



Exercise Can Give Us Brain-Boosting Superpowers?

By Selam Habtemariam

With the snap of your fingers, what if it was possible to boost brain power, longevity, and function against the strains of time? What if we could slow the brain's process of aging? For centuries, questions of maintaining the brain's youth and boosting its power have been grappled with by scientists and nonscientists alike. Legends of fountains of youth have been an alluring topic of many stories throughout pop culture along with similar myths of immortality. Many superheroes in our favorite movies often have these gifts of immortality, extraordinary physical capabilities, sharp instincts, and high-speed problem-solving abilities. Such fantasies of having these superpowers, of course, do not exist to our knowledge. However, the incorporation of a particular lifestyle change has been found to be responsible for extending life expectancy and brain power: staying physically active. In many ways, exercise may be one of the closest things we have to our very own semi-instant power boost for

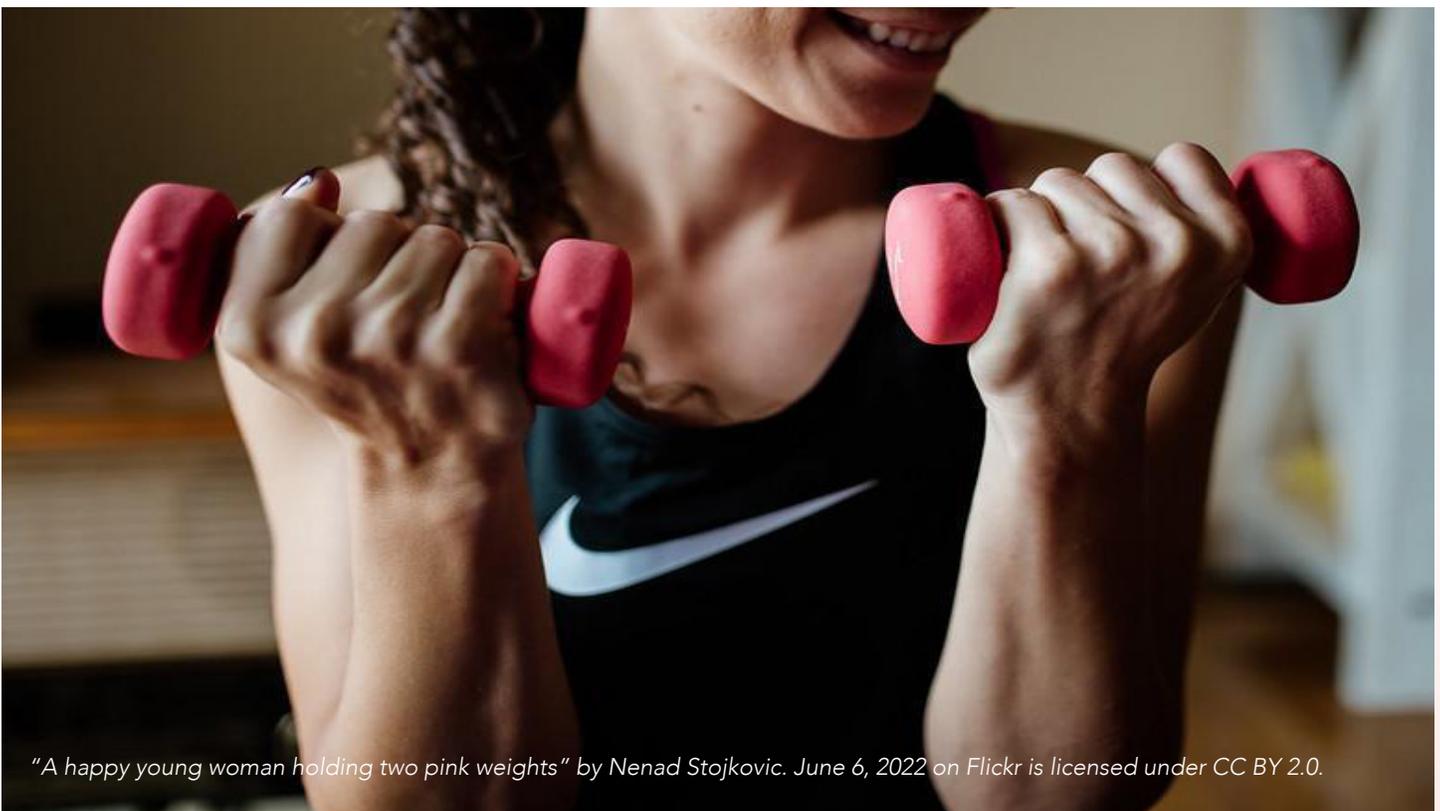
the brain. It does not sound as enthralling as the subject of many expeditions in search of immortality, or having the power to levitate objects with our mind. However, when incorporated into one's lifestyle, exercise has tremendous influences on the brain that you may not expect.

