

The Surprising Role of Muscle Clocks in Strength Loss and Aging

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STORY AT-A-GLANCE

- › Skeletal muscles have their own circadian clocks that regulate daily cycles of growth, repair, energy production, and protein turnover
- › A study found that disabling these peripheral clocks in the muscles caused premature aging, reduced strength, slower movement, and other signs consistent with sarcopenia
- › These findings help explain why shift workers often experience early muscle decline, as disrupted rhythms interfere with the body's natural overnight repair processes
- › Light is the most powerful timing cue for your internal clocks, with morning sunlight helping anchor circadian rhythms and exposure to blue light at night disrupting melatonin and recovery
- › Meal timing and consistent sleep schedules also help reinforce muscle clock function and support long-term strength and resilience

When most people think about the body's internal clock, sleep usually comes to mind. However, the circadian rhythm regulates far more than just your sleep-wake cycle. Each organ, including the brain, liver, and skeletal muscles, operates according to its own internal timing mechanism governed by this rhythm.¹

Skeletal muscles, in particular, maintain their circadian schedule independent of the brain's central clock. These peripheral clocks work continuously to coordinate muscle strength, energy production, and recovery. Although this process occurs in the

background, its impact on your physical health is significant.²

A study from researchers at King's College London showed that when the muscles' circadian rhythm is disrupted, muscular health begins to deteriorate. Over time, this disruption speeds up aging and leads to weaker muscles. This means that if you want to stay strong as you age, your body's timing is just as important as your workout routine.³

What Happens When Your Muscle Clock Breaks?

The featured study, published in the journal *Proceedings of the National Academy of Sciences*, investigated how skeletal muscle health is affected when its internal circadian rhythm is disrupted. Using genetically modified zebrafish, researchers disabled the clock gene exclusively in muscle tissue, which allowed them to observe the specific role of the muscle clocks without altering brain rhythms, sleep cycles, or environmental conditions.⁴

- **Muscle clock disruption disturbs the normal rhythm of nighttime repair** — During the day, muscles focus on growth and strength building. At night, they shift to “nocturnal clearance,” removing damaged proteins, recycling worn-out components, and clearing cellular waste. In the zebrafish with disrupted muscle clocks, the muscles' normal nighttime repair systems were disrupted.
- **Long-term decline in muscle size and performance** — In the early stages of life, external cues like feeding and light exposure temporarily cover up the effects of disrupted muscle clocks. That means younger fish with faulty clocks still grow and function relatively normally for a time. But as they age, those signals are no longer enough to compensate. Jeffrey Kelu, the study's lead author and a research associate at King's College London, explained:

“While no significant differences in muscle size were observed at younger ages — 6 months and 1 year — fish lacking a functional muscle clock showed clear signs of premature ageing at two years. They were shorter,

weighed less, swam less frequently and at slower speeds. These are hallmarks of sarcopenia and overall decline in mobility, which has been reported in shift workers.”⁵

- **Biological disruptions linked to muscle clock failure** — Researchers identified two physiological changes that emerged when the muscles’ internal clocks lost function:

- **Suppressed cleanup systems** — The two primary protein-recycling systems, autophagy and the ubiquitin-proteasome system (UPS), were markedly less active during nighttime, a period when they typically support muscle repair.

The UPS works like a molecular shredder, targeting proteins that are no longer useful, while autophagy removes worn-out cell parts and debris. When the activity of these systems is suppressed, waste begins to accumulate inside the muscle cells, making them weaker and less efficient.

- **Imbalanced clock gene regulation** — The muscles’ internal clocks depend on a balance between two nuclear receptors, Ror and Rev-erb, which regulate the timing of key cellular functions. Ror activates genes involved in breaking down old or damaged muscle proteins.

In the clock-disrupted fish, Ror levels declined while Rev-erb remained unchanged. This imbalance impaired the muscles’ ability to clear worn-out protein and allowed TORC1, a growth-related signaling pathway, to stay active at night, when it would normally be turned down to permit repair.

- **Rev-erb inhibition restored muscle clock function** — Researchers tried inhibiting Rev-erb in clock-impaired fish, which resulted in restored normal nighttime protein turnover. This confirmed that the muscles’ internal clock regulates growth and repair.

