Examination of Gait
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- [Calista] Well, it is my pleasure to welcome back once again, Dr. Jill Seale at PhysicalTherapy.com. Jill has been a licensed physical therapist for over 24 years. She received her board certification in the area of Neurologic Physical Therapy from the American Physical Therapy Board of clinical specialties in 2004 and re-certified in 2014. She has practiced almost exclusively in the field of brain injury and stroke rehabilitation. She has a variety of teaching experiences and physical therapy academia, as well as in the healthcare community at large. Jill is currently faculty and the DPT program at South College. In addition, she teaches in several online and onsite continuing education programs across the nation. She has taught and presented in the areas of neurological pathology, rehabilitation, gait, orthotics, mentoring and research. And is currently involved in clinical research in stroke rehabilitation, orthotic management, and gait analysis and rehabilitation. Well, thank you so much for presenting once again for us today Jill and at this time I'm gonna turn the microphone over to you.

- [Jill] Great, thank you so much Calista. And thanks to everyone who's here in the course. Good afternoon for most of us, I guess it's still a good morning for any of you who might be over on the West Coast. I hope wherever you are, that you are healthy, avoiding getting sick, avoiding all of the natural disasters we have going on today. I commend you for taking time to step away from the news, I guess and join into a continued education course, but I hope you're all well, wherever you are. So, I'm excited to talk to you about gait examination today. I think this combines two of my favorite topics. Gait is definitely one of my favorite topics. If any of you have heard me present before, you may have heard me present on this topic, I don't know of gait, that's definitely something I can talk about for a long time, but also do like talking about examination and about how we can make examination of our patients, whether it's gait specific or other areas, how we can make examination better in a way that's gonna improve what we're finding about the patient, help us, you know, more

definitively discern the movement, dysfunctions that they're having the movement diagnoses that may be going on, but ultimately the goal of a good gait examination is to improve our interventions for that patient, right? So, I feel like no matter how good a knowledge we may have about interventions or how many great ideas that we have, if we don't have a good examination, we're not gonna be as efficient in delivering that intervention as we could be. But I'm probably getting ahead of myself. I should pause for a second and tell you that I don't have any disclosures. I'm not gonna be advocating for any type of product here. And so, we can get that out of the way and read to you the learning objective.

So, after this course, participants will be able to determine at least four terms used to describe normal gait and types of gait analysis. Identify at least four common impairment assessments, utilized as part of the gait examination. Identify three appropriate qualitative gait analysis tools and identify at least three appropriate, quantitative gait analysis tools. And describe at least two methods of utilizing gait examination as feedback to improve gait recovery.

So, I wanted to make sure that we not only talked about how, to conduct a good examination of gait, but also touch on that last bullet point there, how we can utilize our gait examination in an additional way beyond just using it to inform and assess our intervention. We can also use it as a way to provide feedback that will ultimately improve the patient's gait recovery. So, I feel like if we go in and we do just sort of a haphazard halfway gait examination, we may still be able to make that person's gait better. But it's gonna take us longer, because we haven't really pinpointed what's going on? Where do I really need to intervene? And how do I intervene? When we do a good solid examination, we're gonna be much more honed in and targeted then hopefully in our interventions, which is gonna make what we do more efficient. Why is this important? I mean, I think you probably can all guess why this is important, but I don't know about you, but I'm guessing nobody would raise their hand if I said, "How many

of you are getting too much time "with your patients?" Most of us are struggling because we feel like we don't have enough time with our patients. We don't have enough time to intervene the way that we want. And so, rather than focusing on what we don't have, let's focus on making what we do have more efficient, more targeted and getting right at the problem for our patients. So, that's kind of the goal, the overarching goal for this talk for me as I set out to design this. So, this is not a course where we're gonna be talking about normal gait. You know me, I can't, if you know me, you know that I can't not say a few words about normal gait as we go through here, but that's not really the goal of this course. I feel like in order to do a good gait examination, you first definitely need to understand how normal gait occurs. What occurs in normal gait? What does it look like? What joint angles need to be present? What muscle activity needs to happen? What range of motion is necessary? And you need to understand not only the sub phases of stances swing, but the sub sub phases within each of those stance and swings.

So, we will touch a little bit on some normal things, but this is not a normal gait course, but normal gait is absolutely essential to understand in order to be able to then process what's going on with somebody who has pathological gait, right? Not gonna be able to pick out what's not normal. If I don't first know normal, right? I won't be able to recognize that. Or I won't be able to recognize that in a way that helps me determine then an appropriate and again, as I've used before efficient intervention for them. So, not to keep overusing the word efficient, but that's important. We have to understand pathological gait and how it deviates from normal to be able to establish that plan of care, select those again, most effective, most efficient treatments, and also to prescribe appropriate orthotics or even assistive devices to help correct the pathology. But for sure we need it in order to prescribe appropriate orthotics. So, just kind of setting the stage for why normal gait is important. So, I thought it would be good if we started with, what's kind of an overall view of the goals of normal gait. And so, you might be able to summarize the goals of normal gait as saying that it's movement

along a desired path, that it's maintaining weight bearing stability, that it's conserving energy. And then it's absorbing shock. These are some of the critical goals for normal gait. And when you read this slide, you might be thinking right here, I can start thinking about my exam. I can start thinking about how I'm gonna assess and measure. So, you know, can we measure their capacity to move along a desired path? Certainly we can, we can look at their speed capability along a desired path. We can even use some assessment tools that help us at least subjectively talk about whether or not they deviate from the desired path. That they can walk a straight, essentially straight path, or if they have deviations from that straight path, if we use something like the dynamic gait index, for example, as an outcome measure.

And we're gonna talk about outcome measures in a second. So, if you're not familiar with that term, don't worry, but we have ways that we can clinically assess, you know, their ability to move along that desired path. We can certainly use our Observational Gait Analysis skills, which we're gonna talk a fair amount about to be able to determine if the patient can maintain weight bearing stability. And if they are doing the normal biomechanical things to absorb shock. We can look at the patient and make some decisions or some judgements about that in our Observational Gait Analysis.

And certainly we can start to make some really extrapolations about their ability to conserve energy by looking at outcome measures like the Six Minute Walk Test, which we know is a nice measure that correlates very strongly in many diagnoses to a person's overall cardiovascular fitness. So, automatically when we think about the goals of normal gait, we can start to see some of the things that we're gonna want to examine. And what I'm gonna try to encourage you guys to do throughout is to think about your examination of gait as being hypothesis driven. I'm gonna give you a number of tools and ideas that you can utilize. But certainly for every patient, we don't do everything that we could possibly do in our examination, right? We don't test and examine every single thing that we could possibly examine. We want to watch the

person walk and be able then to generate some hypotheses that are then gonna drive our further examination. I'm going look at this, that, and the other, not all the possibilities, and that's gonna get me to the end results of my examination faster, right? So, we want to think about being hypothesis driven and keeping in mind, what are the overall goals of walking that we need to be reflecting back to? So, in terms of gait examination, there's a number of ways that you could talk about this, right? And you can see on the reference there, I have certainly some current articles to reference back to, but there were two primary textbooks that I used there. And those certainly can give you some nice starting points on normal gait and also really good information on gait examination. But I chose to think about gait examination in qualitative measures versus quantitative measures, because I feel like as a clinician, we should be using both. A lot of times, people just stick to qualitative, they just stick to an Observational Gait Analysis. And I think certainly that's important. And we'll talk about how important it is to do a good Observational Gait Analysis. But I think we have to combine that with some quantitative measures as well. So, but as I said, thinking about dividing between, qualitative and quantitative.

Under our qualitative assessment, you know, that starts with our Observational Gait Analysis. And how many of you, just curious, and you can just, if you feel inclined, you can put in the chat box, "Yes." How many of you use some type of systematic tool for your Observational Gait Analysis? Just if you feel like it just so it gives me an idea that you know, that people are listening and thinking about what we're talking about. If you use some systematic tool for Observational Gait Analysis, just put in there, "Yes." So, so far just one person that's popped in their, "Yes." I feel like when I talk to clinicians, often times couple more, there you go. That a lot of clinicians don't even realize that there are some systematic tools for Observational Gait Analysis and we'll be going through those. But they're definitely are. Oh, good. Some more people, "Yes." Some people say, "Not very often." Yeah so, as clinicians, we learned Observational Gait Analysis, and it's probably one of the most relied upon things we do as part of our gait

examination. And people say that they have a systematic approach to Observational Gait Analysis. We did some research that I'll be talking about in a little bit, but we did some research that was published just last year, looking at gait analysis in folks with hemiplegia, following stroke. And one of the questions we ask is, "Tell us about your overall approach gait analysis." How do you go about analyzing the gait of a person who's had a stroke? And really, I would say almost a hundred percent of the clinicians said they had a systematic approach to their Observational Gait Analysis, but when asked further, you know, what is that? Do you use a particular tool? Most of them didn't and none of their systematic approaches were consistent across other people, right? It was just sort of their own siloed thing that they did, but it wasn't anything that was consistent across people, across a system.

And it wasn't anything that used a particular tool in most instances. So, I'm happy to share with you that there are some systematic tools available for Observational Gait Analysis we should be using. And then the next, bullet point really is qualitative and quantitative, but I put it there under the qualitative because we do our Observational Gait Analysis. We find what those deviations are in their walking. And then we follow that immediately by an impairment examination, right? I look at how they're walking and I see, "Oh, they have this deviation "in the stance phase."

And then my mind, my next thing my mind does is it generates a list of possible impairments that could be causing that deviation, right? At least that's how we should probably be doing it. And so, we go from that Observational Gait Analysis into our impairment examination, which may give us some quantitative data as well. So, we're thinking here, you know, range of motion, strength and force production. We're thinking of sensory, we're thinking of alterations and muscle tone. These are the things that we're examining here, following our Observational Gait Analysis. So, that Observational Gait Analysis just flows right into us choosing which of those impairments we are gonna examine. And again, that goes to this idea of being hypothesis driven, right?

And then in terms of quantitative measures, certainly we have those instrumented measures that people read about and research, right? You know, there's all these ways to assess joint angles, using motion analysis and accelerometry, and we can look at activity via EMG and we can use force place to help us know what's happening in terms of ground reaction forces. But for most of us in everyday clinical settings, those are not the kind of quantitative measures that we have the capacity to be able to get. We're mostly relying on our clinical objective outcome measures, which are typically some type of temporal and or spatial measures. So, something that's giving us an idea of something related to time related to walking or distance. So, temporal and spatial measures. And then we're also looking at what we have determined to call functional gait measures. Functional gait measures being sort of more of a combination gait measure. Typically that's gonna give us some idea of not only just their walking, but the collaboration, if you will of walking with, of gait with balance, right?

