HOW EXERCISE HELPS US FIND HAPPINESS, HOPE, CONNECTION, AND COURAGE

THE JOY OF MOVEMENT

KELLY McGONIGAL, PhD

Bestselling author of *The Willpower Instinct*

the JOY *of* MOVEMENT

HOW EXERCISE HELPS US FIND

happiness,
hope,
connection,
and courage

KELLY McGONIGAL, PhD

AVERY | AN IMPRINT OF PENGUIN RANDOM HOUSE | NEW YORK

AVERY
AN IMPRINT OF PENGUIN RANDOM HOUSE LLC
penguinrandomhouse.com

ISBN 9780525534105 (hardcover)
ISBN 9780525534112 (ebook)

Printed in Canada
10 9 8 7 6 5 4 3 2 1

Book design by Lorie Pagnozzi

This book explores the psychological and social benefits of movement. It is not intended to offer individual advice or medical guidance. Although I discuss the potential psychological benefits of movement, this does not imply that exercise is a replacement for other treatments, therapies, or approaches for mental or physical health that you might be currently using or considering. Before beginning any new exercise program or physical activity, seek the advice of your physician or current health-care providers. I also recommend that you seek professional guidance and/or community support for any new physical goal, such as training for an athletic event. When setting physical goals and exploring different ways of moving, take into consideration your current abilities, health, and life circumstances.

CONTENTS

INTRODUCTION

There are very few memories I can look back on and say with certainty, "That was a moment my life changed." One of them took place when I was twenty-two. I was a graduate student in psychology and enrolled in a seminar called The Psychology of Shyness. I had always been a shy kid, and I continued to struggle with anxiety. Our project for the course was to take action on something that was important to us but that we had avoided out of fear or self-doubt. I chose to pursue my lifelong dream of becoming a group exercise instructor. I had grown up doing workout videos in my living room. While other kids fantasized about becoming the next Sally Ride or Steven Spielberg, I imagined myself leading a room full of people in step-touches and jumping jacks. In high school, I studied both Spanish and French because I had read that you needed to speak three languages to teach aerobics at a Club Med resort.

Now I found myself standing outside an exercise studio on campus, minutes away from auditioning to teach for the aerobics program. Despite having practiced for so many hours that I

could perform the choreography in my sleep, familiar sensations of panic flooded my system. I felt sick to my stomach. My fingernails dug into my palms. This mattered so much to me, I thought my heart was going to burst. I was overcome by the desire to rescue myself from my escalating anxiety. To just walk away, go back to my apartment, and pretend the whole thing never happened.

I remember this moment clearly, standing outside the studio, wanting to run—but choosing to stay. Maybe you've had a moment like this, too—a turning point where you said yes to something that you both dreamed about and were terrified by. Looking back, I think one of the reasons I stayed was everything I had learned about courage from my favorite forms of exercise. From yoga, I had learned how to take a deep breath and stretch beyond my comfort zone. From dance, I had learned that no matter how worried and discouraged I felt at the beginning of class, the music and movement would transport me to a state of optimism. And from my toughest cardio workouts, I had learned that a pounding heart is not always a sign of fear. Sometimes, it is proof that your heart is being strengthened.

The decision to stay and audition changed my life because it set me on the path of teaching group exercise. In the nearly two decades since, teaching has become a source of tremendous joy and meaning. Over the years, I saw again and again how movement could shift a person's mood. How it could send someone back into the world renewed with hope. I got to witness how exercise could empower participants to sense their own strength, or give them permission to let loose. As I taught individuals of all ages and varied physical abilities, I learned how movement could serve so many roles. It was a way to practice self-care, an opportunity to tackle challenges, and a place to make friends.

Many of the classes I taught turned into communities that not only moved together, but also supported and celebrated one another. In these classes, I learned what collective joy feels like, in both the synchrony of our steps and in the group hugs when a participant returned after a long absence. Leading group exercise was so fulfilling that I never stopped. It wasn't just the satisfaction of sharing the joy of movement that kept me going; it was also how movement helped me. Exercise has, at various times in my life, rescued me from isolation and despair, fostered courage and hope, reminded me how to experience joy, and given me a place to belong.

Mine is not an uncommon story. Around the world, people who are physically active are happier and more satisfied with their lives. This is true whether their preferred activity is walking, running, swimming, dancing, biking, playing sports, lifting weights, or practicing yoga. People who are regularly active have a stronger sense of purpose, and they experience more gratitude, love, and hope. They feel more connected to their communities, and are less likely to suffer from loneliness or become depressed. These benefits are seen throughout the lifespan. They apply to every socioeconomic strata and appear to be culturally universal. Importantly, the psychological and social benefits of physical activity do not depend on any particular physical ability or health status. They have been demonstrated in people with chronic pain, physical disabilities, serious mental and physical illnesses, and even among patients in hospice care. The joys described above—from hope and meaning to belonging—are linked first and foremost to *movement*, not to fitness.

