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SPEAKERS

Dr. Marie McNeely, Dr. Tyler Susko

D **Dr. Marie McNeely** 00:01

Hello, and welcome to Changing What's Possible: The Disability Innovation Podcast brought to you by Cerebral Palsy Alliance Research Foundation or CPARF. I'm your host, Dr. Marie McNeely. And this season, we are excited to bring you extraordinary stories about how disability technology and innovation come together. And today we have with us Dr. Tyler Susko. So listeners, Tyler is the founder and CTO of Cadence, Inc, as well as principal engineer and owner of Susko Engineering, and also an associate teaching professor and undergraduate chair at the University of California, Santa Barbara. He was a key member of the team that developed the Cadence shoe. And we look forward to talking more about his work and more about Cadence today. So, Tyler, thank you so much for joining us. How are you?

D **Dr. Tyler Susko** 00:47

Thanks, Marie. I'm great. Thanks so much for having me on today. I'm excited to talk to you.

D **Dr. Marie McNeely** 00:51

Well, we are thrilled to have you with us. Can you start by telling us a little bit more about yourself?

D **Dr. Tyler Susko** 00:56

Oh, sure. So I think you've given a good background on where I am right now and my different positions. But I grew up in Pennsylvania and then interested in engineering my whole life. I really got into the disability space through graduate school, and specifically in rehabilitation robotics. So that's where my specialty lies. I've been teaching at UC Santa Barbara for years right now. And I specialize in engineering design, product design and machine design.

D Dr. Marie McNeely 01:22

Very cool. So can you tell us a little bit more about how you first became interested in this area in engineering and developing new products maybe specifically for people with disabilities?

D Dr. Tyler Susko 01:32

Absolutely. So like I was saying, when I grew up, I was always building things. So it's always the typical engineering answer, right? You're doing Legos, Connects, building cars, and seeing how they break and things of that nature. In high school, I had this really great opportunity, I went to a high school that would routinely send us out on service missions. And I went to a school called Cades in Swarthmore, Pennsylvania. And specifically, it was a approved private school for children with intellectual and physical disabilities. And I just got this experience with these children. I was there all day, the majority of them had cerebral palsy and fell in love with them. So it was always in the back of my mind. And I didn't realize how impactful that experience was until I got older. So flash forward, I got my engineering degree, I got a master's degree and I went to work, I was working for a large industrial company making products, and I just wanted to do something else. So I was either going to start a company or I was gonna go to graduate school. So I applied to a bunch of graduate schools and started jumping around the country, trying to figure out where I wanted to go. And I remember I was at UC Davis at the time, I was looking there. And then I took a red eye back to MIT. And I was visiting the labs at MIT. And one of them specifically had something to do with rehabilitation robotics.

D Dr. Tyler Susko 02:41

And again, if there's this moment in your life, sometimes where things kind of flashback and and fit together like a puzzle. And for some reason, that experience that I had when I was about 16 years old, just kind of flooded back in my mind. And I started thinking, oh, man, maybe I can use the skill set that I've developed, which was this engineering skill set to help those kids that I had originally interfaced with when I was younger. So that's kind of what got me there. And then I was just all about it. I wanted to be in rehabilitation robotics, and I was lucky enough to get a fellowship at MIT, which meant the first year I could choose any direction that I wanted to research. And of course, I went right to cerebral palsy because I'm in this lab, and they were really the pioneering lab of robots that interface with humans to deliver rehabilitation. So my advisor's name is Ego Crebs at MIT said, I have this contact at Blithedale Children's Hospital, you should go there and talk to her at the time, they were taking the adult type rehabilitation robots and just making smaller versions that would go into the hospital for children to use, which makes a lot of sense, right? A lot of this is funded by stroke research, stroke is very prevalent, so that there's a lot more funding there.

D Dr. Tyler Susko 03:46

So companies were just miniaturizing, these robots, and a lot of them were reaching robots and kids can play a little game, and the robot will aid them to get to a certain target. So I was looking at those robots and talking with the medical director there. She was the Chief Medical

Officer at the time, her name was Joelle Mast. And she said, we have these great robots. But really what would interest her at the time, she said, nobody's looking at babies. And I thought, That's really interesting. So I started taking some neuroscience, I know you're much more of an expert than I am in that area. I started to get into the neuroscience behind what we were trying to do because as an engineer, we always have to understand the problem first, before we design something. So I started taking neuroscience classes at MIT, just sitting in - wasn't my major or my focus of what I was studying, but I needed to fully understand it. So I started to learn things about neuroplasticity, I started to learn things about critical ages in which we learn certain tasks, you know, the Blind Cat experiments and things of this nature that you're probably familiar with. So the hypothesis started to boil up into my mind to just like Dr. Mast was telling me that if we could interface with these people at a younger age, closer to the time of injury, there might be a higher level of plasticity at that age. And she's like, nobody's looking at the baby space. So my first year at MIT, I really wanted to get into that space. So I call it a baby pod. I started developing a reaching robot for infants that were laying on their back. And of course, as all of my family knows, they are my guinea pigs at the time. We weren't married - my wife now. Luckily, she still married me. But I built a big version of this baby robot and I had her sitting there and the robot was taking your arm to different targets is kind of funny, but I didn't get any funding further for that after a year. So I switched over to adult type stuff and started studying locomotion, similar kind of area, but I had to move away from the baby thing, but the baby thing is still ongoing. We're now in year five of this at UCSB. And now we've switched to ball therapy. So we're automating ball therapy right now. I have students actively working on this at UCSB. Hopefully, by the end of this month, we have a functioning robotic ball therapy device that I'll then be testing. But anyway, going down that story a little bit further, I went into this locomotion type of rehabilitation robotics, and develop something called the MIT Skywalker. So I was lucky enough to try all the rehab robots that were out there at the time, or at least a few of them. If you're familiar, there's the Lokomat machine. It's a beautifully- as a mechanical engineer, this thing was gorgeous. I was just in love with this machine. Have you seen this one, Marie?