So, but let's start with talking about Observational Gait Analysis and spend some time there as well. So, Observational Gait Analysis has a lot of advantages. It's cheap, right? It's just me, it's my eyes. It's my brain. It's you know, super accessible. I take it with me everywhere I go. And some people would say, "Simple." I don't think it's really simple. I think it's quite complex to learn normal gait and be able then to apply that to abnormal gait. But you might say fast, simple and inexpensive. Simple once you've learned it, right? So, there are definitely some advantages, but the literature is really clear that a 3D Gait Analysis is gonna be the most accurate, over Observational Gait Analysis, right? But that 3D Gait Analysis system is really not accessible to most of us. And so Observational Gait Analysis is what we rely on. So, it has its advantages and it has its disadvantages. Its disadvantages is that's obviously not the most accurate way to assess gait. Cause I just told you that 3D Gait Analysis is most accurate. It also has really poor reliability. There's studies that show, and I didn't cite these here and I apologize, but the consensus is across quite a few studies that look at Observational Gait Analysis, that in terms of reliability, it's moderate at best. And that's typically

looking at reliability within the same raider. However, if you start to look at reliability across multiple raiders. So, in other words, if you, and two other people in your class and I, all observed the same person and we all gave our Observational Gait Analysis, the chances of us being reliable amongst us amongst is really low. So, that's a big disadvantage, right? That reliability, accuracy is low. When you think about Observational Gait Analysis, what we're relying on is our eyes, versus relying on something like a camera. A camera has much faster shutter speed so to speak than our eyes. We miss a lot of things by the slowness of our ability to capture frames with our eyes versus a camera.

So, there are definitely some disadvantages, but there are definitely ways that we can go about maximizing the accuracy of our Observational Gait Analysis. So, first of all, I can use one of those tools that I mentioned earlier, and that we're gonna talk about in the upcoming slides. I can use a tool that guides me through my Observational Gait Analysis. So, it ensures that every time I'm doing an Observational Gait Analysis, I'm doing it in the same way or at least using the same scaffold for it, right? That would definitely be one way.

I think we can help maximize our accuracy by if it's possible being able to use video to capture the person's walk, just capture one, good walk. We don't a whole bunch of steps. And then as we watch that and we can watch it as many times as we want without fatiguing the patient, having to have them keep walking and walking so that we can keep looking at it, or we might have the capacity to slow it down. We might have the capacity to use you free online tools, like Coach's Eye or something to help us get a little bit more detail about the observational analysis, but there are definitely things that we can do when we videotape that we can't do when we're just standing there trying to observe them and come up with our Observational Gait Analysis. Now I understand being able to videotape has got many issues. The more, the longer I live, the more red tape we have related to being able to videotape a patient, even when all

we're using it for is just patient care to help us do better patient care. But if we can do that, that's certainly ideal. Other things that I would suggest is making sure that when you observe a person for your Observational Gait Analysis, if possible you're not moving, which means that you can't be the person assisting if they need somebody assisting them, right? If you can have someone else assist them so that you can step back. So, ideally I'd be looking at them, you know, first perpendicular getting a good sagittal view and then I'd be standing in front of, and or behind them getting a good anterior posterior view. Those are all gonna help us maximize our accuracy of our Observational Gait Analysis. When we're moving and the patient's moving, our eyes have a really hard time knowing what's exactly going on. It gets a little confusing for our visual system. So, those would be some suggestions I have about how to maximize accuracy. The other thing that I'd like to talk about is making sure that as we do our Observational Gait Analysis, we're doing a complete Observational Gait Analysis.

So, certainly we all understand that we can subdivide the gait cycle into stance and swing phases, but then we can further subdivide those into the discrete phases of gait, right? So, the goal of walking really is a smooth forward progression and limb stability with minimal excursion of the center of mass and energy conservation, right? Maximizing our energy conservation. So, smooth for progression, limb stability, minimal excursion of the center of mass. Whenever you see somebody that their center of mass, which you could think of kind of as their belly button is moving around, either up or down or side to side a whole bunch, that's definitely not what we want, right? So, that minimal excursion of the center of mass and conservation of the energy expenditure. Every time a person deviates from normal walking, as we learn it, it drives up their energy costs. So, if our goal is maximizing energy efficiency, which it should be, then we want to be trying to get them as close to normal walking as possible. So, just to give you a very quick, just run through sort of the essential accomplishments in each of these, in terms of stance and swing. If you think about in stance a swing, we

have initial contact. And the essential thing that happens there is we make that with our heel first, we have loading response next and what really needs to happen there is that we have that controlled flection of the knee, that controlled lowering of the foot to the floor that starts to transfer weight forward on that stance limb. And it's critical for shock absorption. So, when a person doesn't accomplish, loading response correctly, they really lose that shock absorption capacity. Loading response, transitions into mid stance. And really the big thing that happens here is this dynamic stability. So, the limb is still moving, but being stable as they shift their weight over the foot and the weight of the body then is supported completely on that single limb, right? And we have this controlled forward progression.

And in internal stance. We have a continuation of that dynamic stability, continuation of that weight shift forward. It comes over the forefoot again, still being supported by the single limb. And we have then a stop of forward progression of the tibia and the heel starts to rise. And that's how we end stance and we lead into swing. Some of the essential components that happen or accomplishments that happen during swing and pre swing, because the heel rose in terminal stance in pre swing, the thigh and the knee are going to flex.

We don't get that knee flection or that hip flection in swing unless the heel rose at the end of stance, right? So, now the limb becomes unloaded and weight is transferred to the other side. That was pre swing and initial swing. The thigh starts to move forward. The knee flex is even more, and this is what sets up us up to clear the limb in mid swing you still have the thigh continuing to move forward. Now you have ankle dorsi flection to assist in that foot clearance. And then in terminal swing, you have the knee fully extending to make a heel first contact. If the knee doesn't fully extend at the end of swing, we don't make that heel first contact. So, that was kind of your cliff notes, rundown of what happens in those two phases. Now, let me tell you what happens. Sorry, I lost my cursor there for a second. Let me tell you what happens, often times

when we examine gait in our patients. Often times when we examine gait, we don't examine both sub phases or we don't examine both sub phases well, right? So, I need to look at both swing and stance and in stance I'm looking forward, "Do they have that single limb stability? "Or are they're unstable." And I need to examine swing and look, "Are they clearing the limb?" And if they're not clearing the limb, where are they not clearing the limb? Because it's not just about the ankle and dorsi flexion. It's very often about the knee flexing and or the hip flexing. So, they both need equal examination. Maybe not even equal examination. Maybe we need to spend a little bit more time examining the stance phase because as you'll discover in a few more slides, when we talk about some terminology, you'll discover that we spend about 60% of our time in stance and 40% in swing, which, you know, you might think, "Well, maybe I need to spend a little bit more time, "examining stance because we spend more time there." But again, just, and I'll let you guys put into the comment box here.

Do you feel like you spend an equal amount of time and energy examining both phases, both sub phases of gait? So, just, "Yes," if you feel like you spend an equal amount of time on stance and swing, you can type that into the chat box there, just interested to see your comments and be honest. Oh, I see a frowny face, don't frown. You're in good company Kelsey since you said, "No." Yeah, so we have a mixed response there. Thanks for replying, that's good. I almost wish I could save that for more qualitative research there, but let me tell you a little bit about some qualitative research that we've done about this because it does apply to our topic here. Thanks to everybody that replied. You know, back quite a few years ago, I was talking with some of my colleagues, both PTs and orthotist colleagues. And we started talking about the importance of the stance phase and how we felt like we were really thinking about patients with stroke. And we were like, "You know, "we feel like people don't see the stance phase, "see the problems in stance phase, appreciate the problems "and or, and that leads to them "then not treating issues that are stance phase related." Everybody sees the swing phase problem. And so, this was just us, you know, making

some suppositions. And we decided that rather than just spouting our opinion as gospel, we should probably do some research about that. And so, my colleague, Carolyn Utsey and I, did some research several years back and got it published last year. And again, I will say that this was in a population of folks working with stroke and the questions were all about stroke, but I think we can probably extrapolate some of these answers to really across diagnoses. But in folks with stroke, we ask folks in addition to the how they went about their gait analysis? Which I already mentioned, we also asked them to tell us what they felt like the most common gait deviations were in patients with stroke. And then we followed that up with, what do you think are the most likely causative impairments that lead to those specific gait deviations? And we ask a few more questions, but those were the ones really pertinent to this talk. And immediately we did this in focus groups.

So, we did this in multiple small groups, focus groups, both locally here in Texas, and also nationwide so that we didn't have a regional bias. And we did this with people who were novice clinicians less than two years. And we did this with people who had their NCS. So, that would be considered a novice versus an expert group. And by and large, regardless of whether they were novice or expert and regardless of whether they were local or regional, most people spoke to problems related to the swing phase. And for sure, the first thing that people said was related to swing phase, right?

Because when you do qualitative research, you record these interviews and then you go back and you examine them for themes and you can count the number of times people say certain terms and such. By and large, there were lots of things related to swing. Everything that was the first thing people thought of was related to swing. So, it truly was the most commonly identified, described. And then when they start talking about how they address these gait deviations, all of their interventions had to do with addressing swing face problems as well. Not really a lot of concern about stance phase problems. So, it's something that as many of you said, cause many of you said, "No,

you don't look at both." And some of you said, "You spent too much time on the swing phase." Thank you for your honesty. As many of you said, that was proved up in the literature as well. So, we're spending a lot of time on the swing phase, not really examining both, but what's important to understand is that the swing phase is greatly dependent on the stance phase. So, if we can identify, do a better examination of stance, we're probably gonna be even better at fixing those swing phase problems, right? Swing phase problems also tend to be a little bit easier to fix, whether it's orthotically. If we're thinking about things going on in the distal end or even exercise intervention wise. We can tend to fix those swing phase problems more easily, but we're missing in our examinations, the stance phase, and then subsequently we're missing it in our intervention.

So, let me just explain that point a little bit, because I think this helps us as we sort of round out our thinking about Observational Gait Analysis, about how swing depends on stance. So, remember we talked about, as I just gave you that really fast cliff notes version of the key accomplishments at each phase of gait. We talked about the heel rising in terminal stance, right? So, but let me start at the top. So, how does swing depend on stance? Well, we get knee flection and pre swing, right? We get 40 degrees of knee flection to be specifically, and this happens passively. Not because any muscles work, not because my hamstring fire, it happens passively. This is two thirds of the whole amount of knee flection we're gonna get. So, when I'm observing and I don't see that normal knee flection occurring in pre swing, I know, "Hey, that happens passively, "what caused that not to occur?" Well, have to look back at stance phase. What causes that passive knee flection is the heel rising. The heel rises in terminal stance. What causes the heel to rise in terminal stance? Well, the plantar flexors stop that forward progression of the tibia. They, make the foot and the tibia really a rigid lever. Momentum then causes the heel to rise or the plantar flexors actively propel the heel up, whichever way you want to think about it. And it kind of probably which way is true, depends on whether the person's walking slow or faster running, but the plantar

flexors really being key. They're really the key muscle for a stance, at least for men and terminal stance. And so, that's how we get to that idea that swing depends on stance. And then in the stance phase, stability occurs there or lack of stability, right? So, we understand swing is that lack of clearance. What happens in the stance phase? They have that lack of stability. It can occur early. Like as soon as the foot touches the ground, initial contact, loading response, that's typically a weakness of the quadriceps. It can occur in the mid to late phases of stance, mid to terminal stance. And that's usually a weakness of the plantar flexors, right? If there's a weakness or a force production problem, those are the two muscles that are involved there. Early more of the quadriceps, mid to late more of the plantar flexors. And when we see that lack of instability in our Observational Gait Analysis, it can look two different ways.