Regular exercise is widely known for its physical benefits from maintaining a healthy weight, to supporting our heart health, to heightening endurance, to building strength in muscles and bones (1). Though it is not a muscle, the brain also becomes stronger when exercise is incorporated correctly. In fact, physical activity can help to slow the typical aging processes of the brain, along with boosting brain health and function. Many of these aging processes involve neurodegeneration, processes by which neurons lose function, resulting in the deterioration of memory, motor abilities, cognitive function, and many other capacities (2). It is known that exercise is important for brain health, but what specific pathways does it work through? Research has

revealed that numerous neurophysiological and neurochemical pathways are altered with physical activity that produce long-term effects, as described previously with neurodegeneration prevention, but also valuable short-term effects (2). Chances are, you have also experienced some of these short-term effects after completing a long or intense workout.

Picture this: as you wrap up a workout, you reach your last rep of burpees. Your body is aching, and you feel like you can't finish. Your hands hit the ground and you propel yourself upward with a feeling of fulfillment and elation washing over you. Chances are you feel more exhilarated at the end of the work out than before you began from that boost of adrenaline. This is due to modulation of pathways responsible for elevating your mood.

Together, we will continue to explore new strategies that you can incorporate into your own workout routines to maximize both short term and long-term benefits to your health based on emerging research.



"A happy young woman holding two pink weights" by Nenad Stojkovic. June 6, 2022 on Flickr is licensed under CC BY 2.0.

Acute vs. Long-Term Exercise: What's the Difference?

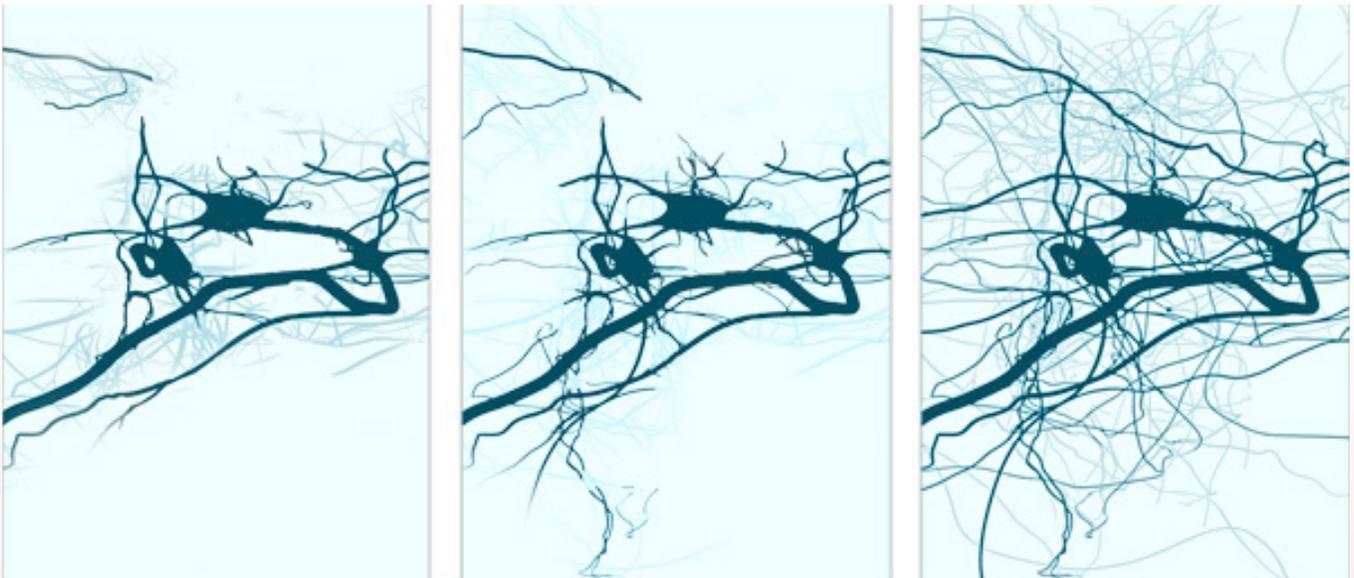
Before we get into the details of how exercise can influence the brain long-term, it is valuable to understand the benefits of a single bout of exercise — clinically referred to as acute exercise. We have discussed some brain benefits from short-term exercise, but interestingly, there are more benefits than just mood. How do these acute brain benefits of exercise compare to long-term brain benefits? Many clinical trial studies have been conducted trying to answer this question.

