How does she run so fast: What a 91-Year-Old Sprinter Taught Us About Aging

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As a postdoctoral fellow, I work in the Integrative Muscle Physiology & Energetics Laboratory of Professor Christopher Sundberg at the University of Wisconsin–Madison, affiliated with the Division of Geriatrics & Gerontology in the Department of Medicine, School of Medicine & Public Health. My research focuses on understanding how muscle function and metabolism change with age, sex, and training, with the broader goal of uncovering ways to maintain health, mobility, and performance across the lifespan.

I am delighted to contribute to the program "Sharing UW-Madison Postdoctoral Scholarly Research with Non-Science Audiences," sponsored by the Wisconsin Initiative for Science Literacy (WISL). This program, made possible by the dedication of WISL staff—Cayce Osborne, Elizabeth Reynolds, and Professor Bassam Shakhashiri—is instrumental in fostering connections between scientific exploration and the broader public. Initiatives like this are essential for helping communities understand the value and excitement of research and for promoting scientific literacy.

Summary

This article talks about my research and in particular the opportunity to test a 91-year-old woman who holds the world record for the 200-meter sprint. Through her, I explored how lifelong physical activity shapes cardiovascular and muscular function in aging. Despite her age, her heart and muscles show a level of efficiency typically seen in much younger individuals. Her physiology reveals that consistent movement and training can preserve vital systems and delay many aspects of biological aging. Beyond the data, studying her was both a scientific and personal lesson in human potential, reminding me that the boundaries of aging are more flexible than we often assume, and that movement is one of the most powerful forms of longevity.

Unlocking the Secrets of Muscle Performance Across Life

My research focuses on understanding aging effects on muscle metabolism, function and fatigue. My goal is to uncover mechanisms that could improve training strategies, prevent injury, and enhance performance—in both younger and older populations, including those at risk of age-related muscle decline.

On a day-to-day basis, my work involves conducting muscle function tests with dynamometers and ultrasounds and analyzing muscle metabolism using advanced techniques. I process muscle biopsy samples and perform biochemical analyses to quantify mitochondrial function. One of the main challenges is ensuring that participants can complete the demanding exercise protocols safely while maintaining high-quality data, sometimes requiring repeated sessions or troubleshooting equipment issues.

A key aspect of my research is that it is translational, meaning that I use both *in vivo* and *ex vivo* analyses. *In vivo* means that I measured real-time muscle metabolism and fatigue using non-invasive techniques like electromyography or ultrasound during exercise, which allowed me to track how muscles responded to contractions in participants. *Ex vivo* means that I analyze muscle biopsy

samples to measure mitochondrial respiration and other markers of metabolic capacity, providing mechanistic insight into the cellular processes underlying the functional data that we observe in vivo. Combining these approaches allows me to link whole-muscle performance to underlying cellular metabolism, bridging the gap between physiology and molecular biology.

Overall, my work helps the community understand how age influences muscle fatigue and metabolism. These insights have implications for personalized training, athletic performance, and strategies to maintain muscle function and quality of life across the lifespan.

How everything started

Alongside my daily work, I had the extraordinary opportunity to study the physiological profile of the world-record holder for the 200-meter sprint in the 90+ age category (Figure 1). This experience is invaluable to my research, as it allows us to explore how lifelong training shapes muscle function and overall physical performance with aging.

When I first met her, she was 91 years old. She held—and still holds—the world record for her age group for the 200 meters, and she graciously agreed to join our project. During her visit to my lab, we assessed her cardiovascular function, muscle strength and power, and muscle oxygen utilization. She even agreed to a muscle biopsy, giving us an unprecedented look inside the tissue that has powered her sprinting for nearly a century. I conducted in vivo assessments in 2024 at my previous institution, and I am now performing ex vivo experiments on her muscle samples here at UW–Madison. This unique opportunity became possible through the collection of a muscle biopsy, that allows me to do additional analyses to uncover how her muscles have adapted over a lifetime of training.

The central question guiding my work was simple: How does lifelong physical activity shape the human body over nearly a century of life?

How We Studied Her Body

In most people, age-related changes are present in all physiological systems. Physical fitness declines, muscles lose strength and power, muscle cells become less efficient, and muscles become more fatigued during exercise.

In her case, time seemed to have written a different story. To understand what made this 91-year-old sprinter so exceptional, five different universities (4 Italian universities and my laboratory at UW-Madison) collaborated together using a combination of physiological tests.

Thanks to this cooperative effort and thanks to devices provided by the University of Pavia I was able to evaluate her cardiovascular function using transthoracic impedance (a noninvasive method

to assess heart function) and gas-exchange analysis to measure how her heart and lungs delivered oxygen during exercise. Her heart still delivered oxygen to her muscles with remarkable efficiency. Her cardiac output — the amount of blood pumped per minute — was higher than expected for her age, more similar to women 30 years younger (Figure 2B). Her muscles, in turn, extracted nearly every drop of oxygen from that blood, demonstrating remarkable metabolic vitality.

