Cycling × hitoe™: Dialogue with the Body via Surface Myoelectric Potentials

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Abstract

For athletes, knowing the state of their muscle activity is key to improving their performance and maintaining peak performance. Using the surface myoelectric potential, which can be measured from the surface of the body, is an effective method for understanding muscle activity with little physical burden. Technology using hitoe™, a functional fabric for collecting biosignals (jointly developed by NTT and Toray Industries, Inc.), for measuring, visualizing, and analyzing surface myoelectric potentials of top cyclists is introduced in this article. This technology is expected to be used for not only top athletes but also for self-analysis by ordinary people participating in daily sporting activities.

Keywords: wearable devices, biometric signals, visualization of muscle activity

1. Introduction

Sensor information captured using power meters, heart-rate monitors, and other devices is actively used for training cyclists. Objective data showing physical information and training progress of top athletes are important clues for not only improving performance but also checking fatigue and injuries to maintain peak performance. Our goal is to evaluate the dexterity of movement and state of fatigue of an athlete from surface myoelectric potentials obtained from the skin covering the muscles and use the evaluation results for data-driven training concerning sports and rehabilitation. Surface myoelectric potentials, which can be measured from the surface of the body, provide athletes with data that are easy to acquire. We are researching and developing a usability-aware system that integrates wearable sensors and applications under the assumption that the system will be used for daily training and in daily life.

2. Measuring surface myoelectric potentials by using hitoe™

To measure the surface myoelectric potentials, hitoe™, a functional fabric for collecting biosignals (jointly developed by NTT and Toray Industries, Inc.), is used as a bioelectrode. One of the advantages of hitoe™ is the ease of movement and placement of the electrode. Conventional myoelectric sensors encounter problems such as detachment of electrodes due to sweat, long preparation time for affixing individual electrodes, and interference with the movement of the athlete in question. For myoelectric measurement using hitoe™, since hitoe™ is attached in advance to the lining of the training wear, the electrode simply contacts the skin when the clothing is put on and will not detach. In sports such as cycling, the cyclist usually wears training clothing that adheres to the skin, and the compression necessary for fixing the electrode to the skin can be secured. Therefore, hitoe™ does not interfere with the normal sensations and movements of the cyclist.

Photo 1.   Eiya Hashimoto, a member of Team Bridgestone Cycling.

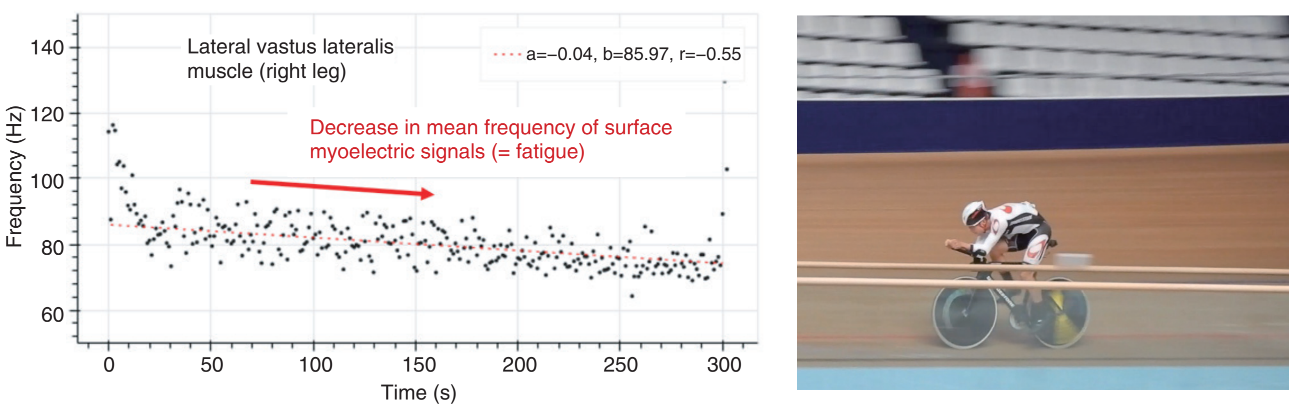
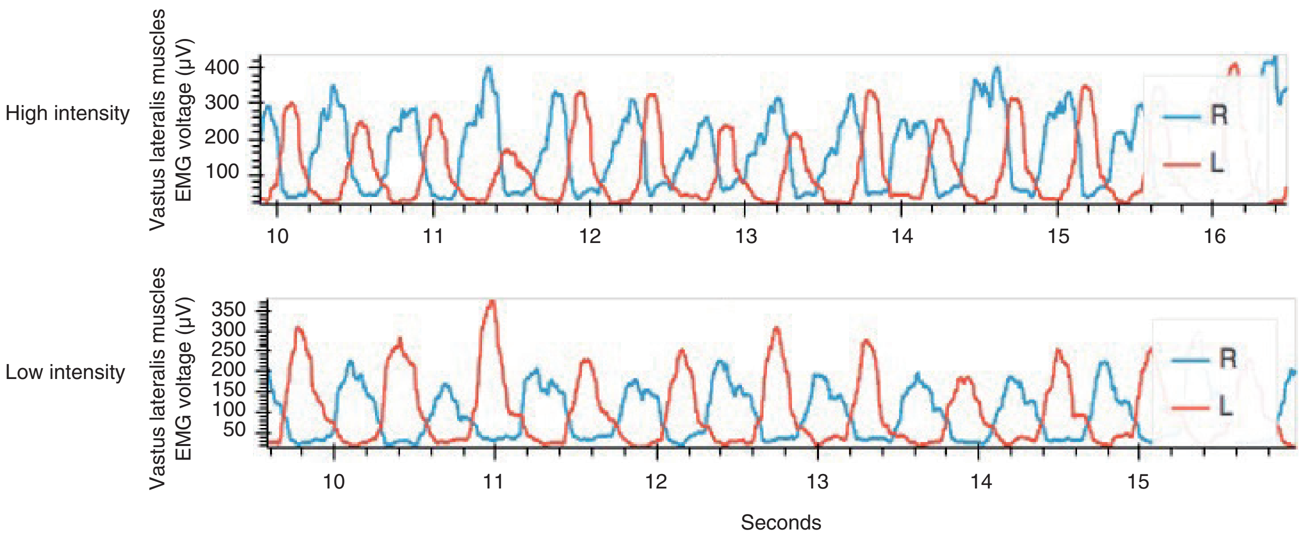


