Power System Technology
ISSN:1000-3673

Received: 16-12-2025 *Revised: 05-01-2026* *Accepted: 20-02-2026*

Smart Wearable Posture Corrector with Integrated Muscle Fatigue Detection Using Ai

M. Deeparani,

Assistant Professor, Biomedical Engineering, Hindusthan college of Engineering and Technology, Coimbatore, India

deepusabari1984@gmail.com

T. Anbumani

Biomedical Engineering, Hindusthan college of Engineering and Technology, Coimbatore, India

anbumanitamist@gmail.com

M. Arsath Parvez

Biomedical Engineering, Hindusthan college of Engineering and Technology, Coimbatore, India

arsathparvez858@gmail.com

S. Dhilak

Biomedical Engineering, Hindusthan college of Engineering and Technology, Coimbatore, India

dhilakpandiyan02@gmail.com

D. Gunasekaran

Biomedical Engineering, Hindusthan college of Engineering and Technology, Coimbatore, India

gunadhanapal2004@gmail.com

Abstract - Musculoskeletal Problems are increasingly popular these days in students, office-workers and other make of long sitting or continuous physical activities. One of the leading causes of back pain, neck pain and other spine problems is bad posture and constant muscle strain. Often, muscle fatigue goes unnoticed and is late in" comping "so injury risk is increasing. To tackle this problem, in this paper we present a smart wearable posture correction system integrated with muscle fatigue detection. The device proposed in [24–26] utilizes MPU6050 accelerometer and gyroscope sensor to track the body orientation related to an abnormal Imation position such as slouched and forward bent. Open EMG is an Electromyography (EMG) signal and fatigue acquisition and analysis platform that uses a minimally intrusive EMG sensor to monitor muscle activity and detect fatigue. Then, the

Received: 16-12-2025 *Revised: 05-01-2026* *Accepted: 20-02-2026*

obtained sensor data is analyzed by machine learning methods such as K-Nearest Neighbors (KNN) and Random Forest so that the posture status and fatigue state are well identified. If the user isn't in a proper posture or too tired, the device will also give a vibration reminder as real-time feedback to stretch and correct their posture.

The collected data is also transmitted to a cloud for visualization and long-term study. This wearable device provides your posture support to keep the muscles in perfect alignment and helps you avoid musculoskeletal diseases.

Keywords: Posture Monitoring, Muscle Fatigue Detection, Wearable Device, EMG Sensor, MPU6050, Machine Learning, KNN, Random Forest, IoT, Vibration Alert

I. INTRODUCTION

The musculoskeletal disorders (MSDs) including back pain, neck pain, and shoulder strain are spreading rapidly as a result of prolonged sitting and incorrect posture along with sedentary lifestyles. Students, office workers, long time sitting people may sit with wrong back postures such as slouching in chair gliding and general bad back sitting position without noticing. Gradually, these postural deviations can cause spinal subluxation, muscle fatigue, and health challenges.

Conventional methods of posture correction, such as physiotherapy and ergonomic training, demand both user attention to habit change and regimens of repetitive practice that users can find tedious. Recent advances in wearable sensors and artificial intelligence have made real-time postures monitoring systems possible that can detect fluctuations in posture and provide immediate feedback.

In this paper, a smart wearable posture monitoring system is developed based on MPU6050 accelerometer and gyroscope sensor with the help of machine learning techniques. The apparatus can identify postural states and produce real-time corrective directives. A PHP driven dashboard is also included for posture history, sensor values and recommendation output available for ongoing monitoring and long-term analysis.

II. LITERATURE REVIEW

The incidence of MSID due to poor posture and prolonged physical effort has been escalating abruptly in recent years. Several works have investigated posture monitoring and rehabilitation by a wearable sensor technology. Carlson et al. presented an early radio telemetry system that measured pressure distribution in the human hip joint and demonstrated that sensorbased monitoring can be used for orthopedic applications [1]. Iso-Ketola et al. developed the HipGuard wearable detector to detect posture and load situation during hip recovery with vibration/audio feedback for dangerous positions [2]. Chutatape et al. suggested the detection of an incorrect hip angle based on accelerometer sensors using a smartphone, the positioning

Power System Technology
ISSN:1000-3673
Received: 16-12-2025 Revised: 05-01-2026 Accepted: 20-02-2026

of which would constrain accuracy [3]. Wireless monitoring technologies in home healthcare have also been investigated and multipurpose systems were employed for patient monitoring and distant assessment [4].