D Dr. Marie McNeely 06:08

Yeah, I've seen videos of it. It's so cool.

D Dr. Tyler Susko 06:10

It's so cool. And being on it was even cooler. And so I got the chance to try it out. And the MIT Skywalker, which was what was different than the Lokomat, other end effector type robots is it wasn't really interfacing with the person at all. So the Skywalker, the thing that I designed at MIT was a split belt treadmill. So there was two treadmills you can walk, one foot was going single treadmill, another foot will go on the other terminal, the full size treadmill, this is a pretty big machine. And then each treadmill was able to drop and it was guided by a machine vision or a system that was watching the body. So as soon as somebody would try to take a step forward, the machine would recognize that, and then it would drop the track away so that the foot can then swing back for like a pendulum. So this addresses things like foot drop, or for anybody that had difficulties advancing the foot during gait. So if you think about gait gaits can be divided into two different phases of your gait. You got the stance phase, when your foot is making contact with the ground, and then you have the swing phase, when your foot is moving from the back side of your body to the front side of your body to take another step. So during

that swing phase of motion, a lot of people have trouble advancing that gait. This is all kinds of disabilities, this is a similar problem that after a stroke, your foot drops sometimes, or drop foot, some people call it and that really makes it hard to get your foot forward during the swing phase in motion. A lot of times we'll see p we'll see kind of a crouch gait, or any type of spasticity that also makes it hard to get your foot back forward.

D Dr. Tyler Susko 06:10

So what we were doing with that machine specifically was we were trying to modify the environment around the person to allow them to direct their own motion without the constraints that existed in the physical world. So we did that by removing the constraint that was preventing them from getting their foot back forward. So what we had found, I ran a little study at MIT, it was an IRB approved study with three individuals over a month. So they came into my lab three days a week, or four days a week and trained on this machine. And that was the main mode of the machine was to get rid of this constraint while you walk. This is really I think the point of the Skywalker machine was to remove that constraint. So I found some rehabilitation benefits for those three people. And there's not a big data set here. So we can't make any conclusions at all. But one of the things I came away with was, I got comments back from people that would walk on the machine that said, it's just so free and easy to walk, I don't have to worry about tripping. If I could have that when I walk outside, that would be awesome.

D Dr. Tyler Susko 08:25

So I was like, Oh, that's really cool. And one of the people that was in my study, she just happened to be moving to Santa Barbara, the same time I was moving to Santa Barbara was getting ready to graduate from MIT. Her family was from this area. And so she's like, yeah, love it if I could just have something that felt like that when I walked down the street. And I thought to myself, interesting, well, why don't we work on it together. And so she said that as a joke, but we started working together, she had cerebral palsy. And the next year, we started working with my students here at UCSB designing robot shoes. The robot shoes weren't a great idea, there was a lot of problems that went into those robotic shoes. They look funny. One of the things that I run into all the time while interfacing with anybody that has a physical disability is the number one thing that they want is to not stand out to be part of the crowd. I've had this come up so many times in my work, and the big robot shoe is not going to fill that bucket. So complexity, software malfunctions, weight, those kinds of things made the robot shoe not necessarily a good idea. So we kept changing it and iterating and iterating and iterating, about 30 or 40 iterations later, we finally have what's called the Cadence shoe right now. And the Cadense shoe was effectively meant to reproduce the feeling of walking on that Skywalker machine, which would have been kind of like a million dollar robot that was put into a hospital for something that would be as affordable as a shoe that everybody could wear.

D Dr. Marie McNeely 09:45

Absolutely. And I know we're going to be going into some detail about the Cadence shoe specifically today. But as you've alluded to, in your previous response, you've worked on a wide range of devices and products over time for people with disabilities. So are there any other

examples you'd like to share? Maybe carry any projects that you're working on that you're excited about?

D Dr. Tyler Susko 09:54

I'm really fortunate to be at UC Santa Barbara and I teach a capstone program here, which is a year long design sequence for seniors before they go off and get jobs at SpaceX or wherever they're going to go work after they graduate. And as part of that, every year, I take two projects specific to disabilities, and how I find them is different. But we've had projects to automate pediatric walkers. That was a really cool story, actually, I started this program to work with a local elementary school here to interface with my students, for freshmen engineers to design dancing robots. So they were going to design a dancing robot, it was their intro to engineering design. And then we brought in fifth and sixth graders from the local elementary school to help design those robots. So the elementary school students would tell my freshmen at the time, what the robot had to do, the dance moves that they wanted to accomplish and what it had to look like and the size of it and all kind of stuff like that. And then we had the program overseen by some of our students at UCSB, where the elementary school students would be building a light up stage that would dance with lights and things of that nature. So anyway, after a couple of years of doing that, a young girl at the school was there and she had a power chair, and she was sweet as all can be. And I started talking to her and she had an aide with her and I said, you know, if there's ever anything that you can't buy commercially, that would make your life easier, you let me know, just as a comment, I didn't expect her to come back with anything. So then at the next meeting that we had with elementary school students, she comes back, and she hands me this picture of her in what she called automatic walker.