Studies on acute exercise explain that performing approximately a half-hour of aerobic exercise has benefits linked to motor learning, characterized by both the excitation and inhibition of the motor cortex observed with transcranial magnetic stimulation (TMS) measurements (2). These measurements provide evidence of motor learning improvements and the potential for enhanced cortical plasticity, or the brain's extraordinary ability to form new

connections between neurons based on lifestyle choices or experiences (2). Intriguingly, this indicates that simply performing a single round of exercise for a short amount of time does so much more than elevating the heart rate and mood. It sparks the performance and adaptation of new motor skills, particularly when there is repetition. Acute exercise also introduces the potential for making more neural connections throughout the brain. It was additionally found that acute exercise performed at a large range of intensities, from low to high, improved the following aspects of executive function for up to two hours: attention, problem solving, decision making, verbal fluency, cognitive flexibility, and even working memory (2). Though one may expect that these brain boosts after physical activity occur from activities performed over a longer amount of time, these effects were seen in as little as thirty minutes of aerobic exercise! This is significant because it illustrates that no matter how little exercise is performed, almost any form of exercise performed for some amount of time is great for brain health. As you may guess, if the

brain begins to develop stronger motor skills within the span of thirty minutes, the influences of the same exercise over a longer period must hold even more opportunities for levels of neuronal plasticity, learning, memory, and many other benefits.

Researchers have found that compared to short-term exercise, exercise consistently practiced over a long period of time results in many more enhancements and protective mechanisms being activated in the brain. In fact, the long-term benefits of physical activity on the brain are so vast, they have been incorporated into treatment programs for patients with various mental disorders. For example, a previous clinical study worked with middle-aged patients suffering from stress-related exhaustion with exercise incorporated into their treatment. Patients were given physical activity recommendations with comprehensive instructions as a part of a multifaceted treatment program for 18 months. It was found that though all of the patients experienced some level of improvement from burnout, depression, and anxiety, strong and mild compliers to physical activity



Neuroplasticity by CogniFit.com, illustrating neural networks before stimulation (1), after two weeks of stimulation (2), and after two months of brain stimulation (3).