The question of how physical activity contributes to human happiness is the central focus of this book. I started by scouring

the science, skipping the countless surveys that show that people who exercise are happier, and searching instead for studies and theories that could shed light on why. I pored through academic papers in fields as wide-ranging as neuroscience, paleontology, and musicology. I talked to anthropologists, psychologists, and physiologists. I interviewed athletes and exercise professionals. I visited places where people move together—gyms, dance studios, parks, even an aircraft carrier. I devoured memoirs and studied ethnographies to better understand the role that movement has played across cultures and history. I expanded my search to include the writings of philosophers and religious scholars. I downloaded podcasts and joined groups on social media. I reached out to friends, family, and strangers, and asked them to share their experiences of movement. After nearly every one of these interviews, I found myself relistening to some part of the recorded conversation. Not just to check my notes, but because I wanted to hear their stories again. Many of the individuals I spoke with were brought to tears as they explained what movement meant to them. By the third time I found myself typing, "She teared up while telling me about this," I realized: These were tears of joy, and the joy of movement is moving.

One of the first things I discovered is that the most common explanation for why exercise makes us happy is far too simplistic. The psychological effects of movement cannot be reduced to an endorphin rush. Physical activity influences many other brain chemicals, including those that give you energy, alleviate

worry, and help you bond with others. It reduces inflammation in the brain, which over time can protect against depression, anxiety, and loneliness. Regular exercise also remodels the physical structure of your brain to make you more receptive to joy and social connection. These neurological changes rival those observed in the most cutting-edge treatments for both depression and addiction. The mind-altering effects of exercise are even embedded in your musculature. During physical activity, muscles secrete hormones into your bloodstream that make your brain more resilient to stress. Scientists call them "hope molecules."

Looking at the evidence, it's hard not to conclude that our entire physiology was engineered to reward us for moving. But why would human biology be so finely tuned to encourage us to be active? A reasonable first guess might have to do with the health benefits of exercise. Perhaps the brain is looking out for the body, making sure we stay active enough to ward off a heart attack. Yet this notion takes too brief a historical perspective on the value of physical activity to human survival. Your doctor might encourage you to exercise to better control your blood sugar, lower your blood pressure, or reduce your risk of cancer. But for most of human existence, the central purpose of movement was not to prevent disease. Physical activity was how we engaged with life. As neuroscientist Daniel Wolpert writes, "The entire purpose of the human brain is to produce movement. Movement is the only way we have of interacting with the world." This is why our biology includes so many ways to reward moving. At the most fundamental level, rewarding movement is how your brain and body encourage you to participate in life. If you are willing to move, your muscles will give you

hope. Your brain will orchestrate pleasure. And your entire physiology will adjust to help you find the energy, purpose, and courage you need to keep going.

There is also a more complex story to tell about why movement is rewarding—one that emerges from the psychology of human happiness. Human beings are hardwired to take pleasure in the activities, experiences, and mental states that help us survive. This goes beyond the obvious practical matters, such as eating and sleeping, to include many of the psychological traits that define us as humans. We enjoy cooperating and find teamwork fulfilling. We delight in making progress and take pride in what we contribute. We form attachments to people, places, and communities, and we experience a warm glow when we care for them. Even our ability to find meaning in life is rooted in the neurobiology of pleasure: stories and metaphors captivate the brain's reward system, encouraging us to craft narratives that help us make sense of our lives. Human beings do not need to re-create these habits of happiness with each new generation. These instincts are buried in our DNA and spring to life in each of us, as fundamental to our survival as the abilities to breathe, digest food, and pump blood to our muscles.

Physical activity—whether through exercise, exploration, competition, or celebration—makes us happier because it stimulates these instincts. Movement is intertwined with some of the most basic human joys, including self-expression, social connection, and mastery. When we are active, we access innate pleasures, from the satisfaction of synchronizing to the beat of music to the sensory thrill of moving with speed, grace, or power. Movement can also fulfill core human needs, such as the desires to connect with nature or to feel a part of something bigger than yourself. The physical pastimes we are most

drawn to seem uniquely devised to harness our individual strengths—the abilities to persist, endure, learn, and grow—while simultaneously rousing our instincts to work together. When physical activity is most psychologically fulfilling, it's because our participation both reveals the good in us and lets us witness the good in others. This is one reason every culture puts movement at the heart of its most joyous and meaningful traditions. As philosopher Doug Anderson observed, "Movement has the power to bring us fully to what is most human about us."

As I investigated the many links between movement and happiness, this book became, by necessity, an exploration of what is most human about us. It is the only way to understand the joys of movement. And perhaps more than anything else, what I was reminded of is that human happiness flourishes in community. Human beings evolved as social creatures, and we need one another to survive. Throughout human history, movement—whether labor, ritual, or play—has helped us to connect, collaborate, and celebrate. Today, physical activity continues to draw us together and remind us how much we need one another. This was something of a revelation—how much the individual psychological benefits of physical activity rely on our social nature. How so much of the joy of movement is actually the joy of connection.