Fig. 1.   Example of analysis of hitoe™ surface myoelectric potential data obtained during a time trial.

3. Evaluation of differences in pedaling styles on the basis of muscle fatigue and muscle activity of cyclists

To measure surface myoelectric potentials during cycling by using hitoe™, we evaluated the pedaling of cyclists on the basis of the muscle fatigue and muscle activity of top cyclists in Japan, including Eiya Hashimoto (**Photo 1**), a member of Team Bridgestone Cycling, during a joint experiment with NTT DATA. In the experiment, cyclists pedaled under various conditions, and from the collected pedaling data, we identified points to be enhanced in competition, provided feedback on the basis of differences in the way each cyclist pedaled, and held discussions that included the subjective feedback of the cyclists.

Surface-myoelectric-potential data obtained during a time trial at the Izu Velodrome, which was used as the venue for the international sporting event in 2021, is shown in **Fig. 1**. The temporal variation of the mean frequency component of the surface myoelectric signals is shown. The frequency component changes as muscle fatigue progresses. It is clear from the figure



EMG: electromyogram

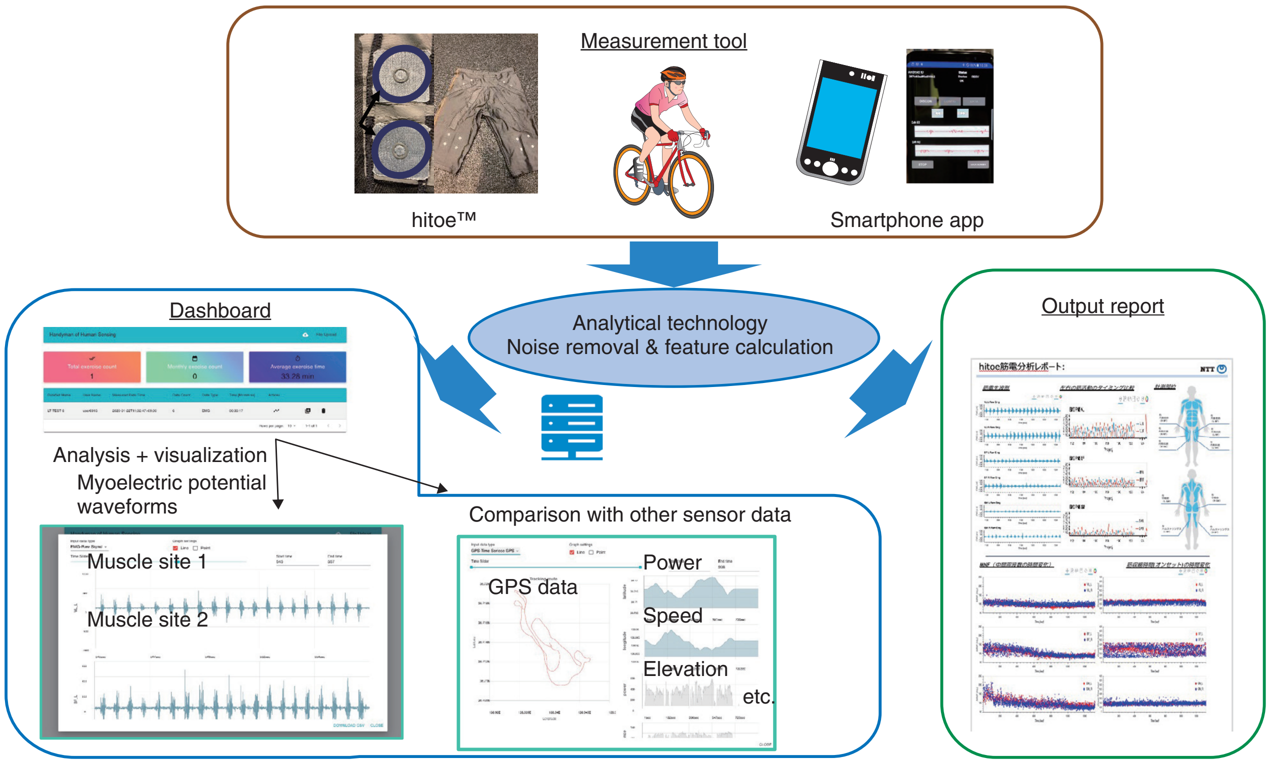
Fig. 2. Differences in timing of muscle activity of the right and left vastus lateralis muscles during high- and low-intensity pedaling.

that the mean frequency of the surface myoelectric potential of the vastus lateralis muscle (the muscle of the anterolateral thigh), which is a main muscle group, decreases over time. Since multiple muscles contribute to pedaling, the muscle areas that show this tendency and the degree of change vary according to race strategy, difference between the left and right legs of the cyclist, and difference in pedaling style. When the interpretation of the objective data matches the challenge facing the cyclist, such as identifying the muscles that tend to fatigue in the second half of the race, we can provide new insights for the cyclist.

