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Breakthrough Technology Improves Concussion Assessment and Player Safety

ReachMD Announcer:
Welcome to ReachMD. This medical industry feature is titled “Breakthrough Technology Improves Concussion Assessment and Player Safety,” featuring Dr. Thomas Bottiglieri, Chief of the Primary Care Sports Medicine Division at NewYork-Presbyterian and Columbia. This audio is a production of NewYork-Presbyterian with world-class doctors from Columbia & Weill Cornell Medicine.

Dr. Bottiglieri:
I think that having the personal experience is part of what makes sports medicine so much fun for me.

Erin Welsh:
Dr. Thomas Bottiglieri is chief of the Primary Care Sports Medicine division at NewYork-Presbyterian and Columbia. He's an expert in the field of concussion care, a specialty that's especially meaningful to him as a former college football player.

Dr. Bottiglieri:
I was a, a linebacker in the '90s, and for my patients, that gives them a sense that, you know, I'm a person who gets it. I'm a person who has been on the other side. You know, it's kind of like in Star Wars when Luke realizes that Yoda was a Jedi, right? Like, you know, he's not just this old, little, wrinkled creature, right, who, who never had any battle action time.

Erin Welsh:
During his sophomore football season, he was knocked unconscious during a routine practice drill.

Dr. Bottiglieri:
There was this moment, and it was sort of a long tick of the clock, where I wasn't moving, but I was conscious, and that was the last time I played football.

Erin Welsh:
Soon after, a neurologist confirmed that Dr. Bottiglieri had suffered a severe concussion, and it was no longer safe for him to play.

Dr. Bottiglieri:
That was a very, very depressing moment, but it highlights so much of what I do in sports medicine, where that sense of losing yourself when, when a sport is taken away from you, it is an identity crisis.

Erin Welsh:
Concussions remain one of the most prevalent injuries among athletes, both at the youth and professional levels. But despite growing awareness of the potential implications on long-term brain health, they are still underdiagnosed in sports medicine, posing significant challenges for clinicians and care teams.

Dr. Bottiglieri:
In the old days, when I played football, if you lost consciousness, that was how you were diagnosed with concussion, and there's still a misconception that loss of consciousness is needed to make a diagnosis of concussion.

Erin Welsh:
But that landscape is beginning to shift. Dr. Bottiglieri and his team are researching a promising biomarker and an innovative assessment tool called ProScope, designed to identify and measure the severity of head injuries with greater precision.

Dr. Bottiglieri:
The blessing of being in a place like this is that there are so many brilliant people doing so many amazing things, that when you have an idea, there's somebody else that has had a similar idea. I want to give people that opportunity to safely participate, reach their potential, achieve what they hope to achieve in sport, not have that premature retirement.

Erin Welsh:
I'm Erin Welsh, and this is Advances in Care, a podcast about groundbreaking developments in modern medicine. In this episode, I'll speak with Dr. Thomas Bottiglieri about how these advancements are helping physicians and coaches more accurately diagnose those who may have suffered head trauma and make more informed decisions about when it is truly safe for a player to return to play.

Dr. Bottiglieri, thanks so much for joining us today.

Dr. Bottiglieri:
It's a pleasure, Erin.

Erin Welsh:
I want to just start off by getting a general scope of concussions. So about how many people are diagnosed with a concussion each year?

Dr. Bottiglieri:
It's somewhere in the range of two and a half million concussions that we estimate occur in the United States, and sports-related, in particular, is our focus. And the reality of that is that these concussions are almost always self-reported. In other words, less than ten percent of them have outward clinical signs.

Erin Welsh:
So what does that mean, outward clinical signs?

Dr. Bottiglieri:
Outward clinical signs would be the things that you might see sensationalized, you know, somebody being knocked unconscious or having some seizure activity. Another common one is fencing posture, where somebody sticks one arm out, and it looks like they're holding a fencing sword.

Erin Welsh:
And so it seems like the people who are getting diagnosed, that's really just the tip of the iceberg, and many more people are probably getting concussed without realizing it, which also means that they're not getting the medical care that they need.

Dr. Bottiglieri:
The simple answer is yes. In my career, I've sought ways of objectively measuring concussion, and the reality is there are none. We don't have a test for concussion. We don't have a diagnostic biomarker, a blood test, an imaging study that we can use to measure the effect.

Erin Welsh:
Wow! Yeah, it seems like, it seems like there's a big window for improvement there. And I know that most standards for measuring concussion, they're subjective, right? They're coming from patients who are self-reporting symptoms. And so I'm very interested to hear about your ongoing research and some of the tools that you're developing to improve diagnosis and also allow physicians to make more informed return-to-play decisions. Can you tell me about how this research started?

Dr. Bottiglieri:
So, I was a private practice guy before I came to Columbia, and in a place like this, when you have an idea, there's somebody else that has had a similar idea and oftentimes, those people have resources and tools that can help you to study that idea. And so I was very fortunate to meet Linus Sun. He's a neuro-ophthalmologist who was studying with Mickey Goldberg, the saccadic motion of the eyes this beating of the eyes that we do in order to help get our fundus aimed at the target and to create an image of the world using proprioception and using part of the brain that sort of anticipates what it's going to see, right? So almost like this imagination part of your brain that creates the picture for you and then lines up the eyes to help reinforce or refute that prediction. It's really quite amazing research they've done.

