Real-Time Muscle Monitoring Using Wearable Sensors

Dr. M. Rajaram[1], Mrs. C. Preethibha [2], Dinesh Kumar G [3], Kavin Prasath R [4],
Mohammed Salman Haarish S [5], Saroth Raja A [6]

[1]*Dean, Department of Electronics and Communication Engineering, Park College of Engineering & Technology, Coimbatore, India*

[2]*Associate Professor, Department of Electronics and Communication Engineering, Park College of Engineering & Technology, Coimbatore, India*

[3,4,5,6]*Student, Department of Biomedical Engineering, Park College of Engineering & Technology, Coimbatore, India.*

doi.org/10.64643/IJIRTV12I12-201623-459

***Abstract*—This project talks about a smart wearable system that can watch muscle activity in real time. Many athletes and patients face muscle fatigue and slow recovery. Often they do not know when their muscles are getting too tired. Because of this, injuries can happen. Most traditional muscle testing systems are used only in laboratories. They use large equipment and wired sensors. Also the data is usually checked later on a computer. So they cannot give instant feedback during exercise. The proposed system tries to solve this problem by using small wearable sensors. The device collects signals such as EMG muscle activity, blood pressure, and skin inflammation. These sensors are placed in a comfortable splint band worn on the arm. A microcontroller processes the signals and sends the data wirelessly to a mobile application. The apps hows the information clearly so the user can understand their muscle condition. This system helps people monitor muscle fatigue and recovery while they are training or doing therapy. It can warn the user if the muscles are under too much stress. This may help reduce injuries and improve recovery. The project shows how wearable sensors and simple mobile technology can be used to make muscle monitoring easier and more practical for everyday use.**

***Index Terms*—Smart Myology, Wearable Sensors, EMG Signal Blood Pressure Monitoring, Mobile Health Application**

I. INTRODUCTION

Muscle fatigue is a common issue for athletes, gym users, and people who are recovering from injuries. When a person exercises or performs physical work for a long time, the muscles slowly get tired. This is normal. But if the muscles do not recover properly, it can lead to pain, poor performance, or even serious injury. Many people cannot clearly feel when their muscles are reaching a dangerous level of fatigue. Because of this, they may continue training or working and put extra stress on their body. Overtime this can slow down recovery and cause long term problems.

In many cases, doctors and trainers check muscle condition using special equipment in laboratories. One common method is EMG, which measures the electrical signals produced by muscles. These systems usually use wired electrodes connected to large machines. The signals are recorded and later analyzed on a computer. This process works well for research, but it has some problems. The equipment is bulky and expensive. It also requires trained professionals to operate it. Most importantly, the analysis often happens after the exercise is finished. This means the system cannot give immediate feedback while the person is still active.

Because of these limitations, researchers started looking for simple rand more portable solutions. Wearable technology has become every useful in this area. Small sensors can now be placed directly on the body to collect health data. These sensors can monitor muscle signals, heart rate, movement, and other physical conditions. The data can be processed instantly using a microcontroller and sent wirelessly to a smart phone or other device. This allows people to see what is happening inside their body while they are exercising or doing daily activities.

Smart myology is a modern approach that combines wearable sensors, biomedical engineering, and simple data analysis. The idea is to monitor rmuscle activity continuously and give real time information to the user. Instead of relying only on laboratory tests, the system can work during normal movement and training sessions. This makes it useful not only for athletes but also for patients undergoing rehabilitation. By watching muscle signals closely, the system can help detect fatigue early and guide the use rotate rest or reduce intensity when needed.

In this project, a wearable monitoring system is designed to track multiple health signals at the same time. Sensors such as EMG, blood pressure, and skin condition sensors are used to collect data from the body. A microcontroller processes these signals and sends the information to a mobile application. The mobile app displays the results in a clear and simple way so the user can easily understand their muscle condition. Athletes, fitness trainers, and physiotherapy patient soften ace this issue during training or recovery exercises. Many times, people continue exercising without realizing that their muscles have already reached a dangerous fatigue level. Since the body does not always give clear signals immediately, people may unknowingly push their muscles beyond safe limits. This can cause muscle damage, inflammation, and poor performance.

Traditional muscle monitoring systems mainly rely on laboratory equipment. One of the most common techniques used is Electromyography (EMG). EMG measures the electrical signals produced by muscle fibers during contraction and relaxation. When muscles work, they generate electrical activity that can be recorded and analyzed. Doctors and researchers use EMG to study muscle strength, fatigue levels, and neuromuscular disorders.

