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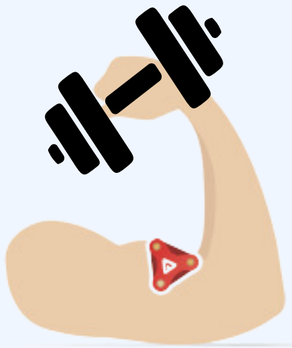
FATIGUE DETECTION FROM EMG SIGNALS: FEATURE-BASED ANALYSIS



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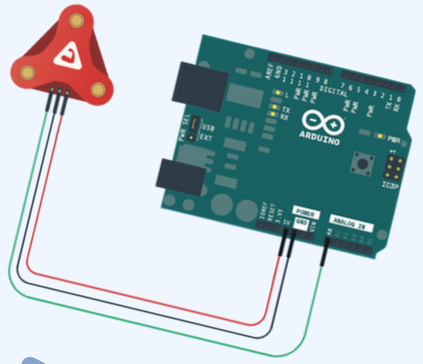

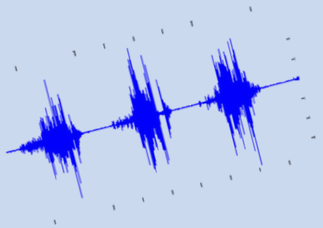

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WHAT IS EMG?

Electromyography (EMG) measures the electrical activity produced by muscles during contraction or rest, providing insights into muscle health and function.

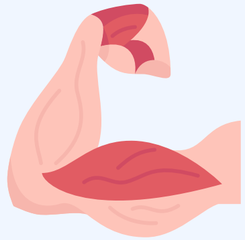
Muscle Strength Testing:
Measure electrical signals during contractions.

Fatigue Detection:
Track muscle activity over time.

Sports Performance:
Analyze muscle efficiency and activation.

Clinical Diagnosis:
Detect neuromuscular disorders.

MUSCLE FATIGUE

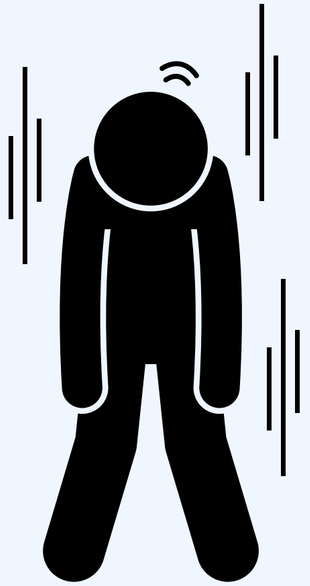


Muscle fatigue occurs during intense physical activity, leading to a temporary decrease in the muscle's ability to generate force.

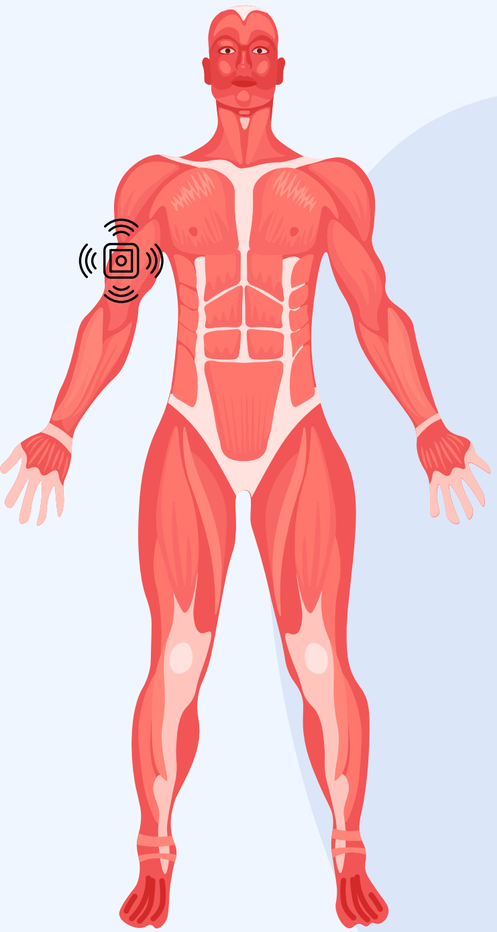
As muscles become fatigued, they may recruit more motor units and fibers to maintain performance.

