# SPARK:
# THE REVOLUTIONARY NEW SCIENCE OF EXERCISE & THE BRAIN
# BY JOHN RATEY

In Spark: the Revolutionary New Science of Exercise and the Brain, John Ratey examines how exercise contributes to better brain function. Ratey discusses how exercise is strongly related to better learning, reducing stress, combatting anxiety and addiction, improving hormones and reducing the impacts of the aging process. Backed up my numerous studies and scientific experiments, Ratey makes a strong argument highlighting that exercise is the most important tool in improving our brain function.

**MAKING THE CONNECTION**

We all know that exercise makes us feel better, but most of us have no idea why. We assume it's because we're burning off stress or reducing muscle tension. But the real reason we feel so good when we get our blood pumping is that it makes the brain function at its best. This benefit of physical activity is far more important — and fascinating — than what it does for the body.

In today's technology-driven, plasma-screened-in world, it's easy to forget that we are born movers — animals, in fact — because we've engineered movement right out of our lives.

The sedentary character of modern life is a disruption of our nature, and it poses one of the biggest threats to our continued survival. What's even more disturbing, and what virtually no one recognises, is that inactivity is killing our brains too — physically shrivelling them. Our culture treats the mind and body as if they are separate entities, and they need to be reconnected.

**WELCOME TO THE REVOLUTION**

Physical activity sparks biological changes that encourage brain cells to bind to one another. For the brain to learn, these connections must be made; they reflect the brain's fundamental ability to adapt to challenges.

The more neuroscientists discover about this process, the clearer it becomes that exercise provides an unparalleled stimulus, creating an environment in which the brain is ready, willing, and able to learn. Aerobic activity has a dramatic effect on adaptation, regulating systems that might be out of balance and optimising those that are not — it's an indispensable tool for anyone who wants to reach his or her full potential.

**LEARNING**

When the students go for a mile run in gym, they are more prepared to learn in their other classes: their senses are heightened; their focus and mood are improved; they're less fidgety and tense; and they feel more motivated and invigorated.

The same goes for adults, in the classroom of life. What allows us to absorb the material is where the revolutionary new science comes into play. In addition to priming our state of mind, exercise influences learning directly, at the cellular level, improving the brain's potential to log in and process new information.

What we now know is that the brain is flexible, or plastic in the parlance of neuroscientists — more Play-Doh than porcelain. It is an adaptable organ that can be moulded by input in much the same way as a muscle can be sculpted by lifting barbells. The more you use it, the stronger and more flexible it becomes.

**The medium is the messenger**

About 80 percent of the signalling in the brain is carried out by two neurotransmitters that balance each other's effect: glutamate stirs up activity to begin the signalling cascade, and gamma-aminobutyric acid (GABA) clamps down on activity.

Going for a run is like taking a little bit of Prozac and a little bit of Ritalin because, like the drugs, exercise elevates these neurotransmitters. It's a handy metaphor to get the point across, but the deeper explanation is that exercise balances neurotransmitters — along with the rest of the neurochemicals in the brain.

**To learn is to grow**

When the brain is called on to take in information, the demand naturally causes activity between neurons. The more activity, the stronger the attraction becomes, and the easier it is for the signal to fire and make the connection.

A neuron is like a tree that instead of leaves has synapses along its dendritic branches; eventually new branches sprout, providing more synapses to further solidify the connections.

These changes are a form of cellular adaptation called synaptic plasticity. Early on, researchers found that if they sprinkled BDNF onto neurons in a petri dish, the cells automatically sprouted new branches, producing the same structural growth required for learning — think of BDNF as Miracle-Gro for the brain.

BDNF also binds to receptors at the synapse, unleashing the flow of ions to increase the voltage and immediately improve the signal strength. Overall, BDNF improves the function of neurons, encourages their growth, and strengthens and protects them against the natural process of cell death. BDNF is a crucial biological link between thought, emotions, and movement.

**The mind-body connection**

Brain scans show that when we learn a new word, for example, the prefrontal cortex lights up with activity. Once the circuit has been established by the firing of glutamate, and the word is learned, the prefrontal cortex goes dark. It has overseen the initial stages of the project, and now it can leave the responsibility to a team of capable employees while it moves on to new challenges.

This is how we come to know things and how activities like riding a bike become second nature. Patterns of thinking and movement that are automatic get stored in primitive areas that until recently scientists thought related only to movement.

