International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 05 | May - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Smart System for Non-Invasive Muscle Monitoring in Polymyositis Patients

A K NIVEDHA[*1],N.SRIPOORNIMA[*2], ALBIN EBBY[*3], ARJUN K B[*4], ASWIN K SHAJI[*5]
*1,2 Assistant professors, Department of BME, Dhanalakshmi Srinivasan Engineering College (Autonomous), Perambalur, Tamil Nadu, India.
*3,4,5 UG Students, Department of BME, Dhanalakshmi Srinivasan Engineering College (Autonomous), Perambalur, Tamil Nadu, India.

---***---

Abstract – This project introduces a wearable system specifically developed to monitor muscle health in individuals with polymyositis using a non-invasive approach. The device integrates a set of biosensors—Electromyography (EMG) to track muscle activity, a pulse oximeter (SpO_2) to measure blood oxygen levels, a Galvanic Skin Response (GSR) sensor for stress detection, and an accelerometer to monitor physical movement. All components are managed by an ESP32 microcontroller, which collects and processes the data in real-time. Physiological readings are wirelessly transmitted to a secure cloud-based platform, while essential health information is also shown on a built-in LCD screen, giving users instant feedback. This design moves away from traditional bulky or invasive systems, offering a portable, user-friendly, and cost-effective alternative. The system is well-suited for use in clinical settings, sports training, and at home. Its capabilities include early detection of muscle fatigue, rehabilitation monitoring, and proactive muscle care. Due to its scalable and affordable design, it can be particularly beneficial in under-resourced environments.Future development will focus on integrating artificial intelligence for predictive analytics and personalized insights, further advancing the quality of care and self-monitoring.

1. INTRODUCTION

The advancement of healthcare technologies has accelerated the relinquishment of ultramodern tools like the Internet of effects(IoT), bedded tackle, and biosensing bias for nonstop health monitoring. One significant operation is in shadowing and diagnosing neuromuscular conditions similar as polymyositis — a long- term autoimmune complaint that causes inflammation and weakness in cadaverous muscles. Conventional individual styles are frequently protrusive or calculate on high- cost medical structure, making routine monitoring and early discovery delicate. With recent progress innon-invasive seeing and wireless data transmission, it's now possible to produce movable , low-cost systems able of covering muscle function in real time and waking healthcare providers to implicit issues. In normal muscle tissue, elongated fibers with multiple nuclei are arranged in parallel and generate contractions through the interaction of actin and myosin proteins. These fibers are nourished by an extensive blood network and regulated by motor nerve signals. Under a microscope, these muscles display uniformity in fiber size and shape, with supplemental capitals and no signs of damage or inflammation. In polymyositis, still, the muscle structure becomes disintegrated by vulnerable cells — particularly CD8 T cells — that attack filaments expressing certain motes, performing in towel damage, inflammation, and muscle degeneration. Affected towel frequently shows variability in fiber size, centralized capitals in regenerating cells, and infiltration by vulnerable cells, along with increased situations of muscle enzymes similar as creatine kinase. To address the limitations of current monitoring styles, this design presents a smart wearable system that combines several biosensors to estimate crucial physical parameters EMG detectors to assess electrical exertion in muscles, SpO_2 detectors for oxygen situations, GSR detectors for stress discovery, and accelerometers for stir shadowing. All data is reused by an ESP32 microcontroller, which handles real- time collection, display through a erected- in screen, and secure transmission to pall storehouse for remote access. The system is erected to be non-invasive, affordable, and fluently scalable, making it ideal for use in home settings, physical recuperation, and athletic surroundings. By enabling early identification of muscle-related issues and allowing for remote consultations, the device supports a shift toward further visionary, individualized

2. OBJECTIVE

This project aims to develop a comprehensive, non-invasive, and intelligent muscle monitoring system that leverages advanced biosensing and embedded technology to support the diagnosis, management, and rehabilitation of individuals with neuromuscular disorders, particularly polymyositis. Polymyositis, a chronic inflammatory myopathy, often leads to progressive muscle weakness, fatigue, and in some cases, autonomic dysfunction. To address the diagnostic and monitoring challenges associated with such conditions, the proposed system integrates multiple physiological sensors—including surface electromyography (sEMG), galvanic skin response (GSR), and near-infrared spectroscopy (NIRS)—to capture a wide range of muscle performance and stress-related data. The sEMG component will provide insights into muscle activation patterns and fatigue levels, while GSR will assess sympathetic nervous system activity, potentially correlating with autonomic imbalance or inflammation-induced stress. NIRS will monitor tissue oxygenation and hemodynamic responses during muscular activity, adding a metabolic dimension to the evaluation. Together, these sensors will feed data into an embedded microcontroller system capable of real-time signal processing, wireless transmission (via Bluetooth or Wi-Fi), and cloud-based storage. This architecture supports remote healthcare monitoring, enabling clinicians, physiotherapists, and caregivers to access patient data in real-time, track long-term trends, and detect early signs of disease flare-ups or therapy inefficacy. The system is designed to be portable, cost-effective, and user-friendly, making it suitable for deployment in clinical settings, outpatient facilities, or home environments. Ultimately, the goal is to empower healthcare providers with continuous, objective data that enhances diagnostic accuracy, optimizes treatment plans, and improves the quality of life for patients managing complex muscle disorders.

