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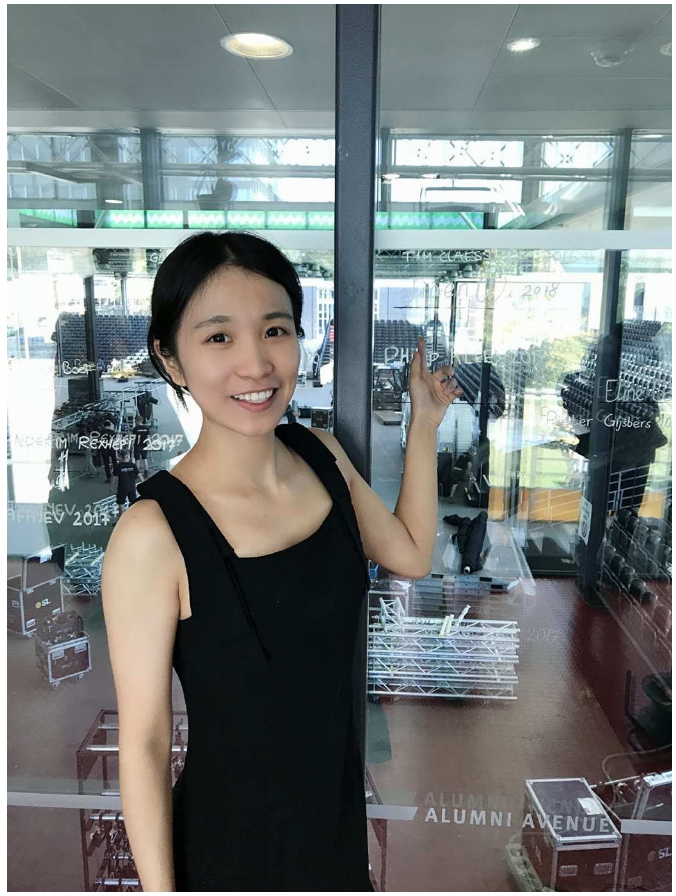
ECR SPOTLIGHT

ECR Spotlight – Jiaen Wu

ECR Spotlight is a series of interviews with early-career authors from a selection of papers published in Journal of Experimental Biology and aims to promote not only the diversity of early-career researchers (ECRs) working in experimental biology but also the huge variety of animals and physiological systems that are essential for the 'comparative' approach. Jiaen Wu is an author on 'Detecting artificially impaired balance in human locomotion: metrics, perturbation effects and detection thresholds', published in JEB. Jiaen is a postdoc in the lab of Steve Collins at Stanford University, investigating human balance and locomotion to develop intelligent robotic exoskeletons that enhance mobility and stability.



Jiaen Wu

How did you become interested in biology?

I've always been fascinated by animal movement, especially how humans walk, balance and adapt. At first, I thought physics and engineering held all the answers. But the deeper I explored, the more I realized the human body functions like an incredibly complex and adaptive machine. Muscles, nerves, skeletons and physics all work together to produce something as seemingly simple as a step or as dynamic as recovering from a stumble. I began to see how deeply biology and mechanics are intertwined. It wasn't just about how we move, but why we move the way we do. That's when I fell in love with biomechanics.

That curiosity eventually led me into robotics, where I saw the potential not only to study movement, but to assist or even enhance it. Robotics gave me tools to build systems that interact directly with the human body, which opened up a whole new world of human-robot interaction. I became especially drawn to designing robots that don't just work near humans but actually work with humans, adapting to our movements, supporting our goals, and responding intelligently to our needs.

This naturally led me to wearable robotics, like exoskeletons. These devices offer a powerful way to assist people with mobility challenges, from older adults to individuals recovering from injury. I became excited about designing exoskeletons that support natural human locomotion, helping people walk farther, balance better, use less energy and recover faster. For me, it's not just about engineering, it's about restoring independence for people. It's the perfect intersection of biology, robotics and human-centered design.

Describe your scientific journey and your current research focus

My scientific journey began at ETH Zurich, where I explored the intersection of biology and robotics through multi-scale systems. I studied how animals move, from tiny sperms to larger zebrafish and used those insights to design small robots that could mimic those movements to perform complex tasks, like navigating tight spaces and delivering drugs inside the human body. That work sparked a deeper interest in how we can translate biological principles into engineering solutions.

As I became more curious about real-world human applications, I shifted my focus to developing wearable devices that interact with the body in meaningful ways. One project focused on developing systems that deliver real-time haptic feedback based on human gait. This approach was particularly impactful for people with Parkinson's disease, where the feedback helped reduce episodes of freezing of gait (FOG) and supported more stable walking.

Currently, I'm a postdoctoral researcher at Stanford University, where I focus on wearable exoskeletons designed to assist human balance during walking. My research investigates how humans maintain balance and how robotic systems like exoskeletons can support this ability without disrupting natural movement. Ultimately, my goal is to design intelligent, responsive systems that feel more like an extension of the body than an external device to enhance mobility, improve safety and restore independence for people with movement impairments.

How would you explain the main findings/message of your paper to a member of the public?

