support our activity through various research grant awards. These entities include:

**Department of Defense – Congressionally Directed Medical Research Programs**

**National Institutes of Health**

**National Institute on Disability, Independent Living, and Rehabilitation Research**

**US Department of Veterans Affairs**

**Center for Orthotic and Prosthetic Learning**



## Industry Collaborators

The Hanger Institute recognizes the need to ensure optimal patient outcomes across a range of patient populations and technologies. Accordingly, we continue to partner with several industry colleagues, including:



**Infinite Biomedical Technologies**  
*Baltimore, MD, US*



**LTI – a Coapt R&D company**  
*Holliston, MA, US*



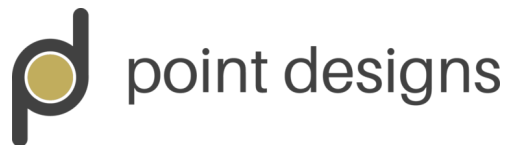
**Össur**  
*Reykjavik, Iceland*



**Ottobock**  
*Duderstadt, Germany*



**College Park Industries**  
*Warren, MI, US*



**Point Designs**  
*Lafayette, CO, US*



**WillowWood**  
*Mt. Sterling, OH, US*



**Fillauer**  
*Chattanooga, TN, US*



# Evidence Update: Benefits of Orthotic & Prosthetic Care

Recent research underscores the critical role of timely orthotic and prosthetic services in enhancing mobility, preventing falls, and reducing the associated healthcare costs. Implementing evidence-based interventions and providing access to advanced prosthetic technologies, like MPKs, can significantly contribute to better health outcomes for individuals with limb difference and limb loss and offer considerable cost savings to the healthcare system.

## Key Findings

- Receipt of prostheses within 0-3 months post-lower limb amputation leads to a significant reduction in total healthcare costs by approximately \$25,000 within 12 months, compared to patients who did not receive a prosthesis, highlighting the importance of timely provision of prosthetic service (Miller et al., 2020).
- Microprocessor-controlled knees (MPKs) significantly reduce the odds of incurring an injurious fall among individuals with diabetic/dysvascular amputation, demonstrating the critical role of appropriate prosthetic technology in enhancing safety for amputees (Wurdeman et al., 2023).
- Inclusion of microprocessor-controlled knees (MPKs) in prosthetic care plans for individuals with above-knee amputations due to diabetes/dysvascular disease can have a significant impact on the expected mobility for individuals across a wide spectrum of age ranges (Fylstra et al., 2023).
- Individuals with lower limb prostheses who reported low self-reported functional mobility had significantly higher odds of experiencing an injurious fall, highlighting the direct correlation between prosthetic mobility levels and fall risk (Miller et al., 2023).
- Individuals who are employed have 3.6x the odds of reaching increased mobility compared to those unemployed, underscoring the significant correlation between employment status and higher levels of functional mobility among lower limb prosthesis users (England et al., 2023).
- Enhanced mobility in lower limb prosthesis users is linked to greater quality of life, reduced healthcare costs, and lower risk of employment loss, making it a critical goal of rehabilitation efforts (Wurdeman et al., 2018, Miller et al. 2023, England et al., 2023).
- Addressing key factors such as employment may aid in improving mobility levels among prosthesis users, emphasizing the role of vocational rehabilitation and support services in the overall care strategy for individuals with lower limb amputations (England et al., 2023).



SCAN TO VIEW  
OUR PUBLISHED  
RESEARCH

## REFERENCES

- Miller, T. A., Paul, R., Forthofer, M., & Wurdeman, S. R. (2020). Impact of Time to Receipt of Prosthesis on Total Healthcare Costs 12 Months Postamputation. *American Journal of Physical Medicine & Rehabilitation*, 99(11), 1026–1031. <https://doi.org/10.1097/PHM.0000000000001473>
- Wurdeman, S. R., Miller, T. A., Stevens, P. M., & Campbell, J. H. (2023). Stability and Falls Evaluations in AMPutees (SAFE-AMP 1): Microprocessor knee technology reduces odds of incurring an injurious fall for individuals with diabetic/dysvascular amputation. *Assistive Technology*, 35(3), 205-210. <https://doi.org/10.1080/10400435.2021.2010147>
- Miller, T. A., Paul, R., Forthofer, M., & Wurdeman, S. R. (2023). Stability and Falls Evaluations in AMPutees (SAFE-AMP 2): Reduced functional mobility is associated with a history of injurious falls in lower limb prosthesis users. *Annals of Physical and Rehabilitation Medicine*, 66, 101679. <https://doi.org/10.1016/j.rehab.2022.101679>
- England, D. L., Miller, T. A., Stevens, P. M., Campbell, J. H., & Wurdeman, S. R. (2023). GGEM: Gender, Geography, and Employment differences based on mobility levels among lower limb prosthesis users living in the United States. *Prosthetics and Orthotics International*. <https://doi.org/10.1097/PXR.0000000000000219>
- Fylstra, B. L., England, D. L., Stevens, P. M., Campbell, J. H., & Wurdeman, S. R. (2023). Creating Adjusted Scores Targeting mobility Empowerment (CASTLE 1): Determination of normative mobility scores after lower limb amputation for each year of adulthood. *Disability and Rehabilitation*, 1-7. <https://doi.org/10.1080/09638288.2023.2208376>
- Wurdeman, S. R., Stevens, P. M., & Campbell, J. H. (2018). Mobility Analysis of Amputees (MAAT 1): Quality of life and satisfaction are strongly related to mobility for patients with a lower limb prosthesis. *Prosthetics and Orthotics International*, 42(5), 498–503. <https://doi.org/10.1177/0309364617736089>





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