Many researchers have studied ways to monitor muscle activity using wearable technology. In earlier days, most muscle monitoring systems used large EMG machines in laboratories. These systems worked well for research, but they were not easy to use outside the lab. The equipment was heavy and usually connected with wires. Because of this, people could not move freely while the measurements were taken. Also the results were often checked only after the test was finished. So it was hard to know what wash appending to the muscles at that exact moment.

Some studies focused on developing standalone wearable EMG devices. These devices are small and portable. They can be worn directly on the body and can record muscle signals continuously. Researchers showed that these systems are useful for real time muscle monitoring. They remove the need for bulky laboratory equipment and allow users to track muscle activity during daily movements or exercise.
Other research looked at real time monitoring of muscle fatigue using IoT based wearable systems. In these systems, EMG signals are collected and processed instantly. Certain features such as signal strength and frequency changes are used to detect when muscles start getting tired. This helps in identifying fatigue early before it becomes a serious problem. Such systems are useful in sports training and rehabilitation programs.

Some researchers also developed wearable EMG feedback devices. These devices do not just measure signals. They also give feedback to the user. The feedback can be visual, audio, or vibration based alerts. For example, if the muscle activity becomes too high, the system can warn the user. This helps people adjust their movements and reduce strain during exercise or therapy sessions

II. PROBLEM STATEMENT

Muscle fatigue and poor recovery are common problems for athletes, fitness users, and people who are going through physical rehabilitation. Many times, people do not realize when their muscles are getting too tired or stressed. Because of this, they may continue exercising or working, which can lead to muscle strain or injury. Without proper monitoring, it becomes difficult to understand the real condition of the muscles during physical activity.

Most existing muscle monitoring systems are use do nlyin laboratories or hospitals. These systems usually use wired EMG sensors connected to large equipment. They require trained professionals to operate the devices and analyze the results. The analysis is often done after the exercise is finished, so it does not provide instant information about muscle activity. Because of this, users cannot take quick action to prevent fatigue or injury.

Another problem is that these systems are expensive and not easy to carry. The bulky hardware and complex setup make them unsuitable for everyday use in sports training, home exercise, or rehabilitation programs. People need a simpler way to monitor their muscles without depending on laboratory equipment.

So there is a need for a portable and wearable system that can monitor muscle activity in real time. The system should be comfortable to wear, easy to use, and able to provide clear information to the user. This can help people understand their muscle condition better and reduce the risk of injuries during physical activity.

III. EXISTING SYSTEM

In most cases, muscle monitoring is done using EMG systems inside laboratories or hospitals. These setups use wired electrodes placed on the skin to collect electrical signals from the muscles. The signals are then sent to large data acquisition systems and computers for analysis. Doctors or researchers study values like signal strength and frequency to understand muscle fatigue. But this process usually happens after the activity is finished. Because of that, the system cannot give instant feedback while a person is exercising or moving. limit their use in temporary and emergency medical facilities.

Another problem with these systems is that the equipment is bulky and expensive. The setup often needs trained professionals to operate it correctly. Also the wires and heavy devices limit the user’s movement. So these systems are mainly used in controlled environments like research labs or clinics. They are not very practical for daily sports training, home workouts, or regular rehabilitation exercises.

IV.METHODOLOGY

A. Sensor Module

The sensor module is the part that collects data from the human body. In this project, different sensors are used to monitor muscle and health signals. The EMG sensor measures the electrical activity produced by the muscles. This helps to understand how the muscles are working during movement or exercise. A blood pressure sensor is also used to check the user's blood pressure level. In addition, a skin inflammation sensor helps detect any signs of strain or irritation on the skin surface. These sensors are placed in a wearable band so the user can move comfortably while the data is being collected. The sensors continuously send signals to the next part of the system for processing..

B. Control and Processing Module

The control and processing module works like the brain of the system. A microcontroller such as ESP32 or Arduino receives the signals from the sensors. These raw signals are first cleaned and conditioned so that noise and unwanted disturbances are reduced. After that the system processes the data and extracts useful information. The microcontroller separates the signals into different categories such as muscle activity, blood pressure values, and skin condition levels. Once the data is processed, it is prepared for wireless transmission so that it can be viewed by the user in real time.