So, we can observe two different things. If we see if we have instability early, what we're gonna see in our Observational Gait Analysis is a knee hyperextension throughout the entire stance phase. They make initial contact typically with their foot flat, that knee hyper extends and they stay hyper extended throughout stance versus that person who makes that either slight crouch at the knee or a knee extensor thrust in mid to terminal stance. That's that person who has more of a weakness in their plantar flexors, or it could be tightness in their plantar flexors either. So, the bottom line being that when my Observational Gait Analysis, I have to be in tune with normal to be able to figure all of this out, right?

If I didn't know normal so well, it would be hard for me to piece together what we've just talked here in terms of what we see abnormally. So, swinging stance important to investigate separately in a very comprehensive way for both swing and stance, and really thinking about how stance sets swing up. We may even want to think about being extra thoughtful, I guess, is what I'm trying to say about our stance phase analysis. So, and again this is that same research that I talked about, and I think I've already made some of these summary points, but again, this was just in patients with

stroke, but I feel like we can really use this data across all diagnoses. They focused on the swing limb dysfunction, regardless of the causative factors, they focus more on proximal impairments and didn't think about distal types of things. And I feel like we do that in our gait analysis often, we're focusing more on what's happening proximal at the trunk and the hip, maybe the knee, we don't focus very much distally. They don't really understand normal gait in the contribution of the plantar flexors to normal stability and stance. So, they don't understand that or identify that as a weakness, a potential impairment, weakness in stance, and many people just don't find stance problems to be bothersome. When you use qualitative research, you can use quotes from your participants. And there was one quote that was said, "Essentially stance phase doesn't bother me, "but swing phase, you have to clear that foot." And I always tell people, stance phase keeps me up at night. Not only does it bother me, it keeps me up at night. And then again, you know, another sample or I guess, example of a comment was, "Control that foot drop, that's always the first priority."

Again, emphasizing this focus that we have on swing limb problems, swing phase problems as opposed to stance. So, I hope I've made the point. I don't mean to get on a soap box there, but I hope I've made the point about the importance of looking at both. But the other thing I will just emphasize again, before I move on from our research. And I said this earlier, but I think it's important to come back and kinda close this out by saying this. When we talk to these folks in this research study, and we asked them about how they analyzed gait, they all said observational, but none of them had a system, right? I know I already said that once, but that's a good lead in to talk about how we can have a better system. So, many people are just unaware that they're Observational Gait Analysis tools. I think a lot of people just think, "Well, when I'm doing my gait examination, "I'm gonna watch them walk. "And I'm gonna write some description "of how they're walking." And for some people that's like a blank slate. They literally in their documentation system, just have free text and they write something about their walking. And I look at a lot of people's notes. I've, you know,

done contract work a lot of places. And you can see of wide variety of ways that people observe and document and examine gait and lots and lots of inconsistency. And you might say, "Well, you know, "all patients are different," so on and so forth, "we need to be, you know, "custom and tailored" and blah, blah, blah. And that's not true. Yes, all patients are different. And I certainly don't want to treat all patients the same, but we should have a better system for observing or for documenting something as important as walking. It's really like the one of the key things that we do, right? And so, we really should have a better system there. And yes, Alicia, my next slide or coming up really soon as about pediatric.

So, I will get to your question there, but thanks for that question. I had a question about, "Are any of these good for pediatrics?" So, we really do need to be thinking about a good tool to use, and we can get one of these tools into our electronic medical record potentially and be able to utilize it there and have that available. So, you need to talk to your facility about, you know, what is the tool we want to use and be consistent about it, so that we have some consistency amongst what we're examining. So, I've put in here several different papers from the evidence to talk about these Observational Gait Analysis tools. So, this first study in 2013, you can see there is all about these tools for patients with stroke.

And so they, you can read this paper and they give you details about all of these, but I want you to know that all of these are possible tools for patients who have stroke, the Gait Assessment and Intervention Tool, the Hemiplegic Gait Analysis Form, the Rivermead Visual Gait Assessment and the Wisconsin Gait Scale. These are all recommended for patients who have stroke. In this particular study, by Ferrarello back in 2013, their review of these outcome measures, their overall recommendation was the Gait Assessment and Intervention Tool for patients that have stroke as being what they felt based on the literature. And based on the evidence, based on the review of the evidence that was there, they felt like that was the tool that they would most

recommend based on the psychometrics of the measure and so on and so forth. There was a paper that was just published in 2020 that looked at the Wisconsin Gait Scale. Now, they understand they only looked at the Wisconsin. They didn't look at other assessment tools, but with the Wisconsin Gait Scale, they were able to show that there were selected not all 3D, not the entire 3D assessment, but there were select measures within a 3D assessment where the Wisconsin gave pretty consistent information. And it had to do with symmetry, it had to do with symmetry indexes that they measured in a 3D way. And you actually got pretty consistent information from this gait observational tool, that Wisconsin Gait Scale. So, that's a pretty good support, pretty good advertisement for using that measure, right? So, those are certainly and you can find all of these online. Other Observational Gait Analysis tools for other diagnoses. If you work with patients who have spinal cord injury, there is the WISCI or actually I think now we have the WISCI 2, I think, and the SCI-FAI. And the WISCI, which is the Walking Index for Spinal Cord Injury. I have to say, it's not really an observational gait tool, but I put it here because I think it's a very valuable tool.

It's really a functional capacity scale. So, it captures the extent and the nature of walking by describing the type of assistance that's needed, whether it's orthosis, assistive devices, assist of another person, those factors that are required for walking. So, we all know that sometimes, you know, we have a patient maybe walking with a particular assistive device, and then we get them to an assistive device that's less supportive, but now they need maybe minimal assist of the therapist. And it looks like they've declined, right? Cause they went from maybe supervision to man assist, but when you use something like the WISCI that looks at a overall walking capacity, you can see that they're actually gonna improve on their overall walking score because they moved down to a lesser supportive assistance device. So, it's a nice measure in that it takes into account, not just assist levels, but it also looks at their use of orthotics and assisted devices and their ability to walk a set distance versus the SCI-FAI. Which is the Spinal Cord Injury Functional Assessment Index, I think I've blanked on the letters

there. It is truly an Observational Gait Analysis tool. You actually do watch the person walk and it takes you through step by step an observational analysis of swinging and stance for them in the SCI-FAI. So, both of those being great measures for patients who have spinal cord injury. The next five measures that are listed, there are all for pediatrics. So, the Edinburg Visual Gait Scale, the Observational Gait Scale, the Salford Gait Tool, the Observational Gait Analysis and the Physician's Rating Scale. And again, there was a review of all of these in 2014 in Gait and Posture. And again, the star there shows what these authors recommended as the tool they would suggest most supported by the psychometrics of the tool when they compared them.

But again, all of these, you should look at these, these may have different values to you to use, but these are all ones that have been used in pediatrics. I've seen in my review of the literature. It seems like there are many more of these measures for folks with pediatric, for use with folks that are pediatric. So, they tend to have a little bit more information out there about Observational Gait Analysis tools for our little patients. There's some non diagnosis, specific Observational Gait Analysis tools. There's the, Rancho Los Amigos Observational Gait Analysis system, which many of us learned when we were in school. That's that chart that takes you, you know through each body segment, head, arms, trunk, pelvis, hip, knee, ankle, foot.

And then it takes you through all of the phases of gait, very nice tool to use, to do your gait analysis, very easy tool to use many people look at that. And they go, "Oh, there's a lot of boxes. "And I feel like it's a little overwhelming." If you just read it, it's actually pretty easy. It's essentially saying, do they have this? Or don't they have this? And you're checking one way or the other, so a very easy tool to use, but again, it forces you to do some important things which all of these are. It forces you to look at each segment of the body and it forces you to look at each phase of gait, as opposed to making general comments like, "They walk slowly," or "they, you know, are asymmetrical when they walk" or, you know, maybe only reporting that they have flat

foot contact, which is probably one of the most common things that people do and say in their observational analysis. There's a couple of scores that were developed by Tinetti, the Tinetti Gait Score, which is a subset of the Performance Oriented Mobility Assessment. The Performance Oriented Mobility Assessment is kind of an overall measure that looks at gait and balance. Both of those are ones that could be utilized. They were specifically developed for older adults. That doesn't mean that that's, you know, all that they can be used for. But it's important to remember that they were developed specifically for older adults, but in terms of whether or not their diagnosis specific, no, they're not. They're gonna be more generic cause they weren't developed for any particular diagnosis just for older adults. And then I wanted to just put in a couple more studies because they were a couple more that I wanted to mention related to the evidence around these Observational Gait Analysis tools.

So, this was a study that was published in 2016, that looks specifically at these scales for people with neuro disorders. So, it went across all types of neuro diagnosis. Obviously a lot of these talked about stroke, but really went across all types of neurological diagnoses. So, the GAIT, which is the one we mentioned earlier about stroke was most suitable for clinical use and for research use. The Rivermead was suggested as being, well It's been utilized a lot, I guess I should say for really diverse neuro disorders, including MS, there's not a lot of specific measures for MS. And the Rivermead is something that has been studied in that population. So, if you're looking for something that's gonna go across diverse disorders, maybe the Rivermead would be one that would be appropriate there. For Parkinson's disease and for normal pressure hydrocephalus. The POMA was predictive and those with Parkinson's disease and was sensitive to change and persons with normal pressure hydrocephalus, which, you know, oftentimes, not oftentimes normal pressure hydrocephalus can mimic Parkinson's disease. So, using Tinetti's measures for those with Parkinson's disease and normal pressure hydrocephalus, as well as Huntington's disease. And it's interesting because, you know, when I read this, I was like, "Well, you know, that kind

of makes sense. "Parkinson's diseases, is a disease, "most often of older adults." And so that sort of makes sense that the work by Tinetti would work well with these folks. But if you think about people with normal pressure hydrocephalus also tend to be older, but those with Huntington's disease do not tend to be older. They typically are in their forties or fifties, but still the Tinetti, the POMA was reliable and valid for that population. That doesn't mean that other outcome measures aren't gonna work well with these populations I've mentioned, but this is just a review of the literature that shows where these specific measures have been studied. So, we can know for certain with these diagnoses, "Yes, there's actually some data "that supports use of these measures," but certainly we don't have to restrict the measures we use just to a paper like this. And then, because I felt like this was, it's really hard to find a lot in the literature about gait examination.

