CRAIG KARPMAN: Thank you for the introduction. Thank you for the opportunity to have me speaking with you guys today. I wanted to start off by letting you know that unfortunately there are no why did the chicken cross the road jokes in this presentation. So I just want to burst that bubble right away. We're going to be just concentrating on gait speed. I have no disclosures.

And we have several objectives today. First I just want to briefly define short distance, gait speed. Go over which factors are influential in the Gate speed measure, what clinical outcomes gait speed has been associated with. Tell you a little bit more about-- the study that we performed about measuring gait speed in our chronic obstructive lung disease patients. And then how we implemented gait speed measurement into the outpatient practice.

Some of you may have heard about gait speed in the past. It has been out in the news, back in 2011. In this article from *USA Today* there was an internet article about a year or so ago from a group here working on gait speed in Alzheimer's disease. So this has been out there.

Just to define it a bit, really what we're talking about is just walking speed. And we're talking about walking speed over a short distance. We take the distance that somebody travels, divide it by how much time it takes them, and then represent it in meters per second. And that's the Gait speed. Typically we are really talking about a short distance here. It's about two meters to 20 meters that you're measuring-- up to 30 meters in some studies. But this is the general range of what is used for gait speed And again it's represented in meters per second.

Now, there have been several questions in previous publications about this topic. One of which being, how do we actually measure this? What's the proper way to measure this vital sign? And then, what factors influence it? What clinical outcomes are associated with it? And how do we actually implement it into practice. And we'll hit on a lot of these.

So in terms of how we should measure it, really the answer is, it is all over the board. Different studies use different techniques when it comes to what time mechanism they use. Whether it's stop-watch, whether it is an automated system, gait mat I believe has been used in this institution in some areas. How you start the test-- so do you have the patient already walking and walking into the course that you have already in a moving motion? Or do you have them in a static start where-- you measure with them having to accelerate through the course?

Also the distance. Again big range, two meters, 30 meters, typically four meters or 10 meters are the most commonly used distances. But again, it varies study to study. So the other factor is really how do you instruct the patient to walk? So you can tell them to walk at a comfortable, natural pace. So that would be the usual pace there. You can ask them to walk as fast as they can safely. And that would be the maximal pace. More frequently, studies have used the usual or comfortable pace. And typically encouragement really isn't provided during the test. It's a short, brief test. But again there is variability there.

Now we do know that gait speed or walking speed is affected by several systems. Heart, lung system are involved, joints, muscle strength, your sensation, proprioception, cognition are all-- they all affect how we walk. And so one of the questions posed was, what are all the patient factors that are associated with walking speed? This is a nice figure showing that age is a big factor. As we get older from our teens and our 30s, our average walking speed goes up. And then once we hit 50s and 60s, it starts to slow down and it really drops off as we get older.

Another factor looked at was with the cognition. So folks that have mild cognitive impairment walk slower than individuals with normal cognition. Individuals with mild to moderate Alzheimer's disease walk slower-- or sorry, walk faster than those with severe Alzheimer's disease. So the severity of your cognitive impairment will also influence your gait speed. Mental health. Individuals with depression, schizophrenia, other mental health problems have been shown to have a slower walking speed than individuals without.

So those are just a few. There are several other factors that have been looked at before. There's been several outcomes that have-- clinical outcomes that have been looked at in relationship with gait speed. And over time, they've been shown that gait speed is associated with mortality, activities of daily living, falls, hospitalizations, even hospital length of stay-- because of all these factors, it's thought that gait speed really should be considered as has been proposed as another vital sign to implement in the clinical setting. Just because it can give you a trend or a sense about all those factors.

This is one of the big studies. Most of you probably have been exposed to it from Studenski and her group in 2011-- this is from JAMA-- where basically they pulled nine cohort studies, almost 35,000 patients, and they followed them out for several years. And basically what they showed is as gait speed goes down, the predictive survival goes down as well. So for example you have somebody who's age 70, if their gait speed is nice and fast at 1.6 meters per second, their expected survival is 25 years. But on the contrary if it's slower, than their expected survival is 10 years. And the same holds true both for men and for women.