Delegating fundamental knowledge and skills to these subconscious areas frees up the rest of the brain to continue adapting, a crucial arrangement. Imagine if we had to stop and think to process every thought and to remember how to perform every action. We'd collapse in a heap of exhaustion before we could pour our first cup of morning coffee. Which is why a morning run is so important.

**The first spark**

By showing that exercise sparks the master molecule of the learning process, Carl Cotman nailed down a direct biological connection between movement and cognitive function. In doing so, he blazed the trail for the study of exercise in neuroscience.

One of the prominent features of exercise, which is sometimes not appreciated in studies, is an improvement in the rate of learning," Cotman says. "It suggests that if you're in good shape, you may be able to learn and function more efficiently.

Cotman's work laid the foundation for proving that exercise strengthens the cellular machinery of learning. BDNF gives the synapses the tools they need to take in information, process it, associate it, remember it, and put it in context.

**The nature of nurture**

In a seminal study in the early 1970s, an electron microscope was used to show that environmental enrichment made the neurons sprout new dendrites. The branching caused by the environmental stimulation of learning, exercise, and social contact caused the synapses to form more connections, and those connections had thicker myelin sheaths, which allowed them to fire signals more efficiently.

Now we know that such growth requires BDNF. This remodelling of the synapses has a huge impact on the circuits' capacity to process information, which is profoundly good news. What it means is that you have the power to change your brain. All you have to do is lace up your running shoes.

**The body-mind connection**

If we're going to have new cells, we'll need fertiliser for them, and from the get-go, neurogenesis researchers have been onto BDNF. They already knew that without Miracle Gro our brains can't take in new information, and now they've seen that BDNF is also a necessary ingredient for making new cells. BDNF gathers in reserve pools near the synapses and is unleashed when we get our blood pumping.

In the process, a number of hormones from the body are called into action to help. During exercise, these factors push through the blood-brain barrier. Scientists have just recently learned that once inside the brain, these factors work with BDNF to crank up the molecular machinery of learning. They are

also produced within the brain and promote stem-cell division, especially during exercise. The broader importance is that these factors trace a direct link from the body to the brain.

**Long term memories**

Take IGF-1, a hormone released by the muscles when they sense the need for more fuel during activity. Glucose is the major energy source for the muscles and the sole energy source for the brain, and IGF-1 works with insulin to deliver it to your cells.

The role of IGF-1 in the brain isn't related to fuel management, but to learning — presumably so we can remember where to locate food in the environment. During exercise, BDNF helps the brain increase the uptake of IGF-1, and it activates neurons to produce the signalling neurotransmitters, serotonin and glutamate. It spurs the production of more BDNF receptors, beefing up connections to solidify memories. In particular, BDNF seems to be important for long-term memories.

**Exercise your options**

Now you know how exercise improves learning on three levels: first, it optimises your mind-set to improve alertness, attention, and motivation; second, it prepares and encourages nerve cells to bind to one another, which is the cellular basis for logging in new information; and third, it spurs the development of new nerve cells from stem cells in the hippocampus.

But now you want to know what the best exercise plan is. I wish there were an ideal type and amount of activity to suggest for building your brain, but scientists are only beginning to tackle such questions. "Nobody's done that research yet, but I suspect in five years we'll know a lot more.

**What we know for sure**

You can't learn difficult material while you're exercising at high intensity because blood is shunted away from the prefrontal cortex, and this hampers your executive function.

However, blood flow shifts back almost immediately after you finish exercising, and this is the perfect time to focus on a project that demands sharp thinking and complex analysis.

So if you have an important afternoon brainstorming session scheduled, going for a short, intense run during lunchtime is a smart idea.

**Combinations are important**

One small but scientifically sound study from Japan found that jogging thirty minutes just two or three times a week for twelve weeks improved executive function. But it's important to mix in some form of activity that demands coordination beyond putting one foot in front of the other.

Aerobic exercise and complex activity have different beneficial effects on the brain. The good news is they're complementary. It's important to take both into account, your regimen has to include skill acquisition and aerobic exercise.

Choose a sport that simultaneously taxes the cardiovascular system and the brain — tennis is a good example. Any motor skill more complicated than walking has to be learned, and thus it challenges the brain.

