

Dampening cramp

Sports physician shows that targeted training with electrical impulses raises cramp threshold frequency

By Anne Hardy

Most people take magnesium against skeletal muscle cramps. However, scientific evidence is thin – and that cramps are caused by an electrolyte deficiency is a theory dating back over 100 years. In his search for what causes cramps, sports physician Michael Behringer has made an interesting discovery: cramps triggered artificially can significantly reduce the tendency to cramp.

It was an abrupt end for top basketball player LeBron James when he had to be carried off the court during the 2014 NBA Finals due to sudden cramp in his calf. Leg cramps are common among professional athletes, especially triathletes and marathon runners. It's hamstrung many a victory. Especially at the Olympic Games, this is a bitter disappointment for athletes after four years of hard training.

But athletes are not the only ones plagued by muscle cramps. Some people have frequent and extremely painful cramps in their calves at night, which forces them to get up and stretch or massage their legs. "In severe cases, the combination of pain and lack of sleep sometimes even leads to suicidal thoughts," says Professor Michael Behringer, sports physician at Goethe University.

Biarticular muscles, such as those forming part of the calf muscles, are particularly prone to cramps. They run across the knee and ankle joints and can therefore shorten more drastically when the joints are in certain positions. At night, for example, when the leg is bent, and the bedding presses down on the toes. Behringer tells the story of a truck driver who has suffered from cramps in his thighs since the age of ten. The frequency and intensity have meanwhile increased to such an extent that he is unable to work. Even the quinine-based medication usually prescribed in these cases has not helped.

Magnesium: effect in athletes not yet studied

In grassroots sports, magnesium is the most popular remedy for cramp. Prior to or after a run, the amateur athlete dissolves a tablet in water to compensate for the electrolyte deficiency caused through perspiration. In doing so, the athlete is following a theory established over 100 years ago. Miners in the USA often suffered from cramps during their hard and sweaty work underground. Blood tests showed that they lacked electrolytes, which is how the theory originated.

"Regretfully, however, little has happened in research since then because it hasn't been possible to trigger and study cramps in the laboratory," says Behringer. According to a meta-analysis published in the Cochrane Database in 2020, there is very little evidence that magnesium prevents or relieves cramps. Most of the studies, however, referenced spontaneous cramps in people between 60 and 70 years of age. Studies were inconclusive on leg cramps at night during pregnancy. And randomised controlled trials (RCTs) on the effects of magnesium in athletes are lacking altogether.

Cramps from fatigue?

In 1997, Martin Schwellnus and colleagues from the University of Cape Town Medical

School in South Africa published a new hypothesis that explained muscle fatigue as the cause of exercise-related cramps. Fatigue, they said, throws the regulatory circuits off balance that the nervous system uses to regulate muscle tension and length. If the muscles are overtired, the activating signals from the spinal cord dominate over the inhibitory ones.

At the present time, cramp researchers are divided into two camps: fans of the electrolyte theory and fans of the Schwellnus deregulation theory. Behringer attempts to link the two by assuming that fluid loss is a common element in both theories, which is supported by the fact that people are more prone to cramps in the summer. For example, an analysis revealed far more Google searches for "leg cramps" during the hot months. Perspiring as a result of physical activity in hot, humid weather thus appears to increase muscles' tendency to cramp. "This could also be observed during a particularly hot summer at Wimbledon," says Behringer. "An unusually large number of matches had to be interrupted because of cramps."

On the other hand, the fact that cramps in the calf are quickly relieved by stretching, that is, by flexing the foot upwards (dorsal extension) supports Martin Schwellnus' theory that the regulatory circuit between muscle fibres and the spinal cord is dysfunctional. In addition, muscle cramps are difficult to trigger if impulse conduction between muscle and spinal cord is temporarily switched off by a local anaesthetic.

Dehydration and lower susceptibility threshold

According to Behringer, fluid loss intensifies this effect known as deregulation. The interaction of nerve impulses that control muscle tension and relaxation is dysfunctional because the muscle loses some of its volume when the body is dehydrated. According to current theory, this in turn increases the probability of spontaneous peripheral activation, that is, activation originating close to the nerve. The muscle contracts even more. If it now tenses and thus shortens even further, it is dangerously close to contracting and shortening as far as it can, which triggers cramps. According to current understanding, this is caused by an imbalance between activating and inhibitory nerve impulses from the muscles to the spinal cord. Cramps can occur in mild temperatures too if the muscle is tired and thus more "susceptible" because the inhibitory

IN A NUTSHELL

- There are surprisingly few hard scientific facts on the cause and treatment of muscle cramps.
- At present, there are two opposing theories: the electrolyte theory and the nervous system deregulation theory.
- The cramp training developed by Professor Michael Behringer raises the cramp threshold frequency but is unsuitable for milder cases because it is accompanied by severe pain.

