EMG Biofeedback: Karin Silbernagel, PT, ATC, PhD

Intro

My name is Karin Silbernagel. I'm a physical therapist and athletic trainer. I'm also a professor in the Department of Physical Therapy. I'm the Principal Investigator of the Delaware Tendon Research Group. So my most important responsibilities is to really be doing research along with my PhD students, but also teaching in the physical therapy program. And I also do a lot of consultations within the clinic.

Why is it important to know which muscles are activated?

So as a physical therapist, we use exercises a lot to help patients recover-- both to improve strength but also, from my perspective, we also use exercises to load tendons to get tendons to heal. So it's really important if you're going to have- trying to load the tendon, you want to make sure that the muscle that actually attached to the tendon activates. And one of the things that we see- my specialty is a lot of Achilles tendon research- and what we see after, for example, Achilles tendon rupture- that's when the tendon completely tears apart- is that when you, you can still kind of move the foot and you try to use other muscle that crosses the foot. So we have, for example, in the ankle, we have a muscle that goes out to the big toe and that one, it also helped to move the ankle into what we call plantar flexion. So when we want to try to load the Achilles tendon, obviously if all the movement is coming from that muscle, you don't get any load to the tendon. So we really is interested in making sure that the right muscles are working. For other things, like where we're looking for the knee for people that had ligament ACL injuries in the knee, it's really difficult for them of recover the quadriceps muscles. And when we indicate what they want to do, a lot of times they try to kind of straighten the knee but using other muscles- like using the calf muscle or the hamstring muscle- but have a hard time activating the quadriceps muscles. So by using EMG and those things, we can indicate that they're actually using the right muscle.

How do you know which muscles are activated?

As a physical therapist, and even before the EMG, we use a lot of palpation- feeling the muscle, trying to make sure we try to give feedback and those kind of things too. That is, however, hard, right? Because sometimes you can kind of- if they don't activate really strongly, it's hard to palpate it. From my research perspective, what we're doing- we use also a lot of ultrasound imaging. Where we can actually use ultrasound imaging to see if the muscle contract and we can see the movement in the muscle. And that works really, really well if you do have an ultrasound imaging machine. So we have that here. So then the patient can even visually see if they're actually moving the muscle and then they can easily get the biofeedback, to continue moving that muscle.

What is biofeedback and why is it important?

Biofeedback to me, in my definition, is the ability for the patient or whoever it is to basically know that they're doing the right thing, right? And that's hard sometimes with the muscles because if you can't see it and if you're trying to do it, it's hard to kind of give yourself- and telling your brain to contract the right muscles. So when you're doing that, what we can do with biofeedback is that you get a direct response that you're actually contracted the right muscle. And that to us is really, really important. And we can do that via ultrasound imaging or we can do that with EMG. So it really helps the patient to kind of connect what they're trying to do with what they actually want them to do.

Why do you use EMG?

For example of what we're doing- we're doing a lot of people that are with Achilles injuries and looking at the calf muscles. And what we're really interested is and see how this work when you're walking. For example, when people have had Achilles tendon rupture, they can easily stop using the right muscle. They

can still walk, but they're not using the calf to push off. So what we're trying to use is to put an EMG onto the calf muscles. And putting on also, IMUs [inertial measurement units] to kind of see what instances that are through gait. To kind of see are they actually using the muscles when you're expecting them to use? Are they using the calf muscles to push off as we would expect, and those kind of things too. So that's kind of what we're really, really interested in. We tend to use surface EMG because it's a lot easier, and it's a lot less invasive for the patients, and they might not like all the needle EMG. The problem with that is- that some of the muscles that are superficial, we know that we're getting the right spot, but for some of the deeper muscles it's hard to know that we actually getting that, and we're getting a lot of crossover from other muscles. So that's one of our issues. But we really do need to understand not only if the muscle is contracting, but when does it contract and when is it actually activated. So the timing of those things becomes really, really important. For us, we use mainly for the lower extremity. It comes both across the knee and the ankle to ensure that the body is recruiting and know how to do that.

What are some challenges when using EMG and EMG biofeedback devices?

Everybody looks different. So we have standardized ways to putting the EMG in the right spot, but it's hard. It's easy when somebody has really good muscles. You can make them contract and you can easily see the definition of the muscle and then you know, okay, this is where I'm going to put the EMG to fit. But when you have somebody with a lot of atrophy and pain, it's really even hard to find the muscle and knowing where the muscle belly is. So then you have difficulty putting it in the right spot. So if you're still using just standardized ways, you might not actually look at the muscle that you think you're looking at. And for us- so for me looking at Achilles tendon injury when you have a complete rupture, the tendon also gets longer and the muscle changes its position. So now it's hard to know where you're putting it. And then we really want to try to find some of those deeper muscles. And that also makes it hard to kind of know that you actually got the right one. Or if you see that the EMG seems to be some activity, but is it really crossover from other muscles to kind of get that feedback?

