The New York Times
Well
Tara Parker-Pope on Health

FEBRUARY 1, 2012, 12:01 AM

Exercise as Housecleaning for the Body

By GRETCHEN REYNOLDS

Kris Hanke

When ticking off the benefits of physical activity, few of us would include intracellular housecleaning. But a new study suggests that the ability of exercise to speed the removal of garbage from inside our body's cells may be one of its most valuable, if least visible, effects.

In the new research, which was published last month in Nature, scientists at the University of Texas Southwestern Medical Center in Dallas gathered two groups of mice. One set was normal, with a finely tuned cellular scrubbing system. The other had been bred to have a blunted cleaning system.

It's long been known that cells accumulate flotsam from the wear and tear of everyday living. Broken or misshapen proteins, shreds of cellular membranes, invasive viruses or bacteria, and worn-out, broken-down cellular components, like aged mitochondria, the tiny organelles within cells that produce energy, form a kind of trash heap inside the cell.

In most instances, cells diligently sweep away this debris. They even recycle it for fuel. Through a process with the expressive name of autophagy, or "self-eating," cells create specialized membranes that engulf junk in the cell's cytoplasm and carry it to a part of the cell known as the lysosome, where the trash is broken apart and then burned by the cell for energy.

Without this efficient system, cells could become choked with trash and malfunction or die. In recent years, some scientists have begun to suspect that faulty autophagy mechanisms contribute to the development of a range of diseases, including diabetes, muscular dystrophy, Alzheimer's and cancer. The slowing of autophagy as we reach middle age is also believed to play a role in aging.

Most metabolism researchers think that the process evolved in response to the stress of starvation; cells would round up and consume superfluous bits of themselves to keep the rest of the cell alive. In petri dishes, the rate of autophagy increases when cells are starved or otherwise placed under physiological stress.

Related
- More Phys Ed columns
- Faster, Higher, Stronger
- Fitness and Nutrition News

Exercise, of course, is physiological stress. But until recently, few researchers had thought to ask whether exercise might somehow affect the amount of autophagy within cells and, if so, whether that mattered to the body as a whole.

“Autophagy affects metabolism and has wide-ranging health-related benefits in the body, and so does exercise,” says Dr. Beth Levine, a Howard Hughes Medical Institute investigator at U.T. Southwestern. “There seemed to be considerable overlap, in fact, between the health-related benefits of exercise and those of autophagy,” but it wasn’t clear how the two interacted, she says.

So she and her colleagues had lab mice run. The animals first had been medically treated so that the membranes that engulf debris inside their cells would glow, revealing themselves to the researchers. After just 30 minutes of running, the mice had significantly more membranes in cells throughout their bodies, the researchers found, meaning they were undergoing accelerated autophagy.

That finding, however, didn’t explain what the augmented cellular cleaning meant for the well-being of the mice, so the researchers developed a new strain of mouse that showed normal autophagy levels in most instances, but could not increase its cellular self-eating in response to stress. Autophagy levels would stubbornly remain the same, even if the animals were starved or vigorously exercised.

Then the researchers had these mice run, alongside a control group of normal animals. The autophagy-resistant mice quickly grew fatigued. Their muscles seemed incapable of drawing sugar from the blood as the muscles of the normal mice did.

More striking, when Dr. Levine stuffed both groups of animals with high-fat kibble for several weeks until they developed a rodent version of diabetes, the

normal mice subsequently reversed the condition by running, even as they continued on the fatty diet. The autophagy-resistant animals did not. After weeks of running, they remained diabetic. Their cells could not absorb blood sugar normally. They also had higher levels of cholesterol in their blood than the other mice. Exercise had not made them healthier.

In other words, Dr. Levine and her colleagues concluded, an increase in autophagy, prompted by exercise, seems to be a critical step in achieving the health benefits of exercise.

The finding is “extremely exciting,” says Zhen Yan, the director of the Center for Skeletal Muscle Research at the University of Virginia, who is also studying autophagy and exercise. The study, Dr. Yan says, “improves our understanding of how exercise has salutary impacts on health.”

The implications of Dr. Levine’s results are, in fact, broad. It’s possible that people who don’t respond as robustly to aerobic exercise as their training partners may have sputtering or inadequate autophagy systems, although that idea is speculative. “It’s very difficult to study autophagy in humans,” Dr. Levine says. Still, it’s possible that at some point, autophagy-prompting drugs or specialized exercise programs might help everyone to fully benefit from exercise.

In the meantime, the study underscores, again, the importance of staying active. Both the control mice and the genetically modified group had “normal background levels of autophagy” during everyday circumstances, Dr. Levine points out. But this baseline level of cellular housecleaning wasn’t enough to protect them from developing diabetes in the face of a poor diet. Only when the control animals ran and pumped up their intracellular trash collection did they regain their health.

“I never worked out consistently before,” Dr. Levine says. But now, having witnessed how exercise helped scour the cells of the running mice, she owns a treadmill.

Correction: An earlier version of this article incorrectly referred to autophagy as intercellular housecleaning; it should have been intracellular housecleaning.