



# Multi-sensing Fusion with Blynk Interface of Internet-of-Things for Health Monitoring System

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Article Info	Abstract
<p><b>Article history:</b> Received Feb 24<sup>th</sup>, 2026 Revised May 6<sup>th</sup>, 2026 Accepted Jun 3<sup>rd</sup>, 2026 Published Jun 30<sup>th</sup>, 2026</p> <hr/> <p><b>Index Terms:</b> Multi-sensing Fusion Blynk Internet-of-Things Health Monitoring</p>	<p>The rapid expansion of the Internet of Things (IoT) has a significant influence on the evolution of wearable health monitoring devices, in particular for fitness and personal wellness. IoT-connected wearables allow real-time, constant monitoring of physiological markers like heart rate, body temperature, etc., with better precision and regularity than the conventional periodic assessment methods. Recent trends are moving away from wrist-wearable gadgets to smart textiles, which allows for a more natural distribution of sensors and increased user comfort. The Arduino is widely used in development platforms due to its low cost, open source and compatibility with biological sensors. However, existing work mostly concentrates on sensor performance and data transport, whereas user interface and coherent garment design are rarely considered. Moreover, many of the proposed technologies are in the prototype stage and have little practical value. Despite advances in smart textiles and data processing technologies, obstacles such as power consumption, system complexity and cost continue to hinder the development of affordable solutions. This work proposes an IoT-based fitness jacket for real-time monitoring of heart rate and body temperature using Arduino, which offers a practical, cost-effective, and user-friendly wearable for everyday health monitoring.</p>

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## I. INTRODUCTION

The fast development of the Internet of Things (IoT) has sped up the development of wearable monitoring systems and smart healthcare in healthcare delivery[1]. These wireless IoT-enabled devices help improve treatment outcomes, promote preventative care and improve quality of life by allowing for the remote, real-time monitoring of patients. Recent advances in low-power sensors and miniaturised embedded systems [2], such as Arduino-based platforms have enabled the continuous non-invasive collection of physiological data in highly portable and cost-effective formats, allowing individuals to manage their health and optimise their fitness [3].

Smartwatches and fitness bands are now commercially accessible to measure basic metrics like heart rate and activity levels but several major issues still remain. Many of these common solutions are either expensive, limited in customisation, or suffer from technical limitations that hamper in the wider adoption and reliability. In particular, traditional fitness clothing does not have embedded physiological monitoring capabilities, providing limited

real-time health input during physical activity, which limits consumer convenience[1].

Furthermore, cheap monitoring systems are frequently faced with crucial technical problems such as signal instability, motion artefacts, and inconsistent or inaccurate sensor readings due to environmental conditions or sensor constraints. Such errors point to the need for better sensor technology and effective calibration methods. Integration of sensing, computation and wireless communication in a power efficient way within a wearable textile platform is still a complicated hardware design challenge. Moreover, many systems use separate devices rather than integrated garment-based platforms, which degrades the entire user experience and utility.

All these major restrictions point to the urgent need for a compact, inexpensive, and reliable IoT-enabled wearable device to provide real-time physiological monitoring with confirmed performance accuracy, hence facilitating equitable and accessible health management.

In this study, the design and implementation of an IoT based Fitness Jacket with heart rate and body temperature monitoring utilising Arduino Uno microcontroller is shown. The system includes a PPG [4][6] based pulse sensor, an LM35 temperature sensor, local LCD display feedback, keypad based user control and HC-05 Bluetooth

connectivity in one embedded garment platform. Most existing systems are limited to monitor only mobile applications or are based on cloud monitoring. In contrast, the suggested method combines real-time local display and wireless transmission in a single embedded architecture at a reasonable implementation cost.

## II. LITERATURE REVIEW

The rapid development of Internet of Things (IoT) technology has tremendously sped up the expansion of wearable health monitoring devices, particularly in the fitness and personal well-being sectors [7], [8]. Sensors, embedded systems and wireless communication are integrated to provide continuous, real-time monitoring of vital physiological parameters including heart rate, body temperature and physical activity in IoT-enabled wearables. Unlike traditional fitness tracking approaches, which frequently rely on self-reporting or intermittent assessments, IoT-based devices deliver objective, continuous data streams. It helps in early detection of unhealthy health habits and also makes the users more health conscious.