**STRESS**

Everyone knows stress, but do they really? It comes in many shapes and sizes, acute and chronic — social stress, physical stress, metabolic stress, to name a few. Most people use the word indiscriminately for both cause and effect.

Biologically, stress is a threat to the body's equilibrium. It's a challenge to react, a call to adapt. In the brain, anything that causes cellular activity is a form of stress. For a neuron to fire, it requires energy, and the process of burning fuel creates wear and tear on the cell. The feeling of stress is essentially an emotional echo of the underlying stress on your brain cells.

**How stress affects you**

Instincts aside, you do have some control over how stress affects you.

Exercise controls the emotional and physical feelings of stress, and it also works at the cellular level. But how can that be, if exercise itself is a form of stress? The brain activity caused by exercise generates molecular by-products that can damage cells, but under normal circumstances, repair mechanisms leave cells hardier for future challenges. Neurons get broken down and built up just like muscles — stressing them makes them more resilient. This is how exercise forces the body and mind to adapt.

The parallel on the cellular level is that stress sparks brain growth. Assuming that the stress is not too severe and that the neurons are given time to recover, the connections become stronger and our mental machinery works better. Stress is not a matter of good and bad — it's a matter of necessity.

**The alarm system**

Severe stress activates the emergency phase, commonly known as the fight-or-flight response. It's a complex physiological reaction that marshals resources to mobilise body and brain, and engraves a memory of what happened, so we can avoid it next time. The fight-or-flight response calls into action several of the body's most powerful hormones and scores of neurochemicals in the brain.

The idea that we can alter our mental state by physically moving still has yet to be accepted by most physicians, let alone the broader public. The purpose of the fight-or-flight response is to mobilise us to act, so physical activity is the natural way to prevent the negative consequences of stress. When we exercise in response to stress, we're doing what human beings have evolved to do over the past several million years.

**Focus**

The overarching principle of the fight-or-flight response is marshalling resources for immediate needs in lieu of building for the future — act now, ask questions later.

If you've ever faced a nerve-racking public-speaking situation, you've experienced this shift in the form of a racing heart and cotton mouth. Your muscles and your brain get stiff, and you lose all hope of being flexible and engaging. Or, if the processed signal from the cortex to the amygdala breaks up, you can't think and you freeze. Technically, the full-blown stress response should be called "freeze or fight or flight." None of this is particularly helpful when you're up at the podium, but the body responds in essentially the same way whether you're staring down a hungry lion or a restless audience.

**Fuel**

To fuel the anticipated activity of the muscles and the brain, epinephrine immediately begins converting glycogen and fatty acids into glucose. Traveling through the bloodstream, cortisol works more slowly than epinephrine, but its effects are incredibly widespread.

The strategy is to make the body insulin-resistant so the brain has enough glucose. Cortisol also begins restocking the shelves, so to speak, replenishing energy stores depleted by the action of epinephrine. It converts protein into glycogen and begins the process of storing fat.

If this process continues unabated, as in chronic stress, the action of cortisol amasses a surplus fuel supply around the abdomen in the form of belly fat. Stress mobilises energy stores that don't get used.

One of the problems with chronic stress is that if the HPA axis is guzzling all the fuel to keep the system on alert, the thinking parts of the brain are being robbed of energy.

**Fighting our instincts**

The stress response is elegantly adaptive behaviour, but because it doesn't get you very far in today's world, there's no outlet for all that energy buildup. You have to make a conscious effort to initiate the physical component of fight or flight.

The human body is built for regular physical activity, but how much? Our average energy expenditure per unit of body mass is less than 38 percent of that of our Stone Age ancestors. And it's fair to say that our calorie intake has increased quite a bit. The kicker is that even if we followed the most demanding governmental recommendations for exercise and logged thirty minutes of physical activity a day, we'd still be at less than half the energy expenditure for which our genes are encoded. Paleolithic man had to walk five to ten miles on an average day, just to be able to eat.

Today we don't have to expend much energy to find food, and we certainly don't have to use our brains to figure out how to get our next meal.

**Loneliness**

It's stressful to be shunned or isolated. Loneliness is a threat to survival. Not coincidentally, the less physically active we are, the less likely we'll be to reach out and touch someone. Studies show that by adding physical activity to our lives, we become more socially active — it boosts our confidence and provides an opportunity to meet people. The vigour and motivation that exercise brings helps us establish and maintain social connections.