That doesn't seem specific to neuro diagnoses. And so, this was a paper that was published more recently in 2019, and they were looking at Observational Gait Analysis scale that were just people with walking disorders, any kind of walking disorder. So, I thought I wanted to make sure that I shared that with you as well. So, they did a systematic review of 14 Observational Gait Scales. And so, I think it's important to just take note that they found in their literature review, 14 Observational Gait Scales. And we're not using many of them or any of them in some cases.

So, we certainly have the scales, the tools available, we just need to get them and start using them. And then they talked about and rank them from highest methodological quality. So, again, looking at those things related to the psychometrics of the tool, how well they had been studied and the four that they listed as highest related to their methodological quality, were the Visual Gait Assessment Scale, which is for children with CP. The Chamorro Assisted Gait Scale, which is actually interestingly enough, a very specific scale for people who use one or two crutches, specifically one or two forearm crutches. It's very detailed, but this, I wanted to make sure one of the reasons

why I wanted to include this study is, I wanted to make the point that even in our patients with a musculoskeletal problem that they're using, this was done in people that had ankle sprains, ankle instability and were using crutches. So, even in that population, we can find an Observational Gait Analysis tool. And then the last two there, the Salford Gait Scale and the Edinburg, I think we've already mentioned for sure, the Edinburg, those are both tools for kids. So, again, those scales for kids being really well done, but still, hopefully out of this presentation thus far, you found a name of an observational analysis tool that you want to pull out and possibly adapt in your setting I hope so anyways. So, we've done our Observational Gait Analysis. Hopefully we started our observational analysis with a really good understanding of normal. And we use that really good understanding of normal to figure out what was abnormal in terms of identifying the deviations. And we used a tool to help us do this systematically. One of these Observational Gait Analysis tools. Now, we've figured out where the abnormalities are.

We need to hypothesize then what the probable or possible impairments could be. And we need to go in and examine those impairments. And Dr. Perry always described there being five functional categories of impairments that impacted walking. And she talked about deformity and muscle weakness and sensory loss and pain and impaired motor control. And deformity, what we're really talking about is range of motion, right? We're really talking about what is their capacity either for passive, well, really for passive movement, right? And so, we all know how to assess range of motion. I just want to make a couple of quick points that I feel like are key to the gait examination specifically. You need to consider length, muscle length when you're, you need to consider, I guess, with caution muscle length. When you're thinking about a muscle, that's a two joint muscle. Specifically, when you think about the importance of the length of the gastrocs and soleus in walking, those are really critical, right? In the stance phase of walking, I need to get 10 degrees of dorsi flection with my knee fully extended. So, that's how terminal stance ends, sort of picture it. The person is, you

know, just about to shift their weight off of that foot, but not quite their ankle is at its max dorsi flection that it ever gets in walking 10 degrees and the knee is fully extended. So, that means when I'm assessing range of motion at the ankle, I need to assess range of motion with the knee extended. If I assess range of motion with the knee flexed, I'm assessing the soleus and the soleus is not gonna be a limiting factor in stance phase because my knee is fully extended in stance phase. I need to look at the, what's the length of the gastroc soleus. So, I want to make sure that I'm measuring that range of motion with the knee fully extended. Make sure you're closing your eyes and picturing this if you need to. The importance of that. So, when I am standing and walking, my knee is fully extended.

So, I want to make sure I'm checking that extensibility of the gastroc. So, that means measuring that dorsi flection range of motion with the knee fully extended. I said that several times, because it's really important and lots of clinicians just don't quite appreciate that. The other thing to think about here in terms of range of motion, and this also goes into impaired motor control is the impact of hypertonicity. It really should be under both of those bullet points, because hypertonicity is really a component or a problem with motor control. So, if they have some degree of hypertonicity, resistance to passive movement, we need to make note of that.

So, we need to not just know their maximum range, but we need to know where is that maybe resistance to passive movement coming into play. And so, the example that I'll give you, I'll go back and talk about the ankle again. So, if I move the patient, if I'm holding the patient's limb and I move them into dorsi flection quickly, like I would do if I was assessing maybe the modified actual scale for specificity, but I moved them quickly towards dorsi flection. And let's say maybe minus five degrees, meaning still in five degrees of plantar flection, I feel a little catch or a little resistance, right? I want to measure that. Where did I feel that, I want to stop right there and measure that. Where did I feel that that's my R1, where their nervous system first try to stop. We can think of

it that way, okay? That's the neurological input there. That's some degree of hypertonicity, there's some resistance to passive movement, but then I can take them and I can slowly crank on them and you know, get them to their max stretch, putting all of my stretch into them. And let's say, I can get them to that 10 degrees of dorsi flection, right? And so, we might say, "We'll have 10 degrees of dorsi flection." So, they have the range to accomplish walking, well, but where was that R1, because wherever that R1 is where they're most likely going to function. They're gonna not neurologically, this isn't a volitional thing, neurologically, they're not going to want to push themselves past that R1. When they hit that R1 mark, their nervous system is essentially saying, "Hey, this is the end of our range. "Don't go any further. "This is gonna hurt," right? Our nervous system gets tricked that that's the end of our range. And so, what you'll find is that, even though they may have a passive range of much more, a max stretch range of much more, they're not using that in function.

So, it's important for us when we're doing our gait analysis to consider not only their passive range of motion, but also this R1 and R2, okay? Really a component that goes under range of motion and impaired motor control together. Perry talked about muscle weakness. I'm gonna say that the term that we probably should put there is decreased force production because it's not always about muscle weakness. And many of our patients, the impairment that they have is an inability to produce force, because they don't have the neurological connection, right? Whether they have a peripheral injury or central nervous system injury, they have lost the ability to connect that muscle, to you know the action generator, so to speak. And so, whether it's weakness, whether it's a decreased force production, also, we might even say decreased power production. We want to consider that, right? So, we typically are gonna assess that with manual muscle test, we might do some other things to think about muscle endurance here. It's important to understand that manual muscle test is very limiting in our patients with neurological diagnosis, oftentimes inaccurate, especially if they do have any hypertonicity, it's a very inaccurate measure. If they are more in the stage of say

flaccidity after a stroke or traumatic brain injury, they may not be able to volitionally move the limb on command as we would ask them to do with manual muscle test, but they may be able to do that in some sort of function. So, there's definitely some considerations and limitations to manual muscle test but we want to look at as part of our impairment assessment, what's going on in terms of motor, right? What's going on in terms of force, production and power. The next thing that was on her impairment list was sensory loss. And certainly we can imagine that a person who has a loss of sensory awareness may have that may be one of the things that contributes to some of their gait deviations. And most typically it's gonna be the loss or the impairment of kinesthesia that makes the biggest impact on walking, right?

You can imagine it in, remember kinesthesia and proprioception very similar, right? Proprioception is joint position sense. Kinesthesia is actual sense of the movement of a limb. So, you could say both of those together are very significant for walking. If I have a loss of proprioception or kinesthesia, I'm not going to really understand where my limb is in space and that's definitely gonna change my walking. Certainly we want to consider if they have an absence of the perception of pain, if they've lost, you know, sharp, dull for example, or some other way that we test pain, because then they may not be as aware of things that may be causing damage to the limb and that kind of stuff.

And light touch may play in some, to walking function. But really when we think about sensory loss, we're thinking about examining proprioception and kinesthesia in terms of how it relates to our walking examination. We also want to assess for pain, oftentimes, especially as a neuro therapist, I go in there never thinking about that they might have pain. And I always joke about this with my entry level students. This didn't actually happen to me, but I can imagine that it could have that, you know, I do my whole gait analysis and they have this abnormal gait pattern and I'm digging into why they have this abnormal gait pattern at the end of the session they tell me they have an

ingrown toenail on that, you know, limb. And they're like, "Well, that explains it all." And it's none of the things that I just, that I just assessed, right? So, we want to make sure in our examination, our impairment examination, that we're asking them about pain and specifically asking them about pain related to the lower lamps that might be impacting how they're walking. And then finally, we want to look at impaired motor control. So, we want to look at what's their capacity to activate the muscle in a graded way, meaning that they have the capacity to grade on and grade off muscle activation, as opposed to sort of being an all or none, that they don't have a lot of co-contraction or synergistic kinds of movements when they try to move. And so, some ways that we might assess that could be with a measure like the Fugl Meyer or the STREAM, those are both measures, mostly used in patients with stroke, but the Fugl Meyers used in other diagnoses, I guess, but where we're looking at, you know, can they have nice, normal, isolated fractionated movement in the extremity? So, those are all things that we would want to include in our gait examination.

After we've done our observational analysis, and now we're hypothesizing the causative impairments. These are really the five categories that we want to make sure that we're looking into in that part of our gait examination. So, hopefully everybody is on board there. We've talked about sort of the qualitative part, and now we're gonna move into the quantitative part. And I want to talk about a few terms. And some of these are things that we don't really assess a lot, but I think it's important to have, have knowledge of these terms. So, when you start reading and talking about gait, you get the terms, kinematics and kinetics thrown out a lot. And so, just to give you a quick appreciation for those terms, as we shift to the qualitative measures. Kinematics is a description of movement without any concern for the forces that are causing the movement. So, I'm simply describing the movement. It doesn't matter how it moved. I'm simply describing the movement. And we can think about this in two ways, as linear displacement and angular displacement and linear displacement is just motion in one plane, without any rotation versus angular displacement is movement or motion

about an axis of rotation. And so, oftentimes we assess kinematics in patients in a research setting by using some type of motion capture where we put reflective markers on the various segments and joints, and then we're able to measure the amount of movement, whether it's linear or whether it's angular, most times we're looking at angular, but whether it's a linear, angular, we're able to measure that using motion capture. Sometimes also in research, but sometimes in a clinical setting, you can use accelerometers. So, you can use these accelerometers that you can put on the person that give us some of these measures that we're talking about here in terms of kinematics. And so, that's a wearable way, which we'll talk about in a second, that you may be able to get some measures of the kinematics of their walking, but those are important to help us understand if the normal and expected motion is happening at each one of the segments at each one of the joints, right?

Versus kinetics, kinetics is the study of the forces and their effects on motion. So, here we are looking in detail about what the forces are and how it's impacting motion. And so the forces that we're talking about when we think about kinetics are primarily the ground reaction forces. Remember that when I stand here on the ground or I take a step onto the ground, I'm exerting a force into the ground. And Newton's law says that the ground is exerting an equal and opposite force on me, right? And so, kinetics is where we study those ground reaction forces.