In implants monitoring, van Gaalen et al. designed the smart hip implant technology with 3D metal printing and wireless telemetry for long-term monitoring [5]. There are proposed some wireless monitoring systems for hip replacement surgeries to promote safety of patients in their recovery [6], [7]. Wei et al. described a modular embedded implant with IMU and force sensing to monitor motion and tension of the breast tissue in operating theater [8]. Rehabilitative monitoring systems using pressure sensors, and smartphone applications were also developed to assist in guided walking training [9].

Wearable devices based on accelerometers and gyroscopes for position sensing in rehabilitation have been examined and their suitability for ergonomic real time monitoring has been validated [10]-[12]. For fatigue detection in muscle, standards of EMG and the placing of sensors were approved to increase signal reliability [13]. Wearable EMG-based systems were also applied towards work-related fatigue monitoring and injury prevention [14] while fatigue detection approaches based on the EMG signal processing methods were used in human-robot interaction studies as well as robotics [15]. Such literature contributions reveal that the majority of systems are either targeted at posture or fatigue and lead to a two-fold requirement for an all-in-one wearable system able to monitor both aspects.

III. PROBLEM STATEMENT

There is a high rate of increase in musculoskeletal disorders (MSDs) such back pain, neck pain and shoulder strain owing to long sitting hours with improper postures as well as the practice of repetitive physical activities. We humans spend a lot of time sitting and we sit with incorrect posture such as slouching or hunched forward without even realizing. Sustained bad posture leads to misaligned spinal column and long-term health problems.

Furthermore, one of the most significant causes for injury and deterioration in physical performance is muscle fatigue due to overexertion and lack of rest. Few people can recognize the signs of initial muscle fatigue and would overstrain muscles and joint to a harm. Current posture control tools only detect the pose of a body without real-time feedback but with delayed analysis. Likewise, the most of EMG-based fatigue monitoring isolated work and didn't associate fatigue with misalignment of posture. This absence of a unified monitoring system limitations the use of ergonomic correction and injury prevention.

Accordingly, there is a need for an intelligent wearable capable of continuously monitoring posture and muscle fatigue concurrently, issuing real-time corrective reminders, and archiving the measured information for long-term health evaluation to prevent MSDs.

Power System Technology
ISSN:1000-3673
Received: 16-12-2025 Revised: 05-01-2026 Accepted: 20-02-2026

IV. PROPOSED SYSTEM

The system is a wearable intelligent device which can monitor human body posture and muscle fatigue in real-time. The main purpose of this system is to identify abnormal posture conditions and early signs of muscle fatigue, and give an instantaneous feedback to the user to avoid musculoskeletal disorders.

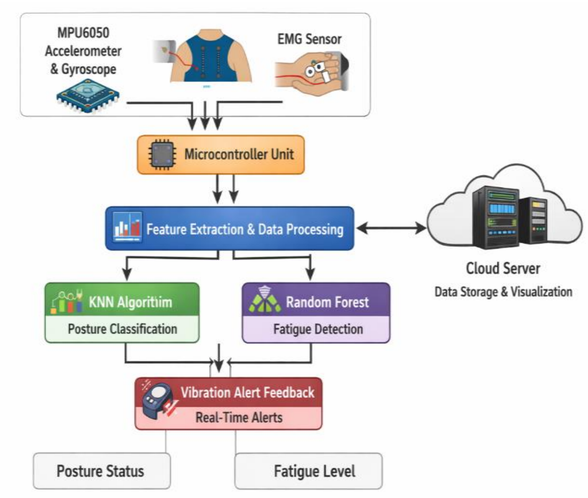

Fig 1: Block Diagram for Proposed System

The device also includes an IMU sensor such as MPU6050, which is composed of an accelerometer and gyroscope to capture body orientation deviations, tilt angles, and patterns of motion. These sensor readings are applied to characterization of postures, such as normal sitting, slouching, and forward lean and left or right lateral leaning. Also, a sensor for EMG (Electromyography) signals is provided to obtain muscle activity signals of user from back and shoulder area. EMG data is analyzed to determine the fatigue status of muscles during extended periods of work or physical activity.

The readings of the sensors are sent as input features to a microcontroller unit. The features like mean, variance, RMS values and frequency components are computed from IMU and EMG signals. Regarding classifiers, K-Nearest Neighbors (KNN) and Random Forest are adopted. KNN is utilized for posture classification with because of its efficiency to learn from similarity based measure, and Random Forest is employed for the fatigue detection as it shows good performances on complex and noisy EMG data.