D Dr. Tyler Susko 11:35

And so she had herself and a dress, in a device with wheels on it with her walking by herself at the time, she couldn't walk independently. And I was just like in tears, right? Like, yes, we're building this we'll find a way. So I was able to raise a little bit of money to make this project reality. And then the next year I had 10 students work on it at UCSB. And they went through the design process. That's what we teach and trying to understand the needs what she really wanted out of this thing. And then they worked on it for a full year. And at the end of the they came up with what they called the leg track, which was kind of this automated walker, it was a walker that was motorized, that would sense when she wanted to move and would move with her. She didn't have the power in her legs to move a passive walker by herself. So this one would kind of guide her it was an auto mode. So that project turned into a little startup company for the students. I think they're still pitching that one. So that was a really fun one. I've done one, I met a child at a birthday party for my son, I've got three kids. And he had malformation on one of his limbs at birth. And we tried to develop him a robotic prosthetic for that arm because it was also his dominant hand to help them do different tasks. He wanted to play basketball he wanted to write but one of the things that was interesting, and I alluded to this before, was when we started to prototype this robot, he hated it, oh, no, absolutely hated it. He didn't want it. This is ridiculous. I'm not wearing that. We want to make sure that people are able to engage with our community. And a lot of times people do not want to stand out. So for him, he was like I'm not wearing that. We ended up changing that completely to be as simple as just the pencil grip that would allow him to grip a pencil easier with his dominant hand. So that's another project. We've been working on this baby bot that I talked about a little

bit before. For years, this is about the fifth year and went through the pandemic. So we were remote a lot. There was a bunch of duct taped together robots those years. But it looks like promising this year, we might actually be able to test this. I have an infant right now who's gonna be the test subject. As I said, my family members are typically my guinea pigs. So we make sure everything is safe before we test anything, but the ball therapy robot should be ready, hopefully in about a month here. And then we'll start testing that for early intervention for children at risk for cerebral palsy. So that's a flavor of them. I'm also working with Steve Ferrara, do you know Steve?

D Dr. Tyler Susko 13:44

I don't.

D Dr. Tyler Susko 13:45

He's a wonderful guy. He's an influencer. He has a company called Beyond Disabilities. And I had known about him because I followed him on social media. He has cerebral palsy. He's very vocal about everything and has this wonderful attitude. It's always about you can do it. He's a Paralympic medal winner gold medal winner in the shotput. He power lifts. He's just outrageously cool. He's coming to UCSB tomorrow, actually, I contacted him last summer because he was in Santa Barbara doing a TED talk. And I couldn't make it but I was like, I'm sorry. I missed you. Let's talk about working together. So I got on the phone with him last summer. And it's just talked to him about what does he need that doesn't exist out there and he likes to go to the gym. He likes to go to a standard gym that is used by everybody. But a lot of the equipment is not accessible to him. So he mentioned one of these cable type machines that you exercise on. We've seen these people do like tricep workout and cable crossover stuff. Anyway, those types of machines are difficult for him to operate because he doesn't have the dexterity to move the pin into the weights. Also, the weight stack for a person in a wheelchair is too low for him to interface and then the cable adjuster thing itself where the cable the pulley can be moved up and down requires two hands and it's also too high or too low for him to get some time. So we've solved all of those problems with an exercise machine. So he's going to be coming tomorrow to try out some of these concepts. And hopefully we'll have something ready for him by the end of the year. So that's just some of the projects we've worked on over the years.

D Dr. Marie McNeely 15:07

Well, it sounds like you've been quite busy. And I'd love to dig in some more detail about Cadence, you spoke a little about it earlier. But to really dig into it, what inspired you to create this Cadence shoe?

D Dr. Tyler Susko 15:18

It was all the learnings from the Skywalker. So with these big robotic systems, they're limited that they can- well, first of all, they're static, meaning they can't be moved outside of a clinic or a laboratory. And I had these original learnings that nobody else had, which was kind of

interesting. When you observed people in a new environment and a new piece of machinery that isn't available commercially, you're able to come out with insights that nobody else in the world has. So the insight that specifically sparked all of this was it was easier to walk when we could reduce some of the problems with the environment around people when they were walking by removing that floor constraint. So actually, the first paper we wrote about MIT, Skywalker was MIT Skywalker, a new paradigm for reduced constraint therapy or something like that, or changing the environment of walking.

D Dr. Tyler Susko 16:06

So with the Cadense shoe, I was trying to do the same thing, but just an inexpensive and simple manner. And that's what we had done. So the Cadense shoe itself, this was about after three years of working on it, a lot of this stuff is all about iteration you try and then you fail, and you try and then you realize something is wrong or dangerous or something. And then you have to go back to the drawing board and keep on changing and changing and changing. So we got to the point where we were drilling holes into shoes, and just putting in different types of foams experimenting with different frictional properties of materials that went inside of that shoe. And we called it a variable friction shoe at the time as low friction when you were to scuff your foot. So this was similar to what we were doing with the Skywalker when we remove the constraint completely about by dropping the track and letting the foot come forward, we're trying to reduce the friction as much as we could, just by decreasing the friction of what is going to come in contact with the ground during the swing phase of walking. Once you put your weight on the shoe. And even on the early versions of these Cadence shoes, we were spelling it with a C at the time C cadence, those early shoes did the same thing, they would have low friction when you would scuff on it or bring your foot forward. But as soon as you applied weight to it, the low friction material would retract up into the shoe and expose a high friction rubber outsole, which would grip the ground. So thereby it would do the same thing, we would have a low friction shoe that sliding across just like the Skywalker when we got rid of the floor completely. As you put weight on the shoe, you got your traction back.