A major trend in [7], [9], [10] is the shift from wrist-worn devices to smart clothes like jackets and vests which allow for a more natural and distributed deployment of sensors. These clothing options boost the comfort and functionality, especially during long hours of activity.

Arduino platforms are popular in wearable health monitoring research due to their low cost, open-source flexibility, and compatibility with many biomedical sensors. It has been shown in [11], [12] that Arduino microcontrollers can collect and interpret physiological data such as heart rate and body temperature and send the data in real-time using Bluetooth or Wi-Fi. These systems have been employed in domains like fitness tracking, patient care, labour safety, and military. However, research nowadays is mostly focused on the sensor function and data transmission with little attention to user interaction, control system and the integration of the whole garment. Moreover, many of these ideas are still at the conceptual or prototype level and have not been validated in real-world garment-integrated scenarios.

Recent advances in smart fabrics and wearable electronics provide flexible sensors and more advanced data processing methods to improve the accuracy and user comfort [13], [14]. However, even with these improvements, problems like as complexity, power consumption, calibration requirements, and cost limitations remain especially in low-cost and educational environments. The uses of cloud computing, sensor fusion and machine learning boost the capability of the systems but also raise the system requirements and hence are less suitable for simple fitness monitoring applications.

The requirement of a practical, low-cost and garment-integrated IoT wearable that emphasises critical physiological monitoring without any excessive complexity [8], [15]. To address this, the present work presents an Arduino-based IoT fitness jacket that can monitor heart rate and body temperature in real time providing a simple, wearable and accessible solution for everyday health monitoring.

## III. METHODOLOGY

### A. Systematic Architecture

This study adopted a systematic design and experimental approach to develop and validate an Internet of Things (IoT)-based Fitness Jacket for real-time physiological monitoring. The methodology consisted of system architecture design, hardware development, software implementation, wearable integration, and experimental validation. The overall objective was to develop a low-cost, portable, and reliable wearable system capable of monitoring heart rate and body temperature during daily activities.

The proposed system architecture was divided into three main subsystems, namely the sensing module, controller module, and output module, as illustrated in Figure 1. The sensing module consisted of a pulse sensor for heart rate detection and an LM35 sensor for body temperature monitoring. The acquired physiological signals were processed by an Arduino Uno microcontroller, which functioned as the central processing unit of the system. The processed data were then transmitted wirelessly through the HC-05 Bluetooth module and displayed on both the LCD module and smartphone application.

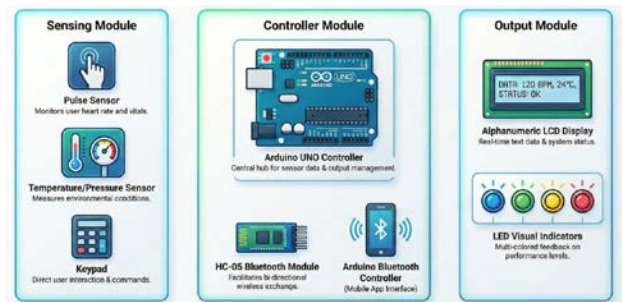


Figure 1. IoT Fitness jacket architecture

The hardware circuit was designed and simulated using Fritzing software prior to physical implementation to ensure proper connectivity between all components. The developed circuit integrated the Arduino Uno microcontroller, pulse sensor, LM35 temperature sensor, HC-05 Bluetooth module, keypad module, LED indicator, and LCD display. The finalized circuit was fabricated on a printed circuit board (PCB) to improve electrical stability and enhance the compactness of the wearable system.