When I started writing this book, I thought it would be a self-help guide, explaining how to find happiness through exercise. It turned out to be something bigger: a love letter to movement in all its forms and also to human nature. In some strange and

wonderful way, working on this book has had the same elevating effect on me as movement itself. It has given me a feeling of hope and fellowship. More than once after I finished talking to someone for the project, I said out loud, "I love humans. People are incredible." I think this was something my heart needed as much as it needs any cardiovascular exercise. Maybe it's something you need, too. If so, I hope that reading this book will give you a bit of what writing it has provided me. I hope that this book will encourage you to rethink why movement matters. I hope it will inspire you to move in ways that bring you joy and meaning. And I hope that at some point you will put this book down with a heart that is full. That you will find yourself thinking, *How marvelous, how miraculous, we humans can be.*

Chapter 1

THE PERSISTENCE HIGH

The runner's high is often held up as a lure for reluctant exercisers, described in terms that strain credulity. In 1855, Scottish philosopher Alexander Bain described the pleasure of a fast walk or run as "a species of mechanical intoxication" that produces an exhilaration akin to the ancient ecstatic worship of Bacchus, the Roman god of wine. In his memoir *Footnotes*, cultural historian Vybarr Cregan-Reid also likens his highs to inebriation. "They are as strong as bootleg whisky. They make you want to stop everyone that you pass and tell them how beautiful they are, what a wonderful world this is, isn't it great to be alive?" Trail runner and triathlete Scott Dunlap sums up his running high this way: "I would equate it to two Red Bulls and vodka, three ibuprofen, plus a $50 winning Lotto ticket in your pocket."

While many runners favor comparisons to intoxicants, others liken the high to a spiritual experience. In *The Runner's High*, Dan Sturn describes tears streaming down his face during mile seven of his morning jog. "I flew closer and closer to the place

mystics and shamans and acidheads all try to describe. Each moment became precious. I felt simultaneously all alone and completely connected." Still others draw parallels not to alcohol or religion, but to love. On a Reddit forum dedicated to explaining what the runner's high feels like, one user posted, "I love what I'm doing and love everyone I see." Another offered, "It's like when you fancy someone and they tell you that they like you too." Ultrarunner Stephanie Case describes her midrun glow this way: "I feel connected to the people around me, the loved ones in my life, and I'm infinitely positive about the future."

While runners have a reputation for praising the exercise high, the side effect is not exclusive to running. A similar bliss can be found in any sustained physical activity, whether that's hiking, swimming, cycling, dancing, or yoga. However, the high emerges only after a significant effort. It seems to be the brain's way of rewarding you for working hard. Why does such a reward exist? And more important, why would it make you feel *loving*?

The latest theory about the runner's high makes a bold claim: Our ability to experience exercise-induced euphoria is linked to our earliest ancestors' lives as hunters, scavengers, and foragers. As biologist Dennis Bramble and paleoanthropologist Daniel Lieberman write, "Today, endurance running is primarily a form of exercise and recreation, but its roots may be as ancient as the origin of the human genus." The neurochemical state that makes running gratifying may have originally served as a reward to keep early humans hunting and gathering. What we call the runner's high may even have encouraged our ancestors to cooperate and share the spoils of a hunt.

In our evolutionary past, humans may have survived in part

because physical activity was pleasurable. In our modern landscape, that same high—whether you achieve it through running or some other physical activity—can elevate your mood and make social connection easier. Understanding the science behind the runner's high can help you capitalize on these effects, whether your goal is to feel more connected to your community or to find a form of exercise that leaves you love-drunk and glad to be alive.

• • •

In 2010, anthropologist Herman Pontzer was startled awake in his nylon tent by the sound of lions roaring. Pontzer, who is now a professor at Duke University, was camped near Lake Eyasi in northern Tanzania. The campsite was not far from the Olduvai Gorge, where one of the first hominid species to use tools, *Homo habilis*, lived two million years ago. Ponzter was in Tanzania to observe the physical activity habits of the Hadza, one of the last hunter-gatherer tribes in Africa. He and his team had only been at the Hadza campsite for a couple of days, and Pontzer was still getting used to the environment. He estimated that the roaring lions were no more than half a mile away. Pontzer tried to push the sounds out of mind and went back to sleep.

The next morning, he woke at six and joined his research team around a fire. As they boiled water for instant coffee and oatmeal, a group of Hadza men walked into camp carrying huge pieces of a hooved animal over their shoulders. These men had heard the same lions that had woken Pontzer, but instead of going back to sleep, they had left camp in the dark, tracked the lions, and taken their prey, a practice known as meat pirating. "Nothing makes you feel less adequate as a man," Pontzer

recalls, "than sitting there eating your bowl of instant oatmeal while five Hadza guys come back with a freshly killed antelope that they stole from a pride of lions."

