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Opposing responses of electromyography and mechanomyography with increasing pedaling cadence

Shinichi Fukuhara, *Member, IEEE*, Hisao Oka, *Member, IEEE*

***Abstract*— This study aimed to investigate the changes in electromyography (EMG) and mechanomyography (MMG) due to the changes in pedaling cadence using an MMG/EMG hybrid transducer. The EMG signal increased and MMG signal decreased with increasing cadence, and their signals showed an inverse relationship.**

I. INTRODUCTION

We recently developed a mechanomyography/ electromyography (MMG/EMG) hybrid transduce system that can simultaneously measure the MMG and EMG signals to display the mechanical and electrical activity of muscles [1]. In addition, a simple analysis method was devised to capture local muscle function during exercise in real time. Using these instruments and methods, the relationship between MMG and EMG during pedaling was investigated [1].

The purpose of this study was to clarify the relationship between pedaling cadence, and MMG and EMG signals as part of a systematic evaluation of muscle function during pedaling.

II. METHODS

The study participants were 15 healthy male volunteers (age: 21.3 ± 0.6 yr., height: 170.5 ± 6.4 cm, and weight: 62.4 ± 2.40 kg). The participants sat on a recumbent bicycle (V67i, SENOH Corp., Chiba, Japan) with their toes fixed. The target muscle was the vastus medialis muscle on the right side, and the transducer (HOHS-122, ERD Co. Okayama, Japan) was attached to the center of the muscle after pretreatment of the skin. Pedaling work rates were set at 30, 60, and 90 W, and the cadence was varied between 30, 60, and 90 rpm at each constant load. Additionally, displacement-MMG (dMMG) during passive joint movement was measured (when participants are relaxing). The dMMG and EMG obtained from the transducer were measured at a sampling frequency of 1000 Hz for 30 s.

dMMG and EMG were evaluated by the energy value of the sum of the squares of the time-domain waveform and were displayed as $dMMG_{TD}$ and EMG_{TD}, respectively. Finally, EMG_{TD} and $dMMG_{TD}$ were normalized by the maximum value and the value during passive joint movement obtained, respectively [2].

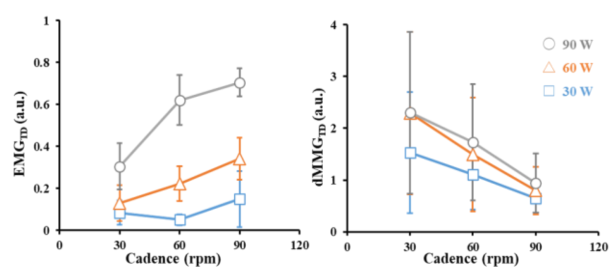
This study was approved by the Kawasaki University of Medical Welfare Ethics Committee (approval number 19-013).

III. RESULTS AND DISCUSSION

Fig. 1 shows the changes in EMG_{TD} and $dMMG_{TD}$ with increasing cadence for each load. In contrast to the increase in EMG_{TD}, $dMMG_{TD}$ showed a decreasing trend.

Previous study have reported that muscle activity increases with increasing cadence [2]; therefore, an increase in the EMG_{TD} is reasonable. However, since pedaling on the recumbent bicycle is load controlled, the torque per revolution decreases as the cadence increases. That is, an increase in cadence reduces the mechanical output of the muscles required to maintain pedaling. It is assumed that $dMMG_{TD}$ represents the torque required to pedal. Based on the above, as pedaling cadence increased, mechanical (MMG) and electrical activity (EMG) of the muscle showed inverse relationships.

In conclusion, to evaluate muscle performance during varying pedaling with cadence, not only the EMG but also



MMG must be considered.

Figure 1. Relationship between pedaling cadence and EMG_{TD} (left) and $dMMG_{TD}$ (right).

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Shinichi Fukuhara is with Department of Medical Engineering, Faculty of Health Science and Technology, Kawasaki University of Medical Welfare, 288, Matsushima, Kurashiki City, Okayama, 701-0193, Japan. (corresponding author to provide phone: +81- 86-462-1111; fax: +81-86-462-1193; e-mail: fukuhara@mw.kawasaki-m.ac.jp).

Hisao Oka is with Graduate School of Interdisciplinary Science and Engineering of Health Systems, Okayama University, Okayama, Japan (e-mail: hoka@okayama-u.ac.jp).

REFERENCES

[1] S. Fukuhara, S. Watanabe, and H. Oka, “Novel mechanomyogram / electromyogram hybrid transducer measurements reflect muscle strength during dynamic exercise - pedaling of recumbent bicycle -” *Adv Biomed Eng*, vol. 7, 2018, pp. 47–54.

[2] M. O. Ericson, R. Nisell, U. P. Arborelius, and J. Ekholm, “Muscular activity during ergometer cycling” *Scand J Rehabil Med*, vol. 17(2), 1985, pp. 53-61.