And also where we look at muscle activity. What muscle activity is happening that then is causing a force on the lower limb? So, more technical than probably most of us get into and measure. But I wanted to just start out with those terms. And then I wanted to take you through, as we start to talk about spatial and temporal measures, I wanted to give you a few more terms and a few more normals. So, many of you probably understand that the gait cycle is the time from one initial contact to initial contact of that same foot. So, my right heel touches the ground, time starts and then our right heel touches the ground again, that's the gait cycle. I've moved through stepping of

the right limb and the left limb. And I'm back to making contact with the right limb. That's one gait cycle. And it should take only about a second, right? Pretty quick that that should happen. And probably some of you are saying, "Man, some of my patients are really slow," and that's true. And then earlier I made mention of stance phase and how we spend more time in stance phase. And so, stance phase, the time when the foot is in contact with the surface. So, we spend 62% of the gait cycle in stance phase, 62%. So, you could do the math, right? And then swing phase. We must be spending 38%, swing phase as the amount of time when the foot is airborne. And that's 38% of the time. So, again, not to try to bias you in one direction or the other, but to say we're spending more time in the stance phase. We sure want to make sure, we definitely want to make sure we're assessing it better than we than we likely are. Why is it that, this would be my final comment about the disparity between stance and swing. I think the reason why we see and report on the swing phase most is cause it's easiest for us to see because the foot is airborne.

The leg is moving and it's not being complicated by the ground. Stance is really complicating because we have the ground, we have the limb on the ground, we have the foot moving on the limb. So, there's just a lot more complication to that stance phase, but want to make sure that we're giving it the appropriate amount of time, considering that we spend two thirds of the gait cycle in stance. The other two important terms to think about are single limb support and double limb support. So, single limb support is the time when only one foot is in contact with the surface. So, one foot is in contact with the surface, 38% of the gait cycle, but you got to think about you multiply that times two, because you got a right and a left. So, when you take a single limp support in totality, you're looking at 76% of the gait cycle, almost 80% of the gait cycle. So, when we think about right and left. And double them support obviously is the time when both feet are in contact with the surface and that's only 24% of the gait cycle. So, we're spending a lot more time in stance than swing. We're spending much more time in single limb support, whether it's the right leg or the left

leg, as opposed to double limb support. But what happens when a person has some type of weakness or instability or they have pain or something like that on one side, they will flip flop those ratios and they'll spend a lot more time in double limb support than they will in single limb support. They'll avoid spending time, at least on that one limb that's either weak or painful and spend more time in the double limb support. So, I just want to make sure that got everybody on board with those terms there. And then I will say just, you know, in case that you have some interest, there are many ways that, and I think I already alluded to this. There are many ways that we can assess the spatial and temporal characteristics of gait. We're gonna spend some time talking about the clinical measures, but you could do motion capture system, which I already talked about, force platforms which I mentioned, you can do sensor embedded walkways, which is a technology that I feel like more and more, some clinics.

I shouldn't say more and more, but some clinics are able to have, right? So, you have a walkway that's embedded with sensors that captures information about each foot fall, and then it's able to calculate a lot of these spatial and temporal measures related to step time, step length, swing time, swing length, symmetry and such, right? So, those are ones that I feel like you're getting more and more accessible to us in the clinic potentially. And then you have wearable devices that are typically either a pressure or an inertial sensor that gives you a biomechanical analysis.

And we're gonna talk about a few of those towards the end of the presentation, but again we're gonna spend most of the time talking about the measures that we have available. And I wanted to start off talking about what has been deemed as one of the most, if not the most important clinical measure. And that's a measure of walking speed. So, many of you may be familiar with, there was a paper that was published in 2009 by Fritz and Lusardi, this was in the Journal of Geriatric Physical Therapy about walking speed, being so important that it should be considered the sixth vital sign. So, it must be pretty important, right? If they're putting it right up there with heart rate,

respiration rate, so on and so forth, pretty important. They, in this paper talk about how it's a key indicator of function, not just a, you know, musculoskeletal function, but cardio respiratory function, neurological function, and overall health. And if you look at this paper, there's a really wonderful schematic where they talk about using walking speed to predict a number of things and things like discharge home versus discharge to a facility, future hospitalizations ability to return to community ambulation. So, there's a number of things that , pardon me, over the time in literature, have been shown to be able to be predicted by using walking speeds. So, we want to spend some time talking about walking speed. So, obviously it's the distance traveled during a specified time. What we typically talk about is meters per second, or meters per minute, or I do know we live here in the U.S. and so it's could be also a feet per second or feet per minute, but we're gonna stick with meters for this. And so, you know, we have a couple of ways to increase our walking speed. We can increase speed by increasing the number of steps per minute, which is our cadence, another term that we need to know, or we can increase our stride length.

So, let's talk about these in a little bit more detail. So, normal walking speed for men is 1.37 meters per second, or 82 meters per minute. So, that's normal walking speed for women is just slightly less than that, 1.3 meters per second. It's important to know those, it's important to know what's normal so that if you're doing a measure, you're able to compare it to that, right? And then in a little bit, we'll talk about some other things that we can start to understand or some assumptions that we can make based on walking speed. Cadence is a measure, as I already said before, steps per minute. And that's not a measure that we use that often, but we can certainly calculate that in patients. And you can see there the normal 108 steps per minute, versus 118 steps per minute. The difference there has to do with leg length. So, a little bit of a higher of steps per minute in females because of being a little bit shorter. Normal stride length, you can see there for men is 1.51 meters and women is 1.32 meters . Stride length is gonna be the distance between two successive events on the same limb. So, in other

words, right heel contact to right heel contact, which I think we already mentioned earlier. So, typically the most common way for measuring walking speed is to do the 10 meter walk test, okay? And you're gonna find some variability out there clinically on how people do this. And you may even find some variability how people will do this in research, but in looking through several sources, the most common thing that people suggest is that you do the 10 Meter Walk Test and you collect data on the middle six meters. So, in other words, I have marked off 10 meters and that's my total distance, but I mark off two and then I count six more and make another mark. So, those end two meters at the beginning at the end are gonna be your acceleration and deceleration. And I'm mostly, what I'm interested in is that middle six meters, when they've attained sort of steady state walking, right?

If I measure the whole time, then I'm measuring their acceleration and deceleration. Now, does it have to be that complicated? No, I think if you would get a measure of a distance and calculate out the speed, I think that would be great. Just telling you what you're gonna read about most in terms of how to measure a walking speed with the 10 meter walk, being the most common. So, how do we calculate this out? Well, we know that walking speed is stride length times one half of the cadence. We also know that walking speed equals distance over time.

That's what we're gonna most normally measure, right? I can measure out cadence that steps divided by time times 60 seconds. I have stride length is gonna equal walking speed divided by half the cadence. So, what I'm trying to tell you here is that we can get several different measures by knowing walking speed. We can actually calculate out what their average stride length is. If we know their walking speed and their cadence as well. So, if we're interested in knowing stride length, that's something that we can get by knowing, walking speed and knowing their cadence. So, I just want to make sure that I gave you sort of those base measures. Don't get overwhelmed with the math there. Mostly, we're just looking for the distance that they're walking in the

time that they're walking and then calculating that down two meters per second or feet per second if what you measured in his feet. Once we have this, and we know how many meters they're walking in a second, or how many feet they're walking in a second, what do we do with that? Well, like any outcome measure, it's great if we know what it means to have meaningful change, right? So, we can know a couple of different things. We can know their minimal detectable change or their MDC, that's just what is the true difference, above measurement error, right? So, we know that there are certain amount of measurement error that is always present. And so their MDC is the smallest change that reflects a true difference above that measurement error. And we can also look at the MCID or the minimal clinically important difference. This is the difference perceived to be functionally significant by the patient or by an expert clinician. And so that's really important.

Both of these are really important, right? If I'm reporting a change, but it's really, really small it's within that MDC, then I can't really say they've had a significant change because they're still within sort of that margin of error. So, that's important to know. And the MCID I think is really important because this is what's perceived me functionally significant. So, is the change I'm making in this outcome, measure something that's functionally significant, both important to know. Now I will tell you, when you start looking at this data for walking speed, it varies greatly. Well, I don't know if I should say greatly, it varies based on diagnosis.

So, when you look at all this evidence in the literature, it depends on whether they're looking at patients with stroke or Parkinson's or older adults or normal folks. And so, I've given you there, the range of kind of everything that's available, at least looking at one database, the range that's available for walking speed. So, 0.08 to 0.18 meters per second. Why do I need to know that? When I'm writing a goal about how I want to address walking speed and I'm using walking speed as one of my outcome measures. I want to make sure that I'm not writing a goal that's just within the margin of error,

right? And then I probably would like to go a step further and use that MCID, which as you can see, there is 0.1 to 0.16 meters per second. I like to write my goal, something that is clinically meaningful. So, I'm gonna be writing a goal that I'm gonna change walking speed, or increase walking speed, at least two or above that MCID right. So, you can see that range there for MCID 0.1 to 0.16, but there's also evidence that talks about using a greater than 20% of initial speed. So, rather than using a specific cut off score, we're going specific to the patient and whatever their starting speed it is. I'm saying that the minimal clinically important difference is at least 20% greater than that initial speed. So, I think that's another easy way that we can use in sort of benchmarking and creating our goals for our patients related to gait speed. How many, and again, I'm just looking for a yes in the question and answer. How many people do a measure of walking speed consistently on, you know, let's say the majority of your patients that are walking of course? And you can just go ahead and type that in there if you do. That just helps me kind of know where people are.

Thanks for being honest. If you say, "No," thank you for being honest. Leonard, older adults are normal folks. Older adults are normal folks. You're right Leonard, thank you so much for catching me on that. They are older folks are normal folks. Cause the older I get for sure. I believe that, right? Yes. So, there were normals meaning below the age considered older adults, as well as older adults. How's that maybe I corrected myself there. So, a lot of people are saying, "No," some people are saying, "Yes." Christie, you say you use the TUG. And that's great that you use the TUG. The TUG isn't really a measure of walking speed though, because there's so much other stuff in it. You have that transition to standing. You have the turns. So, you're not really getting a clear measure of walking speed, but I love that you're using that as a measure. A lot of people saying, "No." Some people saying, "Yes." Some people saying, "Inconsistent." So, again I appreciate that your honesty there, that's awesome. Six minute walk test, and yes the Six Minute Walk Test is a great measure, but as we'll talk about in a second, it's more a measure of endurance and less a measure of speed. You are

asking them to go as fast as they can, but it's less of a measure of speed, but yeah, yeah. So, great. Thank you for putting in your answers there. I think that was really great and I appreciate you being willing to share and be honest there. So, in terms of walking speed and function, and again, we're spending some time talking about walking speed, just again, because it's really critical. So, why is it that we want to know that walking speed? What does that matter? Well, you know, there's some things that talk about you might be thinking, "Why do I care so much about walking speed?" Well, as I've already said, it really correlates with function, right? And so, this is work that was done by Perry, in patients with stroke. But this has been looked at and been pretty widely accepted, across some, especially neurological diagnoses for sure. And they looked at speed, you know, normal walking speed being 1.3 meters per second, which we've already established.