This stark difference between Hadza and Western lifestyles was exactly what Pontzer and his colleagues were in Tanzania to study. The Hadza live in an environment close to the one in which modern humans evolved, and analyses of their DNA reveal that they are one of the oldest human lineages on earth. The Hadza are by no means walking fossils. They are as evolved as any human being you'd find anywhere on the planet. However, their culture has not changed at the same rapid rate as those of other societies. For the three hundred or so Hadza who still follow a hunter-gatherer lifestyle, their survival depends on strategies similar to those that early humans relied on. As one of Pontzer's colleagues told me, if you want to understand what human life was like in the distant past, "This is as close as you can get." And if you want to understand the type of physical activity that the human body and brain are adapted for, this is your best chance to see it in action.

The Hadza spend most of the day hunting and foraging. Men head out in the early morning, carrying handmade bows and poison-tipped arrows to stalk everything from small birds to baboons. (The first time Pontzer went on a hunt with two Hadza men, they tracked the blood trail of a single wounded warthog for hours.) Women spend the morning collecting berries and baobab fruit and digging starchy tubers out of the ground. They carry up to twenty pounds of food back to camp, then go out again in the afternoon. As part of Pontzer's research project, his team gave nineteen Hadza men and twenty-seven Hadza women activity trackers and heart rate monitors, then recorded their dawn-to-dusk activity. On a typical day, the Hadza engage

in two hours of moderate to vigorous activity, like running, and several more hours of light activity, like walking. There is no difference in activity level between men and women or between young and old. If anything, the Hadza become more active as they age. Contrast this to the United States, where the average adult engages in less than ten minutes of moderate to vigorous activity a day, and physical activity peaks at age six. If the Hadza lifestyle reflects what human bodies are adapted for, something has gone seriously awry for the rest of us.

It's worth noting that the Hadza show no signs of the cardiovascular disease so prevalent in industrialized societies. Compared to age-matched Americans, the Hadza have lower blood pressure and healthier levels of cholesterol, triglycerides, and C-reactive protein, a measure of inflammation in the bloodstream that predicts future heart attacks. These signs of heart health are exactly what you'd expect to see in a population with high levels of physical activity. But Pontzer told me that he was even more personally struck by the apparent absence of two other modern epidemics among the Hadza: anxiety and depression. Whether this has anything to do with their active lifestyle is impossible to say, but hard not to speculate about. In the United States, daily physical activity—as captured by an accelerometer—is correlated with a sense of purpose in life. Real-time tracking also shows that people are happier during moments when they are physically active than when they are sedentary. And on days when people are more active than their usual, they report greater satisfaction with their lives.

Other experiments in the U.S. and the UK have forced moderately active adults to become sedentary for a period of time, only to watch their well-being wither. Regular exercisers who replace physical activity with a sedentary activity for two weeks

become more anxious, tired, and hostile. When adults are randomly assigned to reduce their daily step count, 88 percent become more depressed. Within one week of becoming more sedentary, they report a 31 percent decline in life satisfaction. The average daily step count required to induce feelings of anxiety and depression and decrease satisfaction with life is 5,649. The typical American takes 4,774 steps per day. Across the globe, the average is 4,961.

Humans weren't always hunters and foragers. Two million years ago, a major climactic event cooled the Earth and changed the landscape of East Africa. Forested areas became more patchy and transformed into open woodlands and grasslands. As the habitat changed, so did the food supply, forcing early humans to travel far and wide to chase animals, scavenge for carcasses, and gather plants. Anthropologists believe this was a turning point in the evolution of our species—the moment natural selection began to favor physical traits that helped our ancestors run. The humans who survived were the ones whose bodies could endure the hunt.

Running doesn't fossilize, but skeletons do, and the human fossil record clearly shows the appearance, over the past two million years, of anatomical adaptations that make running possible. Predecessors to modern humans were walking upright over four million years ago, but those hominins—who spent some of their time in trees—didn't have the right feet for running. Theirs were flexible and curved, with long toes suited for clasping branches. Feet more like ours, stiffer and non-grasping, and better able to push off the earth, first show up in

fossils dated to between one and two million years ago. This is around the time period you also start to see *Homo erectus* skeletons with thighbones 50 percent longer than earlier hominids, as well as wider shoulders and smaller forearms—all changes to the human form that support a more efficient running stride.

Leave the fossil record aside and you can observe many features in your own physique that help you run. Large gluteal muscles and longer Achilles tendons propel us forward. Compared to other primates, humans have more slow-twitch muscle fibers, which resist fatigue, and more mitochondria in running muscles, allowing them to consume more oxygen as fuel. We are also the only primate to have a nuchal ligament, the strip of connective tissue that fixes the base of the skull to the spine. This ligament—shared by other running species, such as wolves and horses—keeps your head from bobbing when you run. All of these adaptations suggest that we evolved as endurance athletes. Because the survival of early humans depended on traveling far and fast, you were born with bones, muscles, and joints that help you go the distance.