Even superstars like American basketball player LeBron James are not immune to cramps. Again and again, he has led his team to victory in pain – but was also sometimes obliged to abandon the game.

feedback from the muscles is weak, thus oiling the works for cramps.

It was these considerations that led Behringer to examine muscle tension in people more prone to cramps. The experimental setup is extremely simple: the test candidate is asked to sit on a bench with their legs dangling down and two electrodes are stuck to one of their legs. An alternating current is applied to the electrodes, which stimulates the muscle in a similar way to physical exercise or work – but shortens it to a



Photo: Christoph Skuttschik

Muscle cramps are triggered in the laboratory by raising the frequency of electrical impulses. The purpose of this “training” is to gradually increase the susceptibility threshold for cramps – a source of relief for athletes.

maximum. The frequency is now gradually increased with the same current until the muscle begins to cramp. Sports scientists define the cramp threshold as the frequency that is just enough to trigger cramps.

Cramp training only for severe cases

The measurements showed that people more prone to cramps also have a lower susceptibility threshold. Their muscles evidently have a higher resting tone, and it is therefore easier to induce the cramp threshold. In the process, Behringer made a surprising discovery: in the course of successive measurements, his test candidates’ threshold rose from week to week until no artificial cramps could be triggered at all. “We were able to show that the muscles grow as a result of such cramp training,” Behringer explains. “But far more exciting was our observation of the ris-

ing cramp threshold frequency, which so far no other method has been able to achieve.”

Behringer stresses that his “cramp training” is currently only being investigated in the framework of studies. And even if it should enter clinical practice, it will be reserved for people with severe cramps. “How painful artificially induced cramps are should not be underestimated,” he says. When it comes to application in practice, he is thinking about cases such as that of a former pole vaulter, whose tendency to cramp stopped him from competing altogether, or of people who suffer frequently from cramps due to a narrowing of the spinal canal or a slipped disc. He was able to show in a study that the treatment reduced their cramps significantly.

Nobel Prize laureate’s spicy cocktail

Recently, Behringer has taken a closer look at HOTSHOT, which was developed in 2016 by Nobel Prize winner Rod MacKinnon to prevent cramps or muscle strain and is widely used by professional athletes in the USA. According to the story on the website as to how the company was founded (<https://teamhotshot.com/founders>), MacKinnon, neuroscientist and endurance athlete, was overcome by severe cramps while kayaking at sea with his friend Dr Bruce Bean. Both could barely steady their kayaks. It seems that MacKinnon saved himself from this dangerous situation by drinking the vinegar of pickled gherkins – presumably with the idea of replenishing his electrolyte balance. But the cramps subsided much faster than expected.

Back at their institute, the two neuroscientists searched for an explanation. They discovered that the acidic concoction, with spices such as peppercorns and mustard seeds, stimulates sensory nerve tracts from the mouth to the stomach. These send signals to the spinal cord, which in turn dampens excitation signals to skeletal muscles. “The truth is that cramps are caused by misfiring nerves,” it says on the website. Or put even more simply: “It’s the nerve, not the muscle.”

“HOTSHOT” put to the test

To stimulate the receptors in the mouth and stomach even more effectively, MacKinnon and Bean chose ginger, cinnamon and very hot chili peppers (jalapeño) as even hotter ingredients for their “HOTSHOT”. Capsaicin, the active ingredient in these spices, is also found in pepper spray. “I doubt that a marathon runner’s gastrointestinal tract can easily digest such a cocktail at the starting line,” comments Behringer.

But can HOTSHOT at least prevent muscle cramps? Behringer and his colleagues studied this with the help of their experimental setup. They were able to detect only a minor effect,

