Exercise gives genes a workout, but can coffee do the same?

April 27 2012, by Marnie Blewitt

The relationship between mocha-lattes and pilates might be deeper than you think. Credit: Brian Wilkins

Have you ever wondered how you could get more out of your workouts? And have you ever wondered what actually happens to your muscles when you exercise?

Recent studies have begun to look, in detail, at the changes that occur in the way our genes are used both during and after exercise. And the results of the most recent study, by Dr. Juleen Zierath and colleagues, might hold insights into why our fitness trails off after stopping exercise.

But first, a bit of background.

Of the tens of thousands of genes you have in each and every cell of your body, only a subset are used at any one time in each cell. If a gene is used, the information within is used to create a protein product; a process called gene expression.

The genes that are used (the gene expression, in other words) then determines the function of the cell in question. A different set of genes being expressed will produce a cell that fulfils a different purpose.

For instance, red blood cells express the haemoglobin gene and so make haemoglobin, which can bind oxygen, and allows these cells to traffic oxygen around the body. Other blood cells that fight infection, the white blood cells, produce toxic chemicals and enzymes to attack the invading infection.

Over the last few years, it has been shown that exercise rapidly induces changes in gene expression in the skeletal muscle cells.

These are cells that you voluntarily contract when you exercise – such as your thigh muscles – rather than say the heart muscle, which contracts without you thinking about it, even when you're asleep.

Most of the changes in genes induced by exercise are related to the usage of energy within the skeletal muscle cell. Interestingly, these changes are proportional to how hard you train: higher intensity exercise leads to more dramatic changes in the skeletal muscle cells.

This makes sense: the harder you train, the more energy is required by your muscles. The changes in the energy-usage genes are also maintained long after you've finished your workout.

This helps to explain why your metabolic rate – the amount of energy you burn – is high during the workout and for several hours afterwards.

So how does a skeletal muscle cell bring about the quick changes in the genes that are used, to rapidly provide the energy required for exercise? And how do they allow the energy-usage genes to be switched on?

Well, we know calcium is released within the cell, sending a signal to alter gene expression. But then how does the calcium signal alter which genes are expressed?

The recent study by Dr. Zierath and colleagues, published in the Cell Metabolism journal, has started to address this question.

They looked at small modifications made to the genes in skeletal muscle cells, called epigenetic marks.

Epigenetic marks are tags associated with your genes that help a cell interpret when to use a gene and when to switch a gene off.

One way to think of epigenetic marks is as the punctuation marks in the cell. Punctuation marks don't change the words themselves, they just help us to read a sentence. The same is true of epigenetic marks: they don't change the genetic information, they just help the cell to make sense of that genetic information.

Dr. Zierath's group found that exercise induces skeletal muscle cells to switch on the energy-usage genes while removing some epigenetic marks from the energy-usage genes.

Like the changes in the gene expression itself, these changes in epigenetic marks are rapidly induced and are maintained for several hours after the exercise session.

But the epigenetic changes are not retained for even a couple of days after a three-week training program – the length of time the study's

subjects were asked to train for.

Most athletes know that peak fitness is only retained for a day or so after completing a training program. Could the work of Zierath and colleagues explain why?

That is, does fitness wear off because the epigenetic marks on energy-usage genes within skeletal muscle cells have returned to normal?

Perhaps even more interesting is a small part of Dr. Zierath's study which showed that some of the changes in gene expression and epigenetic marks on energy-usage genes can be mimicked by caffeine.

Your daily coffee could be giving your genes a workout!

It's been known for some time that many of the gene expression changes induced by exercise can also be influenced by signals from the brain or hormones in your blood stream. But in the case of caffeine, we are clearly much more able to manipulate the system to our advantage.

There is still much to be learnt about caffeine-induced changes in gene expression, and how it compares to actually working up a sweat at the gym.

Many intriguing questions remain, not least of which: does caffeine exposure alter the effectiveness of your training?

No-one would recommend a coffee rather than exercise but maybe a coffee before your workout could actually enhance your body's physiological response to exercise … even if the coffee does leave you dehydrated and jittery.

This is certainly something worth testing. On the flip side, these effects

may add weight to recent calls for caffeine bans to be reintroduced to competitive sports.

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