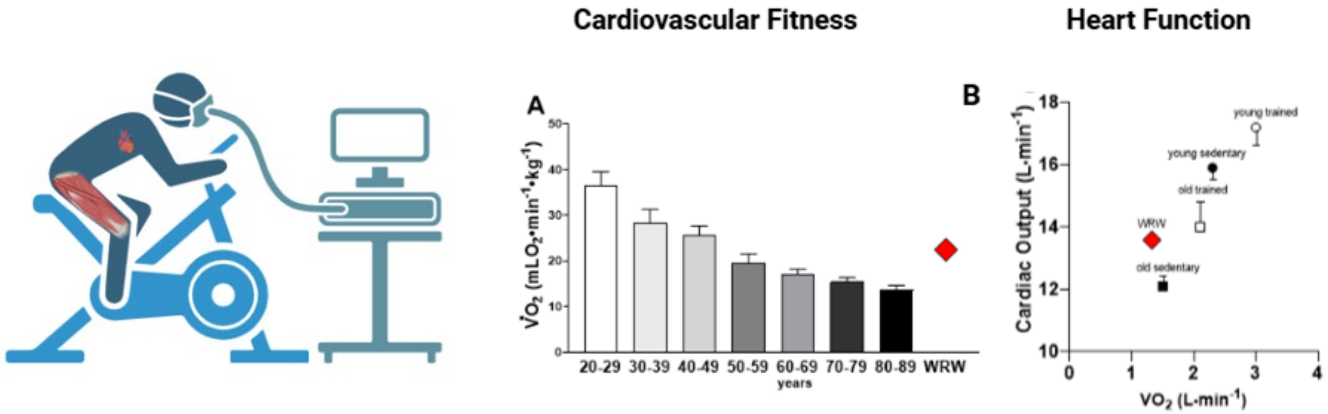

Figure 2. Graphical representation of how the cardiovascular fitness of the world record woman was tested, with a metabolic chart during a cycling incremental test. The two graphs report the world record woman data highlighted as red diamonds, compared to scientific literature. Panel A presents the maximal oxygen consumption (parameter of cardiovascular fitness) compared to women in different ages. Panel B presents the cardiac output compared to young and older (65 years old) women, both trained or sedentary.

Her maximal oxygen consumption (VO_2) — one of the best indicators of aerobic fitness — showed an ability to transport and use oxygen rivaling that of much younger adults. She was comparable to women 40 years younger than her (Figure 2A).

To complement these measurements, my Italian colleagues assessed muscle oxidative function (that is, the ability of her muscles to utilize oxygen to produce energy) using near-infrared spectroscopy (NIRS), a technique that sends light through the skin to track real-time muscle oxygen use (using a pulse oximeter). This evaluation revealed that her muscles were using oxygen almost like women in their 20s — nearly 70 years younger than her.

I was specifically in charge of the knee extensor muscle force and power evaluation. For this experiment, she was seated on a specialized chair equipped with a load cell near the ankle to accurately measure muscle force. Interestingly, her muscle force and power were comparable to those typically observed in individuals in their 80s, even though her overall muscle mass (assessed via panoramic ultrasound) was similar to that of sarcopenic individuals of the same age. Sarcopenia is a multisystem condition characterized by reduced muscle mass, strength, and function. These findings suggest that, despite maintaining functional capacity, she still exhibits certain age-related changes in her muscles.

Finally, through advanced imaging and biochemical tests, my Italian colleagues investigated the mitochondrial function, and I evaluated her muscle structure (and I'm currently adding more data on this). We uncovered a remarkably preserved cellular function that continues to power her movements, evidence that a lifetime of training can maintain the "engines of life" themselves. Specifically, her muscles showed highly preserved mitochondrial function, the powerhouse of the muscle cell.

Mitochondria are responsible for producing the energy that muscles need to contract and perform work. Well-preserved mitochondrial function means her muscles can efficiently generate energy,

resist fatigue, and recover quickly after exertion. This is particularly striking because mitochondrial function typically declines with age, contributing to reduced strength, endurance, and overall mobility. In her case, the preservation of mitochondrial capacity likely reflects the cumulative effects of a lifetime of physical activity, which helps maintain energy production, delay age-related muscle decline, and sustain functional independence. Essentially, her muscles are able to "keep the lights on" at a cellular level, supporting both performance and long-term health.

Moreover, her muscles were composed of a higher proportion of type II fibers—fast-twitch fibers essential for sprinting—and a lower percentage of type I fibers, which are more endurance-oriented. These fiber-type proportions were determined from muscle biopsy samples analyzed using histochemical staining, which allows precise identification and quantification of fiber types. Interestingly, her type II fibers were smaller in cross-sectional areas compared with those of young adults, while her type I fibers were even larger than in younger individuals. This pattern highlights how lifelong training preserved not only the function but also the size of her endurance-oriented muscle fibers, supporting sustained muscle performance despite aging.

Each of these measurements told part of her story, a physiological portrait of resilience written through motion, discipline, and time. Her physiology was a quiet rebellion against what we often assume is inevitable as the aging process.

Lessons from a Lifelong Training Woman

She is the living example of how training sustained across decades is one of the most powerful anti-aging tools. She has been running her entire life. She ran during college, paused when raising her children, and then restarted at 45 and has never stopped since. Even during her breaks from competition, she remained active through hiking and skiing. From age 45 to 91, she has spent nearly half a century running and competing — an extraordinary example of persistence and lifelong dedication to movement.

In her body, her adaptations were extraordinary, cells that learned to endure, a heart that kept rhythm for ten decades, a body that refused to forget how to move. Her run was not just a race against the clock; it was a reminder to all of us — scientists, athletes, and everyone in between — that the boundaries of aging are more flexible than we think.

Her story shows that aging doesn't have to mean decline. It can mean adaptation. The changes we once thought irreversible may, at least in part, be rewritten by a lifetime of movement.

For me, this research is not only about physiology, but also about informing the general public on how our choices can bend the trajectory of aging.

Reviewing these data, it is clear that her muscles and cardiovascular system retain capacities typically seen in much younger adults, offering insights into mechanisms that preserve neuromuscular function. One key takeaway is that aging does not uniformly impair physiological systems; instead, decades of consistent activity maintain muscle function and independence even in the tenth decade of life. Our analyses are ongoing, and we aim to uncover more about how cellular and systemic adaptations support exceptional performance in advanced age.