The image features three different types of exoskeletons. At the top left is a full-body humanoid robot with a blue light on its chest. Below it are two leg exoskeletons: one is a more complex, multi-jointed leg exoskeleton, and the other is a simpler, more compact leg exoskeleton. The entire scene is set against a white background with a large blue circular graphic on the right side.

Exoskeletons

Perspectives in Assistive
Technology, Stanford 2026

Katie Strausser, PhD

Technical Lead, Exoskeletons
Principal Controls Engineer

eksOBIONICS

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What is an Exoskeleton?



Structure which supports the body from the outside and protects soft tissue.



A Quick Device Overview



Wearable robot that provides power at hips and knees
Provide full or partial assistance for those with gait disorders
FDA cleared for: Spinal Cord Injury, Stroke, Acquired Brain Injury,
Multiple Sclerosis

EksoNR & Indego Therapy are for use in a clinical setting
Indego Personal is available for home use.

~~Human-Robot Interaction~~

Human-Human-Robot Interaction



Physical Therapy is Not Easy

Providing quality physical therapy is challenging.

It is challenging physically - moving & supporting a patient

It is challenging mentally - planning a treatment plan for each patient, scheduling, learning how to use tools

It is challenging emotionally - providing encouragement, guidance, and realistic goals for patients

Exoskeletons can help but focus on design is critical.

Continuum of Care Model

Expanding focus beyond Inpatient Rehabilitation

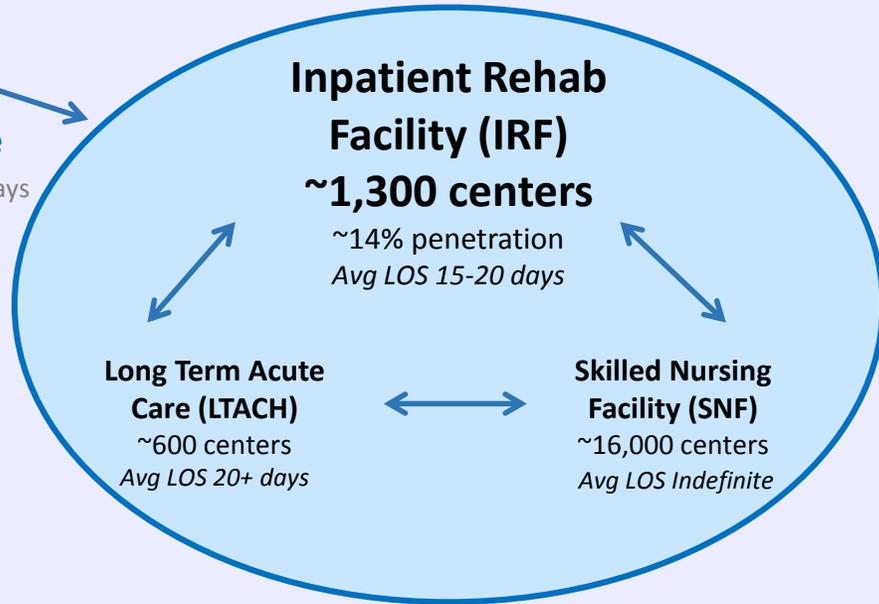


Post-Acute Care



Acute Care

Avg LOS* 5-7 Days



Outpatient

~63,000 centers



Wellness Centers

Emerging Market

~31,000 centers in the US



Home / Community

- Veterans
- Home health
- ~100 personal devices delivered

Patient Service Intensity

Our role...

As R&D engineers, our obligation is to build quality exoskeletons to help our patients, but in order to do that, we must focus on usability and aiding adoption.

This includes (but is not limited to):

- Physical Design
- Ease of Use
- Device Trust

Device Design

The design of the device enables quick setup, safe operation, and physical support for the therapist.



Setup Time

One study from Baylor indicated challenges of adoption due to setup timing: “Survey and focus group feedback revealed that therapists encountered measurement difficulties with the Ekso and limited treatment time influencing effectiveness of usage. After 6 months, therapists reported an improvement in feasibility. ”

Likewise, a multi-center study with Indego shows that self-donning time decreases over the learning period.

Swank C, Sikka S, Driver S, Bennett M, Callender L. Feasibility of integrating robotic exoskeleton gait training in inpatient rehabilitation. *Disabil Rehabil Assist Technol*. 2020 May;15(4):409-417. doi: 10.1080/17483107.2019.1587014. Epub 2019 Mar 19. PMID: 30887864.