Excessive fatigue can lead to an increased risk of injury and prolonged recovery time.

Effective monitoring and management of muscle fatigue is crucial for athletes and other individuals.



MOTIVATION



WHICH TECHNIQUE TO ASSESS? TECHNOLOGY?

There is a great opportunity to test different techniques for assessing muscle fatigue. A low-cost portable EMG sensor, can be used to record EMG signals.

FUTURE EXPLORATIONS

This work demonstrates the potential for incorporating technologies into wearable devices to gain valuable insights for more effective and targeted training strategies.

OBJECTIVE

01

The primary objective of this project is to evaluate and compare the effectiveness of traditional EMG features.

02

This project evaluates using a combination of Root Mean Square (RMS), Mean Absolute Value (MAV), and Median Frequency (MDF)

03

Test the MyoWare 2.0 EMG sensor, a low-cost portable sensor, to record EMG signals.

METHODOLOGY

DATA COLLECTION

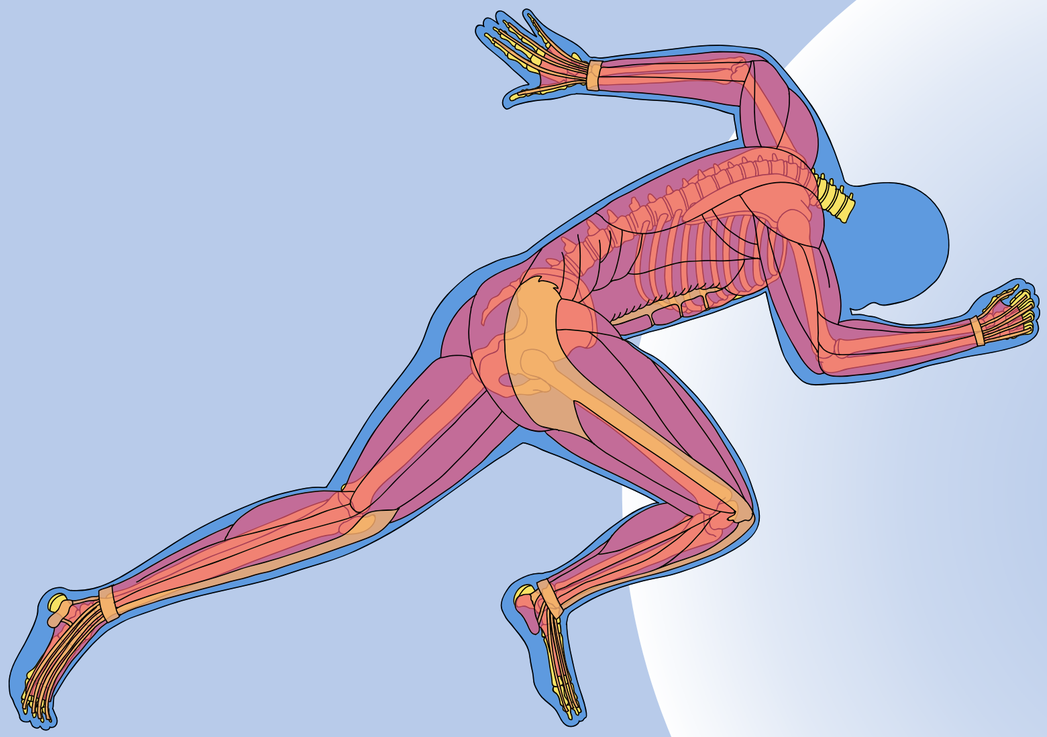
Hardware and EMG signal recording.

