

EMG Biofeedback: Jeffrey Fernandez, DPT

Intro

My name is Jeffrey Fernandez. I'm a physical therapist. I am a DPT. I have a doctorate-level degree in physical therapy, and I primarily work with patients with orthopedic or sports-related injuries, primarily after injury or after some sort of surgery. One of the more common regions that I treat are gonna be the knee and the ankle, but I also treat patients with shoulder or back injuries.

Why is it important to know which muscles are activated?

Especially after surgery, I think one of the issues we have is that patients don't really know how to activate the muscles that we want them to or realize whether or not they're doing it appropriately. So, for example, after knee surgery, one of the issues we find is inhibition of the quad muscle. So a lot of times when patients are performing a task, they think they may be performing the correct movement or they may be performing the movement, but they're using compensatory muscles to elicit that motion. So a lot of times it's important to, or we find value in having them be able to perform the muscles or fire the muscles that we want them to in accomplishing the movement.

What techniques, tools, and/or devices do you use to determine muscle activation?

Surface EMG is a great tool to utilize. That one- we do have the luxury of having a couple of units here in our center that do offer that instant feedback. The other thing, too, that we've used, that is in the past, prior to having surface EMG, we've used like blood pressure cuffs. So when they push into the cuff, it gives them instant feedback whether or not they're doing the motion. Unfortunately, that's not specific and doesn't really tell them whether or not they're firing the correct muscle to accomplish a task. But sometimes we can use that to just see if they can accomplish the motion. An example of where we might use a blood pressure cuff is when doing pelvic tilt type exercises for patients with low back pain. Just to ensure that while they're doing, let's say, a dead bug exercise where they have to move the arms and legs to make sure that they maintain that same positioning the whole time. But again, it doesn't necessarily translate to the muscles firing that we might want them to. That's more of a general overall positioning thing. The other thing that we do is just having the patient visualize whether or not they're firing the muscle. So in the case of the knee, when we ask them to do like a quad set, an exercise where they have to extend the knee, we might ask them to look at their patella, their kneecap, and see if they notice it's moving up and down during the task. If it's not, then the assumption is maybe they're compensating using the glutes to press down instead of the quad.

Why do you use EMG?

We do have a more research-focused EMG here that we've used. We've been playing around a little bit with. So the model that we use is Delsys. Unfortunately, that one is not as user-friendly, and we haven't been able to use it as much clinically. We use it more for our own in-house research. The benefit of that obviously is that it's a little bit more- I think the data that comes out of it is a little bit more objective or just EMG in general. We also use the mTrigger, which the nice thing about that is it's a lot more user-friendly and set-up is a lot quicker, in my experience. A lot of times it's just a matter of connecting it to a device via Bluetooth. And then at that point, it's just calibrating it to the signal that- or the minimum threshold that you want for the given task. So I think with the certain devices like the mTrigger, it's a lot more user-friendly and as a result, in the clinic, it's easier to set up and a lot quicker to implement. But overall, I think with EMG, the nice thing about it is that we can A) assess if they're firing the muscle. For certain tasks, if you want to make sure that they either meet a certain threshold or sustain a threshold during a task- that's one nice thing. So for example, one of the things our physicians ask for after- in patients after surgery, is for them to be able to perform a straight leg raise. So they use that as a, I guess, a

minimum criteria to be able to discharge use of a brace after knee surgery. And they use that more as a, I guess, a determination of whether or not they have sufficient quad strength for walking and other topics like that. So when doing a straight leg raise a lot of times our patients will lose the muscle contraction in the quad. And what we see is that their knee bends as they try to do the straight leg raise. So using surface EMG, we can give them a target like, Hey, maintain this quad activation through this like predetermined range as you do the movement. And in doing so, it allows them to maintain the knee extension throughout the whole motion as opposed to what we commonly see where there'll be straight initially and then as they continue it might bend or on the way down, they lose it and then their knee bends. So we use it in that sense. In addition to using EMG for muscle activation, we can also use it for muscle inhibition. So sometimes, like, let's say if we have a patient that's doing like a prolonged knee extension stretch, we can put over the hamstrings just so that it gives them feedback whether or not they're guarding through the hamstring. So we can also, in addition to using it to see if they're activating the target muscle groups, we can also use it to see if they're turning off the muscle groups when we don't want them to be using those muscles.

What are the most important clinical outcomes?

Strength is definitely an important outcome. So we look at quad strength with patients after knee injuries. The other thing that we use strength testing for is looking at different ratios. So if somebody has a much stronger- more so at the shoulder, we look to see if they have sufficient external rotation strengths and internal rotation strength. Also looking just like for asymmetry. So if it's an overhead athlete, for example, we would expect to see greater strength on the involved or on their dominant side versus their non-dominant- just to ensure that they have the sufficient strength to perform the task that they're going to go back to. But I think primarily we look at any asymmetries to see- especially in the lower extremities, if they're a runner or in a sport that is like- promotes symmetry, we want to make sure that their strengths are comparable prior to them going back to the activity that they were doing before.

How do you measure strength?