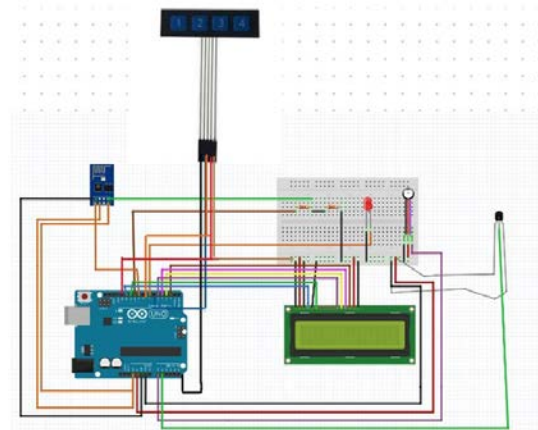


Figure 2. Circuit design using Fritzing

The printed circuit board (PCB) was designed and fabricated to integrate all system components into a compact and stable hardware platform. As shown in Figure 3, the PCB accommodates the Arduino Uno microcontroller, pulse sensor interface, LCD module connection, and power source. Proper routing techniques were applied to ensure organized signal pathways and minimize electrical interference [16]. Jumper wires were used to establish secure connections between the microcontroller and peripheral components, including the LED indicator and LCD display module. The PCB layout was arranged to maintain clear separation between signal and power lines, enhancing system stability and reducing noise. Additionally, connectors were strategically positioned to facilitate easy sensor interfacing and future expansion. The assembled PCB demonstrates reliable electrical connectivity and stable operation during experimental validation, confirming the effectiveness of the design and fabrication process.

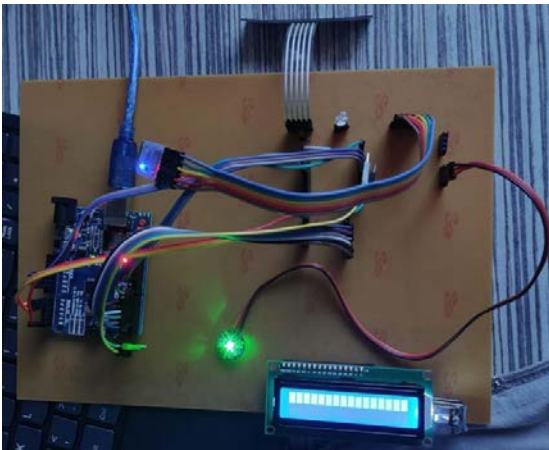


Figure 3. PCB hardware connection

Figure 4 is a flowchart for working logic of the health monitoring gadget. The process starts with the user pressing a given command on the keypad. The device uses the information from the temperature and pulse sensors to perform simultaneous biometric tests when activated and offers visual feedback through an LED. These vital indicators are then processed and transmitted to a mobile device and integrated LCD panel to be viewed by the user. Finally, for a controlled finish of the data gathering process, the sequence only ends when the user voluntarily enters a termination code.

The firmware was written using the Arduino Integrated Development Environment (IDE). The program was developed to initialize the system components, periodically read the sensor data, filter the noise by simple signal conditioning, compute the BPM and temperature values, and send structured data through serial connection [17]. A 16x2 LCD module was assembled for real-time local visualization and an HC-05 Bluetooth module was used to wirelessly transmit data to a smartphone application. The communication was set at a baud rate of 9600 bps to ensure consistent data exchange.

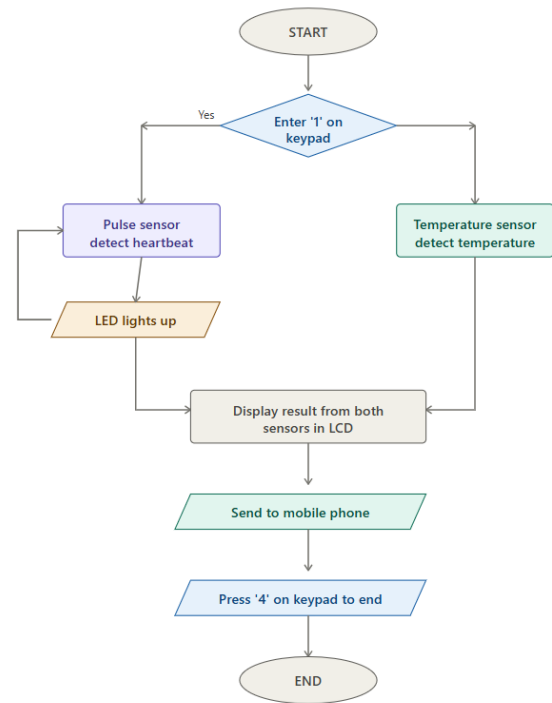


Figure 4. Flowchart IoT Fitness jacket

Figure 5 shows all electronic components were integrated into a commercially available jacket with flexible wire for wearable integration. The positioning of sensors was carefully considered to provide continuous contact with skin and minimize motion artefacts. The modules were placed in protective fabric containers for durability. The graphic shows the location of the sensing modules at significant measurement sites. The pulse sensor is extended to the finger tip for reliable heart rate detection [18]. The upper arm is the location of the LM35 temperature sensor. The fundamental control and communication gear, the Arduino microcontroller and the HC-05 Bluetooth module, is also stored centrally in the principal torso area of the jacket itself in the design of the system. This practical arrangement makes the peripheral sensors capable of accurately collecting data from the extremities and the primary processing and wireless transmission components may be safely and conveniently incorporated in the core of the wearable garment.