D Dr. Tyler Susko 17:36

So we tested that in our lab here that. It started off as these were undergraduate projects that start and then once we got to the point where we're like, okay, we need to get a little bit more serious than it converted one of the students that was graduating, she stayed on for a master's, and then iterated the shoe to the point where we thought it was safe enough for people to try. The lab space that UCSB that I had, we put up a rail with a harness to protect from falls in case somebody fell with these new wacky shoes that we're using. And then we had an IRB approved study with a local hospital here, which is called Cottage Hospital. So they sent a physical therapist over and we had five people with different types of neurological disabilities try out our shoes in the lab. And it was really interesting what happened. So we would give people the shoes, we put them in the harness, we'd have them walk in our lab space, which was tiny as the size of a room back and forth with this harness. And the students had created signs like turn right, when you get to this side turn left when you get to the other side, so that wouldn't tangle up the harness. So they'd walk for a couple of minutes just to get used to this experience of walking with a low friction high friction shoe. After a couple of minutes, they said they were feeling comfortable, we would put them outside the lab, we had a 10 meter long walk test, the 10 meter walk test is a standard clinical test that physical therapists use to

assess walking speed. So we'd have them walk their trials on the 10 meter walk test. And what we found was that three out of the five people that we just brought into the lab to try are cut apart shoes, walks 20 to 60% faster in two minutes.

D Dr. Tyler Susko 18:59

So we only had them in the shoe for two minutes and walking back and forth in that harness before we unharnessed them and let them go in the hallway. And we thought wow, that's weird what's happening. So we brought them back into the lab after and we put them on a instrumented treadmill, we had EMG going to map the muscles. And then we had motion capture six camera motion capture system with a bunch of markers all over the legs to figure out what their gait was looking like. And so we mapped them before and after with the shoes. And we found that the people that were walking faster, weren't utilizing their strategy anymore how they were typically walking, which was in this case, circumduction. So people that were using circumduction, pulling the hip real far out in a circular pattern to make another step that was decreasing. So people were reducing that we would call it the frontal plane angle, how far outside of the hip, people were bringing their foot as they made another step. Those people that were walking faster, were reducing that angle of some by as much as 60%.

D Dr. Tyler Susko 19:50

So what they were doing was relying on this low friction material to just bring their foot back forward. So we published that work. It's in a conference that was held in Berlin. So that work anybody can find online now. So at that point, we're like, Okay, we've got this thing that we have no really statistically significant data here. All we have is a few of these people responded really well to when we change fictional properties underneath the shoe, and this variable friction shoe manner. So I applied for another grant through CNSI, which is a group here on campus. It's called the California Nanoscience Institute, they have grants called Seed Tech, it's $50,000, to seed technology that was developed in a lab and move it towards commercialization. So with that brand money, we were able to take our cut up shoes and hire an actual shoe designer with a shoe factory to create while we got 26 prototypes, there was an iterative process, we did three different iterations of this shoe until we got something that we believe would be safe overground and outside of the laboratory setting. So we use that money to get those and then I ran what I called the beta test.

D Dr. Tyler Susko 20:50

So I had 14 people walk with these shoes outside of the laboratory on kind of an exercise program. So they walked in this new Cadence shoe, and I checked in with them after week after month, monthly thereafter, just to see how things were going, how was testing? Is this going to be safe if we take it out of the laboratory? In thinking about this, I'm taking somebody that has an impaired ability to walk in the normal fashion that we usually are accustomed to. And I'm gonna put them in a low friction material, it doesn't sound like a great idea, right? Slips and falls. Yeah, you think, oh, boy, this is a little scary. So I wanted to see what was going to happen. So we gave these to people, I checked in with them frequently to make sure that we're keeping track of anything that happened, any kind of falls any kind of adverse events. And luckily, we didn't have any adverse events. Some people walked in the shoes up to six months,

and we're getting really great comments back from them. So at that point, well, actually a little bit before then, the University California filed a patent on the shoes, and it was about to expire in a month. So I just went to a little networking thing here in Santa Barbara, and was talking to a couple of people just saying, I have this shoe, I think it actually could affect and help a lot of people, but the patent is about to run out. And once the patent runs out, then it's hard to get any type of investment behind something if you have nothing that can protect that invention, right. And it just so happened that some events transpired where I was able to pull in my co founder of this company, Canaan St. Now, his name is John Gratehouse, and he and I were able to raise a little bit of money to pay for this patent and to get things jumpstarted. And then since then we've raised a little bit more pre-seed money. So we're now able to actually produce these shoes at a reasonable volume. They should be available for commercial sale in about November. So that was kind of the trials and tribulations of trying to get some sort of thing from a laboratory and out into the world.

D Dr. Marie McNeely 22:28

Oh, absolutely. It is a complicated and long road for a lot of products. So I guess Tyler, if you had to give the short marketing pitch, what problem then does the Cadense shoe solve?

D Dr. Tyler Susko 22:39

So the Cadense shoe is for anybody that has trouble advancing their foot during the swing phase of walking, as we talked about. So anybody that has a little bit of difficulty, advancing gait, the shoe will help with getting that foot through where it normally would get stuck. So this could be anybody that suffers from a number of conditions, one of which is just muscle weakness that comes as we age. So we're marketing it from a business standpoint, right now, it's going to be a general shoe. We're not calling it a medical device. We're calling this just a shoe for anybody that needs a little help getting their foot forward.