Candy Tefertiller, Kaitlin Hays, Janell Jones, Arun Jayaraman, Clare Hartigan, Tamara Bushnik, Gail F. Forrest; Initial Outcomes from a Multicenter Study Utilizing the Indego Powered Exoskeleton in Spinal Cord Injury. *Top Spinal Cord Inj Rehabil* 1 January 2018; 24 (1): 78–85. doi: <https://doi.org/10.1310/sci17-00014>

Intuitive Adjustments



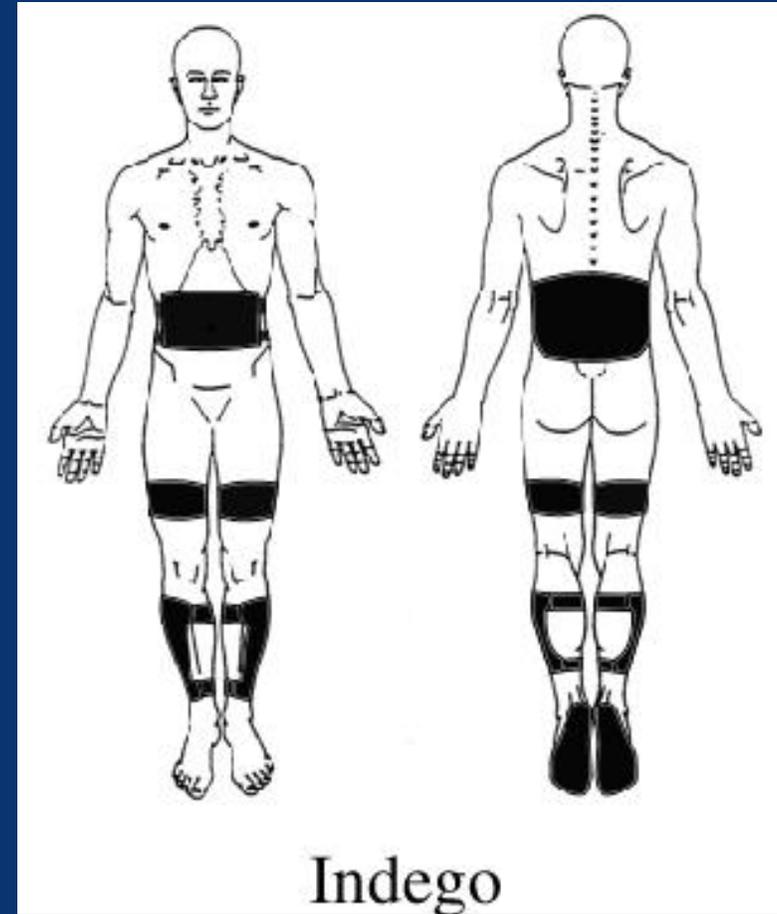
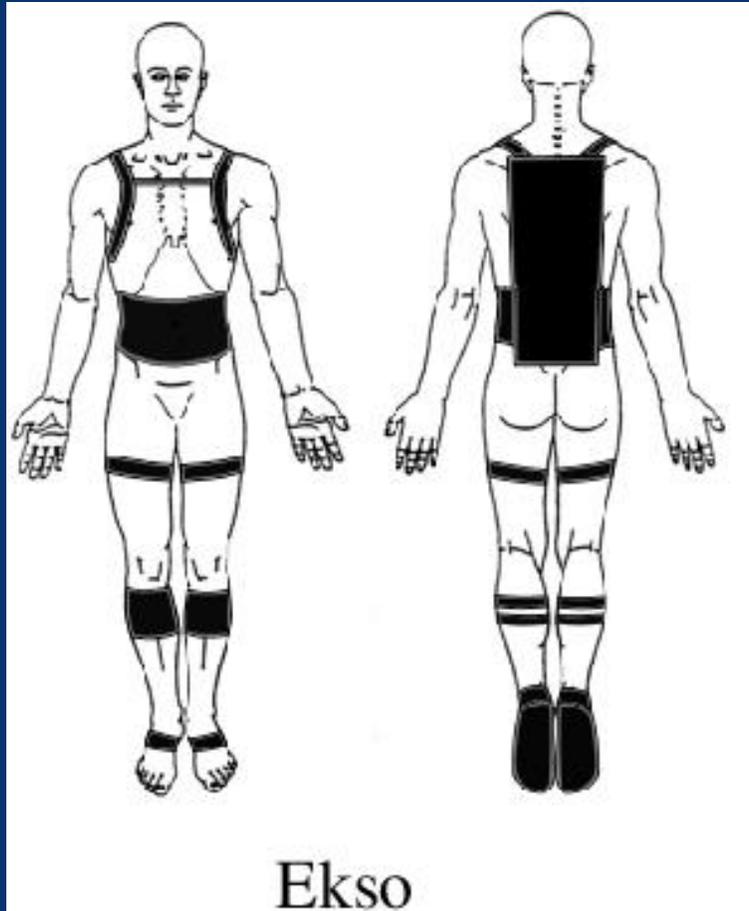
Physical Support