This is a nice study showing gait speed and its association with in terms of daily living. So here you have gait speed. As gait speed goes up your likelihood of having ADL independence goes up as well. This is a study showing how gait speed is associated with hospitalizations, falls, nursing home placement. And really what we have here is three different groups, we have a very slow group walking less than 0.7 meters per second, we have a normal walking group walking faster than 1.1 meters per second, and then in between. And basically what it shows is as gait speed slows down, the likelihood of having falls, hospitalizations, risk of nursing home placement all go up.

And again these are just a couple of these studies. There are several others linking all these outcomes with walking speed. And there's a figure put out in paper by Fritz in '09, and it's a nice summary paper of basically a lot of things that have been put out for gait speed. And it really goes over that about 1 meter per second is a nice cut-off, where if somebody is walking at that ' or faster, they're probably going to do well. And they're less likely to have hospitalizations. They're more likely to be independent in their activities of daily living, less likely for adverse events, more likely be discharged home. And then if you're at 0.8 or lower-- especially at 0.6-- then the likelihood of all of those negative outcomes increases.

Now whatever you read through gait speed and pull out of literature, most of the time it's been extensively studied in a healthy older population, or an individual with a neurological disease, and some other cohorts. Particularly MS, Parkinson's, Alzheimer's disease. But few studies looking at gait speed and cardiopulmonary disease. And that was where our group comes in.

One of our areas of interest is chronic obstructive lung disease, or COPD. It's a very common chronic disease that we treat on a regular basis. It's going to be either chronic bronchitis or emphysema. Again very common. Many millions of cases both worldwide in the US. And it's the number one reason for hospitalizations in the US. By 2020 it's expected to be the most common disease worldwide. So again this is a very prevalent disease process.

And for COPD we actually already have our own-- we have a test that we use and have been using for many years. It's a marker of well-being of basically all chronic lung disease, marker of functional exercise capacity, and disease severity. And it's the six minute walk test. I don't know how many of you have been exposed to that before, but basically a six minute walk test is just, we provide the patient six minutes to cover as much ground or as long of a distance as they can in that time. Typically they start over in this cone, you have the administrators standing right here, and there's another cone standing here about 100 feet away. Typically it's 100 foot course. And the individual just does as many lapses they can in six minutes. And the distance that they walk is the outcome and is a marker of how well they're doing.

This test has been around for decades and has been used widely in individuals with pulmonary disease and heart failure. It's used in our lung transplant applications scores. It's used in our disease severity markers-- disease severity scales-- for COPD, and has been linked with significant clinical outcomes. Just to give you an idea here, so a six minute walk test where the patient is able to walk 400 meters or greater is considered a good walk. So they are-- they don't seem to have a lot of limitation. There are different cut-offs. But once you start getting into 300, especially 200, there is a limitation, and an increased chance of mortality, hospitalizations, several other bad outcomes.

The 6 minute walk test is really not performed routinely. It's done commonly. It's very frequently used in research studies. We do use it in a clinical setting for all of the actors I just told you about. But it's really not done all the time, and not on a basis where you perform it at every visit, because it does have a lot of time, space, and equipment requirements. You do need a very large corridor. You need to have the cones, timer. You are stressing somebody with cardiopulmonary disease, and so you need to be ready for the badness that will come with that. So crash cart, oxygen tanks, you need to have a CPR-certified personnel.

And so all these are-- requirements from the American Thoracic Society guidelines on performing a six minute walk from 2002. So really you need to have a fair bit of setup to have this happen. This is a test that you order on orders 97 just like an x-ray, a lab. They have to show up to either the lung function or the cardiology department does it. And-- we end up charging $590 for the walk. So again there is a little bit more to it than just a six minute walk.

And because of all those limitations, that's where we got interested in, let's look at something simpler, shorter, easier to use like gait speed in our population, since there was a fair bit of similarity with the test that we already use. So our goal is to develop a protocol on how to measure gait speed in our group, that would work the best. Evaluate how well gait speed is associated with a six minute walk test in our group, since that's an important outcome that's already been proven. And then evaluate how feasible it is to implement this in our clinical practice.