David Raichlen, an anthropologist at the University of Arizona, was familiar with the idea that natural selection favored traits that allowed humans to run. His own work in graduate school helped establish the theory, including a 2005 academic paper titled, "Why Is the Human Gluteus So Maximus?" But he was stymied by the problem of motivation. Nature can build a skeleton that makes running easier, but that alone is not enough to create an endurance athlete. What would make early humans willing to exert so much effort? If anything, humans seem predisposed to conserve energy. It's a caloric risk to travel all day, using up your energy reserves in the hopes of catching something big. As Herman Pontzer puts it, hunting and gathering is

"a high-stakes game in which the currency is calories and going bust means death." Hunting and gathering all day can also be painful, tiring, and boring. Was an empty stomach sufficient to make a person persist on an all-day hunt or put up with the demands of foraging from dawn to dusk?

Raichlen is a recreational runner, and he began to think about the runner's high. No one had ever come up with a good explanation for why it exists. What if the high wasn't some random physiological by-product of running long distances, but nature's reward for persisting? Was it possible that evolution had found a way to harness the brain's feel-good chemicals to make endurance exercise rewarding? Maybe, Raichlen mused, early humans got high when they ran so that they wouldn't starve. He reasoned that such a neuro-reward would have to do two things: relieve pain and induce pleasure. Scientists have long speculated that endorphins are behind the runner's high, and studies show that high-intensity exercise causes an endorphin rush. But Raichlen had in mind another candidate, a class of brain chemicals called endocannabinoids. These are the same chemicals mimicked by cannabis, or marijuana. Endocannabinoids alleviate pain and boost mood, which fit Raichlen's requirements for rewarding physical labor. And many of the effects of cannabis are consistent with descriptions of exercise-induced highs, including the sudden disappearance of worries or stress, a reduction in pain, the slowing of time, and a heightening of the senses.

Earlier research had hinted that exercise might trigger a release of these brain chemicals, but no one had ever documented it during running. So Raichlen put regular runners through treadmill workouts of differing intensities. Before and after each run, he drew blood to measure endocannabinoid levels.

Walking slowly for thirty minutes had no effect. Nor did the most intense workout, running at maximum effort. Jogging, however, tripled the runners' levels of endocannabinoids. Moreover, the elevation in endocannabinoids correlated with the runners' self-reported high. Raichlen's hunch was correct. The runner's high is a buzz.

Why did jogging increase endocannabinoids, but walking slowly and running at an exhausting pace did not? Raichlen speculates that our brains reward us for exercising at intensities similar to those successfully used for hunting and foraging two million years ago. If that is true, then natural selection should also have rewarded other animals who hunt or scavenge in similar ways. Canines, for example, evolved to chase prey over large distances. Raichlen decided to put pet dogs on his treadmill, too, to see if they got a high. (Wolves would have made even better candidates for the study, but it's easier to get dogs to cooperate.) As a comparison group, Raichlen recruited pet ferrets. Wild ferrets are nocturnal, hunting small mammals asleep in their burrows. They also forage for toads, bird eggs, and other food sources unlikely or unable to lead the ferrets in a wearying chase. Natural selection had no reason to reward ferrets for physical endurance—and apparently it didn't. After thirty minutes of jogging, the dogs showed increased blood levels of endocannabinoids. The ferrets, despite trotting on the treadmill at an impressive speed of 1.9 miles per hour, did not.

What does all this mean for today's recreational exerciser? For one thing, it suggests that the key to unlocking the runner's high is not the physical action of running itself, but its continuous moderate intensity. And in fact scientists have documented a similar increase in endocannabinoids from cycling, walking on a treadmill at an incline, and outdoor hiking. If you want

the high, you just have to put in the time and effort. Consider Julia, who was diagnosed twenty-two years ago with a rare genetic form of spinocerebellar ataxia, a progressive disease with symptoms that include balance problems, tremors, and muscle spasms. Julia is retired and lives alone, and one of the most important things in her life is maintaining the mobility she needs to babysit her grandchildren. So every morning she walks 500 meters (about a third of a mile) and climbs 140 stairs in her apartment building. Her family helped her calculate the distance and put together a playlist for her to listen to when she trains. The other residents in her building support Julia when they see her out; they refer warmly to her as being "on patrol." These daily sessions challenge Julia enough to give her a high. As she explains it, "I must be getting a kick from it because I really enjoy it. . . . Is it adrenaline you get when you—the walkers, the marathon runners—I think I might be getting a bit of, is it heroin?"

