

# **THE LINK BETWEEN EXERCISE** **AND MORE BRAINPOWER**

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## **Neuroscientists say parents who want to boost their children's mental performance should encourage kids to hit the road before they hit the books**

It is first period at City Park Collegiate Institute in Saskatoon, and the Grade 10 students in Allison Cameron's class are priming their brains for an English assignment.

They strap heart monitors on their wrists and climb on a treadmill or exercise bike for a 20-minute workout. When they're done, they move to their desks and start writing. The students are taking part in a program that aims to help them improve their focus, concentration and, ultimately, their academic performance through regular exercise in class.

The results have been startling: On standardized tests, the children in Movement Matters have dramatically outscored students in classes in which the program wasn't offered.

Ms. Cameron is a special-education teacher, not a scientist. But her hunch that exercise might help kids learn is backed by a growing body of research on what scientists call executive functions, the set of mental skills or thinking processes that help us pay attention to what we are doing and get the job done.

Executive functions include the ability to focus and avoid distractions, to subdue inappropriate impulses and to mentally manipulate the information needed to solve a problem or complete a task. Together, they have been described as the CEO of the brain, responsible for taking the steps and marshalling the resources needed to reach a goal. Some studies have found they are a better indicator of how young children will fare in school than IQ.

For years, many scientists believed that executive functions were inherited and largely immutable, at least without medication. Now, however, there is growing evidence that certain activities may boost that kind of brain power.

Exercise could lead to enhanced mental performance, and so could a more playful approach to kindergarten that focuses on improving impulse control and other executive-function skills. Music lessons may also help, according to preliminary Canadian findings that suggest young musicians do better at certain mental exercises than their counterparts who haven't had formal training in music.

The work offers the possibility of improving the performance of a wide range of students, from those who already get top marks to those with conditions such as attention deficit hyperactivity disorder that make it more difficult to learn. Experts say if training in executive functions is started early enough, it might even protect kids from developing some of those disorders.

It is unclear, however, exactly how these activities change the brain. Some suspect that in the case of simple exercise, such as running on a treadmill, the explanation is better blood flow to the brain. But Adele Diamond, a neuroscientist at the University of British Columbia, has a different perspective that suggests more complex forms of exercise, such as hockey or tennis, might be better for improving executive functions.

Ground zero for executive functions is the prefrontal cortex, the part of the brain involved in problem-solving and complex thought. The brain circuits involved in cognitive function overlap with those relating to motor function, Dr. Diamond says. Priming one system can engage the other.

"If you can get a circuit in the brain working better in hockey, it should also work better in chemistry," she says.

Like many of her students, Ms. Cameron can have trouble concentrating, and finds that running or going to the gym helps her stay focused.

She tried running with a class of children with serious behaviour problems, and found that the exercise led to big improvements in how they handled themselves in school. That prompted her to look into research on exercise and the brain.

For years, most experiments had focused on how exercise could improve cognitive function in the elderly. But the growing body of literature on young people shows there is now a consistent pattern, a correlation between physical activity or fitness and a modest improvement in academic achievement, says Mark Tremblay, who leads the Healthy Active Living and Obesity Research Group at the Children's Hospital of Eastern Ontario.

"It appears that academic performance proceeds at a faster rate when exposed to physical activity."

Researchers in the U.S. and Germany have zeroed in on improvements in executive functions as an explanation for why working out can help kids in the classroom. Charles Hillman, a researcher in Illinois, has done a number of studies that have found that students who exercise do better on executive-function tests than the control group. They also do better on math tests.

Both kinds of tests were administered within an hour of the kids' workout, and suggest that timing may be important. Exercise at the end of the day, or after math or language arts, may not be as helpful. "We don't know how long the effect lasts," Dr. Hillman says.

Still, he and other experts say it's time to rearrange schedules in schools to have exercise breaks throughout the day. More schools in North America need programs like the one at City Park Collegiate or in Naperville, Ill., where high-school students are offered an early-morning exercise class, says

John Ratey, a Boston psychiatrist who has written the book *Spark: The Revolutionary New Science of Exercise and the Brain*.

Schools in Finland have 15 minutes of play after every hour of class, and students there regularly outperform kids from around the world in international education studies, Dr. Ratey points out.

"There is a wave of awareness about the positive effect of exercise on the brain, and in specific executive functions."

The type of workout may make a difference. Getting the heart rate up is important, but in one German study, games that required complex skills - such as throwing and catching while moving - led to a greater improvement in focus and concentration than more rote exercise.

In another study, Sabine Kubesch and her colleagues at the University of Ulm in Germany studied 81 Grade 7 students and found that a group that vigorously exercised for 30 minutes did better on a test designed to assess their ability to avoid distraction than a group that had only a five-minute movement break to stretch and move around.

