Spectroscop
a virtual bio

María Camila Trillos Almanza.

Internal medicine.

Gloria Cecilia Vega Ávila.

Physical Educator, MSc in basic biomedical sciences.

Alexandra Montoya González.

Surgeon.

Raúl Narváez Sánchez Sánchez.

Surgeon, PhD in human physiology. Professor of Universidad de Antioquia's Faculty of Medicine.

Juan Camilo Calderón Vélez.

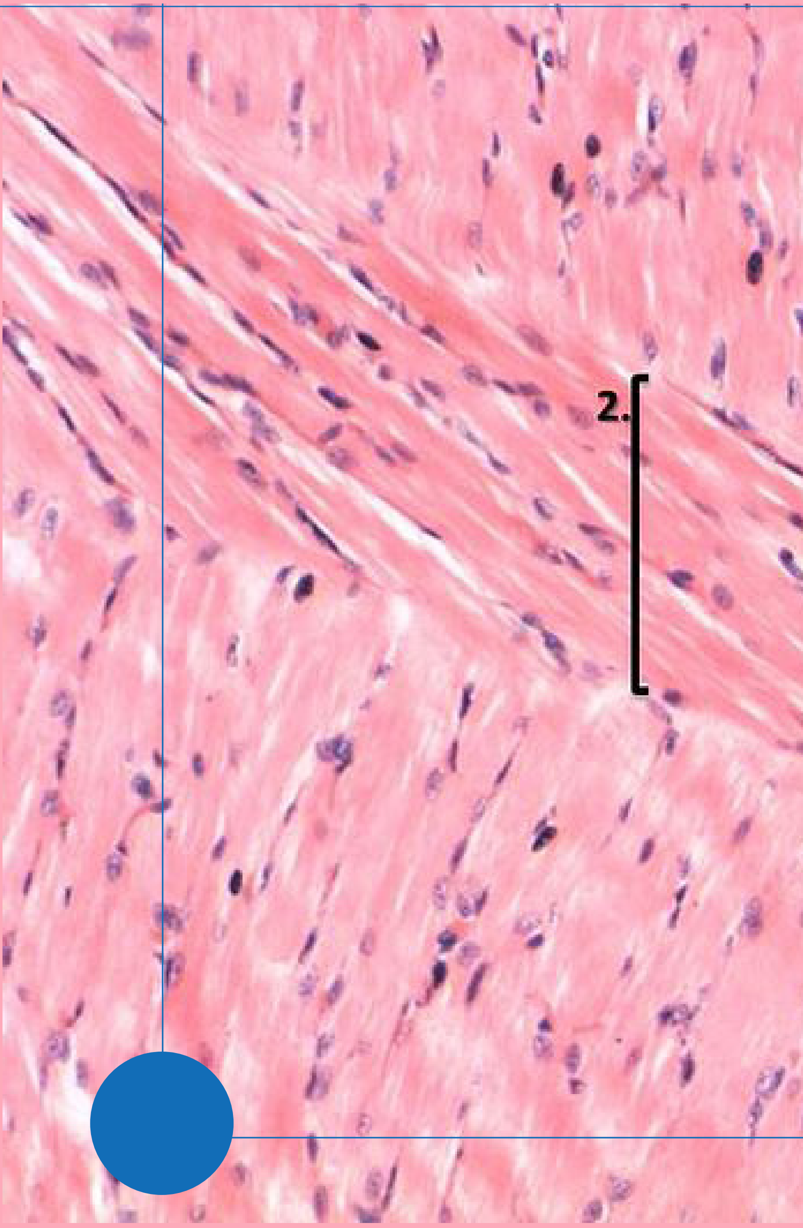
Physician, PhD in physiology and biophysics. Professor of Universidad de Antioquia's Faculty of Medicine. Members of the Physis Research Group, Universidad de Antioquia.

Jaime Alberto Gallo.

Professor of the Faculty of Medicine. Member of the Medicine Applied to Physical Activity and Sport Research Group (Grinmade), Universidad de Antioquia.

Germán Ricaurte Avella.

Physicist, PhD in Engineering. Professor of the Institute of Physics, Faculty of Exact and Natural Sciences. Member of the Biophysics Group, Universidad de Antioquia.