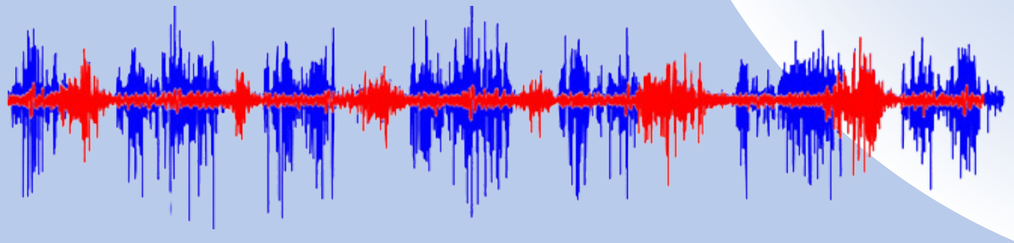
PREPROCESSING

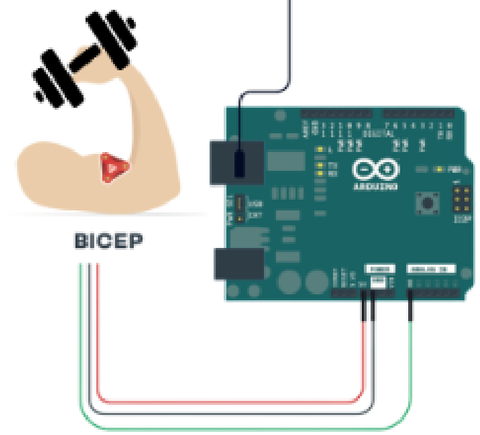
Corrections and Smoothing

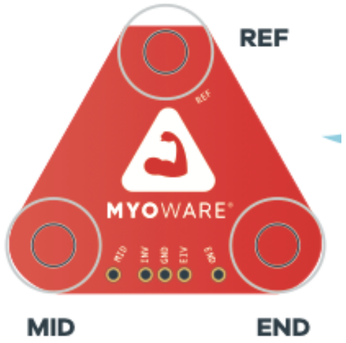
FEATURE EXTRACTION

Transform EMG signals to capture relevant metrics.









DATA COLLECTION

EMG Signals

- Recorded using the MyoWare 2.0 EMG sensor.
- The biceps brachii muscle was targeted, and data was collected while the participant performed the dynamic exercise.
- The recorded signals included timestamps, EMG values, and were exported as CSV files for further analysis.

Data

- 10 samples were collected, consisting of 3 sessions lasting 30 seconds and 7 sessions lasting 45 seconds.
- The files for the 45-second sessions contained approximately 22,000 data points each, sampled at a frequency of 500 Hz.

Arduino Uno and Terminal

- The EMG sensor was connected to the Arduino Uno microcontroller, which digitize the analog EMG signal and transmitted it to a computer.
- The Arduino Ide was used to configure the microcontroller, and the baud rate was set to 115200 to ensure smooth serial communication.
- The terminal software CoolTerm was used to log and download the serial output.

Limitations

PREPROCESSING

This step included baseline correction, filtering, and smoothing, all implemented using Python in Google Colab.

Baseline Correction

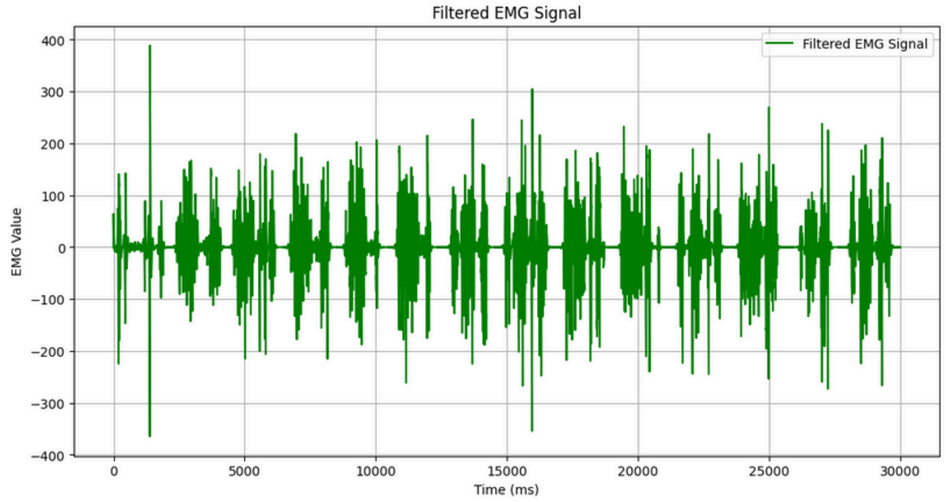
- The baseline was calculated as the mean of the raw signal values, which was then subtracted from each data point.