How These Findings Matter for Your Muscle Health

This study offers insights into how muscle aging begins long before it's visible or measurable. Muscle quality depends not only on how much you move or what you eat, but on whether your muscle cells are maintaining their natural schedule for repair.⁶

- **This pattern closely reflects sarcopenia** — Sarcopenia is the gradual loss of muscle mass and strength that often develops with age. The disrupted repair cycle seen in this study mirrors the slow, progressive weakening that defines this condition. By linking muscle decline to muscle clocks, the study suggests that circadian misalignment triggers sarcopenia-like changes much earlier than expected.
- **Living out of sync with your body's clock affects long-term strength** — The study notes that circadian disruption, whether from shift work, sleep loss, or neurological conditions like dementia, increases the risk of sarcopenia, as it interferes with your muscles' natural cleanup cycle. Over time, missed opportunities for repair allow small amounts of damage to accumulate inside your cells.

"Understanding how circadian disruption contributes to sarcopenia is essential for developing strategies to improve the health and well-being of shift workers," Kelu noted.

"Our findings highlight the possibility of using circadian biology to develop treatments aimed at preventing muscle decline in shift workers ... This paves the way for future therapies that could improve ageing in shift workers."⁷

- **Early signs of dysfunction are easy to miss** — In the study, zebrafish with a disrupted muscle clock showed a gradual decline in physical performance as they aged, even though outward conditions remained unchanged.

In real life, this kind of internal breakdown may show up first as slower recovery, increased soreness, or reduced stamina, which are often dismissed as routine fatigue or aging. These subtle shifts could actually reflect underlying disruptions in the timing systems responsible for muscle repair and maintenance.

- **Timing shapes how the body responds to effort** — When the internal signals that guide muscle maintenance are mistimed or absent, physical activity no longer delivers the same protective effects or translates into lasting strength. This helps explain why some individuals experience muscle decline despite staying consistently active.

To learn more about how circadian rhythm affects every system in your body, not just muscles, read “[How to Sync Your Many Circadian Rhythms.](#)”

Light Sets the Rhythm for Your Body’s Master Clock

Deep within your hypothalamus lies the suprachiasmatic nucleus (SCN), the region that governs your body’s circadian rhythm. This master clock synchronizes nearly every biological system, from sleep and metabolism to immune and muscle function. While the muscle clock operates independently, its rhythm remains more stable when aligned with signals coordinated by the SCN.⁸

- **Light keeps your internal clocks aligned** — To stay on schedule, the SCN relies heavily on light exposure, especially bright, full-spectrum light in the morning, and without this input, the body’s many clocks begin to drift out of sync.⁹
- **Modern life distorts natural light cues** — The invention of electric lighting — and later, smartphones, computers, and televisions — introduced artificial light around the clock, allowing humans to extend waking hours. Much of this artificial light is rich in blue light, which tells your brain to stop producing melatonin, disrupting your sleep cycle and hindering nighttime recovery processes.¹⁰
- **This shift has consequences far beyond sleep** — Studies have linked nighttime light exposure to increased risks of major depressive disorder, generalized anxiety disorder, post-traumatic stress disorder (PTSD), psychosis, bipolar disorder, and self-harming behavior.¹¹ Even low levels of light during sleep have been associated with higher rates of obesity, high blood pressure, diabetes, and certain cancers.^{12,13}

- **Get your circadian rhythm back on track with proper light exposure —** Neuroscientist Dr. Andrew Huberman recommends getting bright light, preferably sunlight, within the first 30 to 60 minutes after waking. This early light input helps stimulate daytime alertness and signals your circadian system when to initiate melatonin release later in the evening.¹⁴
- **Spend time in the sun —** For shift workers, getting regular sun exposure is difficult, especially if your waking hours fall outside the daylight window, but it's still important to take advantage of any sun available during your active hours. One of the most effective times for this is around solar noon, typically 12 p.m. or 1 p.m. during daylight saving time, when UVB rays and near-infrared (NIR) wavelengths are most concentrated.

These light signals stimulate mitochondrial function and help regulate internal clocks. Importantly, NIR exposure also promotes mitochondrial melatonin production. To maximize the benefit of sunlight, expose as much skin as possible so your body can absorb the full spectrum of light needed for energy, recovery, and resilience.