D Dr. Marie McNeely 23:10

Well, I think this is a huge potential market. And to help me and our listeners envision this shoe, what does it look like Tyler, and how does it work?

D Dr. Tyler Susko 23:18

It looks like a very standard shoe. So we chatted a little bit about how my interactions with everybody that's had a disability is that nobody wants to stand out. So that had been a huge point of the design. Here, we ran about 50 interviews with people with disabilities and physical therapists, talking about what the shoe needed to look like and what it needed to do and how it needed to feel. And on top of all the function, it was always about the aesthetics. And it was always don't make this look like some sort of medical shoe. I don't want it to be this black, ugly dual velcro thing that we typically see. Right, right, because we don't want that. It was interesting when I was talking with PTs about this, a lot of people were saying I would ask what's the alternative to this? And we were saying, well, AFOs are the most common thing that people are going to see in my practice, and they said, okay, so they're like, yeah, just about

everybody gets an AFO, and after a month or whatever, only about 25% or so wearing it and I said, So why is that? And they say they don't want to look out of place. It's usually an aesthetic thing.

D Dr. Tyler Susko 24:17

So it was extremely clear early that we had to make something that was going to look really good. So that was the directive to our shoe designer. So I was lucky enough I've got a pretty nice network here in Santa Barbara. Santa Barbara is a very entrepreneurial type place and there's a lot of footwear people here. Are you familiar with the company Decker's? Yes, absolutely. Yeah. So Decker's has the Hoka brand of shoes. UGG, is another one of their brands. So people are really familiar. Their headquarters are here in Santa Barbara. The founders were UCSB graduates they were making sandals. That's how the company started. So anyway, we have this wealth of knowledge here in Santa Barbara about shoes. So one of our advisors and people that worked with me early on. His name is Stuart Jenkins. He was the Chief Innovation Officer over Decker's for a long time, and I was lucky enough to pair up with him and he set me up with one of these world renowned shoe designers. So the guy who's designed the Cadense shoe has designed shoes personally for all the NBA stars. And people come to him to design shoes. He sets like the industry on looks and function of shoes. So this guy was fantastic to work with. His name's Kyle Pulley operates his own kind of consulting shoe company at this point. So he identified with the project, his father was a potential user. And he was like, Yeah, I'm all in. So he made this beautiful shoe. And that was one of the things we were testing with people as they wore them to do like them? And people were saying, Oh, I get compliments on them all the time. And now since we've raised this last round of funding, we were able to make a female specific version with female specific colors, and the shoes look beautiful. So they're, they're gonna look like athleisure type of a shoe, something that you could wear with a pair of jeans, but also could wear with a pair of shorts, take a walk. So that was huge and super important to us to make something that was going to be fashionable. So they look very fashionable, the way that you get them on, we've tried to make it so that they didn't have ties for a lot of people that the shoes will be beneficial for, they may have limited dexterity. So for that reason, we have laces on there. But the laces only exists to make them look like a normal pair of shoes. And we're trying to make them not stand out. But the way that you get them in is the top flaps out pretty far. And you're able to slide your foot in, and then a single Velcro strap that doesn't really look like a velcro strap comes over and secures into your foot. So that's how to get them on. And then they have this variable friction nature on the bottom. So there's two what we call slides on the front. They're kind of like skis, it almost looks like a catamaran if you watch a video, and I'll share a link with you at the end of where you can actually see a video of them working, it looks like a catamaran the outside of the pucks or the slides extend beyond the bottom of the soul on the underside of the shoe. These are low friction, so if you scuff on them, they just zoom out over the ground. As you place your weight on it, these things pop into the shoe they retract up in because they're set behind some compliant foam. And this allows you to get your friction back. So that's the best visual demonstration, I could give of what the shoe looks like.

D Dr. Marie McNeely 27:01

I love it, does it make any noise when these different mechanisms are being activated?

D Dr. Tyler Susko 27:05

It does. So the shoe itself was designed to give a little bit of audio feedback. And we found in our testing and the beta test, this was something that was actually important to people that were wearing them. If you heel strike, which is our typical heel toe walking in a standard gait, we'll see that neurotypical gait, they don't make any noise. So your heel strike, the heel itself will come down on foam. And actually in the back part of the heel, we have a little bit of rubber to prevent any type of slipping, as you then transition to the front of the shoe, it'll be quiet as you just depress the low friction material into the shoe. And then you take your step and friction returns on toe off. If you clip the front of your shoe, if you interfere with the floor, the ground as you're coming through, you will hear a click on the ground. The material below fixed material is a nylon, it's a nylon plastic. So you can imagine the sound of a plastic hitting the ground. And that lets the user know that they just clip the floor. So this has been actually when we were developing it and we were beta testing it we're like, okay, people are not gonna like the fact that it clicks. And that happened for some people. And some people were like, Okay, I don't like to clicking. But the majority of people who responded that it was actually really helpful. So as they got used to walking in it, I suppose one individual I'm thinking of is like, that's the best feature of the whole shoe. And I'm like, really? And he's like, Yeah, I know. And I'm starting to get tired, because I started clicking. I know when I'm not rocking right. And I'm trying to walk heel toe. So I continue to try to practice that because I don't want to hear the clicking. But when I do I know that I've helped before. So yeah, it does make a little bit of a sound. And it's been a feature.

D Dr. Marie McNeely 28:30

Absolutely. I think, yeah, that audio feedback can be really helpful. And you mentioned there was a lot of iteration to get to this point, Tyler. So I guess if you had a little flip book animation, perhaps that the design changes with iteration. How did the design of this product change from this very first iteration to where it is now?