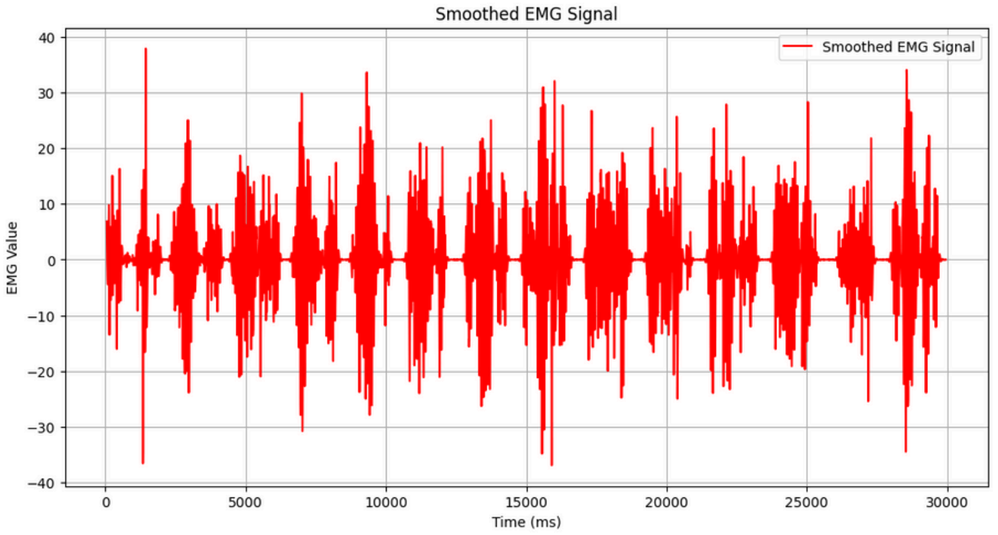
Bandpass Filtering

- Butterworth bandpass filter was applied with cutoff frequencies of 20 Hz and 249 Hz.
- Focus on the dominant power range of 20–150 Hz.

Smoothing

- A rolling average filter was applied. Helped to preserve signal trends while reducing noise spikes.





FEATURE EXTRACTION

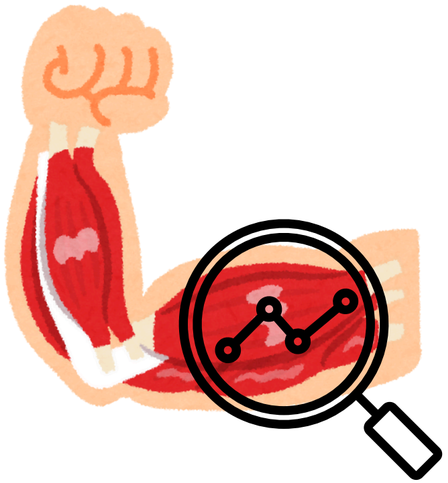
To transform the preprocessed EMG signals into metrics that capture relevant information of muscle activity and fatigue.

Root Mean Square (RMS)

- Represents the square root of the mean of the squared values in each segment and is usually used as a measure of the signal's overall strength.