Anything that keeps you moving and increases your heart rate is enough to trigger nature's reward for not giving up. There's no objective measure of performance you must achieve, no pace or distance you need to reach, that determines whether you experience an exercise-induced euphoria. You just have to do something that is moderately difficult for you and stick with it for at least twenty minutes. That's because the runner's high isn't a *running* high. It's a *persistence* high.

If you were to see Jody Bender, a thirty-year-old human resources manager, on one of her frequent runs through her neighborhood park in Austin, Texas, one of the first things you

might notice is her right leg. Unlike her left leg, it's covered in tattoos. Across the front of her thigh, a black and white Pegasus stretches its wings. From her ankle to her knee, a muscular blue goat with curved horns and a golden mane stands in a field of red poppies. A lucky rabbit's foot is inked near her right foot. The lopsided distribution of tattoos is not a coincidence. When Bender was twenty-three, a stroke left her unable to feel her right leg. She was at home, trying to relieve a sore neck with a heating pad, when she was overcome by the oddest sensation—like a snake was wriggling through the left side of her skull. When she stood up, she realized she couldn't walk straight. It felt like she was on a sinking ship. She made it to the bathroom, became violently ill, crawled back to bed, and passed out.

Bender now knows that the snakelike sensation in her skull was blood seeping through her brain. She has a genetic condition, fibromuscular dysplasia, that leads to abnormally weak and easily damaged blood vessels. When she was stretching her neck, she ruptured an artery, causing a hemorrhagic stroke. In an MRI image taken one week later, you can see a white spot the size of a golf ball on the left side of her brain where blood had pooled. After the stroke, Bender was unable to feel her right leg and foot—it was if they had permanently fallen asleep. Her doctors were not sure if she would ever regain sensation. A year later, she was able to walk, but she would often trip and fall. She was on blood thinners to reduce the risk of a future stroke, and these drugs made any accident more risky. If she injured herself, her body would be unable to control the blood loss. She remembers tripping and falling outside her apartment one day while walking her dog. Lying on the sidewalk, her palm and knee bleeding from where she had broken her fall, Bender became determined to increase her steadiness and strength.

reporter for ESPN, "People were overcome because they were seeing a deep, important part of themselves that they never knew existed."

Witnessing this aspect of our human inheritance—the ability to persist so we can survive—can be an awe-inspiring experience. But it's also something many runners and athletes glimpse directly when they choose to push past the inertia that makes it difficult to begin or the fatigue that tempts them to stop. Jody Bender told me about a recent hiking trip she and her husband had taken in Big Bend National Park in Texas. For three days, they carried the weight of their packs on their backs and covered fifteen miles through the mountains—something that would have seemed impossible back when Bender was in physical therapy, struggling to stay vertical on the balance machine painted to look like a mountain range. On that hiking trip, Bender fell a couple of times. "I was hot and I was uncomfortable, and everything hurt. I almost ran out of water," she recalls. "But the second you finish, you don't even really remember the uncomfortable parts. You remember that feeling at the end: Wow, I said I was going to do it, and it was hard, but I didn't give up, and I did it, and that's awesome."

Persistence is key to experiencing a high while exercising, but maybe that's not the best way to think about it. We don't persist so we can get some neurochemical reward; the high is built into our biology so that we can persist. Natural selection has endowed us with a way to chase our goals and keep going even when it's hard. The runner's high is the temporary reward that carries us to our bigger goals. For many, the experience of persevering is part of what gives movement meaning and what makes the experience rewarding. This is the less heralded but perhaps most lasting side effect of the persistence high: You get

to experience yourself as someone who digs in and keeps going when things get tough. This is how Jody Bender sees herself now, seven years after her stroke. She attributes much of the confidence she's developed since then to running. "I know who I am," she told me. "I don't know that I did before."

• • •

Neuroscientists describe endocannabinoids as the "don't worry, be happy" chemical, which gives us our first clue about what exactly an exercise high does to your brain. Areas of the brain that regulate the stress response, including the amygdala and prefrontal cortex, are rich in receptors for endocannabinoids. When endocannabinoid molecules lock into these receptors, they reduce anxiety and induce a state of contentment. Endocannabinoids also increase dopamine in the brain's reward system, which further fuels feelings of optimism. As runner Adharanand Finn observes, "It may only be chemicals shooting around in your brain, but after a long run everything seems right in the world."

Another way to understand what endocannabinoids do is to look at what happens when you inhibit them. The now-banned weight-loss drug Rimonabant blocks endocannabinoid receptors, an effective way to suppress appetite. In clinical trials, the drug led to alarming increases in anxiety and depression, as well as four suicides. The adverse effects on mood were so pervasive and severe that the drug was withdrawn from the European market and never approved in the United States. In a potentially unwise experiment, *Vice* reporter Hamilton Morris got his hands on Rimonabant to find out what the opposite of a cannabis high feels like. As Morris describes the effects of a

sixty-milligram dose, "I have never felt so un-high in my life." He is plagued by anxiety and nausea and finds himself on the verge of tears for no apparent reason. When Morris's experiment ends, his recovery could be mistaken for a runner's high. "The neurochemical floodgates have opened and there is unimaginable rebound euphoria," Morris writes. "All night I walk down the street, peaceful and optimistic, ready to high-five strangers."