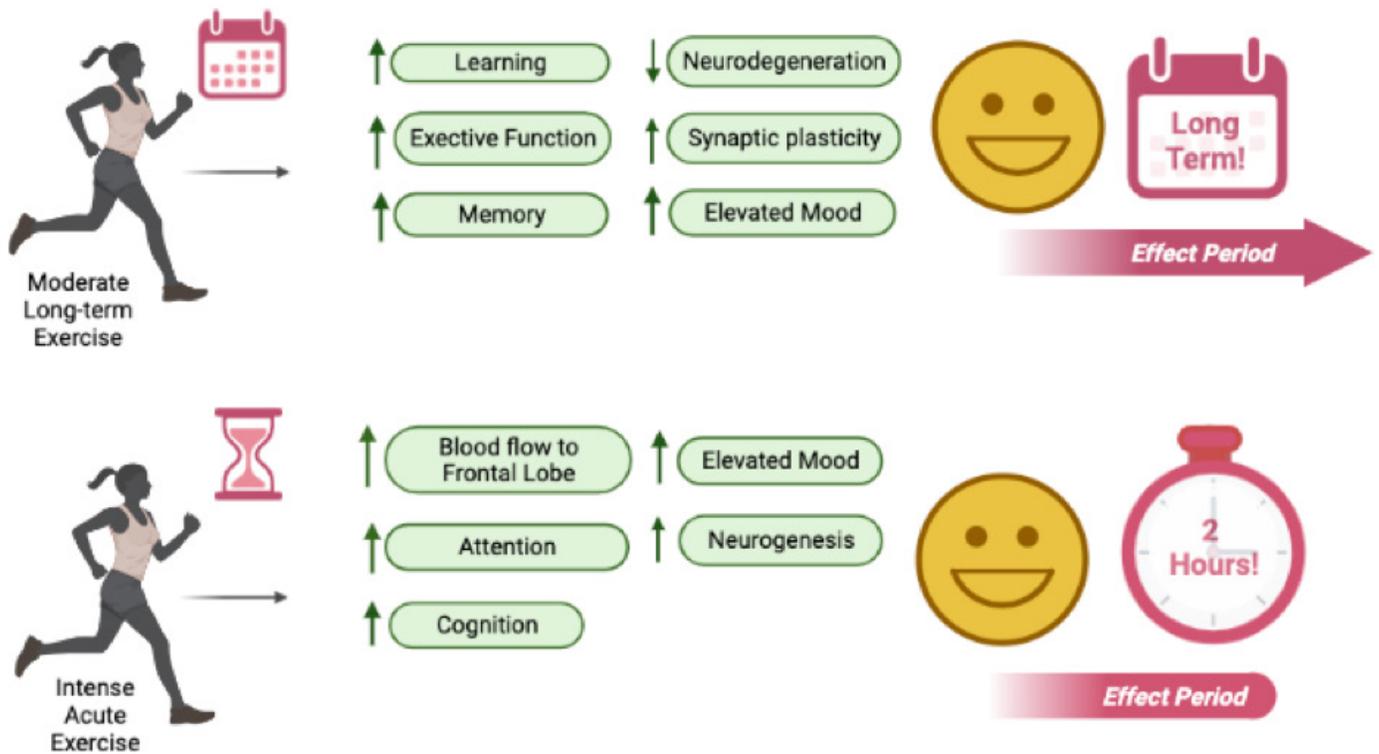


Figure 1. Long-term vs. short-term influences of exercise on cognition, mood, and behavior. Image created with Biorender by Selam Habtemariam.

recommendations reported significantly less burnout compared to non-compliers at the end of the 18-month period (3). This study revealed that long-term exercise helps with treating chronic stress and improving mental health, and can be incorporated into current treatment plans. Compliance with these recommendations is important in maximizing enhancement of brain health. Now that we have looked at long term brain benefits of physical activity in middle-aged people, let's consider these effects on young adults.

Another study with young adult women, ages eighteen to twenty-five years, with moderate levels of depression were also enrolled in an exercise program. The program lasted eight weeks in which researchers found that when students performed aerobic exercises with 60-65% maximum heart rate, levels of depression were reported to significantly decrease over the course of the

eight-week period (4). Of course, it would be too ambitious to assume from these results that curing depression through sport or other forms of physical activity are possible. After all, crucial sessions of psychotherapy, compliance to particular prescription medications, self-soothing techniques, and many other forms of treatment suggested by doctors for depression may be necessary to see substantial improvements in mood. But what other neural circuits do incorporations of regular aerobic exercise work through? If you guessed that long-term aerobic exercise improves brain function in more long-lasting ways than mood and stress deficits, you are absolutely right.

Incorporation of long-term exercise into your lifestyle can reduce the risks of developing detrimental effects of aging on the brain, or neurodegeneration (2, 5). Neurodegeneration is a process that occurs in many cognitive dis-

eases such as Alzheimer's, Parkinson's, and Huntington's disease. How does the brain assemble such a strong protection against these deadly brain diseases? The brain does this through heightening brain plasticity and neurogenesis, or the generation of new neurons in the brain (2, 5). Brain plasticity, or neuroplasticity, is responsible for the brain's extraordinary ability to adapt from experience through growth and reorganization of neural networks. As long-term exercise is performed, neurogenesis facilitates the brain's powerful ability to adapt through the generation and integration of new neurons. As you go for your next routine jog, think of how transformative exercise can be in strengthening these neural connections and protecting you not only from cardiovascular disease, but also many neurodegenerative and behavioral disorders!

Aerobic vs. Mindful Exercise: What's the Difference?

Have you ever tried running up a steep hill as fast as you could without stopping? Each step hiking upward to the top seems to make your steps and chest feel heavier, and you begin to pant heavily. Maybe you have been late to class or work. With the elevator taking too long, you grudgingly decide to take the stairs to class as fast as you can, feeling your heart rate increase and gasping for air when you finally get there. Or maybe you remember jumping rope with your friends when you were younger. Swinging the rope as fast as you could, you may have tried to see who could jump rope fastest or for the longest amount of time. What do all of these periods of physical activity have in common? Commonly known as "cardio," these are all forms of aerobic exercise. Aerobic exercise is characterized by physical activity that produces increased heart rate and increases the body's use of oxygen. Oftentimes, these are exercises of high intensity, though there are some lower impact aerobic exercises such as walking. However, benefits exist for both moderate and high intensity aerobic exercise. Moderate-intensity aerobic exercise is particularly



helpful in improving executive functions, such as working memory. High-intensity exercises, on the other hand, boost information processing (2). Each of these benefits may be something you would like to keep in mind as you think of what aerobic exercises you would like to get into. We now know that intensity matters, but all we have discussed are heart pumping exercises. Let's slow our pace and investigate another exercise.