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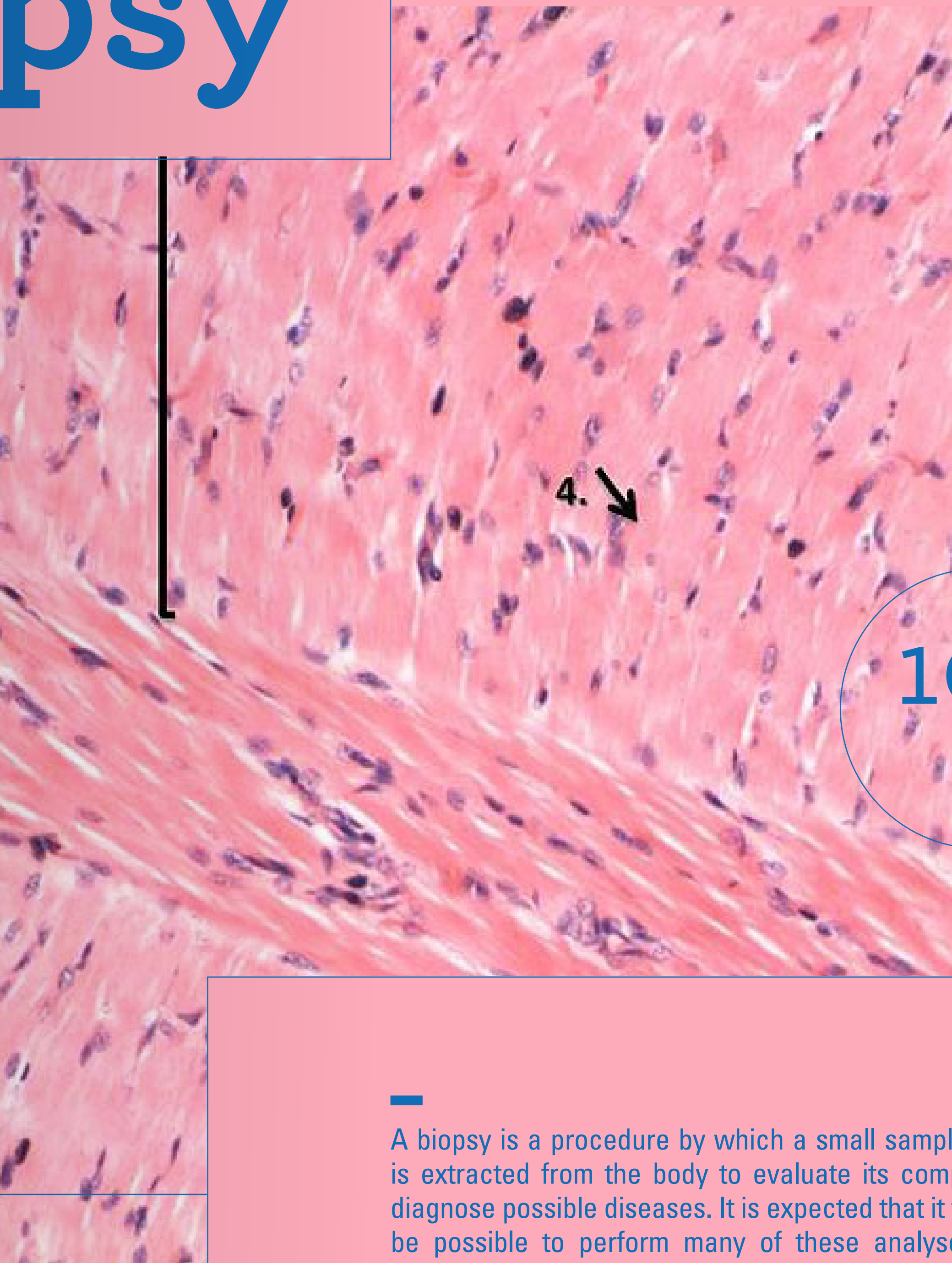

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A biopsy is a procedure by which a small sample of tissue is extracted from the body to evaluate its composition or diagnose possible diseases. It is expected that it will shortly be possible to perform many of these analyses without surgery by using scanning techniques such as spectroscopy. In this case, it is used for the study of athletes' muscles.

Photo: Pxhere.

When we hear the word "biopsy", we may be alarmed because it is associated with tumors. However, for decades, biopsies have been a widely used tool to study many aspects of tissues. In the past, "biopsy" also meant removing or extracting a small piece of tissue, but technological advances now allow us to know the composition of living tissue without extraction, with the help of equipment called a resonator. This makes it possible to research the inside of a patient without intervening, as if we were doing a virtual biopsy!

Indeed, a biopsy is a procedure by which a portion of tissue is removed from the body to evaluate its structure and composition, as well as to determine possible microscopic alterations. This technique is important in the diagnosis and treatment of various diseases, but it is also useful in scientific research. However, as it is a surgical procedure, it can be painful, cause incapacity and entail the risk of bleeding and infection.

In the middle of the last century, a technique emerged for analyzing tissues that would change the way we understand them: proton hydrogen nuclear magnetic resonance spectroscopy—1H-MRS. This is a fast, non-invasive and painless technique that enables the study of the different molecules in the organism.

In this technique, radiofrequency pulses - like those of radio or television - are sent to objects located in an intense magnetic field. The pulses reach the molecules of the object and "disorganize" the protons, which are positively charged particles in the nucleus of atoms and behave like small magnets in this situation.

