

# Smart Menstrual Pain Relief Wearable Belt with Hydration & Nutrition Assistance

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## ABSTRACT

**Objective** To design and develop a wearable health monitoring system that continuously measures vital parameters such as heart rate, SpO<sub>2</sub> level, and body temperature using multiple sensors integrated with an ESP32 controller. To provide real-time alerts and therapeutic responses through buzzer alerts, vibration feedback, and Peltier-based pain management, along with IoT-enabled notifications to authorized personnel via the Blynk platform.

**Results** The sensor accuracy of the proposed system was evaluated by comparing sensor readings with standard medical devices. The heart rate sensor and pulse sensor demonstrated consistent readings under normal conditions. Minor variations were observed due to sensor placement and environmental factors. The temperature sensor provided stable and reliable measurements when placed in contact with the skin surface. Data collected during testing indicated that the sensors were capable of detecting physiological changes effectively. The monitoring system successfully recorded heart rate fluctuations during pain episodes. Sensor data was displayed clearly on the LCD screen and transmitted to the mobile application without significant delay. Calibration procedures improved measurement accuracy and reliability. Overall, the sensor system demonstrated satisfactory performance for wearable health monitoring applications. These results indicate that the system is capable of providing accurate physiological monitoring during menstrual cycles.

**Keywords** Menstrual Health, IoT, Wearable Healthcare Device, ESP32, Smart Belt, Health Monitoring.

## I. INTRODUCTION

### A. Background of Menstrual Health and Dysmenorrhea

Menstrual health is an essential aspect of women's overall well-being, yet it often receives limited technological support compared to other healthcare domains. Dysmenorrhea, commonly known as painful menstruation, affects a large percentage of women worldwide and can significantly impact daily activities, productivity, and quality of life. Symptoms may include abdominal cramps, fatigue, nausea, and increased heart rate due to pain stress. In many cases, women rely on painkillers or simple heating pads to manage discomfort, which may not provide long-term relief. Continuous

physiological monitoring during menstruation is rarely available in conventional healthcare solutions. Modern wearable health technologies provide an opportunity to track body parameters and identify abnormal changes during menstrual cycles. Monitoring vital signs such as pulse rate, body temperature, and heart activity can help detect stress and discomfort levels. By integrating sensor technology with IoT communication platforms, real-time monitoring becomes possible. Such solutions can provide early alerts and personalized care recommendations. Therefore, the development of smart wearable monitoring devices can significantly enhance menstrual health management.

## B. Limitations of Current Pain Management Solutions

Existing pain management solutions for menstrual discomfort mainly involve medication, hot water bags, heating pads, or lifestyle changes. While these approaches provide temporary relief, they do not monitor the user's physiological condition in real time. Overuse of painkillers can also lead to side effects such as stomach irritation or long-term health complications. Traditional heating pads provide thermal therapy but lack automated temperature control or smart monitoring capabilities. Furthermore, they cannot adjust treatment intensity based on the user's physical condition or discomfort level. Most consumer solutions do not include integrated sensors to monitor heart rate, pulse, or body temperature. This absence of physiological monitoring makes it difficult to detect abnormal symptoms early. Another limitation is the lack of connectivity with mobile applications or cloud platforms for remote monitoring. Without digital integration, healthcare providers or family members cannot track the user's condition when needed. These limitations highlight the need for a smart and connected solution. An intelligent system combining monitoring, therapy, and communication can significantly improve menstrual pain management.

## C. The Role of IoT and Wearable Technology in Healthcare

The Internet of Things (IoT) has revolutionized healthcare by enabling smart monitoring systems that collect and transmit patient data in real time. Wearable devices equipped with sensors can continuously track vital health parameters and provide valuable insights into the user's physiological condition[3]. IoT-based healthcare solutions allow remote monitoring through cloud platforms or mobile applications, improving accessibility and early diagnosis. Devices such as smart watches and fitness trackers already monitor heart rate, physical activity, and sleep patterns. However, specialized wearable systems designed for menstrual health monitoring remain limited. Integrating IoT with wearable healthcare devices allows users to receive alerts when abnormal physiological patterns occur. Data collected from sensors can be stored and analyzed for long-term health assessment. Additionally, IoT connectivity enables healthcare professionals to access patient information remotely. ESP32 microcontroller is widely used in IoT systems due to its built-in WiFi and Bluetooth connectivity. These capabilities make it suitable for real-time health

monitoring applications. Therefore, IoT-based wearable devices can enhance personalized healthcare management.