We started off by selecting patients out of our pulmonary function lab or our clinic with stable COPD. And we measured several factors-- I'm just going to contrast on the key ones. We had all of the patients perform a four meter and a 10 meter speed. Walk at two different paces. First they did it at a usual speed and then also at maximum speed. So once we had them walk through a comfortable natural pace, and then we had another two runs with an as fast as you can safely pace. And each time was measured with both handheld stopwatch, that I used, or our automated timer system.

And so this is just to give you an idea of what the setup looks like. And basically the patient starts here, there's a cone right here, and they're given these instructions. And they start walking, and once they cross this path the automated timer starts or the handheld stop watch is started. And then once they cross this line the automated timers stop and the stopwatch is stopped. And again they have a deceleration zone. And we measure this distance both at four meters and at 10 meters. And then obviously we also then-- on the same day-- measured a six minute walking test on all of our patients to see the link between the two and two measures.

So the most commonly used method to measure this is stopwatch. We-- did implement this. I was the one operating it for the entirety of the study. And then we needed to select an automated timing system-- when-- trying to compare the measures. There are a couple systems out there. Thanks to Nathan and Brian we had a couple to review and compare.

So down here we have the Brower System, which is a little bit more intricate. It has a couple more lap counting timers and so forth. And then here we have the TrackTronix System The Brower one runs about $900 to $1,000. The TrackTronix one was $350 to $400. And when-- I played with these, and just saw how to use them in the simplest way, this one really came out as being the most feasible, just cost-wise and ease of use. Much less buttons, much less training on that system.

And this is what it looked like. And this is what it still looks like in our back corridor. Basically we have our cone setup here. We have an emitter system and a receiver here. Same thing here, emitter, receiver. And then another cone right there. So the patient starts here, and they're instructed to walk at a comfortable natural pace. And they walk on through. And they're just timed from this point to this point.

And so the way that the system works is you have the emitter continuously sending a signal over to the receiver. And once this plane is broken between these two, that's when the automated timer starts. And then when the plane here is broken, that's when it stops. So basically your only output is just the time that it took for them to walk that distance. And then when the patient starts to come back it restarts again. So starts when this plane is broken, and then stops when this plane is broken. And to give you an idea-- all you have that comes out on this display is what time it took for them to walk between those two.

We ended up enrolling 130 patients, more men than women. Almost all were Caucasian. You can see our cohort was older and overweight. The FEV1 here is forced expiratory volume in one second. It's our way of measuring the severity of their obstructive lung disease. So 50% is that cut-off between moderate and severe. And so this shows that we had a nice blend between individuals with moderate and mild disease, and individuals with severe and very severe disease. So we have a pretty nice nice range there. You can see a fair bit of our folks were using supplemental oxygen. And the timers do have-- you can program in a two second delay. That way if they're rolling a oxygen tank with them, that won't trip the sensor twice. So there's a way to-- adjust for that.

Here I wanted to show you the average walking speeds that we had. As you can see, again about one meter per second is a pretty reasonable-- it's a nice cut-off between doing OK and doing poorly. And our patients actually did pretty well. As you can see for the usual speeds, they're about 1.1, 1.2 meters per second. And they were able to increase their speed when they were instructed to walk as fast as they could up to 1.6, 1.7. And you can see there is variability between the different measurements. And I will get into that a little bit more.

The first thing we want to do is really look at test-retest reliability. So for each measurement we did, we had the patient walk-- start from one cone, walk to the other, and then they came back. So basically we have a test and then we have retest. And so what we measure is how different is the test retest with all the different variables that we looked at. And the interclass correlation coefficient were very nice. So one is the best you can do.

And here this show shows standard error of measure. So how far-- off will you be from one measurement to the other. And it's 0.5 meters per second. So there's not a lot of difference between the one pass to the other when they're done at around the same time period.

And here we wanted to look at the difference between using stop watch and timer, and how much variability you have between the different timing systems. So this is a Bland-Altman plot where all we're doing is showing what is the difference in meters per second in the one measurement that we got versus the other. And then plotting it over-- what was the average gait speed during for that difference. And so if a dot falls right here, that means that there is no difference at all between the stopwatch measurement and the automated timer measurement. And if the dot falls right here, that means that the difference was 0.06 meters per second in the one versus the other.