Mean Absolute Value (MAV)

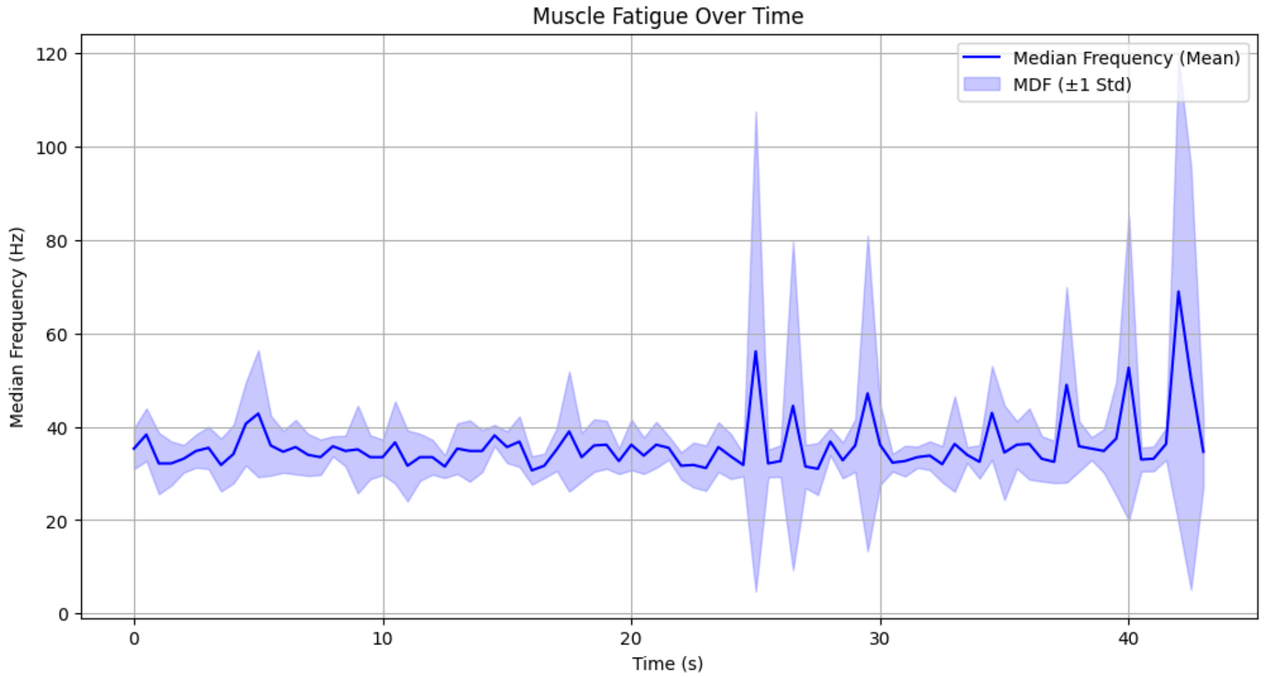
- Represents the average of the absolute values of the EMG signal, often used to indicate the intensity of muscle activity.



Median Frequency (MDF)

- The frequency that divides the power spectrum into two equal halves, commonly used to assess muscle fatigue.