3. EXISTING SYSTEM

Current muscle monitoring systems often rely on traditional EMG machines that are invasive, non-portable, and limited to clinical environments. These setups require specialized personnel and infrastructure, making them unsuitable for continuous or home-based monitoring—especially for chronic conditions like polymyositis. While surface EMG sensors offer a less invasive alternative, they typically measure only muscle activity and lack integration with other vital parameters like oxygen levels, stress, or movement. Most also lack IoT or cloud support, restricting remote access and real-time data analysis. This highlights the need for a compact, wireless, and multi-sensor system capable of holistic and accessible muscle health monitoring..

DISADVANTAGES:

Invasive procedures – Many systems still rely on needle EMG, causing discomfort and not suitable for continuous use.

Lack of portability – Traditional systems are bulky and require a hospital setup.

Single-parameter monitoring – Most systems focus solely on EMG signals, missing out on other vital physiological data.

High cost – Medical-grade equipment is expensive and unaffordable for many individuals or smaller clinics.

No cloud integration – Absence of IoT and cloud technologies restricts remote access and real-time analysis.

Limited accessibility – The need for clinical environments limits usage in rural or home-based care.

Manual data interpretation – Many systems lack intelligent analytics or automated alerts, increasing the burden on medical staff.

Not suitable for dynamic environments – Lack of wireless and wearable features makes them ineffective during physical activity or rehabilitation.

4.PROPOSED SYSTEM

The Smart Muscle Monitoring System is a non-invasive, IoT-based solution developed to provide real-time data on muscle function, fatigue, and overall physiological well-being. Designed for versatility, it combines multiple biosensors to support a wide range of applications including medical assessments, athletic performance tracking, and physical rehabilitation. At the heart of the system is an ESP32 microcontroller, which enables wireless data transfer through Wi-Fi and Bluetooth, allowing seamless integration with mobile devices and cloud-based platforms. The system uses an EMG sensor to evaluate the electrical signals generated by muscle activity, helping to detect fatigue and neuromuscular disorders. A SpO_2 sensor monitors oxygen saturation in the blood, offering insight into tissue oxygenation and potential vascular concerns. The GSR sensor measures skin conductivity to assess stress levels and autonomic nervous system responses, while an accelerometer tracks body movement, posture, and gait to evaluate musculoskeletal function. An integrated LCD screen provides instant feedback, making the system accessible and user-friendly in clinical, athletic, and home-based environments.

ADVANTAGES :

Non-invasive Monitoring – Comfortably tracks muscle health without the need for needle-based EMG.

Wireless Connectivity – Enables remote monitoring through Wi-Fi and cloud integration.

Multi-parameter Sensing – Provides a holistic view by integrating EMG, SpO2, and GSR sensors.

Real-time Feedback – Immediate display of readings on an LCD for local monitoring.

Compact and Portable – Can be used in various environments, including clinics, homes, and fitness centers.

Cost-Effective Design – Uses affordable hardware components like ESP32 and basic sensors.

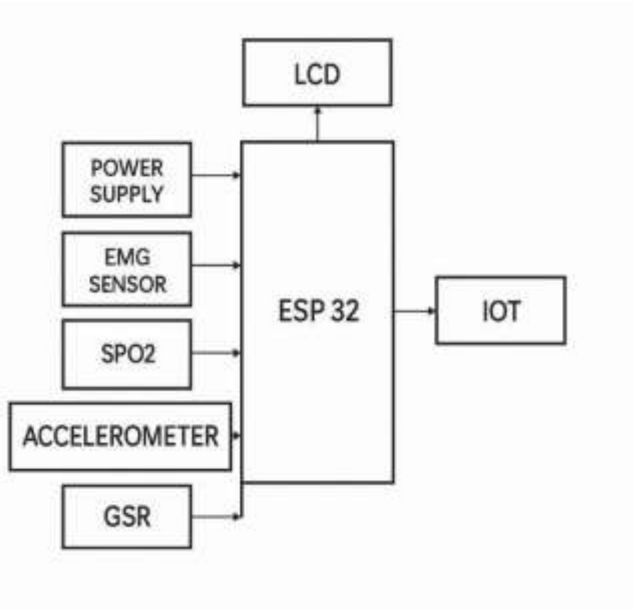
International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 05 | May - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