We don't use the mTrigger to measure strength. What we primarily use is handheld dynamometry as a measure of strength. We use the EMG as a means to get there. I think a lot of times when we do EMG, we tend to focus more on activation patterns as opposed to like, just strictly like using as a strength metric. But we use handheld dynamometry. And then some of the other measures that we use for outcomes in terms of performance are going to be more functional tasks- so like hop testing or doing plyo push-ups, stuff like that. So I think as they progress into rehab, we tend to look more at how they are able to put the pieces together. And then earlier on when they're more in that acute or subacute phase, that's where we tend to focus more on like muscle activation and surface EMG utilization. It would be interesting, later on to incorporate, tie in, a little bit more of a surface EMG with some of the other functional tasks. But at the moment I think we use surface EMG more in that earlier phase of rehab. And then later on we focus more on power and strength measures to assess readiness for return to sport.

What is the process and how long does it take to set up the mTrigger?

First thing will be to identify the muscle that we want to use it on. So- just because we use it more often for postoperative patients with knee conditions- typically we'll put it over the quad. So once we've identified the muscle we want to put over, we put the electrodes over, typically over the VMO area- like the vastus medialis and then the rectus femoris. Then once the electrodes are connected, connect the wires to the transmitter. Then at that point, I'll turn on the transmitter. And then on the smart- the compatible device we'll open up the application that pertains to that device or what we want to do that day. And then it's just a matter of pretty much like connecting the device. So it prompts automatically, and we just via Bluetooth just connect. And at that point, we can start whatever module we want to do. So we have some

that are just a matter of like visual feedback- seeing muscle activation- and then there's others that are games. So the kids, or the patients that we work with seem to like the games a lot.

So if we're using the mTrigger, it's like maybe 2 min. The surface EMG unit that we also have at the clinic that is a little bit more research focused, that one takes a little bit longer. But the mTrigger's pretty quick. So I think what takes the longest is getting the patient positioned and then just making sure that we're calibrating accordingly. So just making sure that everything's good in the sense that like- there's no interference, we have it over an area that is capturing the information we want. So I think that takes the most time, but for the most part, when it's like known- like body parts that we do routinely- I'd say it's within 2 min. Sometimes we kinda veer off and try different muscle groups, and that might take a little bit longer. But for the most part, I'd say it's like within 2 min we can get it up and running.

How do you use the mTrigger?

Typically, if it's just a matter of- to get them like motor-learning wise, it's not too many sessions. So once we accomplish the tasks, then a lot of times we might discharge at that point. For some patients that may have neurologic conditions, I do tend to use it longer or maybe not neurologic, but if there's strength deficits that I want to work on, I kind of use it in that sense, like make it a little bit more exciting. So in that case I might use it a little bit longer. So if it's like a pure teaching the motion or like a pure neuromuscular re-education type of approach where we are just trying to train the movement- so for example, going back to the straight leg raise example, it might just be like two or three sessions where we use it. And then once they gain the motion, then at that point we'll discontinue it and then they can just do typical strengthening. If it's somebody with longstanding strength deficits or deficits that are like neurological in nature, then at that point, we might try using it for an extended period of time. Just because we wouldn't expect to see a drastic change in their performance in one to two sessions. So in that case, we try to use it a lot more. In that case, typically gets discharged once the patient no longer enjoys doing the task or we find that it's no longer having the same challenge as before. So at that point we'll substitute with something else. But I think if it was something where the patient was constantly being stimulated and wanted to continue doing the task, we would probably use it for a longer period of time.

Typically, I try to avoid doing too long just because I think sometimes our patients get really into it and they can exhaust their muscles quite a bit. So a typical session might be maybe capped at five minutes. And then I try to give them a work-rest ratio of one to two, where they maybe fire for like 10 seconds, five or 10 seconds, and then are resting like ten to 20 seconds in-between each bout. Even that's kinda quick. But the problem that I find is that if we rest for too long, sometimes they get bored or they get disinterested. So ideally the rest ratio would be a little bit longer, to give ample time for them to recover. But I feel like if I give them too long of a rest, then they lose a little bit of interest. So I find using a one-to-two work-to-rest ratio seems to be sufficient time so that they can fire or like work really hard the next round and it's not too long of rest where they're getting bored.

How do you determine the appropriate mTrigger threshold for your patient?

That is a bit of an art. So we kind of- I'll ask the patient to like contract, like do an isometric contraction as hard as they can. And then while they're firing, I kind of see where they get to you and then adjust the threshold accordingly.

What are some challenges with using the mTrigger device?