When the users has bad position or high fatigue in muscles, ALERT of being vibrated to sense back and inform it so that I can know immediately. This biofeedback provided during exercise allows the user to work on posture or take rest before fatigue becomes extreme. What's more, the recorded data is able to upload on cloud platform for visualization and long term analysis, users are now can keep an eye for their posture habit and fatigue over time.

Power System Technology
ISSN:1000-3673
Received: 16-12-2025 Revised: 05-01-2026 Accepted: 20-02-2026

In general, the wearable system offers a comprehensive and smart way to continuously monitor ergonomic gesture correcting and fatigue prevention, which enhances health and productivity.

V. HARDWARE IMPLEMENTATION

A. Sensor Unit

It measures body tilt angle and movement using MPU6050 (Accelerometer + Gyroscope) data. It can be used to identify posture situations, such as hunching, bending and leaning. It makes use of an EMG sensor to collect muscle signals and measure the intensity of muscle fatigue.

B. Controller Unit:

An **ESP8266 (NodeMCU)** microcontroller serves as the primary processor. It acquires sensor data, simple preprocessing and controls the alert system. It also provides Wi-Fi communication for connection to the cloud.

C. Alert Mechanism

A **vibration generator** is attached to the controller. When the wrong raising posture or large muscle fatigue is detected, motor vibration feedback is provided for users to alert and raise their correct posture.

D. Cloud and Monitoring

The **filtered sensor** data are transmitted to the cloud Thing Speak server over Wi.Fi. This is useful for real-time visualization and long-term data storage/analysis.

E. Power Supply

All components are supplied power from a stabilized power supply. The entire arrangement is carried on a portable belt for convenient use.

VI. METHODOLOGY

A. Data Collection

The wearable extracts the real-time data from **MPU6050** sensor (accelerometer and gyroscope) for body posture angles and movement. Meanwhile, the **EMG sensor** can capture muscle activity signals for muscle strain and fatigue analysis.

B. Signal Preprocessing

Raw data gathered from sensors can be noisy and create unwanted variability. That is why it necessary to preprocess data in order to eliminate extraneous elements and stabilize the data for further research. 5-4: EMG signals are low pass filtered to remove motion artifacts and enhance precision.

Power System Technology
ISSN:1000-3673
Received: 16-12-2025 *Revised: 05-01-2026* *Accepted: 20-02-2026*

C. Feature Extraction

Relevant features are derived from both posture as well as the EMG signals. For check of posture, Use tilt angles and an orientation value. For fatigue identification EMG features RMS value, mean, variance and frequency changes are extracted.

D. Posture Classification using KNN

The local posture features are input to the **K-Nearest Neighbors (KNN)** algorithm. KNN matches the new posture data to existing training samples and categories them as normal, slouched, forward bend, left lean and right lean.

E. Fatigue Detection using Random Forest

The EMG features are then fed to Random Forest algorithm. A **Random Forest** considers several decision trees to classify the fatigue as low, medium or high. It performs better with complex EMG data.

F. Real-Time Alert Generation

When poor posture or excessive fatigue is detected, it will vibrate the engine to quickly inform the user. The user can take rest or correct posture right away.

G. Cloud Storage and Visualization

The end result and sensor readings are posted to the Wi-Fi cloud service, Thing Speak. This allows real-time monitoring, graphical display as well as long-term posture and fatigue monitoring.

VII. RESULTS & DISCUSSION

7.1 Performance of Posture Classification Model

We used five posture classes for validating the posture classification model: Good Posture, Leaning Forward, Neck Bend, Shoulder Tilt and Slouching. The classification report also confirms that the model reported 1.0 accuracy (which corresponds to 100%). For all posture classes the precision, recall and F1-score are 1.00 which means there was no error in the model classifying any posture. A total of 9000 samples were evaluated, considering Good Posture (2650 samples), Leaning Forward (1581 samples), Neck Bend (1622 samples), Shoulder Tilt (1455 samples) and Slouching (1692). These results validate that the posture detection model is very accurate as well as reliable to be used in real-time wearable posture monitoring.