4.1 SCOPE OF THE STUDY

The Smart Muscle Monitoring System offers numerous benefits by combining non-invasive sensing, IoT connectivity, and real-time data analysis into a compact and portable device. One of its primary advantages is its ability to continuously monitor muscle health and physiological parameters without the need for invasive procedures or bulky clinical equipment. This makes it especially valuable for patients with chronic neuromuscular conditions like polymyositis, who require frequent and long-term monitoring. By integrating an EMG sensor, the system effectively tracks muscle activity and detects signs of fatigue or dysfunction, offering early warnings of neuromuscular deterioration. The inclusion of a SpO_2 sensor further enhances diagnostic capabilities by assessing oxygen saturation in muscle tissue, which can indicate inflammation or circulatory problems. Additionally, the GSR sensor provides insights into the body's stress levels by measuring skin conductivity, which reflects autonomic nervous system activity—a factor that can influence muscle function and recovery. The accelerometer supports movement and posture tracking, making the system ideal not only for clinical diagnosis but also for sports performance evaluation and physical rehabilitation. Real-time feedback displayed on the onboard LCD screen enhances user interaction and enables immediate awareness of physiological states. Moreover, the ESP32 microcontroller's wireless communication capabilities facilitate seamless data transmission to smartphones or cloud platforms, allowing remote access for healthcare professionals and enabling telemedicine applications. The system's multi-sensor integration and IoT-based design promote a holistic approach to health monitoring, bridging the gap between clinical accuracy and home-based usability. It empowers patients, athletes, and caregivers with actionable insights, fosters proactive healthcare, and reduces dependency on hospital visits, all while being cost-effective, user-friendly, and scalable for widespread deployment.

4.3 SYSTEM ARCHITECTURE

The architecture of the Smart Muscle Monitoring System is built around the ESP32 microcontroller, which serves as the central control unit responsible for interfacing with all sensors and communication modules. This versatile microcontroller enables seamless integration and real-time processing of physiological data, while also facilitating wireless connectivity for IoT-based applications. A dedicated power supply unit ensures that each component receives stable and appropriate voltage levels for reliable operation across various conditions. The system incorporates an EMG sensor to detect and measure electrical signals generated by muscle contractions, which is vital for assessing muscle strength, activity, and fatigue in real-time. Complementing this is a SpO_2 sensor that tracks blood oxygen saturation, offering a clear picture of the user's respiratory efficiency and circulatory health—especially relevant for patients with neuromuscular or vascular concerns. Additionally, two GSR (Galvanic Skin Response) inputs are included to measure variations in skin conductivity, which reflect changes in stress levels and autonomic nervous system activity, adding another layer of insight into the user's physiological state. All of these sensor outputs are collected and processed by the ESP32, which then sends the data wirelessly to the cloud using its built-in Wi-Fi functionality. This allows healthcare providers, trainers, or caregivers to remotely monitor users over extended periods, supporting preventive care and long-term health management. For immediate feedback, the system features an integrated LCD display that presents live readings from the sensors, enabling users to stay informed of their condition in real time. Designed to be non-invasive, portable, and user-friendly, this architecture makes the system ideal for continuous monitoring in a variety of settings—from clinical environments and rehabilitation centers to home-based care and athletic training. By combining multi-sensor data acquisition with real-time analytics and cloud-based access, the system delivers a comprehensive, connected solution for muscle and physiological health tracking.