The key here is that the mean difference was very small, and the 95% confidence interval for that range was also fairly small at 0.06 meters per second and minus 0.08 meters per second. So for usual-- so when we tell them to walk at a comfortable, natural pace measuring over four-- meters, we didn't have a lot of difference between the different timing systems. Although again, this is somebody who's doing this on a regular basis, me, doing that measurement. So if you start throwing in people that are less trained your are going to have increased variability on that.

Here we want to look at the same thing. Except now with the maximal walking speed, where we have them walk as fast as they can safely. And you can see the range here is bigger, and overall you can tell that it really splays out once the gait speed is increased. So the faster people walk the more variability we had between our timing systems.

And we also measured very similar things with the usual four meter and usual 10 meter. And saw that there was a significant difference between the different distances, and what speed patients walked at, depending on if it was a four meter distance or 10 meter distance. So based on those-- that analysis-- we really thought gait speed is reliable from test to retest no matter what kind of instructions we used, no matter what we did.

But you really had to stick one method. So you need to select out what's going to work best for your patient population, decide how you're going to use that, and then just stick to that. And you can't really vary-- OK, this time I'm going to use automated timers. This time I'm going to use stopwatch. I'm going to use 10 meters. I'm going to use four meter. You're going to get variability. And you're not going to-- as you follow this measurement out over time, that is going to affect-- that result. But if you stick with the same method, it was reliable.

The next step of our study was really looking at the relationship between gait speed and six minute walk. We did this by looking at the Pearson correlation. And here, what I have down here on the bottom, is six minute walk test distance. So starting from 100 meters all the way to 700. And here we have our gait speed measurement. As you can see as gait speed goes up, six minute walk test distance goes up as well.

So if this was a perfect correlation, you would have all these dots fall along a single line right here, and the Pearson correlation would be 1. If it was a perfect negative correlation the line would go this way. And as you can see it's not a perfect correlation. There is a difference there. And our values fell around 0.8 for almost every measurement. Slightly higher for the maximal than for the usual ones.

The next thing we wanted to do is see gait speed's ability to predict specific outcomes that are important in our patients cohort. So for us, knowing that a patient is going to walk less than 200 meters on their six minutes walk, or walk less than 350, these are key, important findings. And so we basically generate a prediction model with just gait speed alone looking at the ability of gait speed to predict a poor six minute walk test-- so less than 350 meters-- or a very poor six minute walk test with less than 200 meters.

And the area under the curves were very good for those. And basically the area under the curve, one is, it is the perfect prediction model. Where you're going to get it right every time. 0.5 is a flip of the coin. So the closer you are to 1 the better. And so these are pretty nice. Again these are-- the numbers are small, so these may change a bit if you add on more patients. But pretty good initial results with that.

So this is now getting to more-- probably what you are most interested in-- is can we actually use this and implement it in our clinical setting. First thing we want to do is really to get patient acceptability. Will patients care that they're going to be asked to do one extra thing during their clinic visit. One more-- vital sign. And so initially what we did is I took 100 patients, randomly selected out of our pulmonary clinic, and I, as they were being the roomed asked them if they wouldn't mind going and doing a quick four meter gait speed. And then after that I gave them a survey to see their acceptability.

After we did the patient acceptability portion of the study, we then went on into the clinical implementation, where we train our clinical assistants to set up the timers, to do everything. Where I wasn't involved in the process at all. They would perform gait speed measurements as a routine vital sign for our COPD patients. So not all patients coming into through our clinic. It's just those that have an indication of COPD. And then we would then measure acceptability by our clinical assistants, how long it took to train them, how long it takes them to set up, how much time is this adding to their day.

We had-- I felt like-- two main options as far as how to approach the measurement. The National Institute on Aging and NIH, they've put out a nice CD that is available online, that goes through the short, physical performance battery. And that includes how to perform a gait speed measurement. So if you download this and look at-- it's free online-- it goes through in detail how do to measure four meter gait speed.