Provide safe interfaces for both people

Provide means to limit therapist exertion

Enable confident interaction

Support

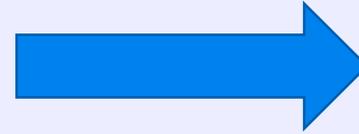


Meyer, Jan Thomas et al. "User-centered Design and Evaluation of Physical Interfaces for an Exoskeleton for Paraplegic Users." *2019 IEEE 16th International Conference on Rehabilitation Robotics (ICORR)* (2019): 1159-1166.

Ease of Use



Simple
Intuitive
Informative
Guiding



Reduced training
burden
Increased confidence



Training

- Highest impact on device abandonment
 - Lack of confidence
 - Unsure of how to integrate into program
 - Staff turnover
- High-cost component
 - Scheduling / loss of patient time
 - Training cost

```

--      R Turn-Pro+      --
◀ Stand           L Step ▶
  Still           Walk ✓
L90              R75    88% █

```

EksoGT

EksoNR

0 A 11:05 AM 49%

Walk | FirstStep
Right stepping...

Stand Still Left Turn

Stats

Walk Time	0:00:17	L	99A	Swing	R	98A
Steps	7		61	Min		62

iPod 2:09 PM

End Motion+AG/FES

Steps Taken

00:00:37 Session Time | 00:00:00 Walking Time

60% Battery | NONE Limiting

Control Panel

Gait FES(OFF) Temps Cycles

Gait Parameters

0 cm Stride Length

-- 0% Step Symmetry | 0 m/s Gait Speed

Save Notes Events Test FES

Indego Therapy+

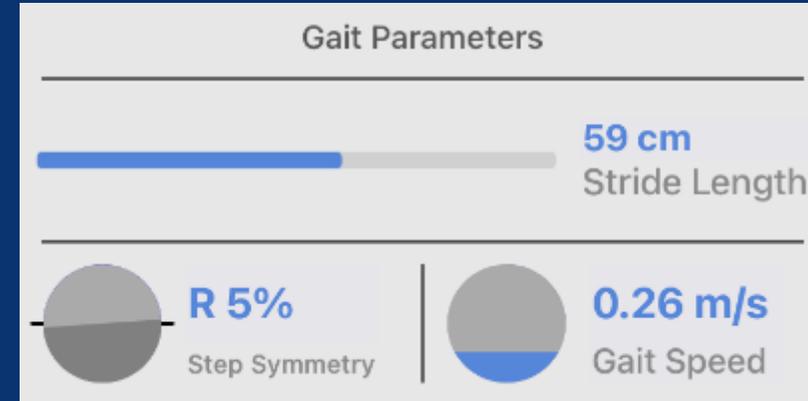
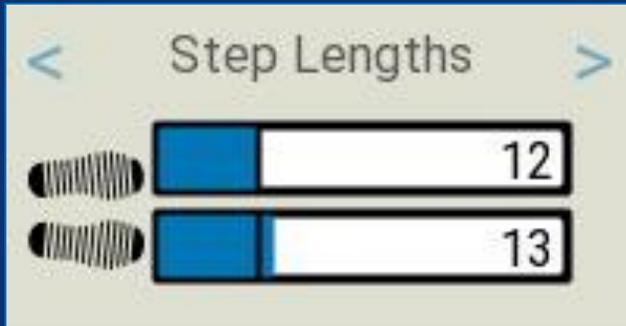
Decision Making