If you exercise or even just socialise, you're tapping into the evolutionary antidote to stress.

**That which doesn't kill you...**

It's well known that the way to build muscles is to break them down and let them rest. The same paradigm applies to nerve cells, which have built-in repair and recovery mechanisms activated by mild stress. The great thing about exercise is that it fires up the recovery process in our muscles and our neurons. It leaves our bodies and minds stronger and more resilient, better able to handle future challenges, to think on our feet and adapt more easily.

Regular aerobic activity calms the body, so that it can handle more stress before the serious response involving heart rate and stress hormones kicks in. It raises the trigger point of the physical reaction. In the brain, the mild stress of exercise fortifies the infrastructure of our nerve cells by activating genes to produce certain proteins that protect the cells against damage and disease.

**Resilience**

Resilience is the buildup of waste-disposing enzymes, neuroprotective factors, and proteins that prevent the naturally programmed death of cells. The best way to build them up is by bringing mild stress on yourself: using the brain to learn, restricting calories, exercising, and, eating your vegetables. All these activities challenge the cells and create waste products that can be just stressful enough. The paradox is that our wonderful ability to adapt and grow doesn't happen without stress — we can't have the good without a bit of the bad.

**Enough is enough**

Everybody's threshold for stress is different, and that point can change in response to influences from the environment or our genetics or our behaviour or any combination thereof. As with the neurochemistry of the brain, our stress threshold is always changing. While the process of aging naturally lowers the threshold, we can hitch it up quite a few notches through aerobic exercise.

**The science of burning it off**

Since exercise influences metabolism, it serves as a powerful way to influence synaptic function, and thus the way we think and feel. Throughout the body, exercise increases blood flow and the availability of glucose, the essentials for cell life.

It's what happens after exercise that optimises the brain. In addition to raising the fight-or-flight threshold, it kick-starts the cellular recovery process. Exercise increases the efficiency of intercellular energy production, allowing neurons to meet fuel demands without increasing toxic oxidative stress.

We do get waste buildup, but we also get the enzymes that chew it up, not to mention a janitorial service that disposes of broken bits of DNA and other by-products of normal cellular use and aging — both of which are thought to help prevent the onset of cancer and neurodegeneration. And while exercise induces the stress response, if the activity level isn't extreme, it shouldn't flood the system with cortisol.

On a mechanical level, exercise relaxes the resting tension of muscle spindles, which breaks the stress-feedback loop to the brain. If the body isn't stressed, the brain figures maybe it can relax too. Over time, regular exercise also increases the efficiency of the cardiovascular system, lowering blood pressure.

**Learn to deal**

The stress of exercise is predictable and controllable because you're initiating the action, and these two variables are key to psychology. With exercise, you gain a sense of mastery and self-confidence. As you develop awareness of your own ability to manage stress and not rely on negative coping mechanisms, you increase your ability to "snap out of it," so to speak. You learn to trust that you can deal with it.

**Work it out**

Since the office is a primary source of stress for a lot of people, it's a good place to look for the benefits of exercise. More and more companies are encouraging their employees to take advantage of in-house gyms or health club memberships, and some health insurance companies reimburse clients for club fees. Their generosity is informed by studies showing that exercise reduces stress and makes for more productive employees.

It all comes back to the evolutionary paradox that even though it's much easier to survive in the modern world, we experience more stress. The fact that we're much less active than our ancestors were only exacerbates matters. Just keep in mind that the more stress you have, the more your body needs to move to keep your brain running smoothly.

**ANXIETY**

Anxiety is a natural reaction to a threat that happens at a certain point in the stress response, when the sympathetic nervous system and the hypothalamic-pituitary-adrenal (HPA) axis shift into high gear. When you're facing an upcoming speech or a brewing confrontation with your boss, anxiety sharpens your attention so you can meet the challenge. And someone with generalised

anxiety disorder tends to respond to normal situations as if they were threatening.

When we are in this state, we begin to anticipate that everything is going to be a disaster, and so we try to avoid everything, and our world begins to shrink.

**The defence**

By using exercise to combat the symptoms of anxiety, you can treat the state, and as your level of fitness improves, you chip away at the trait. Over time, you teach the brain that the symptoms don't always spell doom and that you can survive; you're reprogramming the cognitive misinterpretation. The fact that aerobic exercise works immediately to fend off the state of anxiety has been well established for many, many years.