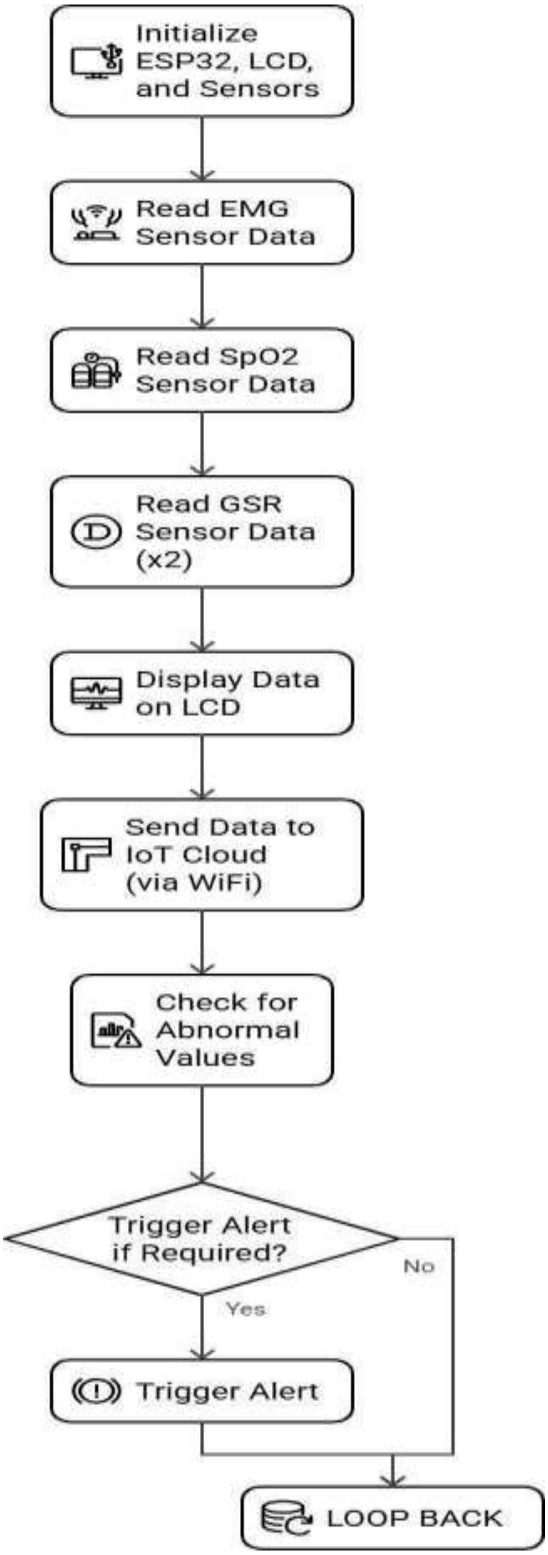


4.4 DATA FLOW DIAGRAM

The flowchart illustrates the functional process of the Smart Muscle Monitoring System, outlining each step in the data accession, processing, and response cycle. The

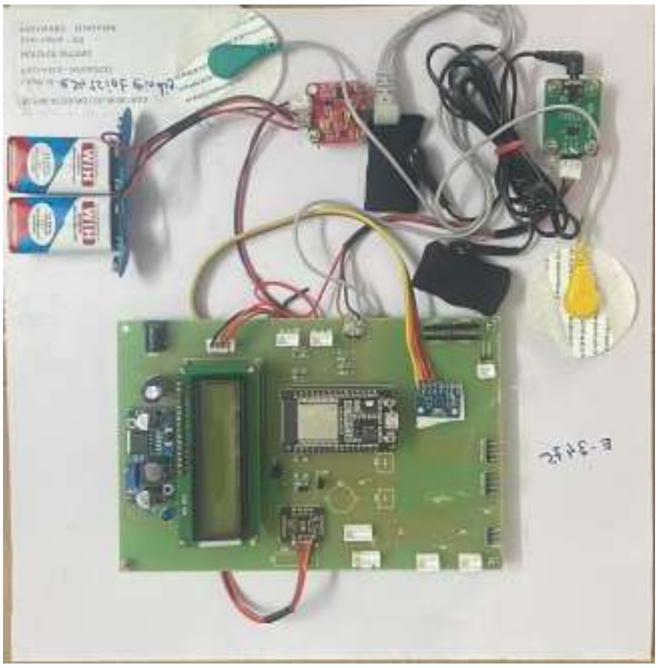
International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 05 | May - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