A case study involving Eiya Hashimoto, who received feedback through insights, is described as follows. Inconsistency was observed in the timing and duration of muscle activity when pedaling under a higher load than normal. As shown in **Fig. 2**, the muscle-activity time of the vastus lateralis muscle of the right foot was longer than that of the left foot, and that time difference resulted in a delay in pedal strokes. When he was given feedback on this point, he felt that this muscle was prone to fatigue during races and was surprised that the difference in his muscle-activity pattern could be read from the objective data. This led to specific feedback such as being aware of the timing of the activity of the vastus lateralis muscle and the length of the pedal strokes during daily training.

We also analyzed how much muscle activity changed on the basis of the difference between indoor and outdoor environments, pedaling speed, and load, and verified the validity of the data through discussions with the cyclists. For meaningful discussion and self-feedback between coach and cyclist, it is important to visualize the data and provide the analysis results promptly after training. Accordingly, for this experiment, we developed a hitoe™-based system for measuring surface myoelectric potentials in stages and shortened the feedback cycle to the cyclist after the measurement (**Fig. 3**).

To establish this system in the field of sports, we must address the practical issues of finding more easy-to-understand indicators that allow the user to understand their issues and the effects of training as well as making it even easier to use than it is now. We are addressing these issues and will continue our research and development with the aim of creating a tool that can be used in everyday sports.



GPS: Global Positioning System

Fig. 3. System using hitoe™ for measuring surface myoelectric potential.

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He received a B.E. and M.E. from the University of Tsukuba, Ibaraki, in 2010 and 2012. Since joining NTT in 2012, he worked as a member of NTT Software Innovation Center and engaged in research and development of cloud computing and distributed computing systems. Since 2019, he has been with NTT Basic Research Laboratories and Bio-Medical Informatics Research Center, where he is engaged in biosignal processing and medical big data analysis.

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