Figure 5. Component placement and wearable implementation of the IoT Fitness Jacket

**B. Heart Rate Measurement**

The pulse sensor operates based on photoplethysmography (PPG) principles, where variations in blood volume produce changes in light intensity detected by the sensor. The detected pulse intervals were processed internally by the Arduino microcontroller to calculate the heart rate in beats per minute (BPM)[19]. The BPM calculation used in the proposed system is expressed in Equation (1).

$$BPM = \frac{60}{T_{pulse}} \quad (1)$$

where  $T_{pulse}$  = time interval in seconds between two consecutive heartbeat pulses detected by the pulse sensor

The calculated BPM values were displayed on the LCD module and transmitted wirelessly to the smartphone application through the Bluetooth module.

**C. Heart Rate Measurement**

The LM35 temperature sensor was used to measure the user's body temperature. The sensor produces an analog voltage output proportional to the measured temperature. The Arduino analog-to-digital converter (ADC) processed the analog signal and converted it into temperature values using Equation (2)[20].

$$Temperature \text{ (}^\circ\text{C)} = \frac{V_{out} \times 100}{1023} \quad (2)$$

where  $V_{out}$  = the analog voltage value obtained from the LM35 sensor through the Arduino ADC

The measured temperature values were displayed in real time on the LCD module and smartphone application.

**D. Heart Rate Measurement**

Experimental validation was conducted using eight healthy participants under resting conditions. The measured heart rate and temperature values obtained from the proposed system were compared with readings recorded from certified commercial medical devices. The percentage error analysis was performed using Equation (3).

$$Percentage \text{ error (\%)} = \frac{|Measured - Reference|}{Reference} \times 100 \quad (3)$$

where

Measured = the value obtained from the proposed IoT Fitness Jacket

Reference = the value recorded from the certified medical device

This analysis was performed to evaluate the accuracy and reliability of the developed wearable monitoring system.

**E. Mean Measurement Analysis**

Repeated measurements were conducted for each participant to improve data reliability. The average measurement value was calculated using Equation (4).

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i \quad (4)$$

where

$x$  = measured value

$n$  = the total number of measurements performed during the experimental validation process

**IV. RESULTS AND DISCUSSION**

The invented prototype of the Internet of Things (IoT) Fitness Jacket was successfully integrated and experimentally evaluated in controlled indoor circumstances. The hardware solution is integrated with Arduino UNO microcontroller, pulse sensor, LM35 temperature sensor, LCD display, Bluetooth HC-05 module and the keypad interface embedded in the wearable jacket platform. The physiological data was effectively captured in real-time and the measured data was wirelessly sent to a smartphone application via Bluetooth communication.

The finished prototype of the IoT Fitness Jacket with interfaced monitoring is shown in Figure 6. While running, the pulse sensor could sense photoplethysmography (PPG) impulses from the user fingertip and the LM35 was used to measure body temperature constantly. The measured data were concurrently presented on the LCD module and the smartphone application, which indicated the stable system integration and real-time monitoring ability.



Figure 6. Prototype of IoT Fitness Jacket

To evaluate the performance of the heart rate monitoring subsystem, experiments were conducted using eight healthy participants under resting conditions. The BPM values presented in Table 1 were generated using Equation (1), where the pulse interval detected by the PPG sensor was converted into beats per minute (BPM). Only the final BPM values are presented in the table for performance evaluation purposes..

Table 1  
Heart Rate Measurements

Test Subject	Reference Device (BPM)	IoT Fitness Jacket (BPM)	Absolute Error (BPM)	Percentage Error (%)
Subject 1	75	78	3	4.00
Subject 2	72	76	4	5.56
Subject 3	80	83	3	3.75

Subject 4	82	86	4	4.88
Subject 5	77	80	3	3.90
Subject 6	74	78	4	5.41
Subject 7	70	73	3	4.29
Subject 8	68	71	3	4.41
Average	74.75	78.13	3.38	4.53

The percentage error values shown in Table 1 were calculated using Equation (3) to evaluate the accuracy of the proposed system compared with the certified commercial pulse oximeter. The proposed system demonstrated consistent heart rate measurements with percentage errors ranging between approximately 3% and 6%. The average percentage error was approximately 4.53%, indicating acceptable accuracy for non-clinical wearable monitoring applications.