In the body, physical activity lowers the resting tension of the muscles and thus interrupts the anxiety feedback loop to the brain. If the body is calm, the brain is less prone to worry. Exercise also produces calming chemical changes.

As for the trait, the majority of studies show that aerobic exercise significantly alleviates symptoms of any anxiety disorder. But exercise also helps the average person reduce normal feelings of anxiousness.

**Outrunning the fear**

The elegance of exercise as a way to deal with anxiety, in everyday life and in the form of a disorder, is that it works on both the body and the brain. Here's how:

1. It provides distraction. Quite literally, moving puts your mind on something else.
2. Reduces muscle tension.
3. Builds brain resources.
4. Teaches a different outcome.
5. Re-routes your circuit.
6. Improves resilience.
7. Sets you free.

## DEPRESSION

The problem with the strictly biological interpretation of psychology is that we sometimes lose sight of the fact that the mind, brain, and body all influence one another. In addition to feeling good when you exercise, you feel good about yourself, and that has a positive effect that can't be traced to a particular chemical or area in the brain. If you've been feeling down and you start to exercise and feel better, the sense that you're going to be OK and that you can count on yourself shifts your entire attitude. The stability of the routine alone can dramatically improve your mood.

### Antidepressants

Aside from elevating endorphins, exercise regulates all of the neurotransmitters targeted by antidepressants. For starters, exercise immediately elevates levels of norepinephrine, in certain areas of the brain. It wakes up the brain and gets it going and improves self-esteem, which is one component of depression.

Exercise also boosts dopamine, which improves mood and feelings of wellness and jump-starts the attention system. Dopamine is all about motivation and attention.

Serotonin is equally affected by exercise, and it's important for mood, impulse control, and self-esteem. It also helps stave off stress by counteracting cortisol, and it primes the cellular connections in the cortex and hippocampus that are important for learning.

**Science**

The closer we get to the cause of depression, the more complex it appears. When we began, everyone was fairly certain that the problem was an imbalance of neurotransmitters at the synapses. Now we know for certain that it's not so simple.

Ironically, this is precisely why exercise has yet to be embraced as a medical treatment. It doesn't simply raise serotonin or dopamine or norepinephrine. It adjusts all of them, to levels that, we can only presume, have been optimally programmed by evolution.

In short, exercise affects so many variables in the brain that its nigh impossible to isolate its effect as we'd like — in the name of hard science. But the evidence is there. Yes, exercise is an antidepressant. But it is also much more.

**Social beings**

Human beings are social animals, so if you're depressed, it would be ideal to choose a form of exercise that encourages making connections and that can take place outside or in some environment that stimulates the senses. Asking someone to join you in exercise and putting yourself in a new setting will give those newly hatched neurons a powerful reason for being; new connections need to be formed to represent the sensory stimulation.

Breaking out of the emptiness that the brain has been locked into provides a sense of purpose and self-worth that evokes a positive future. Once you develop the positive feeling, you need to devote it to something. Then you get the bottom-up motivation and physical boost combined with the top-down reevaluation of yourself. By motivating the body to move, you're encouraging the mind to embrace life.

**Not an instant cure**

Exercise is not an instant cure, but you need to get your brain working again, and if you move your body your brain won't have any choice. It's a process, and the best strategy is to take it one step — and then one stride — at a time. Start slowly and build on it. At its core, depression is defined by an absence of moving toward anything, and exercise is the way to divert those negative signals and trick the brain into coming out of hibernation.

**ADDICTION**

As a treatment, exercise works from the top down in the brain, forcing addicts to adapt to a new stimulus and thereby allowing them to learn and appreciate alternative and healthy scenarios. It's activity-dependent training, and while it may not provide the immediate rush of a snort of cocaine, it instills a more diffuse sense of well-being that, over time, will become a craving in its own right. The inoculation works from the bottom up, physically blunting the urge to act by engaging the more primitive elements of the brain. Exercise builds synaptic detours around the well-worn connections automatically looking for the next fix.

**Fight the urge, shake the habit**

A study in London in 2004 showed that even ten minutes of exercise could blunt an alcoholic's craving.

