



## GAME DESIGN MEETS BIOMECHANICS FOR A REHAB JOURNEY IN THE EXERCUBE



The ZHAW Zurich University of Applied Sciences, the Zurich University of the Arts (ZHdK) and Swiss startup Sphery have taken the gamification of fitness to the next level with an immersive rehabilitation program for athletes with ACL injuries.



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"This project came about through discussions we had with Sphery, the company who developed the ExerCube. We saw the potential for exergames to fill a gap in rehabilitation, something that the physiotherapist cannot offer by themselves," says Eveline Graf, Professor of Physiotherapy at ZHAW Zurich University of Applied Sciences.

The idea was to go beyond the generic fitness offering that was pioneered on game consoles and advanced by the ZHdK spin-off Sphery. The developers planned to offer an extremely focused program drawing on the expertise of biomechanists, PTs and games designers. "We know that there's a lot of untapped potential in this field of interdisciplinary R&D when it comes to exergames," says Anna Lisa Martin-Niedecken, founder and CEO of Sphery, as well as head of the Institute for Design Research at Zurich University of the Arts.

Sphery describes the ExerCube as an 'immersive fitness game setting'. It consists of three walls, which serve as projection screens for 3D game environments and provide haptic feedback when players make contact with them. There are currently ExerCubes at around 50 different fitness and rehabilitation centers globally.

"In our project we specialized in ACL injuries," says Graf. "The ACL is one of the most commonly torn ligaments in sports, and it leads to a long rehabilitation process."

The earlier crop of 'exergames' for the ExerCube provide users with a workout by having them jump virtual obstacles, reach for different objects, and respond to a host of other virtual inputs. To provide effective rehabilitation, however, the developers needed deeper insights into how participants were responding to different elements of the games.

**ESTABLISHING GROUND TRUTH**

“The first step is that we need to know in more detail how people actually move during an exergame, and how they do it while playing it over 25 minutes—maybe they get fatigued, and there are different levels of physical and also cognitive challenge” says Graf.

“That hadn’t been done at the level of kinematics of the joints,” she explains. “So the first step was to use an existing ExerCube game and record movement data of people playing the game. We looked at athletes, and then also athletes after an ACL injury, to see what kind of movement patterns they are producing. We needed to determine which movements are safe and which ones are a little more risky and might need to be left out. The Vicon system, for us, was the key to get that information that we needed—the detailed three dimensional kinematics of the lower extremities.”

“The data we gained from the biomechanical analysis really topped expectations, because we were able to very accurately see exactly which movements are better or worse for inclusion in the training concepts we’ve developed,” says Martin-

Niedecken. “It was really vital to have this Vicon system at the very beginning of the project to allow us to include the right movements for the training concept we were developing for the new exergame concept.”

The system that the interdisciplinary R&D-team used consisted of mixed Vantage cameras, Vero cameras and video reference cameras. “It was a real advantage to be able to combine all those different products and make one system,” says Graf.

**CROSSING DISCIPLINES**

Sphery’s use of Vicon motion capture goes back to the design of the first ExerCube games. “We used Vicon to be able to track all the movements of a real personal trainer to transfer to our core range of games. So for designing new games it offers a lot of benefits, because it’s really accurate,” says Martin-Niedecken. The development of the partnership with ZHAW, however, was the first time they had taken an interdisciplinary approach that paired motion capture for game design with biomechanics.

“One of the factors that I think made our project so successful is that we had experts from their respective fields come together and figure it

out together,” says Graf. “I know marker-based motion capture, while Anna and her team come from a game design and game research background. It’s too much for one person to know it all, but then to take that interdisciplinary approach, to stand in the lab together and figure things out, that was really crucial.”

The exergame would not have been possible without a versatile motion capture solution. “The Vicon tracking system allows a lot of freedom to do things differently,” says Graf. “We really had to think a lot about how we were going to capture and analyze the data we needed, because usually when you do an analysis of gait or running, there are standard protocols. Here, the subjects did 25 minutes of exergaming and there was a lot of variation in the movements.”

One challenge was the setup of the ExerCube itself. “We have those three walls,” says Graf. “You’re really enclosed and we use a marker-based system. So the question was, how are we going to do the analysis under those constraints? We worked closely with Prophysics, our distributor, and figured out how we could capture this broad range of motion in our enclosed space by removing parts of



VICON



the walls of the cube and then placing cameras in strategic positions where we could actually capture the volume.

“Having a Vicon system that is so modular meant we could add new cameras and customize our setup. We had the freedom to place cameras where we wanted—from down low, looking up; and then other cameras looking from the top of the space, downwards. We really needed a system that was flexible enough to adapt to our needs.”

“Because the participants played for 25 minutes, they sweated a lot,” says Graf. “We had to figure out how to make those markers stick. So for this project, we started using a cluster marker set—rigid bases with markers screwed on top. Having the freedom to use different marker sets was crucial in being able to capture this data.”

The current version of the newly developed game, which has already

been rolled out to various ExerCube locations, lasts 25 minutes and has two phases. “One is mainly focusing on strength training for stability, and there’s an element of cognitive performance but it’s rather controlled. Whereas the other section is more focused on representing the chaos and high cognitive load that comes when you’re getting back to your actual sports field,” explains Martin-Niedecken.

Graf and Martin-Niedecken have ideas for future projects for the ExerCube. One natural extension of their work would be to develop exergames for different types of injury, such as issues with the foot or shoulder.

Graf is also interested in creating assessment protocols for physiotherapy. “One idea is going in the direction of implementing clinical assessments. It’s very important that there are objective

assessments to decide, for example, if an athlete can do more complex exercises during rehabilitation, and implementing them in the cube would be very interesting,” she says.

Martin-Niedecken, meanwhile, is interested in further refining the experiential side of exergaming. “I want to find the sweet spot of immersion, because that was one of the starting points for this project. You will be able to perform more or less accurately depending on the grade of immersion, and then it’s very important that you are still in a safe, controlled environment while having the benefits of being immersed.”

To see *The ExerCube in action*, see our video case study: \_\_\_\_\_