D Dr. Tyler Susko 28:46

Okay, so are you ready for this? Okay, so first one was robotic, what that was was a platform at the front of the shoe that would retract everytime you would take a step forward. So we tried to do the same thing that Skywalker did just remove the floor. So we did that by removing a platform at the toe of the shoe that had all kinds of problems. Just weight complexity, I don't like the idea of relying on software for things that are related to safety. So we get rid of that. Then the next one that really came out of this. And there were many more in between it. But the next one, the next student project, there was another platform, but this time, it wasn't electronic, it was passive. So it was a linear spring on a linear guide where this puck thing at the front was able to retract inward to the shoe like front to back. And then when we tested this with my friend who was in our initial MIT study, we had her going downstairs and holding on to a railing and the platform retracted backwards, like Oh, nope, this is completely done, scrap it. We're done. No, not going to go anymore. We're done end of test. So that was dangerous. And we said that's not going to work.

D Dr. Tyler Susko 29:43

So then we went to the drawing board the next year and this started to transform into a master's level project and we started to get IRB approval to test something and we're starting to go through we probably had 30 different designs and we tried one way bearings which allowed motion in one direction but not in the other. And we tried wheels like have you seen those heely shoes that kids used to kind of like skate along on their shoes. So it was kind of like that putting wheels in the bottom of shoe. The problem with that is, the wheels would have different frictional properties versus if you're going in direction of the wheel, or if you're going sideways of the wheel, like a wheels only want to go in one direction. So if the person came down and they hit toe first, and it wasn't at a perfect angle straight, they would pull their foot out to the right or the left. So that was terrible. We don't want to do that we had these like Wolverine claw things that were on the front, we tried horseshoe shapes, the horseshoe shape was a problem, because if you tried to toe-off, the horseshoe of low friction, the toe would be low friction too. So you'd slip out on toe off, that was a problem. So we had to get rid of that. And then eventually, we were just having these, we called them Linear Bushings. So Linear Bushing, it was just a piece of Teflon that we pressed into the bottom of shoes. And then we were putting these low friction in these holes that we drilled out of the shoes, this compliant foam and then this, we were using Teflon, or these pucks after that, and that's what we actually initially tested here at UCSB, we had about six of these Linear Bushing pucks underneath a shoe, which worked great in a laboratory setting because there was nothing to clip your foot on. So these little nubs that would stick out, it's almost like a cleat, and like an athletic shoe that would stick out but be able to retract into the shoe. And they worked fine for perfectly flat, hard floor. But if you were to get that stuck in like a crack on a sidewalk, you would end up tripping.

D Dr. Tyler Susko 31:23

So that wasn't going to be a solution for the long term. And that's when we had to transition this into okay, now let's think about getting this out of the lab. And that's what that seed tech grant allowed us to do. So I hope that gave you a little bit of a picture.

D Dr. Marie McNeely 31:34

Oh, absolutely. I think you can just hear the lessons learned though, with each of these iterations, these changes you had to make. And I'm curious to hear a little bit more about how you incorporated feedback, maybe your perspectives from people with disabilities throughout this design process of the product.

D Dr. Tyler Susko 31:49

Absolutely. So number one comes from testing that initial tests that we did with the holes drilled into the shoes, I had five people try them out, we just listened to what they were saying. We didn't say much during those, we never trained anybody on how to use them, we just watched on how they actually walked. One of the things as an engineering designer that I teach to my students is the best way of getting information from the market is to just observe them. So if you're trying to understand what the needs are for a product, if you can observe somebody having a certain problem, or interfacing with a new situation, in this case. You can understand how that whatever you're going to design fits into that situation. So we watched

people only listen to what they were saying when they're putting on these polls and the shoe prototypes we had. And people were saying, Boy, it's just really, really simple to walk in these. Okay, interesting. And people were saying I can do knee flexion, during my walk, that's really cool. I haven't been able to do this. And we're like, Okay, that's great. So we know that that premise is pretty good.

D Dr. Tyler Susko 32:40

And then there was a period after that, where we just hit the ground with trying to contact anybody we could that had disabilities, were going on Facebook, we would try to get into Facebook groups by posting into the Facebook group, hey, we have this new shoe, we'd love to talk to anybody that potentially has problems walking and having trouble clearing the floor. And then people would start to respond, we had a forum and I got 100 people or something that responded to this, and we call them and we try to set up an interview. And then we would just ask them about their experiences, and you'd get some feedback. And that's where we really learned that aesthetics, were going to be a critical portion of this. And then for the beta test, I just directly interface with people, we got them involved, just like I said before, with the Facebook groups, we got people involved, I only had one size. So I had to find people that were a min size nine and a half to join our study that made it a little bit more challenging, but I was able to find people and interface with them weekly. So after a week, I'd say what do you like about them? What don't you like? Do you like the clicking? Does this annoy you? Are they comfortable? People universally were saying yes, they're comfortable. I said, great. Have there been any adverse events? I would ask things like that. And then you know, there have been any time that you felt unsafe? Things that I learned from people were how to actually operate with the shoe for specifically, this shoe does exhibit low friction when there's a low amount of weight on the front of the shoe. So where this kind of you have to learn how to operate it is in sit to stand situations. So if you sit to stand, you need to make sure that you have your weight on the shoe before you stand up. Or else there's a potential that it can slip out on you. And then also going up and down stairs, you want to make sure that you load the weight onto the shoe before making that step. And so far, those instructions have been helpful and useful for people. But other than that, once you get going, you're kind of just walking in it's a new experience.