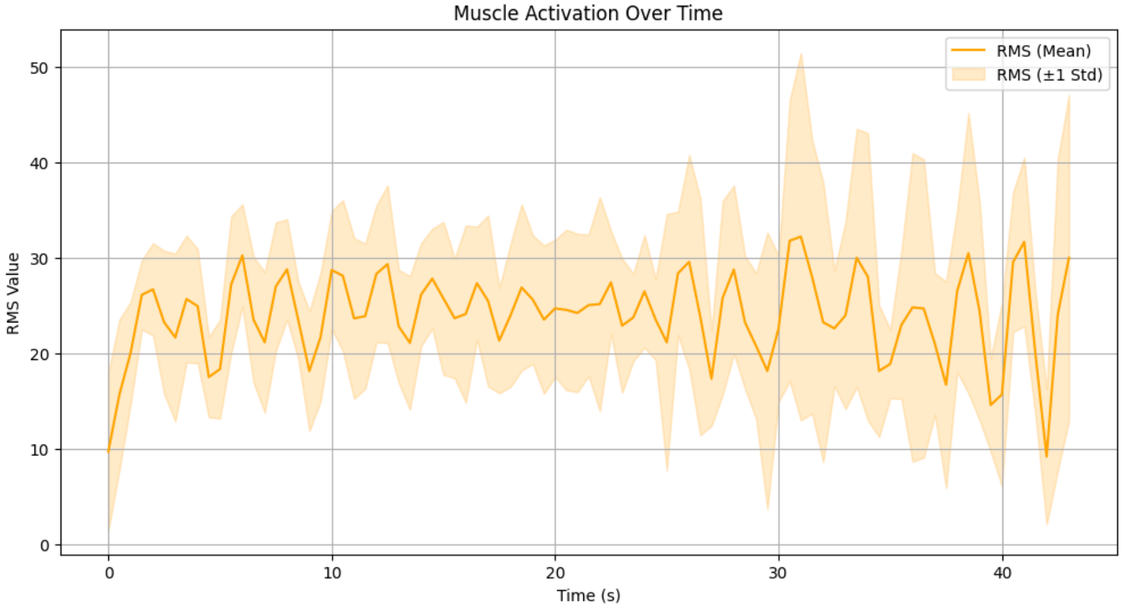
RESULTS



- We can observe that the MDF values remain relatively steady around 40–50 Hz during the first 15–20 seconds of the session. After 20 seconds, the MDF displays increased variability

- A gradual decline in MDF would have been a clear sign of muscle fatigue which is not present in these results.

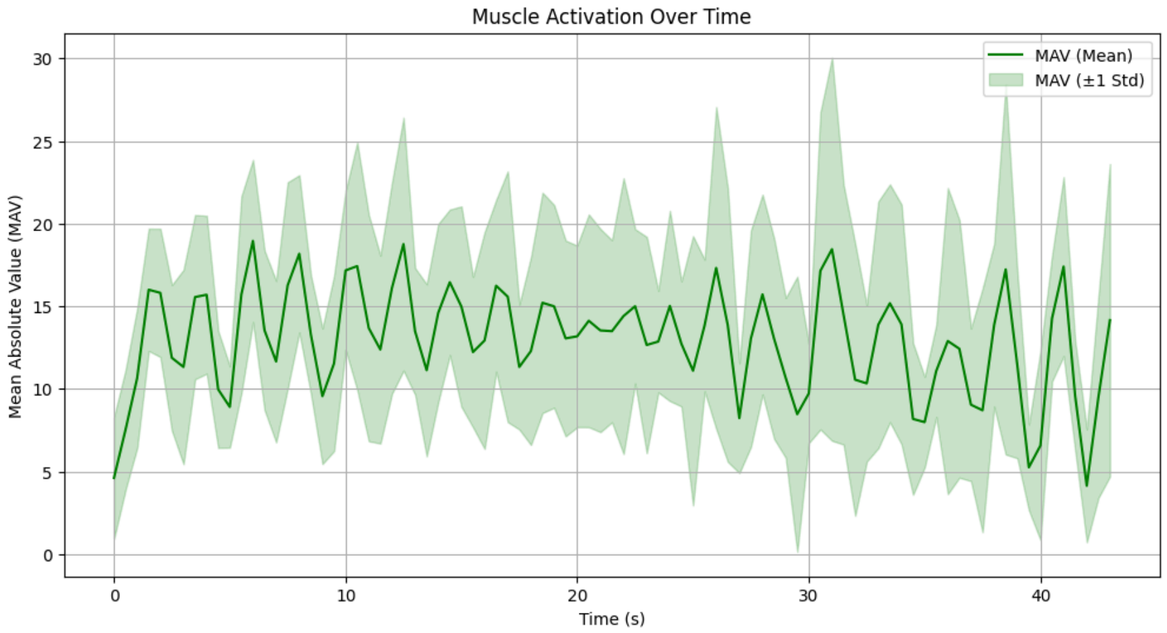
RESULTS



- The trend of the Root Mean Square (RMS) value shows a gradual increase over the duration of the exercise, indicating rising levels of muscle activation.

