**Title:** Developing a Novel Muscle Fatigue Index for Wireless sEMG Sensors: Metrics and Regression Models for Real-Time Monitoring

**Abstract** Muscle fatigue impacts performance in sports, rehabilitation, and daily activities, with surface electromyography (sEMG) widely used for monitoring. In this study, we analyzed sEMG signals, evaluating time, frequency, and combined-domain metrics to identify reliable fatigue indicators. Using these metrics, we developed a novel fatigue index through regression modeling, capturing fatigue progression and enabling personalized muscle-specific assessment. Integrated into a wireless BLE-enabled sensor platform, the system combines seamless body placement, mobility, and real-time data transmission. An initial calibration phase ensures adaptation to individual muscle profiles, enhancing accuracy. By balancing on-device processing with efficient wireless communication, this platform delivers scalable, real-time fatigue monitoring across diverse applications.

**1. Introduction**  
1.1 Background and Motivation

* Importance of **IoT in sports and rehabilitation**
* Significance of **sEMG for muscle fatigue detection**
* Gap in existing systems: lack of **real-time analysis and ML integration**

1.2 Related Work

* Summary of **previous research** (based on the thesis literature review)
* Key advancements in **sEMG-based fatigue monitoring**
* The role of **machine learning** in signal analysis

1.3 Contribution of This Work

* Development of an **IoT-based wearable system**
* **Integration of ML models** for regression analysis
* Creation of **datasets** from experimental sessions

**2. Materials and Methods**  
2.1 System Design

* **Hardware architecture** (sensors, microcontrollers, BLE communication)
* Overview of **two systems** (BioAmp EXG Pill vs MyoWare 2.0)

2.2 Data Collection

* Experimental setup: **Vastus Medialis**, **isometric leg-extension** exercise
* **Placement of electrodes** and noise reduction techniques
* Data acquisition using **Arduino and BLE**

2.3 Signal Processing and Feature Extraction

* Filtering: **Butterworth IIR filter**
* Features: **RMS, IEMG, MNF, MPF** (from the thesis)
* Window size analysis: **800 samples, 75%-87.5% overlap** (from GitHub repo)
* Best performing metrics: **mnf\_arv\_ratio, ima\_diff**

2.4 Dataset Preparation for Machine Learning

* Data preprocessing pipeline (from **GitHub repo**)
* **Splitting data** into training & test sets
* Feature selection approach
* Baseline research: **idle vs active calibration**

**3. Machine Learning Models**  
3.1 Regression Models Implemented

* Overview of **linear regression, polynomial regression, and advanced models**
* Performance metrics: **RMSE, R-squared**
* Fatigue metric regression (from GitHub repo)
* Algorithm implementation: **calibration code and full model**

3.2 Comparative Analysis of Models

* Which model performed best?
* Trade-offs in computational complexity vs accuracy

**4. Results and Discussion**  
4.1 Experimental Results

* **Feature trends across sessions** (figures & graphs from **GitHub repo**)
* Analysis of muscle fatigue progression (from **thesis results**)

4.2 ML Model Performance

* Accuracy and error metrics **comparison**
* Discussion on generalization to **new athletes/sessions**

4.3 Real-Time Application Feasibility

* BLE data transmission: **logic and efficiency**
* Processing latency on **wearable hardware**
* Possible **real-time ML model optimizations**

**5. Conclusion and Future Work**  
5.1 Key Findings

* Success of **wearable IoT-based fatigue monitoring**
* **Effectiveness of ML models** in predicting fatigue progression

5.2 Limitations

* Small dataset size (future **data augmentation**)
* **Model overfitting issues** (if found)

5.3 Future Directions

* Integration with **mobile app for real-time feedback**
* Experimenting with **deep learning models**
* Extending dataset for **different muscle groups & exercises**

**References**  
(Include citations from **thesis** and additional sources)

**Appendix**

* Details of **GitHub repo functionalities**
* Additional experiment logs

**(Figures & tables to be inserted in the appropriate sections)**