Stretch your arms up, take a deep breath in, and slowly pull your arms down by your sides, breathing out. When done with the correct intention and focus, you should be engaging muscles up through the torso with the rising and falling of your breath with this stretch. In fact, you have

performed the first step of a new range of brain-boosting exercises: mindful exercises. You may be wondering how these soothing exercises may compare to aerobic exercise. Scientists have made these comparisons in participants of two mindful, low exertion exercises, Feldenkrais, and yoga. These exercises were compared to a computer class that served as a control, and two aerobic classes: an aerobic dance class, and a swimming class (8). Yoga, Feldenkrais, and swimming were all found to improve subjective well-being, anxiety, and general mood (8). On the other hand, participants' mood did not improve in the control computer class or aerobic dance groups. Interestingly, it was suggested that swimming has



components of both mindful and aerobic exercise. The rapid, rhythmic, and repetitive nature of the movements in conjunction with controlled breathing awareness may produce particularly heightened benefits in decreasing anxiety and improving general mood (8). This suggests that finding an exercise routine that incorporates both mindful and aerobic qualities can maximize the benefits of physical activity on brain health.

Is there such a thing as too much exercise?

We have explored the vastness of benefits that exercise has on the brain along with the diverse modes of exercise that have been studied to maximize these benefits. Taking all of this into consideration, is there a limit to how much we should exercise to reap these benefits? More importantly, how does excessive exercise influence brain functionality? As you may have guessed, too much of anything often leads to more harm than good for the body.

In many of our favorite athletes, we likely have seen the influence of over-training on the physical body. Some of the injuries that result may cause physical burnout, temporary inability to compete, end careers completely, or may even cause life-threaten-

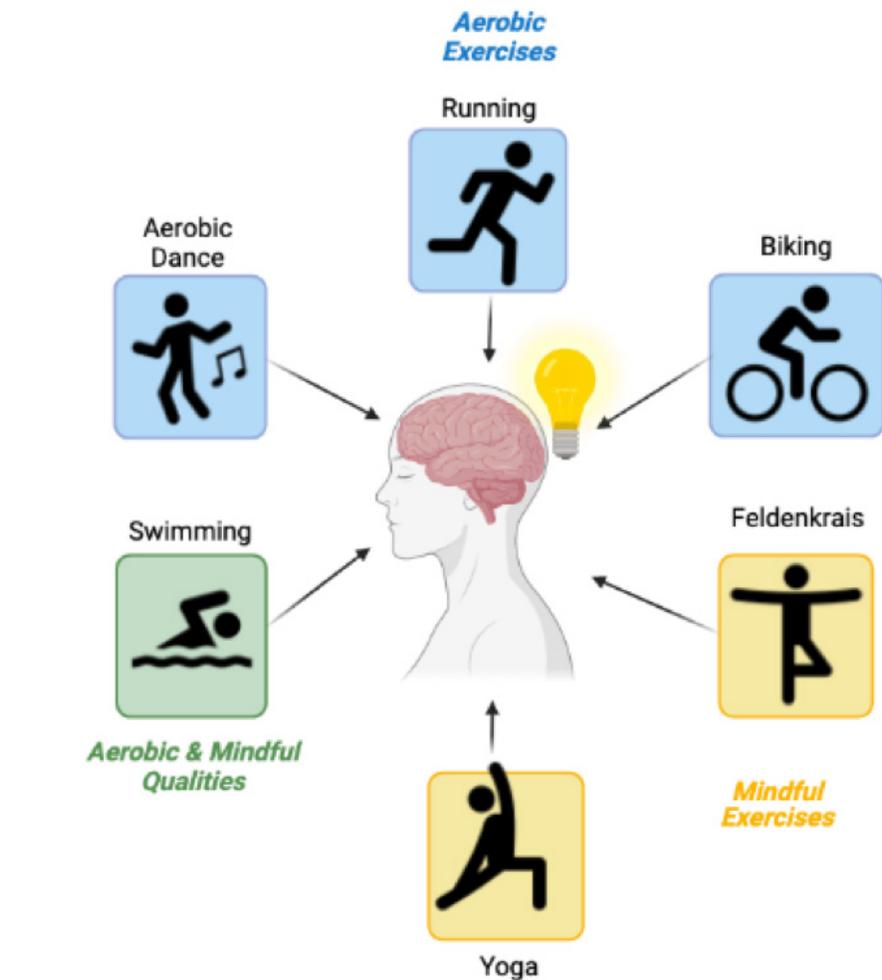


Figure 2. Aerobic, mindful, and combination exercises to boost brain health. Created by Selam Habtemariam. Image created with Biorender by Selam Habtemariam.