Power System Technology
ISSN:1000-3673
Received: 16-12-2025 Revised: 05-01-2026 Accepted: 20-02-2026

```
=== Posture Model ===
Accuracy: 1.0
                 precision    recall  f1-score   support

   Good Posture       1.00      1.00      1.00      2650
Leaning Forward       1.00      1.00      1.00      1581
      Neck Bend       1.00      1.00      1.00      1622
  Shoulder Tilt       1.00      1.00      1.00      1455
      Slouching       1.00      1.00      1.00      1692

       accuracy                           1.00      9000
      macro avg       1.00      1.00      1.00      9000
   weighted avg       1.00      1.00      1.00      9000
```

Fig 7.1 Classification Report (Posture)

7.2 Confusion Matrix Analysis for Posture Detection

The confusion matrix output by the posture model attests to perfect classification. All posture samples were correctly predicted and located at the diagonal of the matrix. The diagonal numbers in the last column of Table 2 (#="label") like 2650 for Good Posture, 1581 for Leaning Forward, 1622 for Neck Bend,1455 for Shoulder Tilt and 1692 for Slouching represent the accurately classified instances in each class. Because all off-diagonals are zero, there is no misclassification. This demonstrates that the model can effectively discriminate posture variations for practical postures as well, which is beneficial for abnormity detection of postures in practice.

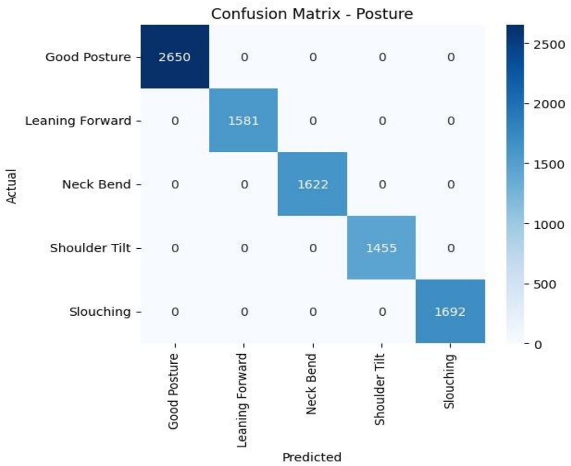

Fig 7.2 Confusion Matrix (Posture)

7.3 Performance of Recommendation Model

The recommendation model was utilized to offer appropriate correction recommendations with regard to detected postures. Its evaluation result indicates that this also has 1.0 as the overall accuracy, having 1.00 in precision, recall and F1-score of all-out recommendation

Power System Technology
ISSN:1000-3673

Received: 16-12-2025 *Revised: 05-01-2026* *Accepted: 20-02-2026*

outputs. The system was able to generate accurate feedback messages including: bring chair up what you are comfortable with, keep your back straight and erect, bring the screen up closer to your eye level, do not bend your neck forward, and have both of your shoulders aligned. This indicates that the posture model is well mapped with the recommendation and gives good ergonomic advice to users.

=== Recommendation Model ===
Accuracy: 1.0

	precision	recall	f1-score	support
Adjust chair height, keep spine neutral	1.00	1.00	1.00	1581
Keep shoulders aligned, avoid leaning sideways	1.00	1.00	1.00	1455
Lift screen to eye level, avoid bending neck too long	1.00	1.00	1.00	1622
Maintain straight back, shoulders relaxed, feet flat	1.00	1.00	1.00	2650
Sit upright, avoid bending neck, support your back	1.00	1.00	1.00	1692
accuracy			1.00	9000
macro avg	1.00	1.00	1.00	9000
weighted avg	1.00	1.00	1.00	9000

Fig 7.3 Confusion Matrix (Posture)

7.4 Confusion Matrix Analysis for Recommendation Output

The confusion matrix showed that all recommendation class were well predicted in the recommendation model. Diagonal values represent the number of all samples correctly classified: 1581, rating no result for chair adjustment recommendation; 1455, shoulder alignment suggestion; 1622, neck bending correction; 2650, straight back recommendation; and 1692, upright sitting suggestion. The lack of off-diagonal values means that the model made correct predictions with no confusion. This serves as evidence that the system is capable of delivering correct real-time corrective feedback right after posture detection.

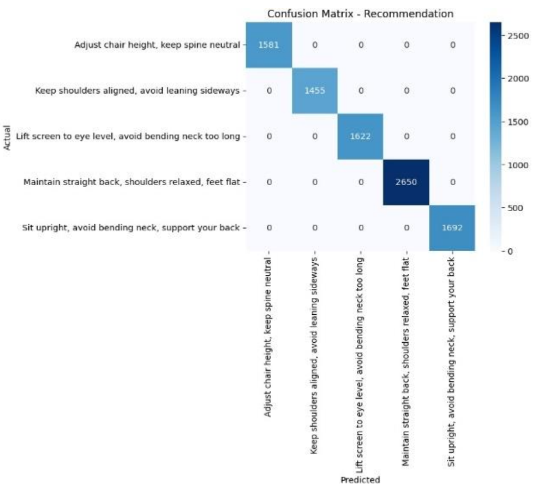

Fig 7.4 Confusion Matrix (Recommendation)