When the pulse stops, these protons return to their original condition, but each at a different velocity. As this velocity depends on the environment, the applied intensity of the external field and the nature

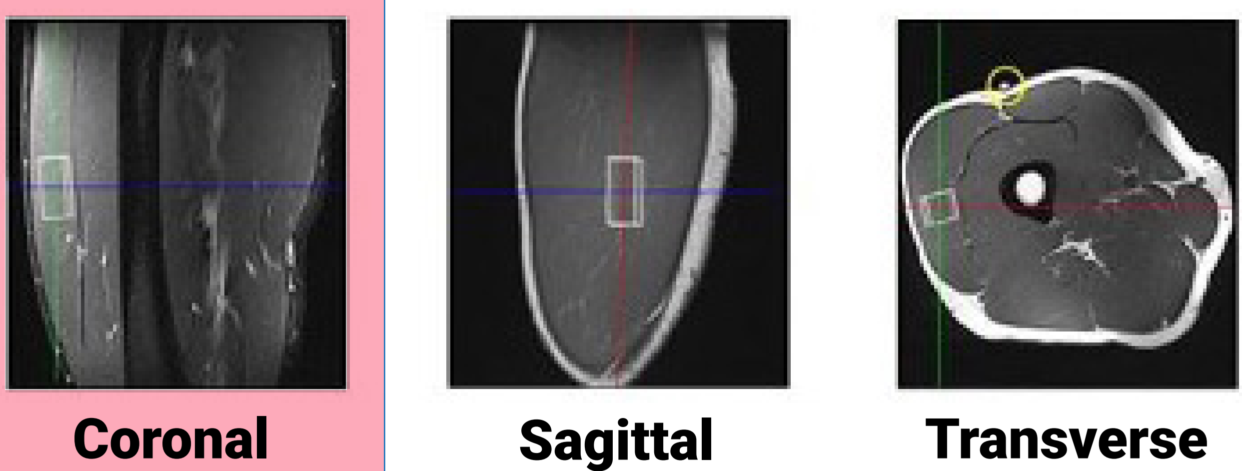

Figure 1. MRI of the right thigh of an athlete in the coronal, sagittal and transverse planes. A vitamin E capsule is observed in the yellow circle. We used it to mark the external anatomical reference of the vastus lateralis muscle. The spectrum is obtained from the region demarcated by the white rectangles (voxel). Image: Authors.

of the molecule itself, they generate different signals depending on the type of tissue.

In the system, a flexible coil acts as an antenna that receives the signals emitted by the object and carries them to the computer, which processes the signals and generates a display of the electromagnetic spectra generated. For example, in Figure 1, the fat molecules appear brighter because their protons are reoriented faster than the protons of other molecules, so their signal is more intense. Likewise, the highest peak of the spectrum shown in Figure 2 corresponds to one of the fat resonances.

In this way, 1H-MRS allows us to know the composition of living tissues without having to extract a part to analyze it microscopically, and it does so in a short time while it continues to function within the organism. Only post-processing of the signals is necessary. With trained personnel, this takes about five minutes. Thus, it is possible to distinguish variations in body tissues almost instantaneously through imaging techniques, even if the variations are not macroscopically evident.

A decade ago, European researchers demonstrated that, in healthy young people and athletes, there is a positive correlation between an intramuscular molecule called carnosine — which can be measured using 1H-MRS — and the area occupied by the type of muscle fiber known as type II fibers. These, also known as white fibers, are fast-twitch, have a fatigue threshold and do not have good aerobic endurance. Thus, it would be possible to estimate the muscle composition of these people without biopsies!

At the time of this discovery, our group was looking for an alternative to muscle biopsies to study athletes on a research project. As muscle is a determinant of sports performance, knowing more about it could help in the search for talent. Therefore, we became interested in this new idea proposed by the Europeans and started to apply 1H-MRS to our athletes.

In our method, the patient lies on the resonator table. We place a voxel — a kind of volume cube to be analyzed — in the anatomic planes of the right vastus lateralis muscle, a human thigh muscle, seen through nuclear magnetic resonance imaging (Figure 1). Since the objective is to find out the concentration of intramuscular carnosine, we programmed the equipment to obtain the intramuscular spectra of that voxel. Subsequently, we estimated the concentration of carnosine and intramuscular water by means of the jMRUI software. With this result, we can calculate the composition of muscle fiber types in our patients non-invasively, painlessly and without the risk of bleeding or infection. In other words, we were able to find out what is inside the patients' muscles without having to take a physical biopsy (Figure 2). Once the procedure was fine-tuned in athletes, we applied it to patients with chronic metabolic diseases, such as metabolic syndrome (MS). These patients are an important

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part of the population. They are overweight and have high blood pressure and alterations in lipids and blood sugar. This type of organism has less muscle mass in some regions of the body, a poorer physical condition and metabolic alterations that are not easy to measure in blood samples.