The device is great. One of the issues I have stumbled across is it's really fun the first couple of times that our patients use it, but I'd say after maybe like five or six uses, because the task is the same, I think sometimes our patients got a little bit bored of the task. It's good that there's multiple apps, but I think it would be fun if they were- you know, those customizations. For example, they could somehow make it so

that the patient could choose the environment that they're doing. Maybe change the vehicle that they're using- that would, I think, make it a little bit more fun. The other thing, too, is, because it's the same task, there's no like- like, for example, when you play a video game, you unlock levels, right? There's no- none of that. So it's always the same task. I think sometimes our patients get a little bit bored after using it for an extended period of time. That's been one of the biggest challenges is keeping that motivation with patients that we use it for an extended period of time. The other thing, too, is sometimes we get a lot of crosstalk. So for example, in the case of the rectus femoris, let's say if we were using it for quad sets, sometimes patients kinda cheat- not on purpose, but subconsciously, they find ways, like workarounds to elicit the task. So I think some- that can pose a problem sometimes if you're not attentive to compensations. They may, for example, flex the hip to elicit a greater muscle contraction instead of extending at the knee. So sometimes that poses a challenge. The other limitation I've noticed with the mTrigger is that during some of the dual channel games, it doesn't allow each channel to have a separate threshold. And I think I've mentioned to them in the past that ideally it'd be nice if we can set different thresholds for the different extremities being used. Just because, let's say if we're working with somebody with hemiplegia, for example, you wouldn't expect both sides so fire at the same rate. So it'd be good to have different thresholds set to challenge either extremity differently.

What is the importance of patient compliance?

I think a lot of times, patients- especially working with the younger population- they don't see the big picture. So unfortunately, there are some things that- Let's say if somebody post-operatively, if they don't re-establish that quad strength early on or if there's a delay in getting them back to a certain minimum amount of strength. Like I think it kind of has like a snowball effect, so it affects them later on.

For example, with ACL reconstruction, we find that there's quad deficits even six months postoperatively. So I think a lot of times, even though the expectation is well, they'll eventually get it-- I think those deficits can have long-lasting effects later on. So one of the reasons I like using surface EMG is because it's an easy way to motivate patients, it increases compliance. And it gives them a better appreciation of what they're trying to do. But I think the main reason we try to incorporate different strategies such as the EMG, is to try to avoid these deficits from staying for longer periods of time. And with the hopes that it will prevent re-injury or issues down the line as it pertains to function or their ability to participate in activities.

How do you use the data provided by the mTrigger?

I do use it- from treatment to treatment- I do assess the millivolts being used, but I haven't tracked too much in terms of outcome measures in that sense. So I'm not as well versed with that, but that would be something worth exploring. I think anytime we can tie in data, I think it's beneficial just because that would also help to explore patterns- like areas for improvement. So that's definitely something we could do better at. But I think one of the- that seems to be a growing trend- at least in the rehab realm- looking at like muscle activation patterns, and collecting data and seeing if that could help predict outcomes as well. So that could be something we explore in the future, but unfortunately, we're not using it in that sense at the moment.

How do you define the success of a device?

Just because of our setting, since it's a little fast-paced, I think one of the things I would consider important for success is like ease of implementation. So that's been something to factor. And if I can't get it on and functioning quick, that might deter me from wanting to use it. The other thing that will determine success is whether or not it accomplishes the task that I'm looking for. So if they're able to move better after using the said device, then I think that would be a win-win, even if it took me a little bit longer to incorporate. I think at the end, if let's say there was a way to like, spend a little bit more time

with this setup as long as it led to improved movement patterns. I think that's where- that's what I would determine as a device being successful or not successful. It doesn't have to be movement-related necessarily. It could be like- as long as it leads to an improvement somehow. So it could be if the said device is going to be to improve strength, as long as I see improvement of strength after a certain number of visits or that, let's say if we're using it to assess whether they've changed the way they land from a jump or from a hop. So looking at those things- I think that would be the most important determinant of success with the device, whether it led to the changes that I wanted to see or not.

What makes a device easy to use?

I think what makes something easy to use is the lack of setup. So we do have at our clinic like a 2D motion system that uses markers. But it uses- it's like, I'm not familiar with the term, but basically you put markers where you want it and then you assign different colors to the markers. And it uses the colors to trace out the body segments and such. It's a great feature, but it takes so long to set up. So it almost becomes like- does that extra time warrant the extra information, versus just using an iPhone camera, right? And then video recording somebody. So I think for research purposes it's great. It's phenomenal. But then at the clinic, because it's so fast paced, you don't want it to use up too much of the time. And then later on, the whole session goes towards us like setting up and recording. So I think, when I think of like ease of use, it's like quick to put on and set up. And then the other thing, too, is the information that's drawn from it-- Is it like something that I can utilize right away? If you- even if it's easy to use, I think if it gives you information that you can't really use at the moment, it loses a little bit of its value. So it'd be good if it gives you something- like some sort of report or some sort of summary where it can tell you like basically where to change or interventions or where to focus your attention on as it pertains to that patient.

I think a lot of clinicians are- it's very fast paced. So I think a lot of clinicians are reluctant to change their ways unless it could be something that could be easily integrated into their practice. So I think if, you know, when developing devices or programs or software, I think it's important to consider like how- especially since not many PTs are like very techie to begin with- I think it's important to consider ease of use when designing these technologies.

Do you have any closing thoughts?

I think technology is definitely the future, and I keep seeing more technology being incorporated into the physical therapy realm. So I'm excited for what's coming down the pipeline for our patients.