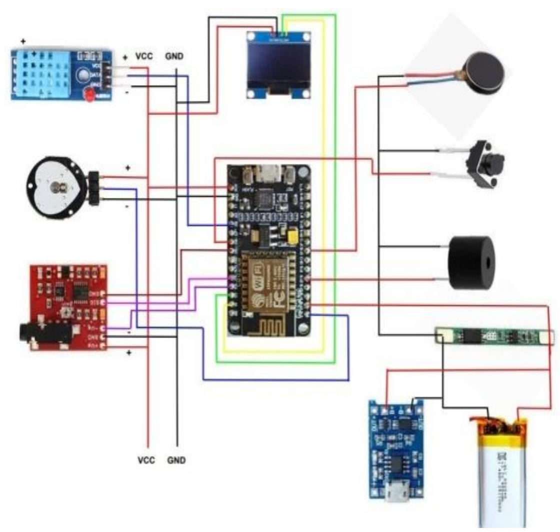


Fig2.Circuit Diagram

C. Mobile Application I.nterface

The mobile application acts as the main interface for the user. The processed data from the microcontroller is sent to the smart phone using wireless communication like Bluetooth or WiFi. The application receives the data and displays it in a simple and clear format. The user can easily see muscle activity, blood pressure readings, and skin inflammation status on the screen. This helps the user quickly understand their muscle condition during exercise or recovery. The app makes the whole system easy to use because most people already carry a smart phone with them.

D. Database

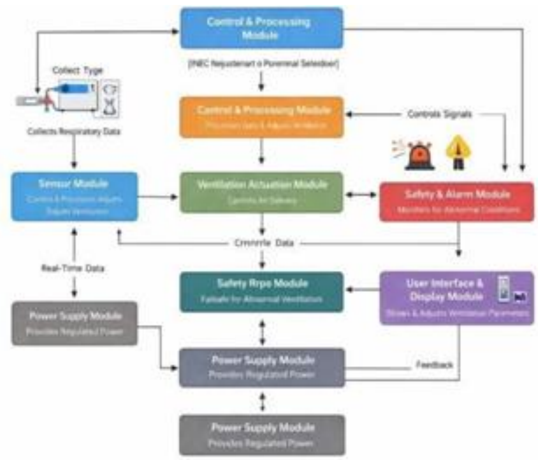
In some cases, the collected data can also be stored in a database or cloud storage. This allows the system to keep a record of the user's health information over time. Doctors, trainers, or researchers can later study the stored data to understand muscle recovery patterns or long term health conditions. Cloud storage also makes it possible to access the data from different devices whenever needed.

E. RealTime Visualization Module

The real time visualization module shows the data in a visual format that is easy to understand. For example, EMG signals can be displayed as a wave form graph showing muscle activity. Blood pressure values can be shown as numbers along with simplest at us indicators. Skin inflammation levels can be displayed aslow, medium, or high. This visual display helps the user quickly understand what is happening in their muscles without needing complex analysis. Real time visualization makes the monitoring process more useful during training or rehabilitation.

F. Power Supply Module

The power supply module provides energy for the whole system to work properly. In this project, a rechargeable battery is used to power the sensors, microcontroller, and wireless communication module. Since the device is wearable, the battery needs to be small and light so the user can wear it comfortably for a long time. The power supply sends a stable voltage to each component so the sensors can collect accurate signals and the microcontroller can process the data without interruption. Proper power management is also important because continuous sensing and wireless data transmission can slowly drain the battery.



V. PROPOSEDSYSTEM

The proposed system is a wearable device that helps monitor muscle activity and health signals in real time. In this system, EMG electrodes are placed inside a comfortable splint band so the user can wear it easily during exercise or daily movement.

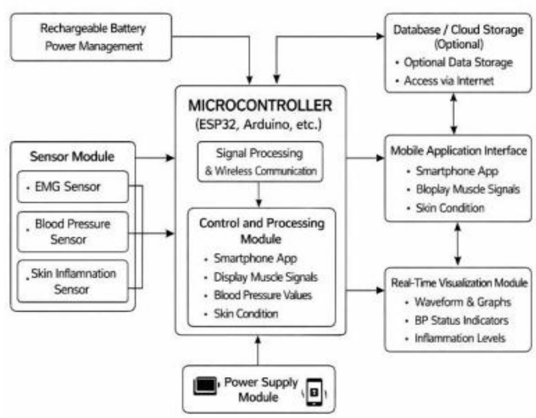


Fig4.BlockDiagram

The sensors collect information such as muscle signals, blood pressure, and skin inflammation. These signals are sent to a microcontroller which processes the data and separates it into clear outputs. After processing, the data is transmitted wirelessly to a mobile application. The mobile app displays the information in simple sections so the user can quickly understand their muscle condition and recovery status. This system makes muscle monitoring easier and more practical compared to traditional laboratory methods.