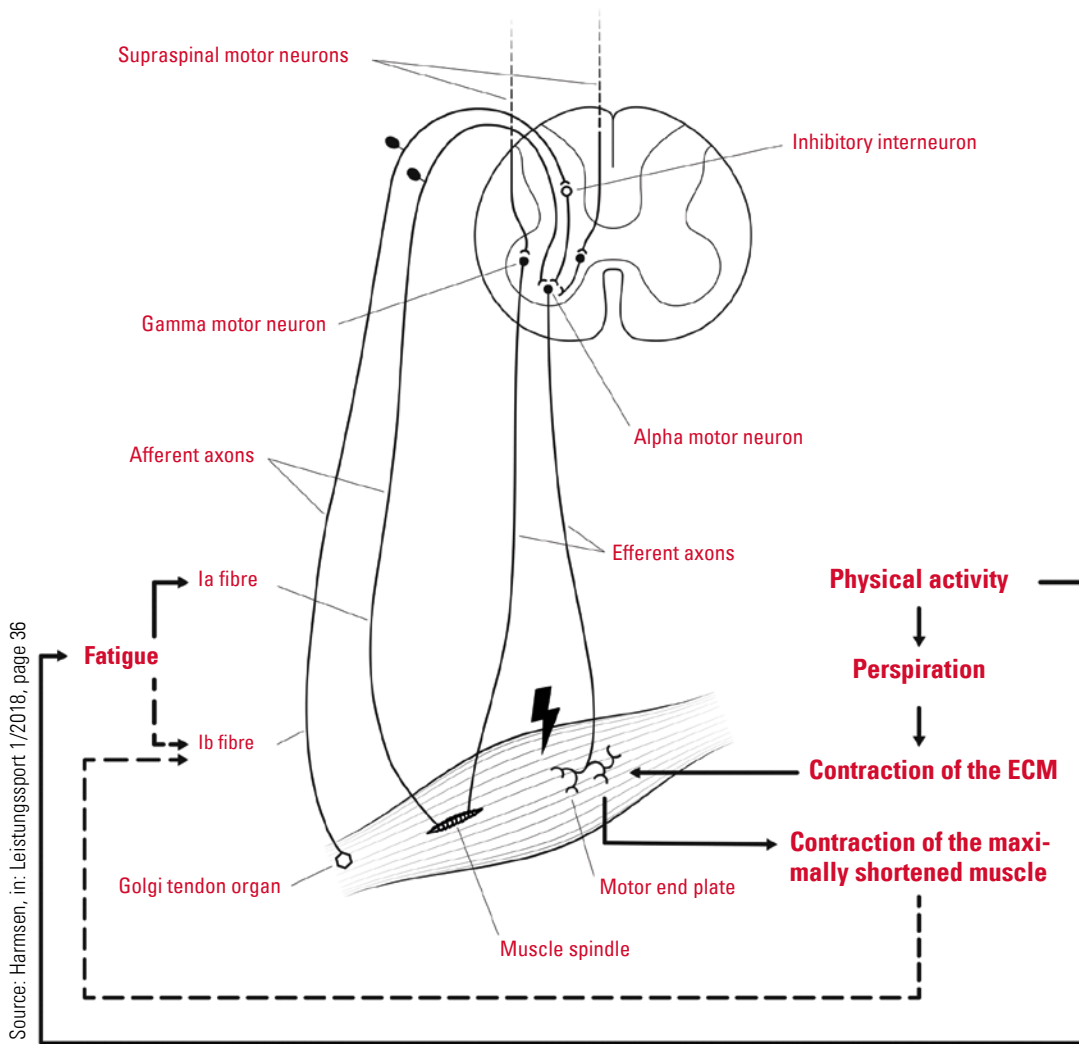
ABOUT MICHAEL BEHRINGER



Professor Michael Behringer, born in 1978, studied medicine at Heinrich Heine University Düsseldorf. He has headed the Department of Sports Medicine and Exercise Physiology at Goethe University since 2017, before which he led the Muscle Research Group at the Institute of Exercise Training and Sport Informatics at the German Sport University Cologne for ten years. In parallel, he worked at the German Research Centre of Elite Sport (momentum) in Cologne.

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CRAMPS CAUSED BY FATIGUE AND HEAT



Source: Harmsen, in: Leistungssport 1/2018, page 36

When the body is under extreme physical stress, muscle fatigue and dehydration often occur at the same time and, according to current theories, lead to cramps via various mechanisms. In the case of fatigue, an imbalance of inhibitory and activating signals occurs in favour of the latter. A severe loss of volume due to excessive perspiration can cause muscle contraction through mechanical deformation of the nerve endings, causing maximum shortening of the muscle. In this position, the imbalance between inhibition and activation induced by fatigue increases even further.

which subsided after a few hours. In comparison, the effect of cramp training lasts for weeks and months.

For Behringer, many questions remain unanswered. For example, he does not rule out the possibility that electrolyte deficiency influences the tendency to cramp. Christoph Skutschik, his doctoral student, is currently examining the significance of magnesium in treating cramps. Magnesium plays a role in over 300 enzymatic reactions in the body. Its inhibitory effect on the nervous system is known, and in cases of an extreme deficiency, cramps that disappeared after magnesium was administered intravenously has been observed in studies. "This shows that the correlation between magnesium deficiency and cramps is not plucked out of thin air," says Skutschik, "the question is rather whether magnesium supplements have an additional protective effect for athletes." Until the data are clearer, he believes that taking a low dose of magnesium can at any rate not

harm. However, it would be better to meet the body's daily magnesium requirement through a balanced diet rich in magnesium, with whole grains, leafy vegetables, nuts, seeds and pulses. According to Behringer's experience, stretching remains the most effective strategy for people with "normal" cramps that occur now and then during physical exercise or hot weather. ●



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