And then they described walkers in the following five categories, physiological walker, limited household walker, unlimited household walker, most limited community walker and unlimited community walker. And I'll show you what those mean on the upcoming slides, but for each one of these, they had a walking speed attached to it. So, if we think about the physiological walker. You can see very, very slow walking speed, 0.1 meters per second, limited household walker, 0.23 meters per second, unlimited household walker, 0.27 meters per second, most limited community walker, 0.4 meters per second, unlimited community walker, 0.8 meters per second.

One of the things that should jump out to you here is that you can be an unlimited community walker and still be pretty far away from normal walking speed if normal walking speed is 1.37 meters per second, right? So, that's kind of a significant thing to think about, but let's look at what they meant by these. So, the physiological walker is that person who is walking really for exercise or therapy purposes only. So, they're there that patient that is only walking, maybe when they come into the clinic with you or they get up one or two times a day at home and they walk, you know, from point A

to point B, but just for walking practice exercise kind of stuff only, they're not doing walking that's in any way functional, versus the limited household walker, walks for some of their household activities, but needs assist with others. They require assistance for, they can require assistance for walking. I'm sorry, they need assistance for walking. And they use a wheelchair to perform some of their activities. So, they walk for some, they use a wheelchair for some. An unlimited household walker is gonna walk for all their household activities. They may or may not be able to enter exit the home. They have difficulty with stairs and uneven terrain. They may not be able to do that getting in and out of a house independently yet, that would classify them as unlimited household walker and you know, the speeds that correlate with that.

So, for most limited community walker again, so getting a little bit faster, independent, and at least one community activity, what they describe as a moderate community activity. So, like gonna appointments or gonna a restaurant, they can enter the home, enter and exit the home independently. They can manage curves and stairs to some degree, maybe not fully independently though. Least limited community walker, they're independent in stairs, all moderate community activities, not just one they're independent and local stores and uncrowded shopping centers, versus unlimited community walker. That person that's walking at least 0.8 meters per second, independent and all home and community crowds and uneven terrain and shopping centers, right? So, it's very nice that they were able to make some connection to a walking speed and a functional outcome, right? So, you useful information.

- So, we'll shift from talking about gait speed, but hopefully before we leave away, hopefully gain some appreciation about the importance of using gait speed. And hopefully you add that to your measures. I won't do this here because we're virtual. But when I do a in person courses, I'm really feel strongly about the use of functional outcome measure. So, I usually make people raise their hand and take a pledge that they're gonna use them. I can't see any of you. So, I can't tell if you're actually doing

that, but I would encourage you to metaphorically at least take that pledge today and really commit to using outcome measures, not just for things related to gait, but really for all of your physical therapy examination. But let's move on talking about functional gait measures, before I run out of time. So, we have some measures that people have already mentioned the Timed Up and Go. Again, this isn't particularly a gait measure by itself because it's looking at things other than just walking, but it is great for general mobility and fall risk. And I do it as a part of every examination as a part of the group of measures I do for gait. But it's important to understand that when you think about the Timed Up and Go, you're getting their ability to rise from their chair, their ability to turn and their ability to turn actually a couple of times and then their ability to sit in the chair. So, we've got multiple things going on there. Not just walking or walking speed, but a great measure because we get an idea of those transitions.

We get an idea of that turning a way that we can give ourselves even more information. And before I move away from the TUG, the TUG is recommended as routine screening for falls, for all of the different geriatric society kinds of organizations all recommend the Timed Up and Go at every assessment of a person who's an older adult as part of the screening for falls, so really important measure. One way that we can use the Timed Up and Go, to give us a little bit more information. And I think a little bit more functional information that helps us is to add to our Timed Up and Go a Timed Up and Go dual task. So, I'm gonna do my Timed Up and Go regular, and then I'm gonna have them do the Timed Up and Go with a dual task. And I can do that either cognitive or manual, or both depends on what I'm interested in looking at. So, with the cognitive test, we're gonna do the Timed Up and Go, but while they're doing the test, I'm gonna have them doing a cognitive task at the same time. So, it could be counting backwards from a hundred by threes or seven. I never say seventh, the literature, often times the seven, I can't count backwards from a hundred by seven. I get to the first one and then I have to stop. I get 93 and then I just can't go anywhere from there. But giving them a cognitive task, like counting backwards, reciting something or you can give them a

manual task, which most commonly is walking while holding a cup of water. So, assuming that they don't have bilateral upper extremity impairment, they probably have at least one arm that they can hold a cup of water. So, you have them do the walk while holding a cup of water. So, what we have here is we have the straight up measure, right? The, you know, regular measure. And then we have maybe one or two other dual task measures. So, we can calculate the difference and see how much does this dual task change their capacity to do this task, right? And that gives us an idea of how disruptive dual tasking is for them and certainly guide us in whether or not that's something we want to be working on. So, I would suggest that you add that to your arsenal of measures that gives you sort of an extra layer of richness to the information you're getting from the TUG. We have a Six Minute Walk Test. This is a test of exercise capacity. This is a test of walking endurance. It correlates very strongly with community mobility and overall fitness.

So, you know, we're oftentimes interested in our patient's overall level of fitness, but not many of us have a way to get, like VO2 Max or something. We don't have a metabolic cart in our clinic that we can hook them up to and get them on a treadmill. But in many , I shouldn't say many. In several patient diagnoses. The Six Minute Walk Test has been found to be a pretty strong correlate to those other more lab specific types of measures like using, you know, the metabolic cart and getting things like VO2 Max. So, Six Minute Walk Tests, easy way to get an idea of their overall exercise capacity and walking endurance. There's some key things to keep in mind about the Six Minute Walk Test. You don't want to pace them, which means you shouldn't walk beside them. You should walk behind them. You don't want to distract them. They should be focused only on walking. So, not talking to you or talking to others. You do want to ask them to go as fast as they safely can, but you also want to state that they're gonna walk for six minutes and they need to do it without, you know, try to do that without stopping. So, you want to make sure that you've set the test up correctly and that everyone is giving the test the same way. I see a lot of variability in several of

these test, but for sure in the Six Minute Walk Tests. The other thing I'll throw in about the Six Minute Walk Test, which is something I've added in the last couple of years of practice is using the Six Minute Walk Test to get an idea of endurance. I'm sorry, I said the wrong word to get an idea of fatigue. We know that this is an endurance measure, but are we really assessing if our patient's fatigue and one of the ways that we can do that is a Six Minute Walk Test. So, as they're doing the Six Minute Walk Tests, usually you're just measuring the distance that they walk in six minutes. But if you measure the distance that they walk in each one of those minutes, so let's say the overall, they walked 1200 feet, but in the first minute they walked 400 feet.

And in the second minute they walked 200 feet. And then the next minute they walked 150 and you know, and it's dropping off precipitously every minute. Then that shows you that they are becoming fatigued, right? Their distance is really the grading. So, they're becoming fatigued versus they walk 1200 feet. And each one of those minutes, they were pretty much getting the same distance. That means that they're not becoming fatigued over that. So, that gives us another nice nugget of information that we may want to use. Now, not all of our patients can do the Six Minute Walk Test. So, we certainly can do the Two Minute Walk Test as an option, a shorter time version.

And that gives us some good information as well. We don't want to just not do a measure of insurance because they can't do the Six Minute Walk Tests. I also throw out there for some of your higher functioning patients, you can do the 12 Minute Walk Test. That's also one that that's available. Now, one thing I didn't mention, and I'm not providing you norms for the Six Minute Walk Tests, but I will remind you that in general, for the Timed Up and Go, 13 or 14 seconds is considered the cutoff for fall risks. But again, that varies depending on the diagnosis. So, I'll show you in a second where you can find information to get those cutoff scores, MCIDs, MDCs, all of that information. I'll show you resources for that here coming up in a second. So, someone asked, how do you recommend documenting the results? Ensure sometimes just doesn't see

distance, just sees distance and they don't care about function. Absolutely, I totally agree about that. So, whenever I document, like for example, the Timed Up and Go, let's say I did the Timed Up and Go, and my patient took, let's say they took 25 seconds to complete the Timed Up and Go, I would put Timed Up and Go, 25 seconds. And then in parentheses, I will put greater than 14 is a fall risk. And then, you know, in my assessment that I'm gonna put patient has, you know, a considerable risk for fall based on their, you know, TUG score or whatever other, and maybe whatever other measures I use to determine that. So, hopefully that helps you with that. But if other people have other ideas, feel free to share those, information sharing is good, but that's how I would use that.

So, some other functional gait measures, again, measures that aren't just about walking, but are things related to, and with walking that I think are important to get. And I already mentioned the dynamic gait index, the dynamic gait index is a series of measures where , I mean a series of activities that I take the patient walking through. They're only walking a 20 foot space. So, each time they're doing this, they're walking a 20 foot walkway, but I'm looking at them walking in response to different tasks demands and having various dynamic conditions. So, you're asking them to do things like turning their head to the right and left and up and down. And they're stepping over objects and around objects and they're having a quick pivot turn and those kinds of things.

And so you're looking at how do various other tasks, besides just straight up walking impact them. Of course, as we said earlier, and you can also start to get an idea about, a little bit of an idea about the Vestibular contribution to walking. So, when a person starts doing head turns, and if they have some difficulty with that, then that's gonna lead me down the path of wanting to do a further Vestibular and Ocular Motor Assessment, right? Because I get some information from this DGI that says, "Hey, maybe I need to further investigate that." So, it's definitely one that's utilized for a

higher functioning level of patient. Some body that's walking, walking independently, but we're seeing some dysfunction in some of those higher functioning skills. And then the FGA is an expansion of the DGI. They actually, because the DGI wasn't quite challenging enough for some patients, but they felt like there were still things that they could pick up with a more, a slightly more complex measure. They added three items to the first seven items of the DGI. And that includes walking with a base of support, walking backwards and walking with their eyes closed. So, if I was thinking about, you know, my patient who comes in off the street, they're walking independently, doing things independently, but they're losing their balance with really high level activities. I'm probably gonna give them that highest level gait assessment being the FGA of the ones we've talked about this far, to be able to determine, you know, so I get a really good idea of their gait. That's the test that they're most likely I'm gonna pick up some of their issues on.

Certainly that patient I described that walks in off the street, that's, you know, walking and living independently and only as losing their balance with some higher level things. If I give them something like a Berg or a Tinetti, they may score perfect or near perfect score. And that doesn't really give me a lot of room to grow in my intervention. And it doesn't really give me a lot of information about how I need to design my intervention. So, we want to make sure we're choosing the appropriate one that matches the patient's current level of function, right? A couple other tests I think are really good. The 360 Turn Test. This is exactly what it sounds, I'm either gonna take the time or the number of steps it takes for them to complete a complete 360 turn, right? Why is this important? Well, actually, I'm a wait till I get to the next one, then I'll say, why is this important. The last test on the bullet points here. And again, there's lots more, lots more out there I'm giving you just an example of ones that I think are good. It's the 4 Square Test. The 4 Square Test is a time stepping test. That's gonna require them to step over low objects and do so changing directions. So, what you typically do is put down four canes, so that you have two of them are, let's say, if I'm standing facing

forward, two of them are gonna be perpendicular to me. One of them is gonna be horizontal to me, right? They're making a T in front of me essentially. And the person's gonna have to step over to the front box, into the right box and then to the back box and to the left box and then reverse that. So, it's getting stepping over and it's getting sidestepping and backwards stepping and forward stepping, right? And the reason why the original test was said to use canes is so that there was actually physically something to step over. A lot of people will do this with tape, and that's good, especially you're like, I really don't want a patient's trip understand that, but doesn't give you quite the same information.