If your diet includes vegetable oils, approach sun exposure cautiously, as these oils are high in [linoleic acid](#) (LA), an unstable omega-6 fat that's prone to oxidation when exposed to ultraviolet light. Learn how to safely optimize your sun exposure for maximum benefit in "[Beyond Vitamin D Production — How Sensible Sun Exposure Supports Overall Health.](#)"

- **Light exposure later in the day matters, too —** Research shows that viewing light during the early hours of the evening will help mitigate some of the consequences of light exposure later in the evening.¹⁵ However, when it's 6 p.m. or 7 p.m., it's important to avoid bright artificial lights of any color.

Once the sun goes down, make it a habit to dim the lights around your home and use as little artificial light as possible. This includes turning down your computer screen and avoiding overhead lights, opting for desk lamps instead. If possible, use

candlelight or moonlight only after sunset.

If your bedroom is affected by light pollution, be sure to use blackout shades to keep light out and remove all sources of light from your bedroom, including a digital alarm clock or cellphone. Another alternative is using a sleep mask.

Take a deeper dive into the power of light, mitochondria, and circadian rhythm in “[The Power of Light, Mitochondria and Circadian Rhythms](#).”

Meal Timing and Bedtime Routines Help Synchronize Your Internal Clocks

While light is the primary driver of your body's master clock, other daily habits, like when you eat and sleep, play a key role in aligning the circadian rhythms that guide your muscles as well as other organs and tissues.

- **Feeding during the day helps reset your muscle clocks** — A study in *Neurobiology of Sleep and Circadian Rhythms*¹⁶ found that physical activity alone was not enough to shift the muscles' internal rhythm. It was only when food was restricted to the animals' active period that the muscle clock adjusted. This shows that eating during your wake phase is essential for keeping muscle timing aligned with the rest of the body.
- **Meal timing affects blood sugar rhythms** — In another study,¹⁷ researchers looked at how delaying meals by five hours impacted various body clocks and biological markers. Ten young men adhered to a 13-day schedule, eating three meals (breakfast, lunch, and dinner) at five-hour intervals, either starting soon after waking (early meals) or later in the day (late meals).

After adjusting to early meals, the participants switched to late meals for six days. The researchers observed that blood glucose rhythms were delayed by about 5.7 hours when meals were delayed, and that average glucose levels dropped. This indicates that meal timing helps synchronize peripheral circadian rhythms.

- **Sleep timing strengthens your circadian stability** — Beyond optimizing light exposure throughout the day and timing your meals, other factors such as getting enough sleep and keeping a regular sleep schedule also affect your body's biological clocks.

Going to bed and waking up at the same time every day, even on weekends, reinforces your circadian rhythms. Inconsistent sleep schedules confuse your peripheral clocks, making it harder for your body to regulate energy, recovery, and stress responses effectively.

For strategies on how to get better, read “[How Sleep Deprivation Impairs Cognitive Performance and Learning](#).” There, I discuss a multitude of useful tips, such as employing stress-reduction techniques and exercise, to improve sleep quality.

Frequently Asked Questions (FAQs) About Muscle Clocks

Q: What is a muscle clock, and how does it affect aging?

A: A muscle clock refers to the peripheral clock located in your skeletal muscle tissue. It regulates daily cycles of protein breakdown, repair, and growth.

Q: Who is at higher risk of muscle clock disruption?

A: People who live outside natural light-dark patterns are most at risk. This includes shift workers, individuals with chronic sleep loss, and those with neurological conditions like dementia. These groups often experience disrupted circadian rhythms that interfere with muscle maintenance.

Q: What happens to muscle tissue when circadian rhythms are disrupted?

A: When circadian rhythms are disrupted, muscle tissue loses its ability to follow the normal cycle of daytime growth and nighttime repair. As a result, cellular waste accumulates inside muscle fibers, impairing their structure and function. Over time, this leads to reduced muscle quality, slower recovery, and earlier onset of age-related muscle loss.

Q: Can fixing the circadian rhythm slow muscle aging?

A: Yes. Aligning your lifestyle with natural circadian cues, particularly light exposure, restores the rhythm of your muscle clocks. This supports nighttime repair processes and helps reduce the risk of muscle decline.

Q: How can I support a healthy muscle rhythm through daily habits?

A: Get bright light exposure shortly after waking, eat meals during your active hours, and stick to a consistent sleep schedule. These actions keep your muscle clocks aligned.

Sources and References

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