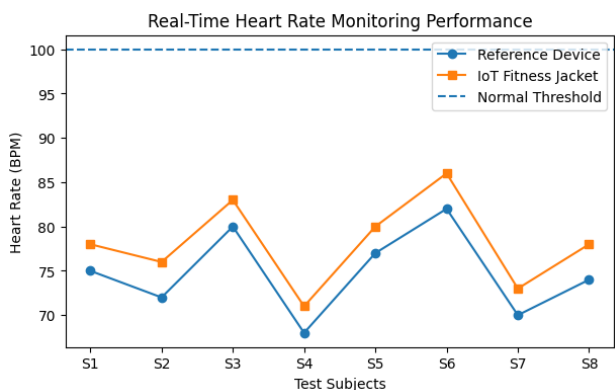


Figure 7. Real-time heart rate monitoring comparison between the proposed IoT Fitness Jacket and the reference device

Figure 7 illustrates the real-time heart rate monitoring performance of the proposed system compared with the certified reference device. The measured BPM values obtained from the IoT Fitness Jacket closely follow the trend of the reference measurements for all participants. Minor deviations were observed due to motion artifacts and signal fluctuations; however, the overall monitoring trend remained consistent, indicating stable signal acquisition and reliable heart rate monitoring performance.

The temperature monitoring subsystem was evaluated by comparing the measured body temperature values with readings obtained from a certified digital thermometer. The body temperature readings shown in Table 2 were obtained using Equation (2), where the analog output voltage from the LM35 sensor was converted into temperature values in degree Celsius.

Table 2  
Comparison of Temperature Measurements

Test Subject	Reference Device (°C)	IOT Fitness Jacket (°C)	Absolute Error (°C)	Percentage Error (%)
Subject 1	36.5	36.8	0.3	0.82
Subject 2	36.7	36.9	0.2	0.54
Subject 3	36.1	36.5	0.4	1.10
Subject 4	36.6	36.9	0.3	0.83
Subject 5	36.8	37.2	0.4	1.10
Subject 6	36.7	36.9	0.2	0.54
Subject 7	36.3	36.6	0.3	0.83
Subject 8	36.8	37.0	0.2	0.54
Average	36.55	36.79	0.24	0.65

The percentage error values in Table 2 were calculated using Equation (3) to evaluate the accuracy of the proposed temperature monitoring subsystem. The LM35 sensor demonstrated stable and linear measurement characteristics throughout the experimental validation process. The average percentage error for temperature measurement was approximately 0.65%, indicating high consistency and reliability of the sensing subsystem.

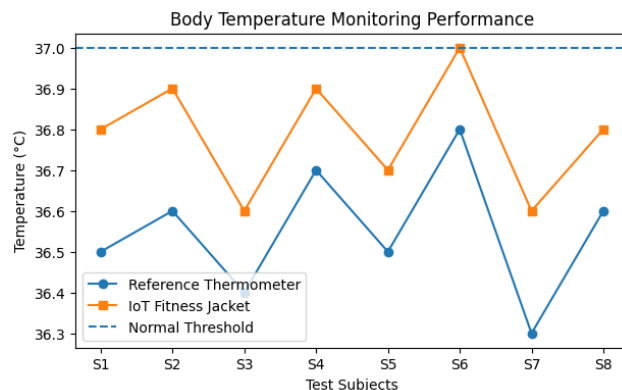


Figure 8. Body temperature monitoring performance of the proposed IoT Fitness Jacket

Figure 8 demonstrates the consistency of the temperature measurements obtained from the developed system. The recorded temperature values remained within the normal physiological range and closely matched the reference thermometer readings, confirming the stability and reliability of the LM35 sensing subsystem.

The Bluetooth communication subsystem was assessed to determine transmission stability and responsiveness between the IoT Fitness Jacket and the smartphone application. Experimental testing showed that the HC-05 Bluetooth module maintained stable connectivity within an indoor operating range of approximately 5–8 meters.