D Dr. Marie McNeely 34:18

That is phenomenal. And I guess looking at the current Cadense model, we'll call it How does Cadense differ from other solutions that might be available out there on the market for people who have mobility disabilities, and maybe specifically drop foot?

D Dr. Tyler Susko 34:31

So the number one thing that people we're going to see if they again, we're trying really hard to stay out of medical device land here. But if somebody were to let's say they had a stroke and they went to a physical therapist, the first thing they're going to get as an ankle foot orthosis we see AFOs with people with cerebral palsy all the time. And AFOs those are inexpensive, they're molded to the person and then they're given to people at some regular interval as they grow. So that would be the main thing that people are getting on their ankles if they have a drop foot or some inability of cleaning the floor. Let's hold that ankle up. And the way that as

those ankle foot orthoses work is by limiting the plantar flexion of the foot or the angle at which we're pushing down and extending our toe downwards. So they're pulling that up so that it makes it easier to clear the floor in the way that a healthy ankle would typically move during the swing phase of the gait.

D Dr. Tyler Susko 35:17

So that would be the number one way that people are compensating other things, you know, of course, canes and walkers. And that and physical therapy is absolutely a great option for people. What our shoe does differently than an AFO and some other robotic solutions is we do not apply any sort of restrictive or active force on the ankle joint. That's really the differentiator here, I know that sounds scientific, but we're purely trying to alter the environment around the person to make it easier to walk. So we're changing the frictional properties between the shoe and the surface that you're walking on, we're doing nothing to the ankle. And again, I'm trying very hard not to get into the medical side of this. But with an AFO or something that alters or applies forces to the ankle, it could be interfering with what we're trying to send it from the brain, you know more about this than I do. Sorry, the motor control. Exactly. So if we don't interfere with that at all, and we let the mind itself control the motion exclusively, I think that there's a fundamental difference there. It's kind of like if you ever hurt your ankle, right? If you hurt your ankle, your knee or your hip or whatever, uh, humans are remarkably good at responding to changes in the environment. So right there, there's a change in the body. And now my ankle hurts, and it hurts if I move it in a certain way. So I start limping, right, and really your optimal limp probably comes a few steps after that injury occurs, right? I mean, I'm thinking back to the last time I injured my knee, I injured my knee playing basketball, like six months ago, I was being stupid. I was coaching my son's team, and I'm like, Hey, dads, let's play and I'm getting old, and so injure my knees really badly. But I immediately started limping. My body figured out this optimization function to reduce the pain that I felt every step, right, that's what we do.

D Dr. Tyler Susko 37:00

So the human body is remarkably good at finding new patterns of movement, when we change circumstances around that movement. For example, for our shoe, we're reducing the penalty for scuffing the floor. So normally, that penalty would be you would hit the floor, your shoe would catch traction, that would create a torque on your body that would put you forward. And if you weren't quick enough, you trip and fall. Our shoe, if you'd catch your toe, it'll keep moving forward and extend your base of support forward. So by doing that, and this is what we saw in our lab on that very small test, and it's not statistically significant at all, I didn't want to make any claims. We're making no claims on this shoe at this point. But what I saw is three out of five people just walked faster, no instructions, the shoe versus a placebo shoe that was the same shoe without the holes, because the environment changed the circumstances around their walking change.

D Dr. Marie McNeely 37:51

Very interesting. And it sounds like kind of looking at the broader market. This is really the only maybe incognito option where it really doesn't look like a supportive device or anything that would be assisting you and walking potentially.

D Dr. Tyler Susko 38:01

Exactly. Yeah, that's the idea is that if we can make it look just like any other shoe, a stylish one, one that's actually nicer than the other ones.

D Dr. Marie McNeely 38:10

A better shoe.

D Dr. Tyler Susko 38:11

That's what we're going for and Marie, you'll be able to see in about five months here, we should be up and going. And then you'd be able to see all the designs and I'm happy to show you if you're interested.

D Dr. Marie McNeely 38:20

Oh, that's wonderful. So Tyler, it sounds like an amazing experience and kind of a long journey to get to this point. So what has it been like for you being a part of this team working on this product?

D Dr. Tyler Susko 38:31

Yeah, it has been it's been a long time. I mean, I started at MIT. I started working in this area 12 years ago. That's Oh, wow, it's been a long time. So the journey is really a quite an interesting one. And I think what you realize in any of these projects that you get yourself involved in is that it's not a one man show, by any means. The number of people that have come in and out of this project is probably somewhere around 40, I'd say. And I've kind of just kept it going ever since at MIT, I had probably eight undergraduates that were working on the Skywalker machine with me. So I'd give them parts to go to the machine shop and make and then we'd assemble and one student who was designing a different bodyweight support harness for it. And I was working on the main machine and the controls and things of that nature. And of course, my advisor, Ego Krebs, they're working on the machine and then all my committee that was involved in the science behind that machine. They of course, formed the foundation from which this shoe is coming from. And then after that all the people all the students that had worked on it with different ideas over the years, the undergraduates at UCSB, there were probably 15 of those over the years, graduate students and Sloan she's the one whose master's thesis was then eventually published and other undergraduate students came on and finished off that paper and went to Berlin and got the experience of presenting it there to a bunch of doctors.