Rimonabant can still be procured for scientific research, and if you give the drug to rodents who love to run, it dramatically decreases their wheel-running. (One such experiment gave some of the mice THC, the psychoactive ingredient of cannabis, instead of Rimonabant. THC didn't have any effect on how much they ran, but it's always possible it led to some interesting experiences on the wheel.) Blocking endocannabinoids also eliminates two benefits of the runner's high: less anxiety and higher pain tolerance. Mice typically fear a new environment, but after running on a wheel, they are considerably braver when placed in an unfamiliar dark box. They also show less physical discomfort—jumping and licking their hind paws—when put on a hot plate. If mice are injected with a Rimonabant-like drug before they run, they don't get these benefits. Instead, they act just as scared and hurt as mice who hadn't exercised.

These findings provide further evidence that endocannabinoids make running rewarding. They also raise intriguing possibilities about the psychological effects of our own daily workouts. It's easy to notice and savor the peak high, but we might not recognize how its underlying brain chemistry is preparing us for what comes next. The National Study of Daily Experiences tracked the physical activity and moods of over two thousand adults in the United States, age thirty-three to

eighty-four, for eight days. Every night they called participants and asked them about the most stressful events of that day. On days when people were active, stressful events—such as conflict at work or taking care of a sick child—took less of a toll on their mental well-being.

In laboratory experiments, exercise can even make you immune to the panic attacks typically induced by CCK-4, a drug that triggers severe anxiety and physical symptoms like a racing heart and breathlessness. The effect of exercising for thirty minutes before being exposed to CCK-4 is equivalent to taking a benzodiazepine like Ativan, but without the sedating side effects. Think about that: Physical activity can counteract anxiety that has literally been injected into your bloodstream. I am not a morning person, but I have learned to drag myself out from under the covers, stumble to the kitchen for coffee, and exercise before I do anything else. For me, it's a survival strategy. I want to face the day as the version of myself who takes over by the time I'm done with my workout: braver, more optimistic, and ready to face whatever challenges await me.

Niki Flemmer, a thirty-seven-year-old nurse practitioner in Seattle, had gotten into a rut running a 5K on the treadmill at her gym every day. She was sick of doing the same workout by herself all the time when she heard about a local studio that offered group treadmill and rowing classes. "It sounded hard, and I didn't know if I could keep up with the intensity," she remembers. But she was also at a time in her life when she was committed to doing things that scared her, so she decided to check the studio out.

During class, everyone works at a pace that is challenging for them. One person might be running a seven-minute mile while another walks a fifteen-minute mile. Flemmer was delighted to find that in the group setting, the same physical movement means something different than it does when she exercises alone. It feels like everyone in the class is pursuing a collective goal, putting in the effort not just for themselves but also to support one another. One of her favorite parts of the workout is when the coach calls for an all-out attack, and she looks at the person on the treadmill next to her and says, "Let's kill it!" "When I see twelve people giving it their all, I often am so moved, I get tears in my eyes."

The studio is lined with mirrors, and during a recent workout, Flemmer made eye contact with a man on the treadmill behind her. "We had that moment of absolute connection, with gestures to indicate we were cheering each other on. I felt grateful. Grateful for him and his ability to show up for himself, and grateful for the human capacity to connect." This feeling lingers after class ends. "I feel more brave out in public, to make eye contact and engage people more," she told me. "It's helping me realize that everyone wants connection. Even though they might not admit it, people like it when you smile at them."

Social confidence may seem like a surprising side effect of breaking a sweat, but the chemistry of a runner's high primes us to connect. In a 2017 review of how the endocannabinoid system works in the brain, scientists identified three things that reliably amp it up: cannabis intoxication, exercise, and social connection. The three psychological states most strongly linked to low levels of endocannabinoids? Cannabis withdrawal, anxiety, and loneliness. Endocannabinoids aren't just about not worrying and being happy; they are also about feeling close to

gym and sees the face of someone she high-fived or cheered on in a previous workout.

Sharing may also be a pleasure that that draws people to exercise in groups. A woman who practices jiujitsu told me that one of her favorite parts of training is the tradition of sharing gear. "Jiujitsu gyms are like a family, and shared gear is important. It's how you're welcomed." Her first gi, the heavy cotton jacket that practitioners wear, was borrowed from a friend. Her mouth guard was a gift from another student at the gym. Taking what is offered is part of how you belong. "It's okay if you don't have something yet," she said. That gives others a chance to let you know, "We're here for you."