You don't really know if they completely clear something. If they're just stepping over tape, just to throw that out there. Still, I think doing it either way would be great and would certainly be better than not doing it. But the reason why I made sure I included the 360 Turn Test and the 4 Square Test here is because of this. We oftentimes, as therapists assess the patient walking forward period, we don't look at anything else. Where do our patients typically have difficulty with their walking? And when do they typically have walking related falls?

Well, when they're stepping backwards. So, like when they're opening a door and they have to step backwards while pulling on the door or opening the refrigerator, stepping backwards while pulling on the refrigerator door, backing up and turning to the toilet, that's another place that people often times fall. So, I really like adding these measures because these get at some of those things that we need to be addressing in our intervention. So, why don't we assess that to give us that guidance in our intervention, right? To make sure that we're addressing that. And then we're able to write more detailed functional goals when we have some of this objective data. So, that was why I wanted to make sure that I included that. And then I think the last thing in terms of specific measures that I wanted to include is the functional ambulation categories. And the reason why I included this is because you may say, "I work in acute care "and all of

our patients are like super low level. "And so we're just taking a few steps "and maybe we need two people" or you know, that kind of stuff. So, there are ways to categorize your patients to at least give a little bit more data about their walking. So, the functional ambulation category is a zero through five category, and you can see it here. Zero is that can't walk or they need the help of two or more persons. One is they need essentially a lot of support, but of one person, two is they need continuous or intermittent support of one person to help with balance and coordination, but you're not really supporting their body weight. Three is they really have only verbal supervision or stand by help, no physical contact. That's always a big mark that we want to be able to show that they need no physical contact. Pardon me and then four walks independently on level ground, but need some help with those unlevel surfaces versus five, he walks independently regardless of surface.

So, I wanted to show you that you kind of use a wide range of measures to be able to give some quantitative and or qualitative assessment of your patient's walking. So, hopefully it's given you some choices about things that you may be able to add to your toolbox. Speaking of toolbox, how can you find some of these measures if you are one of those people that says you aren't using much in the way of objective measures? Maybe one of the reasons why is you don't have access to them, you don't know where they are. So, I've you a couple of resources here?

The Shirley Ryan Abilities Lab is what we used to call http://www.rehabmeasures.org. And if you put http://www.rehabmeasures.org, it still works. But the updated link is there for the Shirley Ryan Abilities Lab. This is a database of outcome measures. You can just go in and type your particular measure. Or if you know the particular measure, you can put that in there and you can find it there, but you can also just type a category of measure that you want and it'll search and find you something that fit that. The cool thing about this, as well as the core set of outcome measures that's above, the cool thing about the Shirley Ryan Abilities Lab is not only can you actually get the

measure, download, print, save whatever the measure from there, but you can also find the MDCs and the MCIDs, so that I think is really valuable for us to use in our goal setting, right? And in our examination. So, I think that provides you some critical information. The first bullet point, which I jumped over is the core set of outcome measures for adults with neurologic conditions. Again, I hate to always be specific to neurologic just cause that's what I think about most, but there are some really good resources in neuro that I can share with you. And maybe there's some good resources for, you know, more musculoskeletal kinds of things. And I'm just not aware of them, but this is through the Academy of Neurologic Physical Therapy. They've developed a clinical practice guideline, specific to outcome measure. So, you can go and you can see specifically what they recommend. Also when you go to the Academy of Neurologic Physical Therapy, if you have specific diagnoses, like spinal cord injury, stroke, traumatic brain injury, MS, Parkinson's.

I can't think if there's anything other than that, you can go to the Academy of Neurologic Physical Therapy and search the EDGE documents, strokEDGE, the TBI EDGE, SCI EDGE, so on and so forth. And there you can find the recommended outcome measures for those specific diagnoses. Again, nice resources, all free and available to you without any sort of membership to any society. I also want to just show you, this is a nice resource that the Academy of Neurologic Physical Therapy has put together. And again, you can go there and download this for free. They put together what's called a physical therapy report card. And I thought it apropos to mentioned here, because a lot of it has to do with walking and it has to do with those core outcome measures that they have determined are most important for us to be doing in our patients with neurological diagnoses at least. They do the 10 meter walk, comfortable speed. They do a 10 meter walk fast speed. It is important to see if your patient can shift into a faster speed and what that fastest speed is. They do get walking distance or what I would probably maybe label as walking endurance with a Six Minute Walk Test. They use the Berg balance for standing balance, as well as the

FGA. So, here what they've done is they've chosen a more, a less dynamic test that your lower functioning patients are probably gonna be appropriate for. And they've chosen a higher functioning test the FGA, again I think to make sure that they're getting the whole gamut of people's balance abilities, but they also put on here the balance confidence scale the ABCs. And I did not mention that in my specific outcome measures for walking, but I'm just gonna put in a plug for why. It's super important, if you're doing a balanced measure, like the Berg or the FGA or the DGI or Tinetti or any of those, you also want to be getting balanced confidence or fear of falling, either one of those. So, the ABC the activities of balance confidence scale or the FFABQ, which is the fear of falling activities, I can't even remember the rest of it, avoidance it's, but it's an avoidance scale, but both of those are gonna get at their overall confidence with balance.

And why do you wanna get that? That's actually more predictive of a fall than any of those balanced measures that are listed there. So, you want to make sure when you're combining your good Physical Function Balance Test with a self report, of their balanced confidence or fear avoidance, either one of those. And then the last one has to do with transfers, ability to perform transfers. So, I've given you the link there. You can download this for free. It's just a nice thing. If you're like, "I don't always use outcome measures. "I wish I had something that reminded me."

You know, maybe you don't use the specific report card, but you use this sort of a template in your electronic medical record, but they've set this up so that it gives you their original score, their current score, you mark whether they're doing better, worse or same. And it also allows you then to be able to use this, to show the patient, to be able to give them some feedback about their outcomes, which is what we're gonna talk about next, which is using outcomes, using gait analysis as feedback. So, just wanted to share with you that little tool there that you might be interested in. So, the last thing we're gonna talk about is gait analysis as feedback. Sorry, I can always tell I'm talking

too much when I start getting this little tickly cough there. Yes, Deborah says, "I love the ABC tool, "especially for education of the overconfident patient." Absolutely, I would say flip side of that. It can be helpful for education of the over-confident patient, but it also can be a really good motivator when they're getting, when their confidence is getting higher, to be able to show them, "Okay, here's where you started. "You really had a lack of confidence. "Now your balance is improving as evidenced "by these particular measures "and your confidence is also improving." Yeah, yeah. So, they're both important, great point, but yeah, just definitely a measure we want to make sure that we're using. So, which is a perfect lead into using gait analysis for feedback. So, we know that feedback can improve motor learning and certainly feedback can improve walking recovery or walking relearning, right? And we also know we walk a very fine line about feedback, because too much feedback can be bad and how we provide feedback can be good or bad.

And so we want to make sure that we're providing feedback. We're using this gait analysis feedback in an appropriate way and we can do that via technology or via the outcome measures that we just talked about. So, we have a couple of options. So, technology can provide great feedback. And I'm talking about a few things here, but I'm sure there are other things that you can think of as well. And I certainly want to make sure that you throw those out again. I'm just giving you kind of my thoughts as I've thought through this and a little bit from the literature, but there are certainly treadmill systems like the AlterG or other treadmill systems. I just said AlterG because that's what I actually have clinical experience using where we can give them some feedback. And I'll show you an example of that in a second, but typically our treadmill systems can give them some spatial or temporal data. So, information about their speed, maybe information about their symmetry, maybe a visual or video representation, either live of their walking or a playback of their walking. And that can be super helpful. And let me before I get too deep in that slide, let me show you a picture here. So , this gentleman on the left is in an AlterG system, but again, I'm just

using this so that you can see how this feedback could help them relearn walking. So, if you see, let me get my little pointer here. Ah, here we go. So, if you see here, they have a screen in front of them. And so, they can actually have real time video, because there's cameras down here. They can actually have real time video of their legs on the treadmill walking, right? They can have a ladder, depending on how you set up the cameras. You can have a nice sagittal view as this person has there, or you can put it behind them. Can't really put it in front of them. And most of this we can put it behind them and they can have a nice view. Oh, actually the one on the right does have from the front, they can have a nice view of their legs as they're walking. They also, if you look here at this little panel off to the left, they're getting some more detailed. Some people say some more granular data about their walking.

They can get details about their speed. They can get details about symmetry. They can get details about foot pressure and where they're putting all their weight on their foot. So, they can get a little bit more detailed data about that. Now, from a motor learning standpoint though, I wanna use this always. No, I don't want to use this always. I want to use this to help them learn. And then I want to take this away and have them still be able to perform that walking or running at that improved degree of function, right? But can provide some great, great feedback that helps them learn. This is much better feedback than me as a therapist, standing there trying to verbally tell them feedback about their walking.

This is them using more of their intrinsic system to interpret something that they're being given extrinsically, but they're using their vision to be able to interpret what's going on there. So, a nice way of giving them feedback most likely, more effective and better than me verbally giving them feedback. Even on more simple treadmill systems, we can get feedback about how fast they're walking. We can get feedback about their steps per minute. I mean, there's all kinds of readouts that you can change on just a regular treadmill to be able to give them some data. But how many times would we

actually cue them to look at that data and to use that data and to set goals based on that data, right? Every time you get the patient on the treadmill, you should be using this to set a goal. Let's keep your heart rate at above this, or let's keep your meters per second speed at above this. So, we can be using that to set goals, but also give the patient some feedback. And the bottom here, you can see the front view of the patient, where this is what the camera is actually seeing and the patient sees this on their screen. So, again, can provide really good real time feedback about their walking. So, that's the way that we can use some type of treadmill system. And again, there's other treadmills that do other types of visual feedback. I just showed you that as an example. And then there's wearable technology that we use. And this is something that I feel like in the last few years has just exploded.

And it's becoming a technology that, you know, maybe was really expensive to start out with, but this is becoming a technology that's more and more in our grasp as coalition and for our clinics and for our patients to be able to use. So, there's wearable technology that we can use to identify movement disorders. They use it to assess surgical outcomes, improve walking stability, reduce joint loading of a limb. And typically it's gonna be either some type, it's typically going to be some type of inertial measurement, which is like an accelerometer or a gyroscope or a type of goniometer that we can place on the lamp to get those kinematic measures that we talked about.