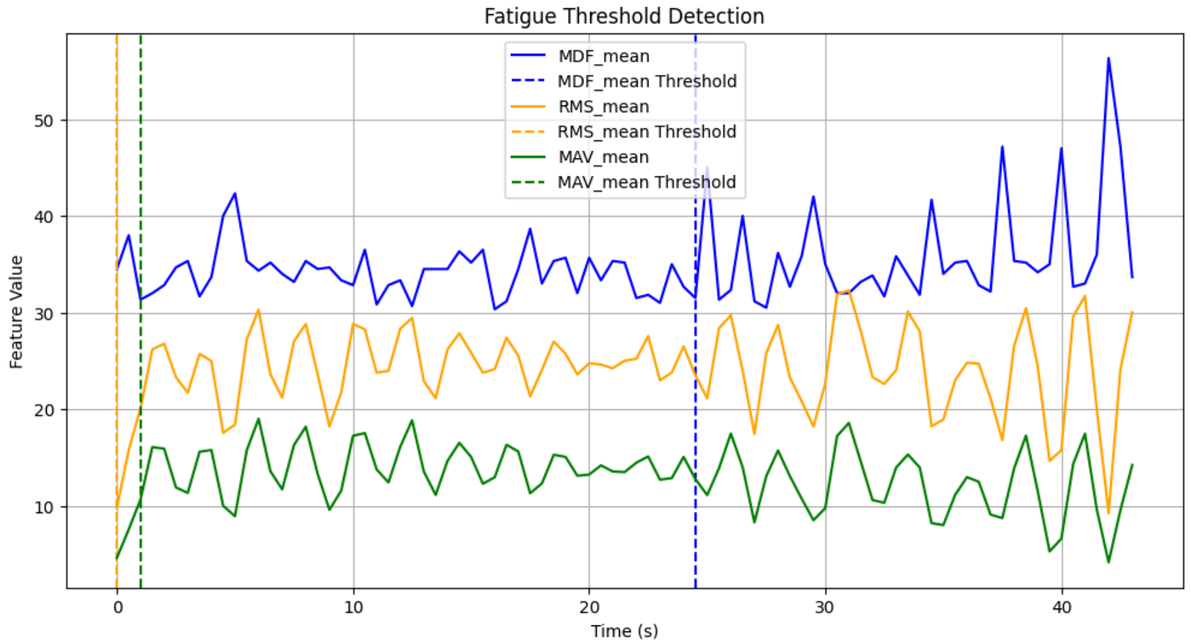
- RMS also shows the periodic oscillations corresponding to contraction and relaxation during the dumbbell curl exercise.

RESULTS



- The Mean Absolute Value (MAV) presented also shows the periodic oscillation corresponding to the muscle contraction and oscillation.
- The shaded region broadens after 20 seconds, indicating increasing variability of the MAV values.
- As muscle fibers fatigue, additional motor units are required, increasing the overall signal amplitude.

RESULTS



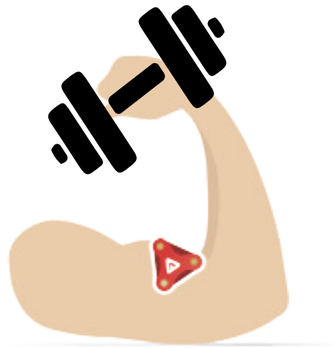
- Each feature's mean values are plotted with corresponding thresholds marked as dashed lines.

- The threshold for RMS and MAV captures the point at which muscle activation significantly increases. MDF provides a more realistic view by detecting the spectral shifts that align with fatigue progression.

DISCUSSION

- The analysis of the EMG data through various features Median Frequency (MDF), Root Mean Square (RMS), and Mean Absolute Value (MAV) provide valuable insights into muscle activation and fatigue.
- Periodic oscillations in RMS and MAV effectively captures the contraction relaxation phases of the exercise and showed slight upward trends over time.
- MDF provided complimentary insights associated to fatigue but were much less pronounced
- There was a growing variability in all features at the later stages of the sessions.
- The results demonstrate the potential of EMG feature analysis for fatigue monitoring, especially when implemented with high precision devices.

THANKS



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