The issue here is to watch this and see how to do it, it's 25 minutes of kind of figuring things out. Just watching. Let alone training how to properly-- they use a stopwatch-- time it, and to do those things with 12 to 15 clinical assistants. We thought it was going to be a very difficult task. And so we already had a nice easy setup that was ready to go. So even though this is out there, and I think it's something that's a nice option, we decided to go with our more homegrown, easier to use system and see if that would be actually feasible in the clinic.

For the patient acceptability part-- again we had 100 patients-- overall 99 out of 100 said that it was either very acceptable or acceptable. One patient said it was somewhat acceptable, but overall we had very little push-back from patients to say, no, this is not something I want to do. And as far as the clinical implementation part-- this is right as you walk in from the waiting room into our department-- we have a little room here where we do our weight, our height, our oxygen saturation, and our heart rate. And then the next step would be that the patient would be walked and roomed into their room in this corridor. But what we had of the clinical assistant do was, the patient would just walk over, they would drop off their belongings in this room, and they would keep walking down the hallway into the back hallway where we have our equipment all set up-- everything is ready to go-- and basically we hit the power button on this-- and that's the only thing that the clinical assistant has to do is hit power on the display. They measure the patient walking from here over to here, and then from here back, and they record the fastest walk. And then they room the patient back.

This is the report that the clinical assistant provides to the physician. And basically we just have the patient's name or label placed on there. And all that clinical assistant has to do is put on what time was displayed out on the machine. Then the clinician looks. OK, it took them 5.2 meters-- 5.2 seconds. Let's take this, bring this over, OK. Their six minute walk distance is going to be roughly between 250 and 350. So again this isn't going to be perfect, but it at least gives you a ballpark idea of where is their exercise capacity-- functional capacity-- going to fall.

And then on the backside, obviously our staff aren't used to gait speed. This is not something that we do. So on the back side I provided them with this. With again, a way to both educate the clinician on what does this moment mean, but also the patients. The patients come back going, what was this? What does this mean? They know what a blood pressure value means and they know what a heart valve means. They want to know, why did you measure this, and what does that mean? And we've had good feedback as far as physicians being able to say, OK, well you're in the nervous range. This is concerning. Or you're doing just fine.

For the clinical implementation part, we saw that it took about three to five minutes to train each person. So-- because the set up and the administration is so simple, it really didn't take much time, and we could group clinical assistants together when we did the training. So every morning the equipment has to be set up. I have it all up here, so you guys can just take a look and play with it. But we do break it down every night, and then put it back up in the morning to get it out of the hallway. And it takes three minutes plus minus one to set it up depending on how quick the clinical assistant doing it is.

And in terms of that extra time from walking past the room there would have been roomed to, to do that the gait speed and coming back, it adds an extra minute and a half. So that's-- with the two passes, we added an average of a minute and a half to our rooming period. And then-- the response from our clinical assistants-- was really that the measurements were either very acceptable or acceptable. But at the same time, we're not measuring it on all our patients. It's just our COPD patients. We're performing around 10 to 15 of these a day.

So when we ask the secondary questions of, would you want to do this all patients? The answer was no. And this is already-- especially during-- there are peak rooming periods of 8:00 in the morning and 1:30, when it does cause a little bit of traffic jam. And because it's not every patient then it's doable. And so-- we believe that it does need to be selective in terms of how to do this, especially if you just have one area where you are going to measure this.

So in summary, we do think that we have a highly informative measure here. We think that it's associated with six minute walk test well. And it is reliable as long as you stick to one method and just follow that through. And at the end of the day we thought that the implementation was fairly easy with the use of the automated timers. And obviously, depending on the workload on your staff and their technology savviness, all that varies. But in our department it has worked out well. We're continuing to do this even now.

So I had to steal this. I'll have to set this all back up after lunch.

AUDIENCE: In three minutes.

CRAIG KARPMAN: Yeah. So pretty soon. So I wanted to thank all the people that have been instrumental in this study. Dr Benzo was my primary mentor. And then all other individuals including, Nathan, Zach, everyone else involved. And then I have me email address here in case there are any other questions after this talk.