One of the tissues that we were interested in studying was skeletal muscle, a type of muscle tissue under voluntary action. It is formed by elongated fibers, has several nuclei and generates the movements in the body, which, in turn, is controlled by the central nervous system. This muscle is of great interest because it can regulate its own metabolism and that of other tissues. Thus, it modulates, for example, the development of insulin resistance, a condition that can lead to diabetes. However, studying this type of muscle in large groups of patients was risky because it required the mass performance of biopsies. Spectroscopy allowed us to study muscle composition in this population safely.

Funded by the Ministry of Science, Technology and Innovation and Universidad de Antioquia's Committee for the Development of Research (CODI), we evaluated 82 sedentary participants. Fifty-three of them had metabolic syndrome, and 29 were controls: an average group of people aged 40-60 years old that will be compared with the results of the group of interest. We found that patients with metabolic syndrome had a higher percentage of type II fibers than controls, and this was not due to gender differences. We are analyzing the relationship of this result with other blood proteins, and how it is modified when patients exercise.

This is the first project to study the muscle composition of a large number of patients with MS without physical biopsies. It used 1H-MRS and proved its power to discriminate carnosine content between patients and healthy volunteers. A previous study led by Barbora de Courten, from the School of Public Health and Preventive Medicine in Melbourne, Australia, reported that the 1H-MRS technique can discriminate carnosine con-

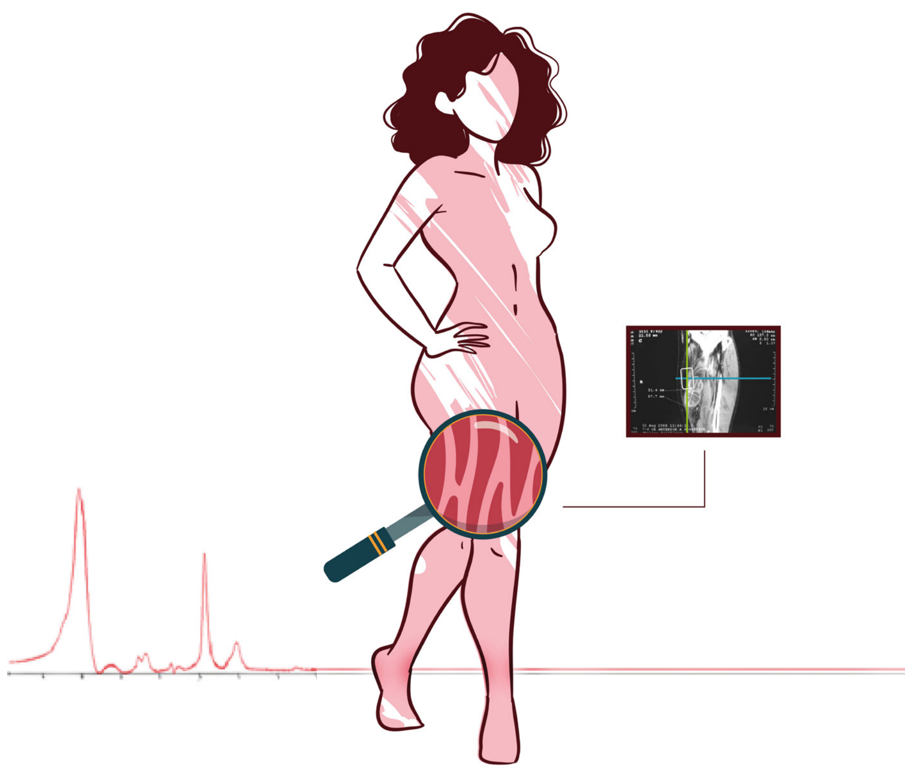

Figure 2. Proton spectroscopy allows us to perform a virtual biopsy and generate spectra to find out muscle composition in different populations. The line corresponds to a typical intramuscular spectrum of the thigh.
Image: Carolina Gomes

centration between diabetic and non-diabetic patients. Likewise, the master's degree dissertation by Gloria Vega, from our research group, showed that 1H-MRS can also differentiate between power and endurance athletes.

We are pioneers in Colombia in the use of 1H-MRS in human muscle. With these results, we hope to complement the explanatory models of chronic metabolic diseases, improve their diagnosis and contribute to the therapeutic approach, either with drugs or lifestyle changes.

We believe that the 1H-MRS technique can be used in other tissues for which replacing biopsies as a surgical procedure may be beneficial for patients. Can 1H-MRS send biopsies to retirement soon?

We thank the patients, health entities and financing entities involved for their contributions. We hope that these results will soon improve the quality of life of our population. X

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