Power System Technology
ISSN:1000-3673
Received: 16-12-2025 *Revised: 05-01-2026* *Accepted: 20-02-2026*

7.5 Accuracy Comparison of Models

The comparison graph of the model's accuracy demonstrates that, not only both Posture Model and Recommendation Model obtained perfect accuracy - synonymous with 100%. This also confirms that the complete system gives stable and errorless performance (classification). This high level of accuracy is advantageous for wearable applications as it guarantees reliable detection and recommendation production without false alerts.

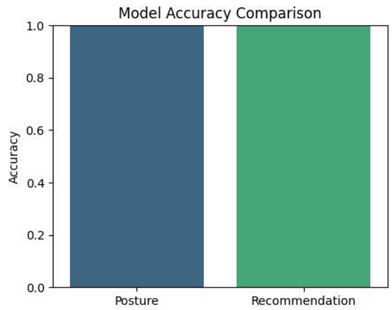

Fig 7.5 Accuracy Comparison Graph

7.6 Dashboard Output and Real-Time Monitoring

A dashboard for monitoring the results of posture analysis in real time is provided to improve usability of the system. An interactive user interface appears on the dashboard, displaying detected posture status, recommended one and real-time sensor values (e. g.: acc and gyro). It also features a real-time posture history graph, which allows users to track and visualize posture changes over time. Further, a posture records table is shown with the timestamp, the detected type of posture, sensor values and recommendation generated. The system is further enhanced by a PHP dashboard that allows real-time monitoring, data archival and offline posture trend analysis. It also enables the system to be used for student, office worker and health care personnel applications where real time monitoring and reporting are needed.

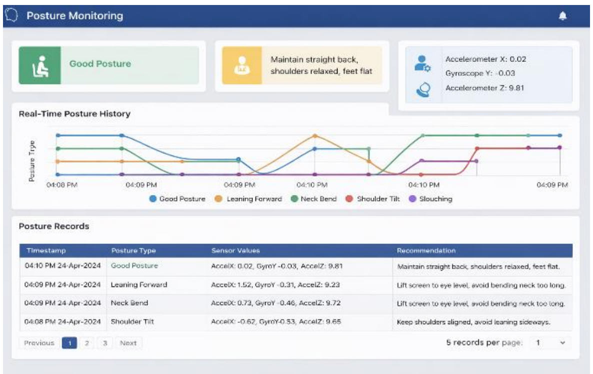

Fig 7.6 Dashboard Output

Power System Technology
ISSN:1000-3673
Received: 16-12-2025 Revised: 05-01-2026 Accepted: 20-02-2026

7.7 Discussion

The experimental results show that the designed smart wearable posture correction system delivered promising performance. The posture classification model and recommendation generation model achieved an accuracy of 100%, indicating that the features of MPU6050 sensor drives were extracted from posture variations well. The confusion matrices could verify that no misclassification was done; thus, the performance of the framework can be confirmed. In addition, an advantage of incorporating the PHP dashboard is that real-time visualization, posture trend analysis and storage of posture logs are possible. In summary, the proposed system offers an effective and intelligent approach for posture correction and musculoskeletal disorder prevention through machine learning classification, recommendation generation and monitoring via Web.

Table 7.1 Overall Model Performance Summary

Model	No.of Classes	Accuracy	Precision	Recall	F1-Score
Posture Classification Model	**5**	**1.00**	**1.00**	**1.00**	**1.00**
Recommendation Model	**5**	**1.00**	**1.00**	**1.00**	**1.00**