So, we're gonna use that wearable technology to tell us some things about their walking. It can also be a pressure sensor in the shoe. So, we have lots and lots of systems. I just saw one advertised just yesterday on something that I got. I can't even remember the name to even throw it out there, but it's essentially a pressure system in the shoe. Some of them have like a little gyroscope that you wear at the ankle, but that's able to give tons of information about foot contact, foot pressures, step length, symmetry. All of those kinds of things can be measured from the data that you get from any of these. And then, and we can just share that data with our patients, right? And

use that as a way to give them some feedback, to help with their learning. But you can also use these wearable systems to them provide some sensory feedback. So, there's multiple systems that will provide some vibratory feedback to help people change, to either unload a joint, to shift their weight to a different part of their foot. There's vibratory and auditory systems that cue patients about their specific posture while they're walking. So, there's lots of ways that we can use these wearables to get information in terms of measurement, but also to give the patient information about what they're doing. So, in terms of wearable technology, I put some, a few studies in here just to give you a little bit more information.

So, in terms of using it for feedback, there we can get various kinematics as I mentioned to the lower limb, center of pressure of the foot, we can get understandings about the amount of trunk displacement in this particular study in 2017, there were looking at kids with CP and they were actually able to use the data they got from wearable technology to decrease that typical crouch gait pattern that persons with CP have, right? So, that's a very well ingrained, strongly learned pattern. And they were able to decrease that pattern based on giving them feedback related to limb movement, center pressure and trunk displacement that they got from the wearable technology.

The study that cited there in 2013 was looking at patients with knee OA and they did weekly training sessions. As you can see, to train more toe in walking again, to try to help them well with that knee pain to walk with more, with less, I'm sorry, less medial compartment loading, and not only were they able to change their walking pattern using the sensory feedback that they got, but they actually maintained that once they were outside of the feedback device which is really important. They're devices that are being used to train runners, to run with less tibial shock based on the sensory feedback they get from the wearable technology. So, I'm sure there's other things that we could utilize that I haven't mentioned. I think one of the obvious ones is we can

certainly utilize a Fitbit and most all of us have one on our arm or lots of us have one on our arm right now. And we can at least use step count technology to be an assessment of our patient's walking and definitely for goal setting of our patients walking. I mean, how many of you, I know I've done this at the end of the day, I looked down, I've got 9,900 steps and I'm like jogging in place the side of my bed to try to get that last a hundred steps you know. So, that's another wearable technology we can use. And if you can think of others, feel free to throw those up in the, in the chat. The last thing I want to mention about outcome measures related to providing feedback is this is a study that was done in 2014. It was a multinational site study, international study I guess I should say, this was looking at patients who'd had a stroke. And the goal was to investigate whether there was value in providing them feedback, structured verbal feedback, to improve walking by using their outcome measures.

And so, they had two groups, they all were receiving conventional inpatient rehab, nothing different about what they were getting in terms of intervention, but each participant daily participated in a 10 Meter Walk Test and the experimental group received feedback on their walking speed and the control group was timed, but they didn't receive any information about their walking speed. And the group that got information about their walking speed had significantly faster walking speeds than the experimental group at the end of the study.

The only thing different between the two groups is one group found out how they were doing each day with walking speed. And one group did the same test, but didn't get that information. So, I love this study as a reminder of the power of using the data we're gathering for the patients to be a motivator for the patients to help them actually improve their walking. So, hope that you will keep that in mind. So, I do have a couple of video cases. I wanna just talk through a little bit in the remaining time. So, if we could go ahead and get to video case one. Ah, there you go, thanks. Ah, good. And I can see it. So, here we have somebody walking, just a really quick short video, and we

don't have time to do a full Observational Gait Scale analysis, but I just want to talk through a couple points to kind of drive home some of the things we've been talking about. So, this woman, just to give you a little history about her, she lives independently in the community. She lives alone, she's independent and all of her ADL and IADL, she had bilateral cellulitis and ended up with bilateral, and she also is diabetic. So, she has bilateral peripheral neuropathy that has essentially taken out her anterior tibialis. And really for those of you who are watching her and hopefully doing your Observational Gait Analysis, her swing phase is the problem. Which almost never happens that it's only swing phase, but her stance phase actually looks really pretty solid. She has some minor deviations there, but her swing phase is the problem, right? Why did she come to us? She was falling a lot as you can imagine, right? She has no active dorsi flection and swing.

So, she's really having to work extra hard. If you think about energy conservation, look at how high she's having to step every step, you can imagine that her hip flexors and knee flexors are really working over time to be able to keep her walking without falling, but she's falling often. And that's why she came to see us. So, this is a good example of someone who really doesn't have much going on in stance phase in terms of a problem, but they have bilateral swing face problems. So, I'm just gonna show it one more time. So, what I want you to think about is, certainly we've kind of run through the Observational Gait Analysis. We can talk about what tool we might use for Observational Gait Analysis. We could use one of those generic tools that might be appropriate for older adults. She is an older adult. I think I can't remember her age, so we could use something from the Tinetti or we could use the Rancho tool, something that's generic cause it doesn't really fit into any of the diagnoses that we talked about. You can go back to this slide for me Kathleen. That might be the Observational Gait Analysis tool, but what type of other clinical measures or Functional Gait Assessments might you do with this patient? She's walking in a pretty decent speed there, looks like just from observing her. Can any body put in the chat bar, what other examination,

other outcome measures they might want to use with this patient in addition to our Observational Gait Analysis if they you wanna have a go at it? Everybody's getting quiet, always the TUG. Certainly that would be good. Certainly that would be good, sure. Yeah, so I like Kathleen or Katherine sorry, said the DGI. Yeah so, I think I would choose a higher functioning one for her as well. I think the TUG is good. So, I definitely, especially if she's an older adult, that would probably be in an automatic, but I like the idea of doing the DGI. Something that's a little higher functioning and yes, Debra, unless you really were there with the patient, you would be hard pressed to decide between the DGI or the FGA, right? If I did the DGI and then she scored almost a perfect score, I might be like, darn let me do those other three items and get it what the FGA would have said. Yes, one of the Turning Test, Kelsey, 4 Square, Rita absolutely. She is definitely gonna be a tripper, right? So, the 4 Square Test where she's having to step over something, the Turning Test again, we tend to trip more when we're turning.

So, I think the 4 Square would be great and I would do the 4 Square for sure. And probably do the 360 test as well. Great, excellent. You guys did awesome on that. Let's go to the next video. So, this is pretty, I don't have a very long video of her. So, this is a woman that had a spinal cord injury, incomplete cervical level spinal cord injury. And as you can see, she's walking with an assistive device. She's walking pretty slow. She looks super dependent on the assistive device. You may be hard pressed to see cause she has on white pants, but she also has on an orthosis. It's not a very good orthosis, but she has one on, on the left. So, she has some significant gait deviations that we could certainly identify in our Observational Gait Analysis. She has an extensor thrust, really a hyperextension and stance really early on from the minute she makes initial contact. And even though she has another orthosis, she doesn't have good foot clearance during swing. She's having to, you can't see from behind, but she's having to circumduct, she's hiking and she's vaulting, right? You can see on the right limb, how she pushes up onto her toes in order to swing that limb. So, we can see just right away without going into the width of our Observational Gait Analysis, that she has

stance instability problems, that extensor moment and hyperextension that she's doing in stance. And then she has swing limb clearance problems as well. But in thinking about and so what tools might be used, both Observational Gait Analysis tools as well as Functional Gait Assessment might we do for this person? Anybody willing to just chat? The Six Minute Walk Test. Yeah, for sure. I'm gonna tell you that this person probably couldn't do the Six Minute Walk Test cause they walk very little. They don't, they are using their wheelchair mostly, but definitely a test for endurance, because she looks like somebody that's really sucking energy right there, right? I mean all that, the vaulting and the overuse of the upper extremities, that's definitely wanna do an endurance.

So, I'm with you on that. TUG and 4 Square, definitely. I think those would be appropriate. Tiffany says the WSCI. Yeah, the WSCI as well as probably the SCI-FAI, because they're kind of different measures. The WSCI is gonna help me just sort of over overall categorize her walking based on the fact that she is in a device and she has an AFO, but then the SCI-FAI is gonna give me more of a Observational Gait Analysis guide for her. That's specific to people with spinal cord injury. So, I love that thought.

Yeah, 2 Minute Walk Test might be more appropriate for her. Which tool is best for driving intervention? I don't know that Leonard, I don't know that we can decide a best tool here. You can go back to the other slide. Kathleen, I don't know that we can decide a best tool here, but I think the ones that have been suggested were good. I wouldn't choose a high level balance for her. High Level Balance Test for her, I definitely want to, if I can't use something in my Observational Gait Analysis that's spinal cord injury specific, because there's some good spinal, because the SCI-FAI is a very good measure and it's specific to spinal cord injury. And that's gonna give me some good information, about her observable gait deviations. The WSCI is gonna help me document her progress. Given the fact that she uses an orthosis, she's using an

assistive device right now, that she's heavily relying on and is a very supportive assistive device that the WSCI might give me a good chance to be able to document her progress if I get her to a lesser device and such. So, I don't know that there's actually a best tool for that. I think all the ones that were said would be good and definitely confidence test. Yeah, I definitely for both of the patients, I don't know if we set it for the last patient, but for both of them, I definitely would want to do an ABC or an FFABQ. So, either getting their balance confidence or their fear avoidance, either one definitely wanna get with both of those patients, absolutely. I don't think I've ever finished right at 1:59 and almost 2 o'clock, but we are almost at the hour or two hours rather. So, we are right at two hours. Are there any more questions or comments either about the cases or just questions in general? Can I explain question number two on the quiz? It's just asking you a question related to what Observational Gait Analysis, which one of those is essentially true, about Observational Gait Analysis. So, is it qualitative? Is it quantitative? Is it low cost? Is it a low cost quantitative? So, you're just looking at which one of those statements really is true about Observational Gait Analysis. Thank you, Deborah. I appreciate that. Virginia, you're very welcome. Any other questions? You're welcome Leonard. Sure thing, Christina. Thank you, Megan.

- [Calista] All right. So, that looks like we're at the end and no questions coming in, but some great comments. Thank you again, Dr. Seale for sharing your expertise with us once again today, and we're gonna go ahead and close out the classroom unless you have anything else to add Jill before I do so.

- [Jill] No, there's one more question. What intervention would you suggest for I think improving plantar? I'm not sure aren't sure Ankar if mean a plantar flection strength or what you're asking there, but if you want to just send me an email with that. I can follow up on that question. My emails at the end, like we're good.

- [Calista] All right.

- [Jill] Well, thanks for progressing, I forgot to progress.

- [Calista] No worries. Thank you everyone for attending and hope to see you all in the classroom real soon. Have a great day, everyone.