Erin Welsh:
That's super interesting. What was your next step?

Dr. Bottiglieri:

We wanted to study the VOMS. The occulomotor screen is a nice, reliable tool, but ultimately, the objective findings of that tool are not so well defined. You know, this is where we look horizontally back and forth at two targets about eighteen inches apart from one another at about thirty inches from the patient.... and then up and down, that's called saccadic motion, scanning back and forth and scanning up and down. What we wanted to do is we wanted to objectify that saccadic motion. We wanted to measure it.

Erin Welsh:
Right.

Dr. Bottiglieri:
And one day I got a phone call from Linus, and he said, "Thomas, have you ever seen head titubation in your concussion patients?" And I said, "Okay, first, what's head titubation?"

Erin Welsh:
'Cause yeah, great question.

Dr. Bottiglieri:
Right? And he explained, and, and yes, I had seen it. It's a slight tremor of the head and neck when you're trying to get somebody to focus on a target.

Erin Welsh:
Okay.

Dr. Bottiglieri:
The head doesn't necessarily stay perfectly still, and in our severely concussed patients, you could actually see them struggling to keep their head still. And so we started to look for ways of measuring that. It was not what we set out to do when we were measuring the eyes, but it was an accidental and really revealing discovery that through some grant funding at Columbia, through the Department of Orthopedics and Technology Ventures, we were able to start a lab. And we went from a tiny pilot study of about 10 patients, we now have over 250 patients enrolled, and we're planning on publishing our findings in a few weeks for submission. We'll submit our first paper.

Erin Welsh:
That's amazing. And, you know, as you said, you saw more head titubation or head movement in severely concussed patients. Was that a signal that got you thinking, "Maybe this is also apparent in less severe head trauma, but it's just more difficult to notice?"

Dr. Bottiglieri:
Yeah. You know, your neck houses the most proprioceptors of anywhere in your body, and proprioception, your body's ability to know where it is in space first starts with your head position, which is ocular and vestibular, but it's also very tightly regulated by the proprioceptive system. Where your head goes, the body follows, and so I started to really think about this a bit more in terms of what are we seeing with patients? Patients tell me all the time they just don't feel right.

Erin Welsh:
Right.

Dr. Bottiglieri:
And so since we've discovered that there's a proprioceptive deficit of the head and neck, we apply that to this idea that their sense of body, their sense of ability to navigate in space, is impaired, and so they just don't feel right. This has led us to be much more focused on head and neck rehabilitation.

Erin Welsh:
And what's your method for measuring head titubation?

Dr. Bottiglieri:
So if I ask you to stare at a target, we have a software program that allows us to use a head-mounted camera to measure head movement and came up with an algorithm for isolating the signal.

Erin Welsh:
And just to clarify, that software program is called ProScope, correct?

Dr. Bottiglieri:
Yes, and we can isolate that signal, and then we can create a power band, and that power band has a fairly clear cutoff, a number where normal exists, and then beyond that number, abnormal is, for concussion generally, is about two standard deviations above that

cutoff. And so we have this really nice way now of saying, "This signal is there," or, "It's not there," without having to interpret anything.

Erin Welsh:
I mean, that is amazing that you have the technology to be able to measure that. And so now that you have this new way to diagnose and identify the severity of a concussion, what's next?

Dr. Bottiglieri:
Yeah so right now, our sensitivity and specificity is above 80% in both domains, and, you know, our RUC analysis is somewhere around 83. There's some really positive statistical findings, but we want to expand and collect normative data at other universities and collect injury data at other universities. So that's our next move is to expand beyond our institution and develop some of these research partnerships so that we can refine the signal, right? So my main goal is get this into the hands of clinicians as soon as possible so that they can improve upon it, right? That we can get an even better tool.

Erin Welsh:
Yeah, of course. I mean, I know that improving the tool will help so many other people, but I imagine that this tool is already making an impact in the lives of some of your patients. Are there any specific stories that come to mind that you could share?

Dr. Bottiglieri:
So this was a really, an aha moment for us. This was one of the first times we realized that this tool could be used in real time to actually impact the health of our players meaningfully. So we cover a hockey program. They come in, they were driven into the boards. They caught an edge, and somebody clipped them, and they landed on their head on the ice. So this kid comes in. He had a big hit. You know, he was very honest with us, told us everything he was feeling. We sat him out. It's generally seven to 10 days for most of these guys.

Erin Welsh:
Okay.