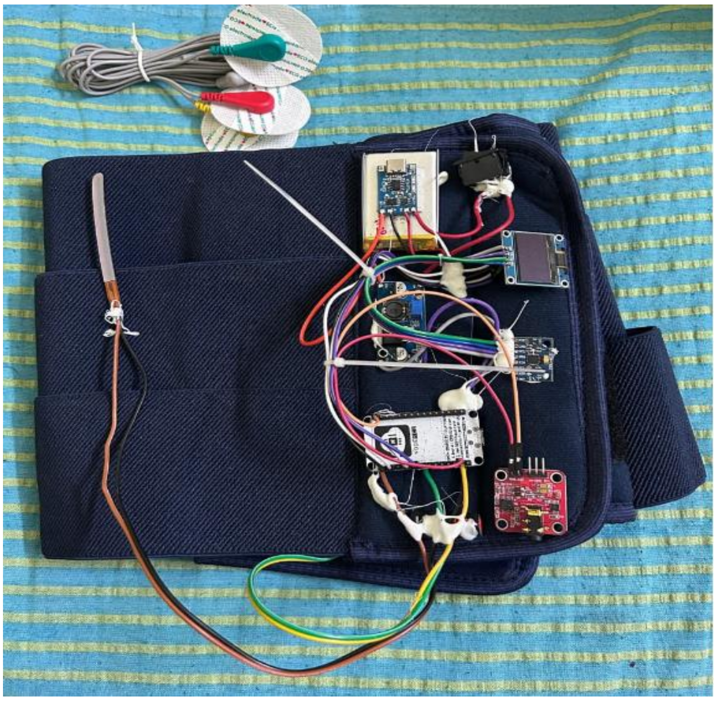

Fig 7.7 Output Prototype

Power System Technology
ISSN:1000-3673
Received: 16-12-2025 Revised: 05-01-2026 Accepted: 20-02-2026

VIII. CONCLUSION

This paper presented an AI-based smart wearable posture corrector to recognize the incorrect sitting postures and make real-time recommendations for correction. The system could successfully differentiate the five posture conditions with 100% accuracy and well-working for recommendation model feedback was also found in that case. This built-in dashboard allows for real-time monitoring as well as tracking of posture history and data storage for analysis over time. The proposed system is working well for improving posture overall and to prevent MSD.

REFERENCES

[1] C. E. Carlson, R. W. Mann and W. H. Harris, "A Radio Telemetry Device to Measure In Vivo Knee Forces," 1974

[2] H. Hermens, B. Freriks, C. Disselhorst-Klug and G. Rau, "Development of recommendations for SEMG sensors and sensor placement procedures," Journal of Electromyography and Kinesiology, vol. 10, no. 5, pp. 361-374, 2000.

[3] P. Iso-Ketola, T. Karinsalo, and J. Vanhala, "HipGuard- a wearable measurement system for postoperative hip-replacement patients" 2008.

[4] S. Junnila et al., "Wireless, multipurpose in-home health monitoring platform: Two case trials"ANGES-0, pp.

[5] H. Chen, S. Su, Z. Wang, and X. Zhang, "A wirelessly monitoring system for Total Hip Replacement surgery," 2014.

[6] H. Chen J Gao, S Su, X Zhang and Z Wang, "A Visual-Aided Wireless Monitoring System Design for Total Hip Replacement Surgery," 2015.

[7] J. B. van Gaalen et al., "Versatile smart hip implant technology using 3D metal printing," 2016.

[8] O. Chutatape, K. Naonueng and R. Phoophuangpairoj, "Detection of improper postures lead faster dislocation of hip prosthesis by smartphone," 2017.

[9] Q. Zheng and H. Chen, "A monitoring system for walking rehabilitation after THR or TKR surgeries," 2017.

[10] S. R. B. Rautaray and A. Agrawal, Real-time posture monitoring and feedback system using wearable sensors," in Proc. IEEE ICECA, 2018.

[11] R. C. Luo, L. Liu, and S. H. Su, "Posture detection and correction system using wearable accelerometers and gyroscopes," IEEE Trans. Instrum. Meas., vol. 68, no. 3, pp. 765-774, 2019.

Power System Technology
ISSN:1000-3673
Received: 16-12-2025 *Revised: 05-01-2026* *Accepted: 20-02-2026*

[12] D. H. Kim, J. H. Lee, and S. H. Park, "Wearable EMG-based system for real-time monitoring of muscle fatigue development in prosthetics and industrial applications," J Rehabil Res

[13] M. H. Lee, Y. J. Lee and H.J.Kim, "Muscle fatigue detection using EMG signal processing for human- robot interaction," IEEE Trans. Robotics, vol. 35, no. 6, pp. 1504-1513, 2019.Aggressive Tumors as Prognostic Marker Cancers mdpi:10.

[14] J. P. Reynolds, S. A. Ferguson and M. P. Smith,"Wearable sensor systems for body mass ratio testing during dynamic exertion: demonstration with squatting,"IEEE Transactions on Neural Systems and Rehabilitation Engineering, pp! 21, no. 8, pp. 9504-9517, 2021).

[15] J. C. J. Wei et al., "Design of an Affordable, Modular Implant Device for Soft Tissue Tension Assessment and Range of Motion Tracking During Total Hip Arthroplasty," 2022.