What are some challenges with using the mTrigger device?

I think trying to find the right muscle. And then even if they're contracting, it's hard to kind of set the settings to kind of get the right sensitivity for each patient to really make sure that you're engaging it and getting it to increase or the sensitivities. I think sometimes those are the challenges. And I think as a clinician sometimes we get too picky too, right. So I think that's not the mTrigger's fault necessarily. It could be our fault, right? Because if we put things in the clinic and things, we want everything to be perfect. But we also need to be thinking about if we can get people to do things more on the outside, maybe doesn't have to be perfect. Just more repetitions might be beneficial as well. But I think that is the issue- to really finding the right balance. How are we going to set the sensitivity of the settings for each patient every single time.

What are the benefits of using the mTrigger device?

So the mTrigger device is really exciting. I mean, it's not anything crazy new in the sense- it's just the plain biofeedback using EMG. What's really interesting though, is because our patients a lot of times, especially if you're thinking about those with ACL injuries, they have difficulty getting the quadriceps going- telling them to continue doing three sets of ten or three sets of 20 to continue to activate- they get a lot of times distracted. You get bored. You start thinking and maybe you start playing around with your phone. And then you can actually try to do the activity without really activating it. So it's just kind of repetitions that doesn't give you anything. So that's what's really nice, and we've used in the clinic; we're using the mTrigger. Because you're- the mTrigger keeps you activated and you're not gonna be able to achieve what you're trying to achieve- if you're playing the games too- if you're not contracting the same muscles. I think a lot of times it's really the feedback that you're using the right thing, but also make sure that you're actually continued to stay focused on the task.

What is the importance of patient compliance?

Exercise or loading- and we're thinking, what I'm thinking about for tendon is really important, right? Because that's the key- and that's the key variable that's gonna get your tendon to heal. So we're giving exercises, but it can take anywhere from six months to a year for somebody to recover. And telling somebody to do the same repetitions of a kind of loading, kind of gets boring. So the compliance is probably a really big part of the success sometimes that we're having. We also work with not just a complete rupture, but people that are painful. So telling them to do exercises- exercising might be painful and those things to kind of getting that compliance to continue to do it and moving forward. So if you have something like the mTrigger and things, that can make it a little more exciting and kind of get you to stick with it. And it's really, really important.

What populations especially benefit from biofeedback?

I think there is a lot. I mean, first you're kind of thinking about a lot of the children that we work with. We work with children and adolescents with heel pain. We're trying to give them exercises. They get easily distracted or bored with what we're doing. So I think that is a population that would probably be- much rather, if we can give them something to do the exercises and have them more of a fun and more of a game, we would probably would get a lot more compliance. We should actually- thinking about it, we should be able to much easily record the compliance too.

I think that is a population that are easily bored, maybe not necessarily- and sometimes their parents are making them do the exercises, but if they're not doing it correctly, it's just like repetitions, but not really activating. But that goes across actually, it's not only for children, that get bored too. We have a lot- if you are- regardless of your age and you're injured and you're in pain and you're sitting in the clinic and those things, anything that we can do to distract you to focus on getting things moving- I think it's really, really important.

What's the difference in assessing functional versus benchtop movements?

When we're doing things when people lying down, we're in control. We can tell them to contract. We can measure, we can see those kind of things too. But it doesn't mean that it carries over to when you're walking and that. So we see that a lot, especially with Achilles tendon ruptures, that people have this kind of avoidance gait. And you see it in the knee, too, that you have the quadriceps avoidance gait. And in order to get that goal, we can practice for a little bit in the clinic, but as soon as they walk outside, you continue to do your old patterns. So you don't really retrain the new pattern. So kind of having ways that can really measure while you're walking or those kind of things- like in the daily activities would also help the gait retraining or those kind of things to really carry over. Because just doing three sets of ten doesn't mean that your body has started to automatically starting to use some muscle again. So I think that's really important. So for us it's a lot of measurements when you're walking-- thinking about, how do you recruit the muscles for every step, like when you're landing on the heel versus when you're pushing off on the toe and those kind of things too. So that's when we like to use the EMG along with either IMUs or motion analysis to start measuring that. On the other hand, we can't do that outside, so it doesn't carry over. So other types of instruments like the mTrigger and things too, they can help us carrying over outside of here- will be really, really important.