ing complications. Unfortunately, overtraining or excessive exercise may cause the brain to burnout as well. For this reason, it is vital to understand the limitations of how much physical activity we should incorporate in our daily lives. We have previously discussed the necessity of compliance with suggested physical activities given

by medical providers, and studies have also explored the negative influences of overexertion of the body on the brain (3). Studies have shown that excessive training, particularly through aerobic exercises, causes cognitive fatigue, reduced activity in the prefrontal cortex, and increased impulsive behaviors (9). Cognitive control is required for goal setting behavior. Goal setting behavior helps prevent impulsive behavior, such as not stopping physical exertion of the body when it hurts. These results may seemingly conflict with our general findings on aerobic exercise benefits, but they actually describe how the cognitive effects of burnout can persist if not attended to. For this reason, it is important to be mindful of what should and should not be incorporated into your exercise routines.



Tips for Creating your Brain-boosting Exercise Routine

Many people likely have a new year's resolution of staying active to improve their health. We have explored the specifics of the influence of exercise, so now is a good time to get up, do some stretches, and start warming up before we secure a solid routine! Nevertheless, it can be really intimidating to know where to begin. With time constraints of classes, work schedules, and an even longer list of commitments, it can also be difficult to set a routine that works effectively for one's individual needs. The main objective is to incorporate exercise into a long-term plan to improve brain function more effectively. It likely will take some time to explore what modes and levels of exercise work best for you.

While these may all be healthy ways to boost brain health, always consult your doctor before preparing lifestyle changes. If other health complications may get in the way of remaining physically active, this is particularly important. Moreover, here are some suggested tips before you make your own routine:

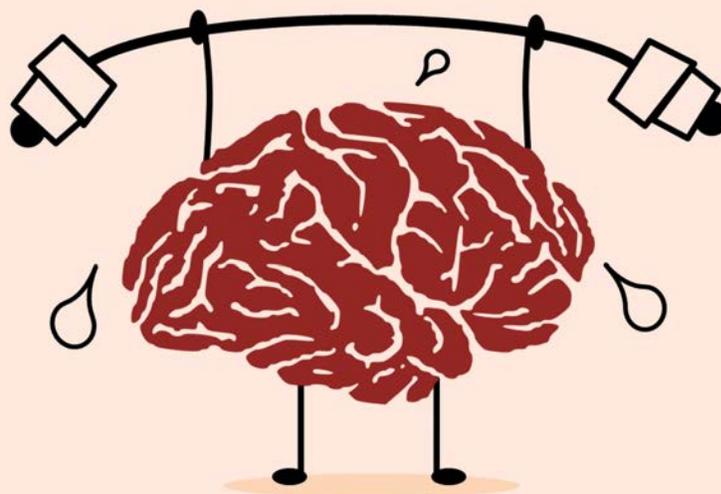
Suggested Tips:

1. Oftentimes, exercises that improve heart health aid in brain health as well.
2. Practicing exercises regularly is crucial to reaping benefits in brain health, longevity of cognitive function, and production of long term changes in brain plasticity.
3. Know the limits of both what your brain and body can handle.
4. Try and craft an exercise routine that incorporates all the benefits of exercise. This likely will mean you may want to try out a mix of aerobic exercise, mindful exercise, high-intensity exercise, moderate intensity exercise, etc. We have discussed that swimming is a mode of exercise that thoughtfully engages in many of these aspects, making it a great option for enhancing your brain health.
5. Know what your brain needs. This will likely mean you will want to work with a professional and do your research before you dive in.

"Exercise is really for the brain, not the body. It affects mood, vitality, alertness, and feelings of wellbeing. Exercise is the single best thing you can do for your brain in terms of mood, memory, and learning."

John Joseph Ratey, M.D., clinical professor of Psychiatry at Harvard Medical School.

As you engage your body in some healthy physical exercise, think of all these lasting benefits and hopefully they will motivate you to fulfill your goal of elevating the power of your brain.





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