


Next-generation exercise analysis technology: Visualization of muscle activity

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Emily Warrender

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Professor Yoshihiro Shimomura from Chiba University explores next-generation exercise analysis technology, using electromyography (EMG) and mechanomyography (MMG). His vMMG system visualizes muscle activity with a low-frequency microphone and LED indicators, enabling real-time observation and data recording for further analysis of muscle function

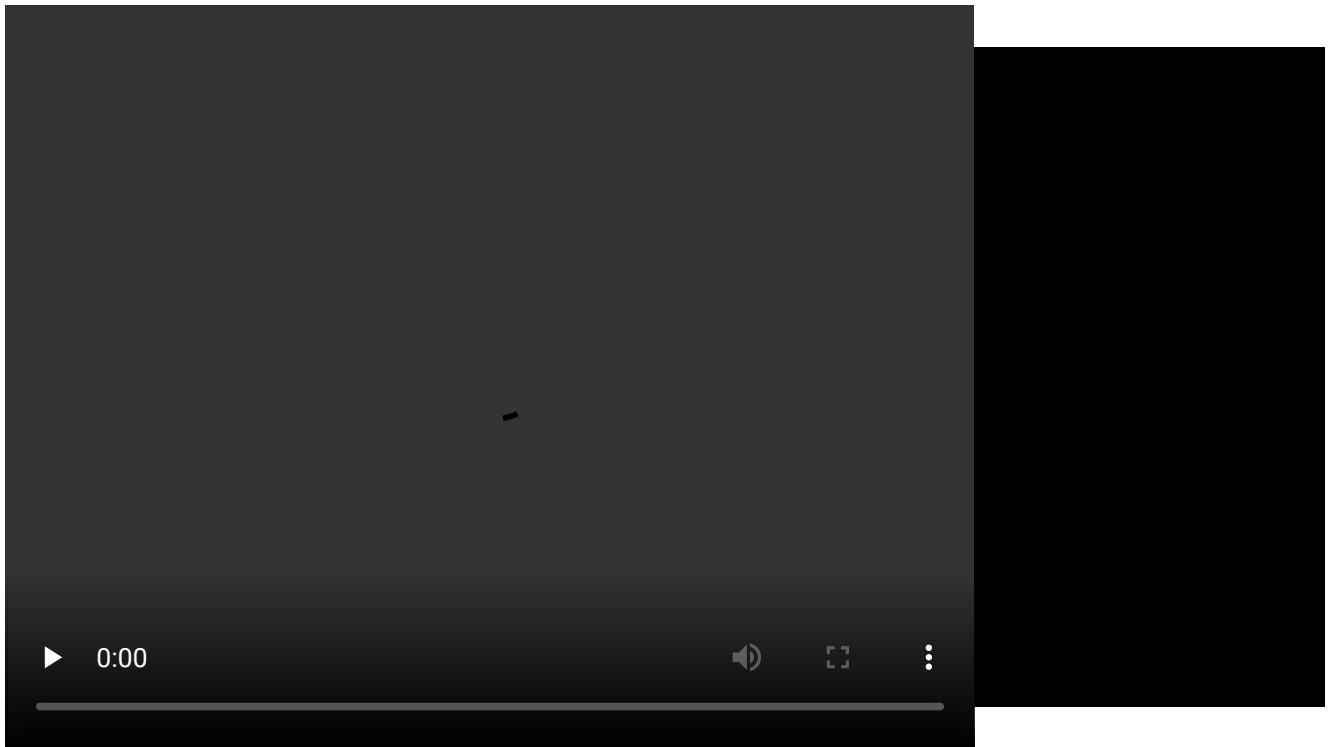
What does it mean to be visible?

This technology makes it possible to observe skeletal muscle activity with the naked eye, similar to looking at a flower through a magnifying glass or a small insect in water with a microscope. Our visualization technology allows us to see muscle activity just beneath the skin. We can determine where athletes exert their strength, when they relax, and why some can throw a ball farther, run faster, generate more force, or endure longer during play.

In rehabilitation, visualizing muscle activity becomes particularly important when injuries or frailty occur. By being able to see their own muscle activity, individuals can engage in treatment more efficiently, potentially speeding up their rehabilitation process.

The products we encounter can vary in their ease of use. This visualization technology may also benefit the universal design of industrial products for older adults, infants, and users from diverse cultural backgrounds who speak different languages. We believe there is significant potential in making previously invisible muscle activities visible.

Video Player



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Electromyography and mechanomyography

Electromyography (EMG) is the preferred method for measuring muscle activity during physical exercise. However, we also utilize another approach: mechanomyography (MMG). With the advent of high-precision vibration sensors in the 1980s, MMG can now be measured as a waveform, similar to EMG. Despite this similarity, EMG and MMG operate on completely different principles. EMG captures the electrical signals generated before muscle contraction, while MMG measures the mechanical signals produced as a result of that contraction.

MMG offers distinct advantages over EMG when it comes to visualizing muscle activity, akin to using a magnifying glass. The amplitude of EMG signals is very small, measured in millivolts (mV). To ensure accurate readings, it's essential to clean the skin and electrodes, arrange surrounding electrical devices to minimize noise, and connect a ground cable to the person being tested. Additionally, two electrodes must be placed in alignment with the direction of the muscle fibers, making it challenging for non-specialists to obtain accurate measurements of even a single muscle.

In contrast, MMG is much simpler to use. In fact, it can even be detected with a stethoscope. MMG oscillates at a frequency of about 10 to 100 Hz, which means it can be heard as a low rumbling sound. To experience this, try inserting the index fingers of both hands into your ears, making a fist with your other fingers, and squeezing tightly. You should hear the sound of MMG. Since the direction of the sound is not critical, only one sensor is needed per measurement site, much like a stethoscope. This simplicity allows anyone to detect MMG by simply applying the sensor to the skin.

vMMG

In this study, this system for visualizing mechanomyography is called the vMMG. The vMMG module Master of Engineering, Mr. Yuma Koza and we produced is equipped with a low-frequency condenser microphone, a small air chamber with a diameter of 4.5 mm that connects the skin to the microphone, electronic circuits, and LEDs. The microphone detects the vibration from the skin surface, then the microcontroller reads the amplitude of the envelope, encodes it non-linearly into the color tone corresponding to the value, and PWM controls the green and red visible light LEDs. By attaching multiple modules to the observation subject, we can see the muscle activity as a distribution image (map) like a picture.

Furthermore, we will explain another important point when talking about visualization technology. When we observe nature, we see and understand it with the naked eye, and at the same time, we keep a record. It can be said that vMMG can also be recorded in addition to being seen with the naked eye, so that visualization is complete. We decided to shoot the vMMG modules. This is not far-fetched at all. It is the same as taking a picture of what the observer sees. By recording numerical data by vMMG's machine vision system, it became possible to quantitatively handle the results of observations, and it became easier to perform subsequent comparisons and verifications.

Technical challenges of vMMG

The development of vMMG's technology is still in the early stages. Therefore, there are many issues that need to be solved. These include the density of devices due to miniaturization, optical diffusion plates to increase visibility, and so on. In the future, we will solve these problems one by one and proceed with the development of machine vision so that it can respond to multiple points.

The future of vMMG

Our technology, which allows you to observe muscle activity without the need for an expert, offers new methods for training, rehabilitation, and physical expression. In the future, our research team will accumulate research examples and applications of vMMG, including motion capture technology, and disseminate them to the world. We expect that vMMG will become the next generation of exercise analysis technology.

Primary Contributor

Yoshihiro Shimomura
Chiba University

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