The biology of stress ties in with addiction in that withdrawal puts the body in survival mode. If you suddenly quit drinking, for instance, you're turning off the dopamine spigot and the hypothalamic-pituitary-adrenal axis gets thrown out of balance. The intense unpleasantness of withdrawal lasts for only a few days, but your system remains sensitive for much longer. If you're in this delicate state and come under further stress, your brain interprets the situation as an emergency and sends you looking for more alcohol. The most effective solution to a stressful situation — and the only one an addict knows — is the drug. But exercise is another solution.

In smokers, just five minutes of intense exercise can be beneficial. Nicotine is an oddball among addictive substances as it works as a stimulant and a relaxant at the same time. Exercise fights the urge to smoke because in addition to smoothly increasing dopamine it also lowers anxiety, tension, and stress levels — the physical irritability that makes people so grouchy when they're trying to quit. Exercise can fend off cravings for fifty minutes and double or triple the interval to the next cigarette.

**Hooked on the good stuff**

If exercise acts like certain drugs in the brain, then you might wonder whether it can also be addicting. I get this question all the time, and the short answer is yes, but don't worry about it.

The danger of getting addicted to exercise applies to a very small segment of the population, most notably girls with anorexia or anyone with a body dysmorphic syndrome, a mental disorder defined by a preoccupation with a perceived deficit in appearance. They eat less and less, and when they exercise they become light-headed and exhilarated, the high only reinforcing the cycle.

**Filling the vessel**

When an addict quits, what's left is emptiness. In this respect, dealing with addiction is similar to battling feelings of anxiety and depression: getting rid of the problem is only the first step. Once the addiction or the negative emotions are gone, the void needs to be filled with some positive behaviour for the change to take root. There can hardly be a better option than physical exercise. After all, this is what we're supposed to be doing — moving in the world.

The fact that exercise counteracts anxiety and depression directly can have a huge impact on any form of addiction, as both of these mood states undermine treatment. A recovering addict who is feeling anxious or hopeless is much more likely to slip in her determination and ability to quit. People are more impulsive when they feel lousy. Both strength training and aerobic exercise decrease symptoms of depression in recovering alcoholics and smokers who have quit. And the more fit you are, the more resilient you are.

**Regain control**

If you have a tendency toward addictive behaviour it's vital to develop some sort of consistent exercise habit.

How much exercise you need depends, of course, on how severe the habit is. But I would say thirty minutes of vigorous aerobic exercise five days a week is the bare minimum if you want to root out an addiction. To begin, however, it's best if you can do something every day, because the exercise will keep you occupied and focused on something positive.

If you haven't been in the habit of exercising, it can be helpful to join a gym or hire a personal trainer, because spending the money is a strong motivator. If you have an addiction to food, try a quick walk around the block or a few minutes with a jump rope or even a set of thirty jumping jacks — anything to snap your mind out of the cycle of thinking about the reward.

Exercise isn't necessarily a cure, but it's the only treatment I know of that works from the top down as well as from the bottom up, rewiring the brain to circumvent the addictive pattern and curbing the craving. Try it. Maybe you'll get hooked.

**HORMONAL CHANGES**

Hormones have a powerful influence on how our brains develop as well as on our feelings and behaviours and personality traits throughout life. After adolescence, hormone levels remain fairly steady in men, but in women, they fluctuate like clockwork. The constant shifting affects every woman differently, and this must be factored in to any discussion of brain health. Exercise is particularly important for women because it tones down the negative consequences of hormonal changes that some experience, and for others, it enhances the positive. Overall, exercise balances the system, on a monthly basis as well as during each stage of life, including pregnancy and menopause.

**PMS**

Exercise isn't necessarily the only answer if you suffer from PMS, but it can dramatically reduce the symptoms and give you a handle on a part of life that feels beyond your control. And with a lifestyle change, medication may not be necessary.

One explanation, certainly, is that physical activity increases levels of tryptophan in the bloodstream and thus concentrations of serotonin in the brain. It also balances dopamine, norepinephrine, and synaptic mediators such as BDNF. By stabilising such a broad number of variables, exercise helps to tone down the ripple effects of shifting hormones.

For younger women with PMS, I would suggest five days a week of aerobic exercise at the same level, but it might be a good idea to mix in more intense

bursts like sprinting on two of those days, though not back-to-back. Some of the studies suggest that higher intensity effort has a more dramatic effect on symptoms such as irritability, anxiety, depression, and mood instability. And if your symptoms are particularly bad, and you're not completely sidelined with cramps, it's probably a good idea to do something every day during the premenstrual phase of your cycle.