No packet loss or communication interruption was recorded throughout continuous monitoring periods. The average transmission delay was determined to be one to two seconds, which is suitable for real-time wearable health monitoring applications. The recorded physiological data were successfully displayed on the smartphone interface without significant delay, which confirms the reliability of the wireless communication architecture utilised in the proposed system. Figure 7 shows the real-time data shown correctly on the smartphone interface without communication failures.

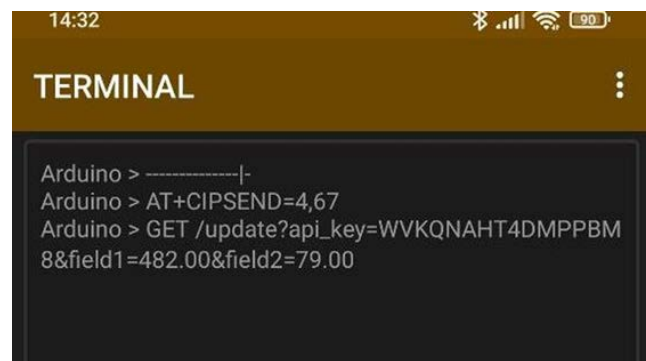


Figure 7. Smartphone interface

Overall, the developed IoT Fitness Jacket demonstrated reliable operation for real-time physiological monitoring. The mathematical formulations introduced in Equations (1)–(4) were successfully implemented in the Arduino-based processing system to calculate physiological parameters and evaluate measurement accuracy. The experimental results validate the effectiveness of the proposed equations for real-time wearable health monitoring applications.

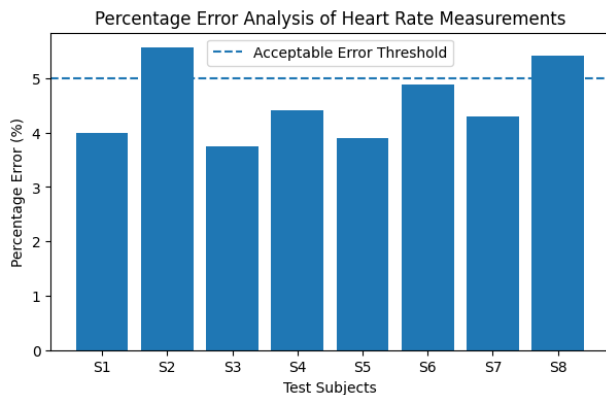


Figure 9. Percentage error analysis of heart rate measurements

Figure 9 illustrates the % error values for all the participants. The percentage error values were within an acceptable range for wearable health monitoring applications. The uniform error distribution shows the stable performance of the system and the satisfactory agreement with the reference medical device.

Under controlled conditions, the suggested system showed satisfactory agreement with certified commercial medical equipment and showed its appropriateness for non-clinical personal healthcare monitoring applications. Moreover, the low-cost implementation and portable wearable design are advantages for ongoing daily health tracking and exercise monitoring.

The experimental testing proved several limits, although the system exhibited a good performance. Motion artefacts and uneven sensor positioning could influence the signal stability under dynamic movement settings. Future developments may involve sophisticated filtering techniques, miniaturized hardware integration, cloud-based data storage, and more physiological sensor modules to further improve system performance and usability.

## V. CONCLUSION

In this research, IoT based Fitness Jacket for real-time heart rate and body temperature monitoring has been successfully constructed and validated utilising Arduino technology. The device demonstrated steady performance, acceptable measurement accuracy in comparison with a commercial digital pulse oximeter and digital temperature, and reliable Bluetooth communication for real-time data transmission. The combination of sensing, computation and wireless communication in a wearable platform shows the possibility of developing low cost smart clothes for personal health and fitness tracking applications.

To improve future performance, it is recommended to increase motion artefact filtering to improve heart rate accuracy during physical activity. Other potential developments might include miniaturising the hardware to make it more comfortable to wear, adding cloud-based data storage to enable remote monitoring, and incorporating more advanced physiological sensors, such as a blood oxygen sensor or activity tracking module. Such improvements would make the system more scalable, usable and performant in real-world fitness settings.

These enhancements would improve system scalability, usability, and overall performance in real-world fitness environments.

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## CONFLICT OF INTEREST

Authors declare that there is no conflict of interest regarding the publication of the paper.

## AUTHOR CONTRIBUTION

All authors contributed equally to the conception and design of the study, data collection and testing, analysis, and manuscript preparation.

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