

# TONAL'S VICON SYSTEM UNDERPINS THE SMART GYM REVOLUTION

VICON

MOTION CAPTURE PROVIDES THE GROUND TRUTH FOR STRENGTH TRAINING ANALYSIS AT HOME



LIFE SCIENCES

“You use wearables to look at how people run in the real world, but we use Tonal to look at how people strength train in the real world,” explains Lauren Benson, Senior Manager, Research, at Tonal.



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Tonal has created a smart home workout system that combines comprehensive analytics with virtual coaching and a compact form factor to provide resistance across a wide range of strength-based exercises.

The system, which replaces traditional weight training equipment with two arms, two handles and some sophisticated motors and cables, has gained attention (and investment) from the likes of Serena Williams and LeBron James.

Increasingly, everything Tonal does is underpinned by sports science that's informed by motion analysis performed using Tonal's Vicon system.

### INTELLIGENT PERFORMANCE IMPROVEMENT

Prior to her time at Tonal, Benson earned her doctorate from the University of Wisconsin-Milwaukee and studied running and wearables as a Postdoctoral Fellow at the University of Calgary before a stint monitoring athletes for the United States Olympic & Paralympic Committee. She was interested in performance-monitoring wearables, but remained skeptical.

“I was always curious about companies that produce wearables designed to help human performance for the public,” she says. “But I was so cautious, because I didn't know

whether the companies actually invested in the intelligence that is needed for their products.

“I never felt comfortable moving into the commercial space until Tonal came along and I saw their commitment to a full performance innovation department. And as soon as I started, I was talking to Vicon about how to buy a full system.”

Benson is part of the Tonal Strength Institute, which is essentially the sports science support unit for the company. It boasts personal trainers, Olympic coaches and even the former head of the US's national ski and snowboard team on its staff. Benson brings a background in biomechanics to the team, and her role with Tonal is focused on understanding how people move while using the system; testing the equipment itself and bridging the gap between the small, high-fidelity data samples that her team collects in the lab and the mass of data gathered from home users.

It was the breadth of the Vicon ecosystem that made it the right choice for Tonal. “I like the Vicon interface: that's great,” Benson says. “But what I think really helped with us choosing Vicon was the ability to have the marker-based cameras, the markerless functionality and multiple ways of capturing with the IMUs, all in one integration.”

The system is also integrated with Delsys EMG technology and AMTI force plates, as well as Futek load cells on the lab's Tonal units' cables.

An additional perk for Benson is the buy-in that the system enables her to get from her subjects.

"We have a group here that we call Employees as Athletes, and that's who we tap into to run tests. Honestly, the way that I get a lot of people in is I'll post a video of someone with the markers on and the bones overlaid on their video, and they see that and say, 'Oh, that's so cool! Can you make a video of me doing that?'"

Tonal's system comprises 12 Vantage cameras, eight Vue cameras, 14 IMUs and markerless integration. The system provides the ground truth against which Tonal's data is measured.

### AN EXTERNAL VIEW

"We wanted motion capture because we want to know what users are doing," says Benson. The company can capture a range of user data out in the wild, but needs its Vicon system to validate its interpretation of that data.

Tonal's form feedback is based on sensors on the cables that track the symmetry, balance, smoothness, the pace of a user's movement and, most recently, Tonal's new phone-based Smart View feature.

"We know how the arms are positioned and so on, and we are able to give some level of form feedback with just that information," says Benson. With Smart View, users can also set up their phones to record themselves performing exercises and receive automated feedback from Tonal's

algorithms, adding another layer of depth to Tonal's form feedback. It's a feature that's made possible thanks to the company's Vicon system.

"Without having some kind of a ground truth to know what a body position looks like when someone's doing a particular movement on Tonal, it's really difficult to fully understand what's happening. Being able to use the gold standard to look at joint angles is really helpful for that.

"And we're looking at the velocity of movements, incorporating those velocity-based measures into our understanding of how people are doing different movements."

So the motion capture and other lab data are used in conjunction with the much larger dataset from Tonal units out in the wild to build a picture of how people are using the device.

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The system is also used to provide external validation of Tonal's resistance profile and the speed and acceleration of the handles, confirming the data from the machine's own motors and cable tension.

"Because I've modeled the Tonal arms and the Tonal handles, and Tonal itself tracks the trajectory of the cable, I can sync those signals together," explains Benson. "And then when Tonal counts the reps, we know exactly what it looks like in the Vicon model. That's really giving us a lot of information back to Tonal. So we can say, at this exact point in the repetition, on Tonal we know in three dimensions, with all the positions and forces, what's happening with the user."

### UNLOCKING POTENTIAL

This deeper understanding of the interaction between machine and user is translating into new advances for Tonal.

"This lab is going to help us do the things that we've always wanted to do," says Benson. "People at Tonal have already known that they wanted to create certain new products or features, but they couldn't do it until we had the Vicon system and someone who could use it to gain this understanding. I've had so many people come to me and say, 'I'm so glad you're building this, we can finally look at this particular thing, we can finally create this feature.'"

The system isn't just offering a framework for realizing pre-existing ideas. Benson's team is also laying the groundwork for applications that no-one has thought of yet.

"Every time we have someone coming through the lab, we switch on the load cells and the force plates, and we marker up if we need to, or we put the markerless cameras on, so we're getting joint angles all the time," she says. "So we have that information so that if we're ever interested in, say, what the forces are in the shoulder during bench press, we've got a full recording of 50 sets of bench press, and so we can start to piece that together."

### KNOWLEDGE SHARING

Benson praises Vicon customer support for helping her to make her plans a reality. "They're awesome," she says. "They came out and did our setup and I've been on multiple calls with them since then asking questions. Or they'll say: 'Here, try this script. It's not official, but just give it a try and let me know what you think.' I think that's awesome. I can tell that Vicon is always trying to improve and come up with new things. And the willingness that they have to work with their users is great. So I've been super excited to work with them, and every time I'm on a call with them it's really exciting and fun."

That future-facing approach is a fit with the Tonal Strength Institute's culture.

"We don't want to just be something that hangs on the wall that you pull on every now and then," says Benson. "We want it to actually have a strong human performance value. And to do that, we have to do it right. So we're just going to keep collecting, growing our database of movements on Tonal with full motion capture data, and using that for future questions."