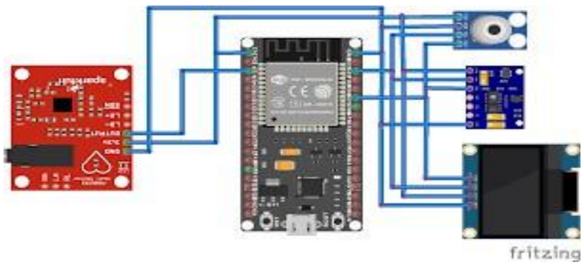


Fig5.Simulation

VI. RESULT AND DISCUSSION

The developed system was tested to check how well it can monitor muscle activity and other health signals in real time. The wearable device was able to collect data from the EMG sensor, blood pressure sensor, and skin inflammation sensor while the user was moving. Them icro controller processed the signals and sent the information wirelessly to the mobile application. The app successfully displayed three types of outputs. Blood pressure values were shown as numerical readings with status indicators. The EMG signal appeared as a waveform that showed the level of muscle activity. Skin inflammation was displayed in simple levels such as low, medium, or high. To overcome these limitations, researchers have started focusing on wearable health monitoring technologies. Wearable devices are small, lightweight electronic systems that can be worn on the body like a watch, band, or patch. These devices can continuously collect physiological signals and transmit them wirelessly to smart phones or computers. Wearable systems allow users to monitor their health in real time without visiting a laboratory,

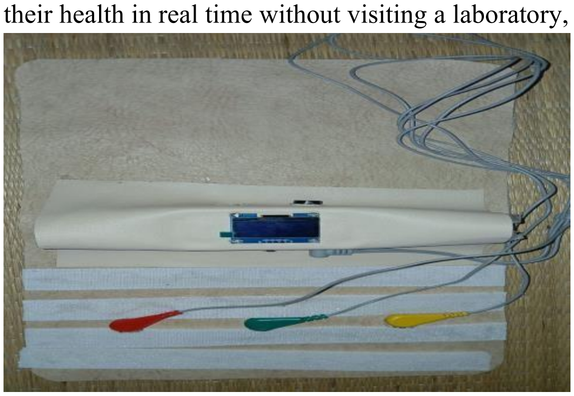


Fig6. Hardware Prototype

The results show that the system can help users understand their muscle condition more clearly during exercise or recovery. The wearable design made the device comfortable and easy to use without restricting body movement.

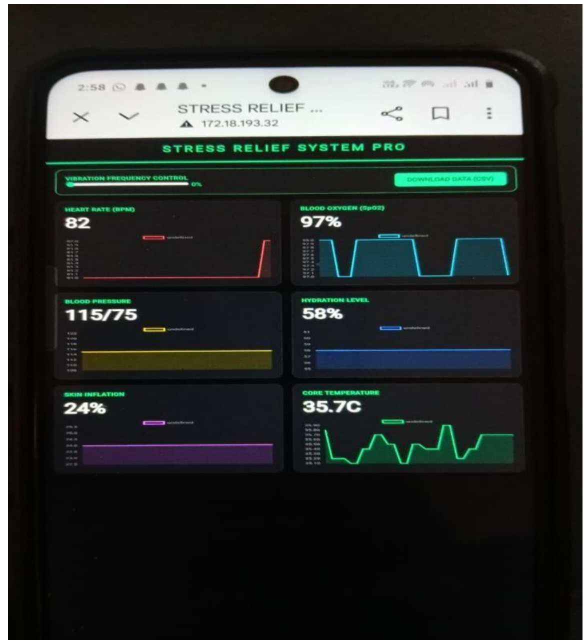


Fig7.DashBoardOutput

Real time monitoring also helps in identifying muscle fatigue early so the user can take rest or adjust their activity. However, some limitations were also observed. EMG signals can sometimes be affected by sweat, body movement, or incorrect electrode placement, which may create noise in the data. Also continuous data transmission may increase battery usage. Even with these small challenges, the system shows good potential for use in sports training and rehabilitation monitoring

VII. CONCLUSION

This project shows a simple way to monitor muscle activity using a wearable device. The system uses sensors to collect signals like EMG muscle activity, blood pressure, and skin inflammation. These signals are processed by a micro controller and then sent to a mobile application for real time display. The results help users understand their muscle condition during exercise or recovery. The wearable design also makes the device comfortable and easy to use in daily life. Overall, the system helps detect muscle fatigue earlier and may reduce the risk of injury. It also show wearable sensors and mobile technology can make health monitoring easier and more practical.