How to set up the device for the best clinical outcomes for this patient

Selection of appropriate patients

Guidance of treatment within the session

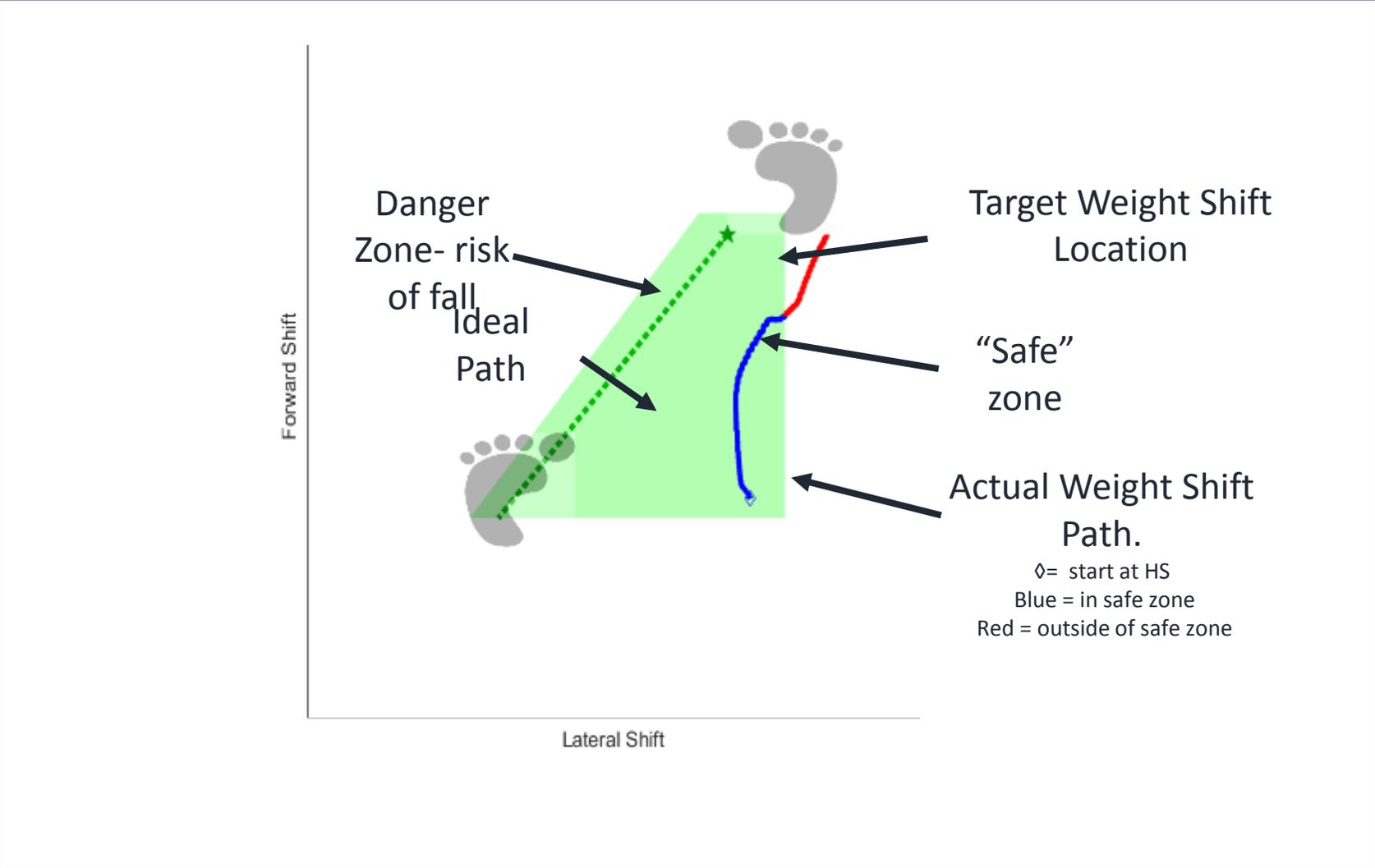
Guidance



Provide clinical feedback that is:

- easily understood by the therapist (without training)
- can be directly acted on
- timely

Too Complex – No Clear Action



Trust

Robot Trust is critical to quality human robot interaction

- The timing of errors matters
- Explanations of behavior can help build trust

Zhao Han and Holly Yanco. 2023. Communicating Missing Causal Information to Explain a Robot's Past Behavior. *J. Hum.-Robot Interact.* 12, 1, Article 10 (March 2023), 45 pages. <https://doi.org/10.1145/3568024>

M. Desai, P. Kaniarasu, M. Medvedev, A. Steinfeld and H. Yanco, "Impact of robot failures and feedback on real-time trust," 2013 8th ACM/IEEE International Conference on Human-Robot Interaction (HRI), Tokyo, Japan, 2013, pp. 251-258, doi: 10.1109/HRI.2013.6483596.