## AGING

The mental and physical diseases we face in old age are tied together through the cardiovascular system and metabolic system. A failure of these underlying connections explains why people who are obese are twice as likely to suffer from dementia, and why those with heart disease are at far greater risk of developing Alzheimer's, the most common form of dementia. Statistically, having diabetes gives you a 65 percent higher risk of developing dementia, and high cholesterol increases the risk 43 percent. We've had the medical proof that exercise protects against these diseases for decades, yet, according to the CDC, about a third of the population over sixty-five reports that they engage in no leisure-time activity.

### How we age

Getting older is unavoidable, but falling apart is not. People who stay involved and active as they age can slow down the degeneration. In one study of recent retirees, researchers found that those who exercised maintained nearly the same level of blood flow in the brain after four years, while the inactive group had a significant decrease. If your brain isn't actively growing, then it's dying. Exercise is one of the few ways to counter the process of aging because it slows down the natural decline of the stress threshold. "Paradoxically, it's good that cells be periodically subjected to mild stress because it improves their ability to cope with more severe stress.

In addition, exercise sparks connections and growth among your brain's cell networks: it increases blood volume, regulates fuel, and encourages neuronal activity and neurogenesis. Because the aging brain is more vulnerable to damage, anything you do to strengthen it has a more pronounced effect than it would on a young adult.

**Cognitive decline**

It shows up in the little things first. As the connections in the brain break down, you have a harder time calling to mind people and places you've known.

Exercise not only keeps the brain from rotting, but it also reverses the cell deterioration associated with aging. Exercise improves the brain's ability to compensate. Let's say the prefrontal cortex isn't functioning quite up to par, you might be able to recruit other areas of the cortex to do the task in a different way. One way to think about the increased volume is that it might turn back the clock in terms of how well the circuits function to do different things.

**The life list**

When people come to recognise how their lifestyle can improve their health span — living better, not simply longer — they will, at the very least, be more inclined to stay active. And when they come to accept that exercise is as important for the brain as it is for the heart, they'll commit to it. Here's how exercise keeps you going:

1. It strengthens your cardiovascular system.
2. Regulates fuel.
3. Reduces obesity.
4. Elevates your stress threshold.
5. Lifts your mood.
6. Boosts your immune system.
7. Fortifies your bones.

8. Boosts motivation.
9. Fosters neuroplasticty. The best way to guard against neurodegenerative disease is to build a strong brain.

**Steady does it**

For anyone over sixty, I recommend exercising almost every day. In retirement, why not? Six days a week would be ideal, but make it fun rather than work. Your overall strategy should include four areas: aerobic capacity, strength, and balance and flexibility. You should consult with a doctor or trainer who knows your history.

**THE REGIMEN**

Exercise is the single most powerful tool you have to optimize your brain function.

When people ask me how much exercise they should do for their brain, the best advice is to get fit and then continue challenging themselves. The prescription for how to do that will vary from person to person, but the research consistently shows that the more fit you are, the more resilient your brain becomes and the better it functions both cognitively and psychologically. If you get your body in shape, your mind will follow.

In fact, many of the most convincing studies use walking as the mode of exercise. But focus on getting fit because we know with certainty that having a normal body mass index and a robust cardiovascular system optimizes your brain. Any level of activity will help, certainly, but from a practical standpoint, if you're going to bother doing something for your brain, you might as well do enough to protect your body against heart disease, diabetes, cancer, and the like. Body and brain are connected. Why not take care of both?

**Follow our ancestors**

The best advice is to follow our ancestors' routine: walk or jog every day, run a couple of times a week, and then go for the kill every now and then by sprinting.

Your choices aren't limited to these modes of aerobic activity, naturally, but they're helpful categories to distinguish between low-intensity (walking), moderate-intensity (jogging), and high-intensity (running) exercise

If you want to make the most of your time and effort, you'll need a way to accurately judge your level of exertion along these divisions. Walking, or low-intensity exercise, is exercising at 55 to 65 percent of your maximum heart rate. Moderate intensity falls in the range of 65 to 75 percent, while high intensity is 75 to 90 percent. The upper end of high-intensity exercise is sometimes painful but always powerful territory that has gained a lot of scientific interest recently.