Evenings in Hadzaland are spent around campfires. It's a time to unwind after a day of risk-taking hunts and focused foraging. Scientists will tell you that sitting around a fire encourages social bonding. The warmth, the flickering flames, and the crackling sounds lull us into a state more receptive to the pleasures of connecting with others. As I thought about the Hadza's evening rituals, I began to wonder: What if the runner's high does something similar? Could the afterglow of physical activity make you feel more warm and fuzzy about the people you share your life with? And make coming together at the end of the day, to share stories and a meal, even more satisfying?

It seemed to me that a runner's high fueled by endocannabinoids wouldn't just make hunting and foraging more enjoyable. By priming you to connect, the high should also make sharing the spoils with your tribe more rewarding. An experiment at the Sapienza University of Rome suggests that physical activity

can have this effect. Participants played an economic game that required contributing money to a communal pool. The more they contributed, the more all parties would benefit. Participants who exercised for thirty minutes before playing the game shared more than when they played the same game without exercising first.

I ran my hypothesis—that the runner's high encourages cooperation and bonding—by anthropologist David Raichlen. He thought it was plausible that exercise-induced endocannabinoids contribute to social cohesion. In fact, he had been itching to run a study looking at whether exercising with others would lead to a bigger increase in endocannabinoids than exercising alone. But I was even more interested in another possibility—that being physically active can enhance the cooperation high and help us extract even more joy from working as a team or helping others. As it turns out, I wasn't the first to consider this proposition. When you bring together the runner's high and the helper's high, the rewards go beyond a more satisfying workout. Runners become family, communities get cared for, and humans find their tribe.

• • •

Nykolette Wallace, a thirty-five-year-old administrator for the National Health Service, was running through the streets of Southeast London in a torrential downpour. Heavy rain hadn't been expected until later that evening, and she was not dressed for the weather. Her hoodie and baseball cap were inadequate defense against the deluge, and soon she was soaked. Wallace was running with a pack of volunteers for GoodGym, a London-based organization that combines running and community

projects. The group was running through Wallace's own neighborhood of Lewisham to the Goldsmiths Community Centre, which provides locals with preschool, prayer groups, ballroom dance classes, chicken lunches with bingo, and sobriety support. On the way to the center, the group ran right by Wallace's home, and she was tempted to abandon the pack, dry off, and get warm. But there was so much camaraderie, she didn't want to leave. "Humans, we moan a lot: 'It's raining, I want to get inside.' We were all out there, everyone still laughing and chatting," she remembers. "We were going to do something good because we all wanted to. Nothing else mattered."

The founder of GoodGym, Ivo Gormley, used to watch exercisers running to nowhere on treadmills in gyms, and think, *What a waste of energy.* He wondered if there was a way to harness that energy. As a first experiment, Gormley sent volunteer runners to visit socially isolated older adults in London. According to government data, half the older adults in the UK say that television and pets are their only companions, and many leave the house less than once a week. Two hundred thousand older adults in England and Wales have not spoken with a friend or family member in more than a month. As one person who requested visits from a GoodGym volunteer explained, "It would be very nice to see another human being. My only friends are people on the telly." The older adults who receive visits are given the title of "coach." Their role is to keep the runners motivated by giving them somewhere and someone to run to. The runners make regular social calls to their coaches and, when needed, help out around the house with things like changing lightbulbs. Over time, these visits turn into real friendships. More than once, when a coach has fallen ill, GoodGym runners have been their only visitors in the hospital—and at discharge,

they are often the ones who take the coaches back home. Sometimes the tables are turned, and it's the coach who shows up to support a GoodGym runner.

As GoodGym grew, the organization expanded its reach, connecting runners with other volunteers in their neighborhoods and sending them to all sorts of projects in their communities. Every group run starts with a warm-up, where they learn more about that day's mission. Then they run for a mile or two to the project location, maintaining a pace that lets them talk and share stories. A designated backmarker trails the pack to make sure no one gets left behind. GoodGym has also added walking groups, for those who need or prefer a slower pace. Once on site, they might sort donations, pull weeds, organize the neighborhood toy library, or, as one recent group did, cook spaghetti Bolognese and prepare beds for locals who are homeless. The day Wallace's local group got soaked in the rain en route to the Goldsmiths Community Centre, the volunteers sanded down doors and frames to prepare them for fresh paint. Busy scrubbing wood with sandpaper, Wallace forgot her cold, damp clothes and soggy sneakers. When the rain let up, the runners distributed flyers around the neighborhood for the center's upcoming Christmas Fair, where locals could enjoy mulled wine and mince pie and do some holiday shopping. After their return trek, the GoodGym volunteers cooled down with a stretch and made plans for their own Christmas get-together at a neighborhood pub.

Before GoodGym, Wallace ran for fitness only once every couple of months. Now she runs weekly with her group. "Every time I go to catch a train, I can see something I did," Wallace says. One of her favorite group tasks was planting tulips, daffodils, and pansies in new flowerpots outside the neighbor-