Stanford researchers record 'optimal force' of tai chi master

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Mercury News
Article Launched: 05/03/2007 01:33:41 AM PDT

Tai chi master Chen Xiang performs tai chi movements while a motion analysis test is being conducted at the Motion and Gait Analysis Laboratory in Palo Alto on April 30, 2007. (Joanne Ho-Young Lee/Mercury News.

Jessica Rose, an orthopedic surgery professor at Stanford, could not believe her eyes. Tai chi master Chen Xiang, sensor balls taped to key body joints, was demonstrating palm, elbow and fist strikes so fast - and with such force - that the sensors kept flying off his body. And then she glanced at her computer screen, where Chen's movements were mirrored by an animated stick figure. Like a light-footed dancing skeleton, the figure's grace was undeniable. And frightening. The explosive power of the strikes was stunning - 400 pounds of force generated by Chen's body accelerating from 0 mph to 60 mph in 2.8 seconds - faster than any Lamborghini out on the street. This level of power was a first for her lab. It's also just plain unusual. In its mainstream form, practiced by millions looking to boost their health, tai chi moves typically are performed in slow motion.

What Rose recorded in her lab this week, for the first time ever, she believes, was a biomechanical document of optimal force generation. (Some might call it pure *chi* - a.k.a. energy. Think "Star Wars": "May the force be with you.") Chen's demonstration, conducted at the Motion and Gait Analysis Laboratory at Lucile Salter Packard Children's Hospital, will serve as another example of a human performing at its peak and it will be used by Rose and her colleagues to paint a more detailed picture about how the body moves, and why.

Chen, one of China's best martial artists and a revered master in the tai chi style he practices, was in Rose's lab purely by happenstance. A friend of Rose's also happens to know the man organizing Chen's weeklong Bay Area visit, and he knew immediately that Rose would be eager to bring Chen in. Not only did Chen oblige, but he also showed charming modesty and humor about the experiment, laughing when those sensor balls went flying and gamely dressing in non-traditional tai chi garb: red lycra leggings and a red cotton T-shirt lettered with the name of the tai chi academy in Beijing where he teaches.

In-depth view

Although Chen's performance awed his impromptu audience at Stanford, Rose said, what the recording devices divine will be far more important. Chen's lightning-fast movements will be compared to a computer's projections of a human's ideal biomechanical movement, as well as those of a tai chi novice, potentially revealing detailed and nuanced information about the heights that the very controlled thought behind tai chi can propel the body to achieve.

Tai chi is a martial art that begins with cultivation of the mind, learning to discard everything except the thought of moving energy within the body, to nourish it and bring it to full health and, if necessary, to defend it. Various schools of tai chi have developed their own ways of training the body, but the aim is always to keep the joints relaxed to allow a free flow of *chi*.

What Chen offers, Rose said, is "an example of a highly refined movement which may be as close as we can get to biomechanically optimal movement patterns."

He is also, she added, demonstrating a basic law of motion: force equals mass times acceleration. "No one turns mass into force as well as tai chi masters," she said. Chen has perfected the art of putting the entire mass of his body into the impact, accelerating at a rate that makes that force even more extreme.

Golf, dance, tai chi

With Chen as their latest performance model - Stanford researchers have made motion-capture records of a professional golfer and a dancer - researchers can continue to identify which movements are controlled by which parts of the brain - and what role an individual's particular set of muscles and bones plays in those movements.

And that, Rose said, will mean improving treatment strategies for people suffering from a wide range of physical limitations, from cerebral palsy to arthritis.

The Motion and Gait Analysis Laboratory is the oldest of several Stanford biomechanical measurement programs working to deconstruct the architecture and chemistry of human movement. Rose and Stanford pediatric surgeon James Gamble are the authors of "Human Walking," a guidebook to the highly complex mechanisms and influences behind this most basic of human skills. Some labs are even focused on how to translate the best of human motion into something inhuman.

When Chen's visit was confirmed, Rose invited another Stanford professor, Oussama Khatib, the director of the university's Artificial Intelligence Laboratory. One of his primary interests is robots. While many robots look nothing like humans, using the body as a starting point for the construction of humanoid robots takes advantage of our millions of years of evolution-honed design. And in Chen, Khatib said, "We have a lot of great data."

Of course, motion-capture technology is not new. Since the 1980s, when cumbersome eyewear was used to create a virtual reality for wearers, the methodology and applications have grown in sophistication and popularity. Now, motion capture is a basic tool for big-screen special effects, allowing increasingly perfect depictions of human movement, right down to the subtlest of facial expressions.

In its medical application, data gathered through motion capture will soon enable medical students to practice surgery before they ever come near a real patient. Eventually, researchers hope to build a database that includes every element of human movement, down to the molecules that drive our muscles. Since Chen's lab performance, Rose has added another inquiring mind: Packard pediatric neurologist Terrence Sanger. He looks not only at movement, but also at how movement is learned. The result of Chen's years of training indicates something special - mysterious, even - about how his particular skills were acquired.

And, Sanger said, "You want to understand everything."

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