Unclear Messages Leads to Loss of Trust



- Lack of use
- Loss of treatment time
- Decrease in treatment quality
- Cost of service

Trust

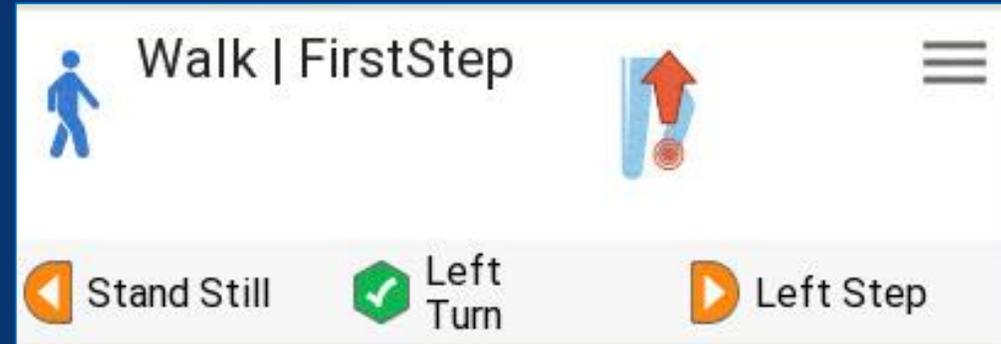
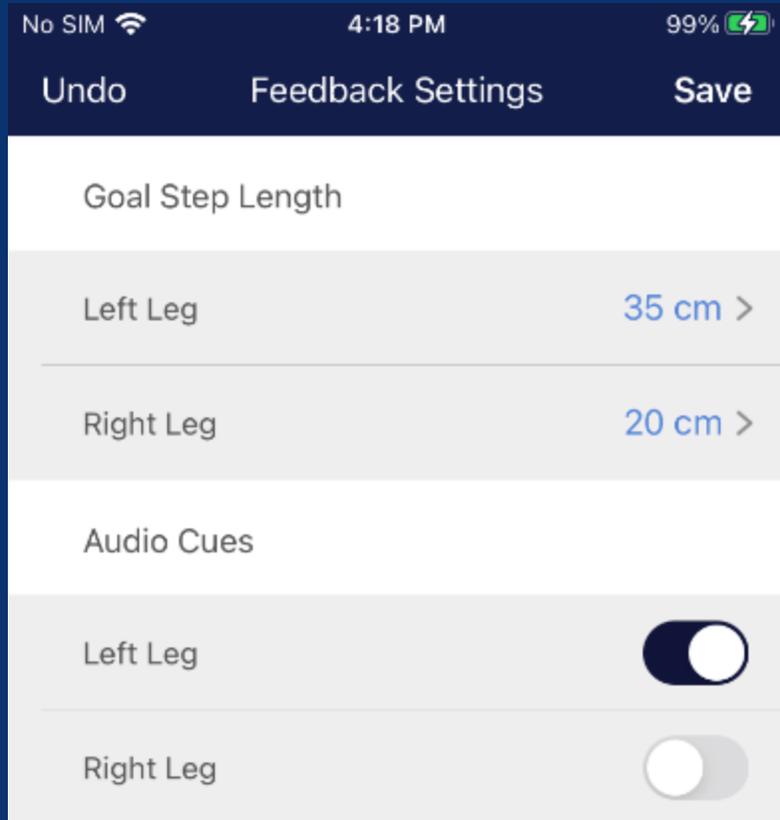


Did the robot
error or did the
patient error?

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Counters for Loss of Trust



Clear indications of issue and resolution.

To drive widespread adoption

Physical Design



Determine the necessary features / adjustments

Ease of Use



Focus on interface design and guidance

Device Trust



Improve reliability and clarity

eksoNR

Thank You



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