As we get older or experience injury or illness, our ability to maintain our balance can gradually decline, often without us

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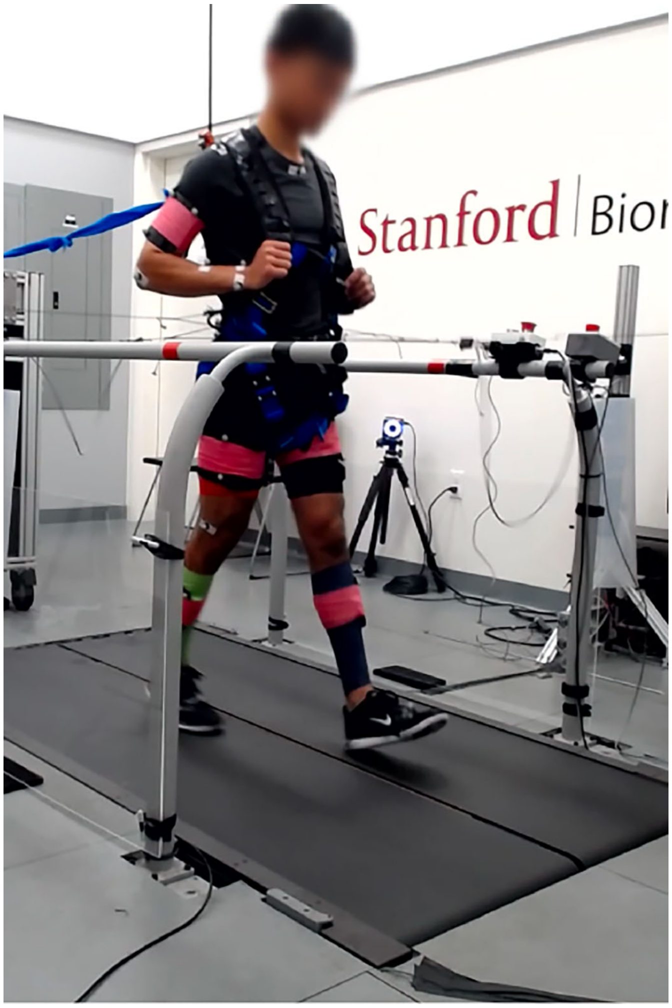

A participant walks on a treadmill while wearing motion capture markers, EMG sensors, and a safety harness, as part of a study using the 'Bump'em' perturbation robot to simulate real-world balance challenges.

noticing. This can increase the risk of dangerous falls. In our study, we wanted to find better ways to detect small changes in a person's balance before a fall occurs.

We tested several ways of measuring balance by having people walked under normal conditions and then under small challenges, such as wearing ankle braces, walking with eyes covered or experiencing air jets near the foot. During walking, we also applied pushes to simulate real-world slips or bumps. We then tested how well different balance measures could detect declined balance, such as how much step width or timing varied or how predictable each footstep was. We also compared whether it was more accurate to assess balance by comparing someone to themselves or to a larger group.

We found that some measures work better than others at spotting hidden balance problems, and that comparing someone's performance to their own normal walking pattern was often more accurate than comparing them to others. This approach could eventually help doctors and therapists catch early signs of balance issues and tailor interventions like training or assistive devices to individual needs, potentially preventing serious falls.

Why did you choose JEB to publish your paper?

We chose to publish in Journal of Experimental Biology because our work bridges biomechanics, physiology and motor control – core themes of JEB. The journal has a rich history of publishing foundational studies on animal and human movement, and we felt our research on balance metrics and perturbation responses during walking would resonate with its readership. Our study not only addresses human balance but also has broader implications for understanding locomotor stability across species, which aligns well with JEB's emphasis on comparative physiology and fundamental biological principles.

What is the hardest challenge you have faced in the course of your research and how did you overcome it?

One of the hardest challenges I've faced in my research is designing experiments that are both scientifically rigorous and safe for human participants, especially when dealing with balance impairments and perturbations. We needed to challenge people's balance in ways that were meaningful and realistic, without putting them at risk of falling. To overcome this, we developed a system that could deliver precisely timed and sized perturbations while subjects were secured in a safety harness. We also spent a lot of time fine-tuning the impairments like ankle braces or visual blocks so that they mimicked real-world balance deficits without being too extreme. It took a lot of pilot testing, creative problem-solving and close collaboration with clinicians to strike the right balance between challenge and safety.

What is the most important piece of equipment for your research, what does it do and what question did it help you address?

One of the most important pieces of equipment for our research was the perturbation robot, named Bump'em, used in combination with a motion capture system. This setup allowed us to safely deliver controlled, unexpected pushes to participants while precisely tracking their full-body movements in 3D. It enabled us to study how people respond to balance challenges in real time and analyze subtle changes in gait and posture. This was essential for evaluating which balance metrics are most sensitive to detecting hidden impairments and for understanding how people recover from disturbances during walking.

Reference

Wu, J., Raitor, M., Tan, G. R., Staudenmayer, K. L., Delp, S. L., Liu, C. K. and Collins, S. H. (2025). Detecting artificially impaired balance in human locomotion: metrics, perturbation effects and detection thresholds. *J. Exp. Biol.* **228**, jeb249339. doi:10.1242/jeb.249339