This kind of work is still at an early stage, and scientists do not know how exercise improves executive functions. Dr. Ratey's theory is that exercise warms up the brain circuitry involved in executive functions, priming it for action.

But a different explanation is needed for other activities that seem to boost this type of brain power, such as Tools of the Mind, an experimental approach to teaching kindergarten that is now being studied by the UBC's Dr. Diamond and other researchers.

It focuses on dramatic play, and Dr. Diamond has found that it helps children regulate their impulses and develop mental flexibility. When they are playing at being a doctor and a patient, they have to inhibit the urge to act out of character. They also have to adjust quickly and flexibly to whatever plot changes may be introduced by another child.

"Play is really important, and taking it out of the curriculum actually hurts academic performance," Dr. Diamond says.

Tools of the Mind has a number of important components, she says, including a social one, which she sees as key. The children do most of their work in pairs or small groups. In math, the children are paired up, and one child is the checker, since picking out others' mistakes helps them learn to identify their own.

Dr. Diamond's first study looking at Tools of the Mind, published in 2007, produced strong evidence that it significantly improved executive functions in four- and five-year-olds from low-income families in the United States.

Now, she and her colleagues are following up with a large, longitudinal study that they hope will follow 4,000 to 5,000 children in Colorado. The kids are now in kindergarten and the researchers will track them until Grade 6. They are also hoping to get funding to study Tools of the Mind in Canada.

Dr. Diamond wants to know if the benefits in kindergarten will continue over time. Do kids who have not participated in the program eventually catch up? Does it help only poor kids or those at risk of problems or children from all kinds of homes?

"I predict there should be mental-health benefits. Less attention deficit hyperactivity disorder, or it will be less severe. Less conduct disorder, the behaviours that get kids into trouble," Dr. Diamond says.

Music might be another option for improving executive functions. The University of Toronto's Glenn Schellenberg wants to know why kids who take piano lessons or learn to play another instrument improve their scores on IQ tests after a year. These scores are usually stable - people tend not to improve over time.

Dr. Schellenberg and his colleague, Sylvain Moreno at York University in Toronto, are investigating their hunch that the improvement stems from music's ability to improve executive functions. They are testing the executive functions of musicians seven to nine years old who have had three years of training and comparing them to students who have not studied music.

Preliminary results suggest that their hypothesis is correct, Dr. Moreno says. The young musicians performed better on a test called the Tower of London, in which they have to think ahead to solve a problem in as few moves as possible.

They also had faster reaction times on a test in which two squares appear on the computer screen, one red, one blue. The children are told to press a key on the right side when they see the red square and a key on the left when they see the blue one.

This is easy when the square is in the middle of the screen. But when the red square appears on the left, they have to press a key on the right. "The instinct is to press on the left because the stimulus is on the left," Dr. Moreno says.

Preliminary data show that the children who took music lessons had faster reaction times.

It is easy to see how studying piano or another instrument probably strengthens executive-function skills such as staying focused and ignoring distractions, but Dr. Moreno suspects that music also activates the brain and strengthens it indirectly.

"We are talking about transferring skills, not direct training. Music trains different areas of the brain that are also involved in memory and language," he says. "You stimulate one neuron, and this neuron is involved in music but also in other areas. That is my main hypothesis."

Dr. Diamond argues that the best activities for improving executive functions involve cognitive, physical, emotional and social elements. To engage in social activities you have to exercise executive functions, she says. "It provides training and practice."

She suggests that taking part in a youth orchestra would be even better than individual music lessons because it involves a social component. Dance lessons could be ideal, she says. She is planning two studies in the Vancouver area to look at whether dance can improve executive functions and academic attainment.

Like music, dance requires sustained concentration. "You have to hold complex sequences in mind. You have to flexibly adjust to what is happening." Hockey is another good bet, she says, because players have to use skills they learned as situations change on the ice.

But back at City Park Collegiate, a more basic kind of workout seems to be helping many of the students. Many have attention deficit hyperactivity disorder, behavioural problems or other difficulties. Many are from low-income families and have faced tough times in their young lives

Ms. Cameron has been amazed by the students' improved performance on math and writing tests, but also by changes in their behaviour.

Some of the students were able to stop taking medication for ADHD. They were finishing assignments and coming to school regularly.

Today, Movement Matters is in its third year and most classes at the school take part. Companies have donated equipment, as has cyclist Greg LeMond, who offered Ms. Cameron six top-of-the-line spinning bikes. A number of schools across the country are interested in setting up something similar.

Fifteen-year-old Benji, whose guardian doesn't want his last name published, goes twice a day to the room with the exercise equipment. He alternates between the bike and treadmill, and usually gets his heart rate up to 140 beats a minute.

"When I first started, I was real tired," he says. "When I got used to it, it woke me up more. I kind of got better at doing math and reading."



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