D Dr. Tyler Susko 39:40

So that would have been cool. After that. Another professor at UC Santa Barbara here named

Elliot Hawkes, he studied soft materials and soft robotics. He and I really continuously iterated on this shoe and made it today what you're seeing and then we had all the shoe folks jump in, Stuart Jenkins from Decker's jumped in. Kyle Pulley designed the shoe. We had a Our trading company called Shinook that's based in Portland that was able to get us into the manufacturers and make them take us seriously when we're only producing 26 pairs of shoes they're used to producing a million - they're able to do it. So there was a huge village that was able to create this - people that then reviewed our applications to make this seed tech grant. And then since then, now we have about 10 people that are working on this project Cadense. So I mentioned before we hired a CEO of the company, we have a board of directors now that's directing the company, we have people in marketing, and we have people in fashion, because we know that that's an important thing. David Bunch, another one of our advisors in the company, he comes from the world of fashion, he is a company that's taking over DKNY the fashion direction and he was really into the brand building with Tory Burch, it's a handbag brand that my wife knows it really well. But he's kind of the fashion guy and making sure that we're fashion forward and making something that people are going to want to wear. So yeah, all in all, probably 50 or 100 people have touched this.

D Dr. Marie McNeely 40:57

That's remarkable. So what is your vision for the future of Cadense, Tyler?

D Dr. Tyler Susko 41:02

Yeah, so we're going to roll this out in November, we're going to be launching it with QVC. So hopefully live and on air, with QVC. And on our website, there'll be cadense.com And then after that, we're already thinking about what's next for the company. And what's next for kind of this technology, that we want to position ourselves as being a company that's focusing on mobility for those who need a little assistance. So with that, there's about 10, or 11 products in the pipeline here, and we're just choosing which one to go forward with.

D Dr. Marie McNeely 41:35

I love it. And we touched on it a little bit earlier in our conversation, but who do you think could benefit from using Cadense shoes? And I guess what are the potential impacts that these shoes could have for people?

D Dr. Tyler Susko 41:45

So we saw in the, in the original published study, we saw that some people will have an impact their gait speed instantaneously. And there's no statistics to this, this some people have. And again, I'm trying to be very cautious about anything that I claim, because we have no statistical measures yet. We are hopefully closing in on doing a clinical trial at Northwestern University. And we're hoping that's going to start in July August timeframe. After that study, it's a four year study, we hope that we'll have enough information to then make more substantial claims about what it's going to do for people. But through our beta testing, I've interfaced with a lot of people that have seen some pretty nice effects of using a device like this, and again, not

claiming anything that the shoes could do. But one guy was able to increase his walking speed significantly over a long period of training using this as almost a training device at home. So the way that I would classify it is restorative exercise. So your ability to walk then, outside of a PT clinic just walking. He was able to substantially increase his walking speed, and also was able to see some gains muscular gains in previously somewhat paralyzed muscles. So that was really quite interesting. And something I hope to see in the larger clinical trial that we actually do and have statistics to back up. But people talk about the comfort. So the comfort of just having a little bit of mental relaxation as they walk one of the things that one of my good friends with cerebral palsy, has told me, the one who inspired this shoe was actually named after her, she said, every time I take a step, I have to think about it. And if there's something, they could just give me a little bit less of that feeling every time I take a step, I'd feel pretty good about it. So we've heard that a bunch that it's just more comfortable to walk in for that reason. We've heard stability, I'm not sure I don't have a scientific understanding of that it is a wide base shoe, and also potentially something to do with the audio feedback that you're getting there. But again, these are not claims that we're gonna make about the product. It's just things that I've seen and observed while working with people.

D Dr. Marie McNeely 43:40

Absolutely. And I think like you said, you're still early in the process, you're doing these trials, hopefully, you're going to have great results coming out soon. But you mentioned that this could be a product of interest for really anybody who may have trouble advancing their foot during gait. So we mentioned specifically cerebral palsy, and a variety of other conditions, I imagine as well.

D Dr. Tyler Susko 43:57

Absolutely. So it doesn't have to be tied to cerebral palsy only. It's any kind of condition that makes it hard to advance gait. So there's a ton of conditions that would lead to that. And like we said, one is just aging process. But if you look at different types of either injuries, neuro-injuries or diseases, you see this type of difficulty advancing the gait and a lot of them. My dad has Parkinson's and he's doing the Parkinson's shuffle. That's the typical gait that we see with people with Parkinson's. So you can imagine a low surface while you're shuffling is a lot easier. People that have MS start to shuffle they have the foot drop foot drop is associated with a lot of different things. And again, it can be just aging. So we're not saying that this shoe is made for any of those populations. It's just anybody that has a little bit of an issue, advancing a foot drop. So it's not meant to treat the disease. That's the definition of a medical device. And we're trying to stay far away from that until we get our clinical trial results back in hopefully in about four years.

D Dr. Marie McNeely 44:52

Absolutely. Well, Tyler, this is really exciting, and I think an exciting time for Cadense right now. So if our listeners want to learn more about you and more about Cadense shoes what is the best way for them to do so?

D Dr. Tyler Susko 45:03

Absolutely. So you can just go to cadense.com. And people can look me up just on Google at Tyler. My last name is Susko.

D Dr. Marie McNeely 45:20

Perfect will Tyler, thank you so much for joining us on the show today and sharing some of your stories and insights and giving us more detail about Cadense shoes. It was such a pleasure to have you with us today.

D Dr. Tyler Susko 45:30

Always a pleasure to be here. Thanks, Marie.

D Dr. Marie McNeely 45:32

Thank you so much again and listeners. It's been great to have you here with us as well. And it would be wonderful if you could take a moment to subscribe to the show on your favorite podcast platform. And we look forward to connecting with you again on our next episode of Changing What's Possible.