Dr. Bottiglieri:
And then they come back, and they go through their exertional protocol, right? So you're symptomatic, and we know we wanna exercise these guys, even if they're symptomatic controlled sub-symptom threshold rehabilitation. And, you know, his symptoms go away, and then he starts his return-to-play protocol, you know, which is a series of five or six steps that, that gets you ready to be back on the ice. And so we go through our normal protocol, everything, and he checks out, no symptoms. Neurologic exam, perfect. Exertional test, perfect. Ready to sign the kid out, my research assistant says, "Can I talk to you for a second?" He shows me an elevated biomarker, three times normal. I said, "That's interesting. Let me talk to the kid." So I sit down and say, "Look, we, we have this research going on. I'm not sure of the significance of the signal, but I just want to run this by you. We think we're seeing changes in the brain that are unreported, undetectable on other tests. Are you really feeling all right?" And, and he said, "You know, Doc, I'm actually stuttering quite a bit. I don't really know why, and my friends have noticed that I'm, I'm a little less able to get in a conversation with them, and I, and I, I don't know how to explain it. I just don't feel right." And that was that moment where it really started to come together in my mind how the head and neck proprioceptive signal that we're detecting influences this subjective experience.

And so I said, "You know what? Let, let's do this. I'm gonna have you go non-contact another week. I'm gonna get you back in the clinic." We took another week, he came back in the clinic, and his number had dropped to the normative range, and we retested him. Everything tested fine, and then we brought him back again because we wanted to see if that persisted, and it did. He stayed in the normative range even after return to play. So we look at that as, like, our- well, that's one of the sentinel cases. We have a bunch of those now.

Erin Welsh:
Yes, okay.

Dr. Bottiglieri:
But, that was the sentinel case where we said to ourselves, "Wow, we can see this signal, and it, and it correlates really well with these nebulous symptoms."

Erin Welsh:
Yeah, I mean, a case like that just, it truly demonstrates how powerful this tool can be. But I know that access and affordability still remain huge challenges when it comes to concussion diagnostics overall. You know, MRIs are expensive. They're not exactly portable, and so I'm curious how your team is going to address some of those challenges.

Dr. Bottiglieri:
One of the goals of our technology is to make this available to people. There are lots of technologies that are going to help change the

landscape of concussion, but they're not portable. They're not available because they're super expensive, and they're isolated to these academic medical centers. We're hoping that our product will be somewhere in the three to five dollar range for athletes and widely available from youth through elite sports. But the commercial product will look different than our research project. Our research project is a head-mounted camera, but we're gonna flip that around. We're gonna have the camera pointed at your face, and using some biometrics, we're gonna be able to measure your head movement. This is really an exciting time because that will make this technology available on the sideline, in the clinic, really anywhere that somebody's being evaluated for a concussion.

Erin Welsh:
It's incredible. I mean, accessibility is so crucial, and it seems like this tool has the potential to really ensure that athletes don't suffer repeated trauma. And I'm curious, what is the biggest potential impact of a misdiagnosed concussion?

Dr. Bottiglieri:
Ultimately, what we're worried about is the accumulated impact of these injuries leading to neurodegeneration. And if neurodegeneration is the end game, well, is there a spectrum in between the concussion that resolves completely and folks that may have some subclinical impairments, things that aren't diagnosed, mood disorder as an example, cognitive impairments as an example, and, you know, how many brains are, are impaired playing collision sports that we don't detect over time?

Erin Welsh:
Right.

Dr. Bottiglieri:
So, you know, I don't want everything to sound doom and gloom. "Oh, my goodness, we're made of glass. If you hit your head, you're gonna have permanent brain damage." That's not really what we're concerned about. We're not concerned about the one-off concussion. We're really concerned about repetitive head trauma. That's the thing. The brain does have the ability to heal, and you have these beautiful glial cells that can restructure the myelin, restore the normal brain conduction, but it takes time. We know that neurologic injury takes time.

Erin Welsh:
Right, and so understanding that time to recovery is really crucial in terms of how do we then reduce the risk of long-term effects, long-term impact? And with that in mind, I just want to know, in general, some of what your hopes and goals for the future are when it comes to this research and where this will take you.

Dr. Bottiglieri:
I've told you I love sport. I loved football. These games, you know, have a virtue, and my hope is, is that we can advise athletes, "You are or you are not injured, and it's safe for you to continue participating."

Erin Welsh:
I love it. I mean, this is truly will... sounds like it will change the lives and just the landscape of being able to better understand the impacts of concussion in both acute and chronic situations, and also just to make sports safer for everyone. So, Dr. Bottoleri, thank you so much for chatting with me today. I really, really enjoyed our conversation about this, this understudied field of concussion, so thank you.

Dr. Bottiglieri:
Thank you for the opportunity, Erin. I'm really excited to get this out to the world.

Erin Welsh:
Huge thanks to Dr. Thomas Bottiglieri for taking the time to speak with me about these exciting new advancements in concussion diagnostics that are already making a difference in the lives of athletes.

I'm Erin Welsh. Advances in Care is a production of NewYork-Presbyterian Hospital. As a reminder, the views shared on this podcast solely reflect the expertise and experience of our guests. To listen to more episodes of Advances in Care, be sure to follow and subscribe on Apple Podcasts, Spotify, or wherever you get your podcasts. And to learn more about the latest medical innovations from the pioneering physicians at NewYork-Presbyterian, go to nyp.org/advances.

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