Do you have any concerns with home-use of the mTrigger device?

I don't see any concerns. I mean, the biggest issue would be- and that's what we're working on every time they do any kind of electrical stimulation, even too to EMG and those things- because they all have to have the pads placed in the right spot. Right. So anytime- if they place in a completely the wrong spot, they might be training thinking they're doing the right muscle, but not. So those will be the main thing. But I think anytime- that's equally hard sometimes for people that are putting it on. So if you can train

somebody to do it- and a lot of times when we do, we actually mark the skin with markers that don't go away.

But I don't see it as a problem otherwise. I mean, if somebody played with it too much and activated too much, I don't see that an issue because it's not generally not any- the activity or the resistance, you're not using very heavy resistance for it because it's more of the activation that you're looking at.

Describe your perfect tool to assess neuromuscular function.

I would like to have- and kind of what we're working on for research too, with UPenn, looking at the electrode pads- if they could be better, easily formulated to the individual, like if you have the 3D printed electrodes, right? So that would actually fit, then if we could have one that was in the sock or a pad that is easily put on, so it doesn't have to be in a specific part of the muscle-- like you can just put it on as a sock and then it will fit you or whatever it is that stays on, that will be really, really good. And also then having it along with maybe, for us, pressure sensors-- like for the insoles, too. That's what we're looking at for the children to see. Because we can do measurements here, but it's a lot of times very artificial how much you move or how you move, right? Because we tell you to walk at your normal speed from here to there and don't pretend like we're here- and that's not happening. So really if we could have measures that would really be out in the real-world, that we could collect. And the problem is some of those things we would like them to collect consistently. So we would like to get a lot of data that doesn't interfere with the patient. That then we can download so it doesn't get lost because batteries die and those kind of things. So those would be the ultimate things for us to be able to have.

What data are you most interested in looking at?

For what we're really looking at, a lot of times is the timing, right? When does the muscle turn on and when does it turn off? Sometimes it's what we will be really, really interested in when we're thinking about for walking and all that. So that's also really hard to set up for the evaluate, right? What is the base noise of the EMG and when are we really triggering it to start and when- how do we set our data to match everything that we really want to know?

Are there differences in the data a researcher needs versus a patient?

For your students, it would be really interesting to start thinking about challenging the whole concept. Because we really want more and more wearables that really function, right? But we're also very particular of what the data we can get. So that's like the balance on making it simple, but also making sure that we get enough data. So I think from my perspective, what I would like to see your students start thinking about is, how do you have this two level of data? You can collect data that you can give feedback to the user, the patient, and those kind of things. While in the background you collect all the data that we want in an easy way to store that still is safe and not concerned about losing the data and those things. That's kind of what I would like. So it's plug and play for the patient, but it's also plug and play for us, then we can get the whole raw data easily.

For example, thinking about timing, right? We would need to collect data consistently, right? To make sure that the timings are right down to like the seconds or milliseconds or certain things- instances are happening at the same time if you have different variable devices. For the patient, it doesn't really matter. If there's a little bit of a delay between they're contracting and they see it on the screen, it's not that big of a deal. But from a research perspective, any kind of delay between sensors is gonna be a really big problem. And it's going to make our research not correct.

What's your process to adopt a new device?

There's two different answers to that question, since I'm both the researcher and a clinician. As a researcher, and I think that probably hat takes over. I like to take it into my research and kind of figuring out, okay, what does it really do? What are the mechanisms with why we're working? And does it really do what it's claimed to do? That's really, really important to me. So that will be like the first step. Because a lot of times as clinicians, we can get a lot of things that people want to sell and there's lot of snake oil out there too. So that's a big concern. And as a clinician, it's also, it has to be something that's really easy to do because the timing and the people and all that. So a lot of times you have assistants with you in the clinic or PT aides and things too. So if you need help, it needs to be things that can be easily implemented and easily started. So those things are really important. And every time it comes to portable devices and things too-- things can't take too long to charge. If the batteries run this out. Those things always becomes a problem, too. And the number of devices to use as well. One of the things is- if you get a really good device, but you only have one or two and then you start using it on all the patients and then you can't use it. So all of those things kind of plays a role in trying to make sure that you're starting to implement it. And the more things we can also get the patients to have their involvement, not necessarily cost, right? But I'm thinking like if, people can have the app on their phone and we just have the device, that might be easier because then they can save theirs; we don't have to keep setting up like what were you using, what were your settings, right? If they can have their own settings coming in, we can have the device set up. So all of those kind of things. So in the clinic a lot of times, it's the timing and the instruction, and then we also have to consider it beneficial, right? Are there other more important things that we think we should be doing?