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EE499
Research Project - Literature Review

Wearable Surface EMG for Muscle Fatigue Detection

Muscle fatigue is a very important factor in exercise and it basically dictates how an athlete performs and recovers. When a muscle becomes fatigued, it leads to the muscle losing strength and control which can lead to poor form or possibly injury. From research ive found, most of the regular methods for measuring muscle fatigue are done in labs using wired electromyography (EMG) systems and motion capture equipment. While these systems are probably the most accurate form, they are expensive and not very practical for everyday use. There is growing interest in developing wearable devices that can monitor muscle fatigue outside of a lab. A huge part of this research for me is that muscle fatigue in a weight lifting sense, leads to more muscle growth, but there needs to be a balance as well.

Surface electromyography (sEMG) is commonly used to measure muscle activity. The way it works is by detecting the electrical signals produced when a muscle contracts. Basically it is shown that as a muscle becomes fatigued, certain characteristics of the EMG signal change. De Luca [1] explained that fatigue causes changes in both the strength (amplitude) and frequency content of the EMG signal. To be a little more precise, the median frequency of the signal tends to decrease during sustained muscle contractions. De Luca [2] showed that these frequency changes can be used to measure muscle performance and fatigue progression. These findings form the basic idea behind many fatigue detection methods used today.

Cifrek et al. [3] reviewed different ways to analyze muscle fatigue using EMG signals. They described common features such as Root Mean Square (RMS), which measures signal strength, and median frequency, which measures changes in the signal's frequency content. Their review also pointed out that results can be affected by electrode placement, noise, and the type of muscle contraction being performed. This is a huge part of when designing the actual wearable device, since wearable sensors are more likely to experience movement and signal interference compared to lab systems.

Researchers have worked on making EMG systems smaller and wearable. Liu et al. [4] developed a wearable EMG patch that can monitor muscle activity and estimate fatigue in real time. This is proof that it is possible to move fatigue monitoring from the lab to a wearable device. The difficult part is that many wearable systems still require calibration or only work well under specific conditions.

Martins et al. [5] reviewed wearable technologies for fatigue monitoring and discussed some of the challenges involved. These include motion artifacts, differences between users, and changes in skin contact during movement. Even through these challenges, simple EMG features like RMS and median frequency can still provide useful information about muscle fatigue when used carefully.

For this research project, I would like to research and develop some kind of wearable that someone could wear at the gym to detect muscle fatigue. To make it more realistic I want to focus on the contraction of the bicep. This would focus on the flexion of the muscle to hopefully detect fatigue and the perfect number of reps needed for optimal muscle growth. The goal is for the device to record EMG signals and calculate features like RMS and median frequency over time. The goal is to see whether clear fatigue trends can be observed during the exercise.

References

[1] C. J. De Luca, “The Use of Surface Electromyography in Biomechanics,” *Journal of Applied Biomechanics*, 1997.

[2] C. J. De Luca, “Use of the surface EMG signal for performance evaluation of back muscles,” *Muscle & Nerve*, 1993.

[3] M. Cifrek et al., “Surface EMG based muscle fatigue evaluation in biomechanics,” *Clinical Biomechanics*, 2009.

[4] S. Liu et al., “An EMG Patch for the Real-Time Monitoring of Muscle-Fatigue Conditions,” *Sensors*, 2019.

[5] N. R. Martins et al., “Fatigue Monitoring Through Wearables: A State-of-the-Art Review,” *Frontiers in Physiology*, 2021.