REFERENCES

[1] De Luca, C. J., "The Use of Surface Electromyography in Biomechanics," Journal of AppliedBiomechanics, vol. 13,no. 2, pp.135–163,1997

[2] S. Patel, H. Park, P. Bonato, L. Chan, and M. Rodgers, "A Review of Wearable Sensors and Systems with Application in Rehabilitation," Journal of NeuroEngineering and Rehabilitation, vol. 9, no. 21, 2012

[3] J. Young, M. G. Gannon, and D. P. Ferris, "A Biomechanical Study of Human Muscle Activity Using EMG Sensors," IEEE Transactions on Biomedical Engineering, vol.59, no.3,pp.803–810, 2012.

[4] G.Yang,BodySensorNetworks,Springer,London, 2014.

[5] J. G. Webster, Medical Instrumentation: ApplicationandDesign,4thEdition,John Wiley& Sons, 2010 Espressif Systems, "ESP32 Technical Reference Manual," Espressif Systems, 2023.

[6] S. Majumder, T. Mondal, and M. Deen, "Wearable Sensors for Remote Health Monitoring," Sensors, vol. 17, no. 1, 2017.

[7] World Health Organization, "Guidelines on Physical Activity and Health Monitoring," WHO Publications, 2020.

[8] M. H. Al-Muhtadi and A. B. M. Shawkat, "Wearable EMG-Based System for Real-Time Muscle ActivityMonitoring," IEEE Access, vol. 8,pp.186245–186256,2020.

[9] H. M. Fahim, S. A. Chowdhury, and M. S. Kaiser, "Development of a Wearable Health Monitoring SystemUsingIoT," IEEESensorsJournal, vol.21, no. 4, pp. 5473–5480, 2021.

[10] A. Pantelopoulos and N. G. Bourbakis, "A Survey on Wearable Sensor-Based Systems for Health Monitoring and Prognosis," IEEE Transactions on Systems, Man, and Cybernetics, vol. 40, no. 1, pp. 1–12, 2010.

[11] J.Heikenfeldetal.,"WearableSensors:Modalities, Challenges, and Prospects," IEEE Engineering in MedicineandBiologyMagazine, vol. 37,no. 4, pp. 25–38, 2018.

[12] Espressif Systems, "ESP32 Technical Reference Manual," Espressif Systems, 2023.

[13] S. Majumder, T. Mondal, and M. Deen, "Wearable Sensors for Remote Health Monitoring," Sensors, vol. 17, no. 1, 2017.

[14] WorldHealth Organization, "Guidelineson Physical Activity and Health Monitoring," WHO Publications, 2020.

[15] M.H.Al Muhtadiand A.B.M. Shawkat, "Wearable EMG-Based System for Real-Time Muscle Activity Monitoring," IEEE Access, vol. 8, pp. 186245– 186256, 2020.

[16] H. M. Fahim, S. A. Chowdhury, and M. S. Kaiser, "Development of a Wearable Health Monitoring System Using IoT,"IEEESensorsJournal,vol. 21, no. 4, pp. 5473–5480, 2021.

[17] A. Pantelopoulos and N. G. Bourbakis, "A Survey on Wearable Sensor-Based Systems for Health Monitoring and Prognosis," IEEE Transactions on Systems, Man, and Cybernetics, vol. 40, no. 1, pp. 1–12, 2010.

[18] J. Heikenfeld etal., "Wearable Sensors: Modalities, Challenges, and Prospects," IEEE Engineering in Medicine and Biology Magazine, vol. 37, no. 4, pp. 25–38, 2018.

[19] S. Patel, H. Park, P. Bonato, L. Chan, and M. Rodgers, "A Review of Wearable Sensors and Systems with Application in Rehabilitation," IEEE Journal of Biomedical and Health Informatics, vol. 17, no. 3, pp. 602–611, 2013.19.

[20] Y.Khan,A.Ostfeld,C.M.Lochner,A.Pierre,andA. C.Arias,"MonitoringofVitalSignswithFlexible and Wearable Medical Devices," IEEE Reviews in Biomedical Engineering, vol.11,pp.252–264,2018.

[21] G. Yang, "Body Sensor Networks and Wearable Health Monitoring Systems,"IEEE Communications Magazine, vol. 52, no. 5, pp. 66–72, 2014