system begins by initializing the ESP32 microcontroller, TV screen, and all connected detectors, setting up the terrain for data collection. Once initialized, the device reads data from the EMG detector to assess electrical signals generated by muscle exertion, which helps in assessing muscle performance and detecting fatigue or neuromuscular anomalies. Following this, the SpO ₂ detector is actuated to measure the stoner's blood oxygen achromatism position — an important index of respiratory and muscular health. Next, the system captures data from two Galvanic Skin Response(GSR) detectors, which cover changes in skin conductivity that relate with stress and emotional thrill. After collecting all detector data, the information is displayed on the TV screen in real time, furnishing immediate feedback to the stoner. latterly, the system transmits the collected data to a pall- grounded IoT platform using the ESP32's erected- in Wi- Fi capability. This enables remote monitoring by healthcare providers or caregivers and facilitates long- term health shadowing. Once the data is uploaded to the pall, the system checks for any abnormal or out- of- range values that might indicate physiological stress, muscle damage, or other health concerns. .However, the system evaluates whether an alert needs to be touched off, If abnormal values are detected. .However, it activates a announcement medium to advise the stoner or shoot cautions to remote caregivers or croakers. If an alert is required.. However, or after the alert is touched off, the system circles back to renew the monitoring cycle, If no abnormal values are detected. This nonstop circle ensures real- time, dynamic monitoring of muscle and physiological health, making the system largely suitable for operations in clinical care, recuperation, and sports performance operation.



International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 05 | May - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

IMPLEMENTATION AND RESULT



5.CONCLUSION

The Smart System for Non-Invasive Muscle Monitoring represents a major advancement in wearable healthcare technology, delivering a compact, affordable, and user-friendly platform for real-time muscle health assessment, particularly suited for individuals with polymyositis and related neuromuscular disorders. By integrating multiple biosensors—EMG for muscle activity, SpO_2 for blood oxygen levels, GSR for stress response, and an accelerometer for movement tracking—the system offers a comprehensive and continuous view of a patient's physiological state. Powered by the ESP32 microcontroller with built-in Wi-Fi, the device ensures efficient data acquisition, on-device processing, and wireless cloud connectivity via the Blynk platform, enabling remote monitoring and eliminating the limitations of traditional, invasive EMG systems. Its non-invasive design, portability, and low cost make it ideal for use in rehabilitation, elderly care, sports training, and home-based healthcare. Real- time feedback is displayed locally through an LCD screen, while historical trends and data visualization are accessible through a mobile app, enhancing both user engagement and clinical decision-making. While the current prototype fulfills its core objectives effectively, future enhancements such as AI-driven diagnostics, predictive analytics, and integration with additional biosensors could further expand its diagnostic potential. This project lays a strong foundation for next-generation wearable systems that make continuous, accessible, and intelligent health monitoring a reality.

REFERENCES

1. Analog Devices. (2010). *ADXL335 3-Axis Accelerometer Datasheet*. Retrieved from https://www.analog.com

2. Andreassi, J. L. (2010). *Psychophysiology: Human Behavior and Physiological Response*. Taylor & Francis.

3. Arduino. (2023). *Arduino IDE Official Documentation*. Retrieved from https://www.arduino.cc

4. Blynk Inc. (2024). *Blynk IoT Platform Documentation*. Retrieved from https://docs.blynk.io

5. De Luca, C. J., Gilmore, L. D., Kuznetsov, M., & Roy, S. H. (2010). Filtering the surface EMG signal:

Movement artifact and baseline noise contamination. *Journal of Biomechanics*, 43(8), 1573–1579.

6. Espressif Systems. (2023). *ESP32 Datasheet*. Retrieved from https://www.espressif.com

7. Hughes, E., & Bell, A. (2007). A wireless surface electromyography system. *IEEE SoutheastCon Proceedings*, 253–253.

8. Islam, M. M., Rokonuzzaman, M., & Mahmud, M. (2021). IoT-based smart health monitoring system. *International Journal of Engineering Research & Technology (IJERT)*, 10(6), 1–6.

a. *Journal of Electromyography and Kinesiology*, 9(1), 3–4.

9. Kamen, G., & Gabriel, D. A. (2009). *Essentials of Electromyography*.

a. Human Kinetics.

10. Merletti, R., & Torino, P. D. (1999). Standards for reporting EMG data.

11. Potvin, J. R., & Brown, S. H. (2004). High-pass filtering to remove EMG signal power improves biceps muscle force estimates. *Journal of Electromyography and Kinesiology*, 14(3), 389–399.

12. Salazar, O. A., Angarita, J. G., & Vargas, J. M. (2007). Diseño de un electromiógrafo con procesador digital de señales. *Revista Médica de Risaralda*, 13(1).

13. Seeed Studio. (2014). *Grove - GSR Sensor Technical Manual*. Retrieved from https://wiki.seeedstudio.com

14. Webster, J. G. (1997). *Medical Instrumentation: Application and Design* (3rd ed.). Wiley.

15. Youn, W., & Kim, J. (2007). Development of a compact-size and wireless surface EMG measurement device. *SICE-ICASE International Joint Conference*, 2504–2508.