

Vigorous exercise boosts critical neurotransmitters, may help restore mental health

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Richard Maddock and his team conducted MRI exams of people before and after vigorous exercise to determine the effect of exercise on neurotransmitters.

People who exercise have better mental fitness, and a new imaging study

from UC Davis Health System shows why. Intense exercise increases levels of two common neurotransmitters—glutamate and gamma-aminobutyric acid, or GABA—that are responsible for chemical messaging within the brain.

Published in this week's issue of *The Journal of Neuroscience*, the finding offers new insights into [brain](#) metabolism and why [exercise](#) could become an important part of treating depression and other neuropsychiatric disorders linked with deficiencies in neurotransmitters, which drive communications between the brain cells that regulate physical and emotional health.

"Major depressive disorder is often characterized by depleted glutamate and GABA, which return to normal when mental health is restored," said study lead author Richard Maddock, professor in the Department of Psychiatry and Behavioral Sciences. "Our study shows that exercise activates the metabolic pathway that replenishes these neurotransmitters."

The research also helps solve a persistent question about the brain, an energy-intensive organ that consumes a lot of fuel in the form of glucose and other carbohydrates during exercise. What does it do with that extra fuel?

"From a metabolic standpoint, [vigorous exercise](#) is the most demanding activity the brain encounters, much more intense than calculus or chess, but nobody knows what happens with all that energy," Maddock said. "Apparently, one of the things it's doing is making more neurotransmitters."

The striking change in how the brain uses fuel during exercise has largely been overlooked in brain health research. While the new findings account for a small part of the brain's energy consumption during

exercise, they are an important step toward understanding the complexity of [brain metabolism](#). The research also hints at the negative impact sedentary lifestyles might have on brain function, along with the role the brain might play in athletic endurance.

"It is not clear what causes people to 'hit the wall' or get suddenly fatigued when exercising," Maddock said. "We often think of this point in terms of muscles being depleted of oxygen and energy molecules. But part of it may be that the brain has reached its limit."

To understand how exercise affects the brain, the team studied 38 healthy volunteers. Participants exercised on a stationary bicycle, reaching around 85 percent of their predicted maximum heart rate. To measure glutamate and GABA, the researchers conducted a series of imaging studies using a powerful 3-tesla MRI to detect nuclear magnetic resonance spectra, which can identify several compounds based on the magnetic behavior of hydrogen atoms in molecules.

The researchers measured GABA and glutamate levels in two different parts of the brain immediately before and after three vigorous exercise sessions lasting between eight and 20 minutes, and made similar measurements for a control group that did not exercise. Glutamate or GABA levels increased in the participants who exercised, but not among the non-exercisers. Significant increases were found in the visual cortex, which processes visual information, and the anterior cingulate cortex, which helps regulate heart rate, some cognitive functions and emotion. While these gains trailed off over time, there was some evidence of longer-lasting effects.

"There was a correlation between the resting levels of glutamate in the brain and how much people exercised during the preceding week," Maddock said. "It's preliminary information, but it's very encouraging."

These findings point to the possibility that exercise could be used as an alternative therapy for depression. This could be especially important for patients under age 25, who sometimes have more side effects from selective serotonin reuptake inhibitors (SSRIs), anti-depressant medications that adjust neurotransmitter levels.

For follow-up studies, Maddock and the team hope to test whether a less-intense activity, such as walking, offers similar brain benefits. They would also like to use their exercise-plus-imaging method on a study of patients with depression to determine the types of exercise that offer the greatest benefit.

"We are offering another view on why regular physical activity may be important to prevent or treat depression," Maddock said. "Not every depressed person who exercises will improve, but many will. It's possible that we can help identify the patients who would most benefit from an [exercise prescription](#)."

More information: "Acute Modulation of Cortical Glutamate and GABA Content by Physical Activity, *The Journal of Neuroscience*, 2016.

Provided by UC Davis

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