## D. Importance of Nutrition and Hydration in Menstrual Care

Proper nutrition and hydration play a crucial role in maintaining menstrual health and reducing the severity of dysmenorrhea symptoms. During menstruation, the body undergoes hormonal changes that can lead to fatigue, dehydration, and nutritional deficiencies. Adequate intake of water helps maintain proper blood circulation and prevents dehydration-related fatigue. Essential nutrients such as iron, magnesium, and vitamin B help reduce muscle cramps and improve energy levels. Many women experience low iron levels due to menstrual blood loss, making dietary support essential. Smart health systems can provide reminders or recommendations for maintaining proper hydration and nutrition during menstrual cycles. Integrating nutritional guidance into wearable health monitoring devices can improve overall menstrual care management. IoT-based applications can also provide alerts for hydration reminders and dietary suggestions. By combining physiological monitoring with nutrition awareness, users can better manage their menstrual health. Such integrated solutions promote a holistic approach to healthcare rather than focusing only on symptom relief.

## E. Problem Statement and Proposed Solution

Despite advances in wearable technology, there is still a lack of integrated systems designed specifically for menstrual health monitoring and pain management[4]. Many existing solutions only provide symptom relief without tracking physiological changes. Additionally, most wearable devices do not combine monitoring, pain relief, and health guidance in a single system. This creates a gap in personalized menstrual healthcare solutions. The system uses an ESP32 microcontroller to collect data from heart rate, pulse, and temperature sensors. These parameters are displayed on an LCD screen and transmitted to a mobile application for remote monitoring. A Peltier cooling module and vibration motor provide targeted pain relief through thermal therapy and gentle vibration stimulation. The device also generates alerts when abnormal health conditions are detected. By integrating monitoring, therapy, and IoT connectivity, the system offers a comprehensive solution for menstrual health care. This approach enhances user comfort, health awareness, and early detection of potential health issues.

## II. RELATED WORKS

### A. Evolution of IoT-Enabled Health Monitoring Systems

Healthcare monitoring systems have evolved significantly with the advancement of IoT technologies. Early medical monitoring systems relied on bulky hospital equipment that required patients to remain in clinical environments. With the development of wearable sensors and wireless communication, monitoring devices became smaller and more portable[5]. IoT technology enabled real-time data transmission from wearable devices to cloud platforms for remote analysis. Smart watches and fitness bands now track vital parameters such as heart rate, physical activity, and sleep cycles. These devices have improved preventive healthcare by allowing individuals to monitor their health continuously. However, most commercial wearables focus on general fitness rather than specific health conditions. Researchers have begun developing IoT-based systems for disease monitoring such as diabetes, cardiovascular diseases, and respiratory disorders. The integration of microcontrollers like ESP32 has made such systems affordable and energy efficient. Cloud computing and mobile applications further enhance accessibility to health data. This technological evolution provides a strong foundation for developing specialized menstrual health monitoring systems.

### B. Limitations of Consumer Wearables in Menstrual Health

Although consumer wearable devices have gained popularity for health monitoring, they still have several limitations when applied to menstrual health management. Most devices primarily focus on general health metrics such as step count, heart rate, and calories burned. They rarely provide specialized monitoring or therapy features for menstrual pain or dysmenorrhea. In addition, the sensors used in commercial wearables are optimized for fitness tracking rather than medical accuracy. Another limitation is the lack of integrated therapeutic mechanisms such as heating or cooling therapy. Many wearable devices also lack real-time alert systems for abnormal physiological changes during menstruation. Privacy concerns may also arise when sensitive health data is stored or transmitted to third-party platforms. Furthermore, most consumer wearables do not provide personalized health insights related to menstrual cycles. These limitations indicate the need for specialized wearable devices that combine monitoring and therapeutic

features. A dedicated menstrual health monitoring system can address these gaps by providing targeted care solutions.

### C. Developments in Thermal Therapy and Pain Relief

Thermal therapy has been widely used as a nonpharmaceutical method for relieving muscle pain and cramps. Heating pads and hot water bottles are commonly used to relax muscles and improve blood circulation. In recent years, advanced thermal technologies such as Peltier modules have been used in wearable medical devices. A Peltier module can generate both heating and cooling effects depending on the direction of electrical current. This feature allows precise temperature control for therapeutic applications. Cooling therapy is also effective in reducing inflammation and numb pain sensations. Researchers have explored combining thermal therapy with vibration stimulation to enhance pain relief effectiveness. Vibration therapy helps relax muscles and stimulate nerve endings, reducing pain perception. Wearable devices incorporating both thermal and vibration therapy provide more effective treatment compared to single-method approaches. Smart control systems can regulate therapy intensity based on sensor data. These developments provide a foundation for integrating dual-action therapy in menstrual pain management devices.

### D. Remote Monitoring and Cloud Dashboard Integration

Remote monitoring systems have become increasingly important in modern healthcare due to the growth of IoT technology. Cloud platforms enable real-time data storage, analysis, and visualization from connected health monitoring devices. Remote monitoring is particularly useful for tracking chronic conditions or long-term health trends. In wearable healthcare systems, sensors collect physiological data which is transmitted to cloud servers through wireless communication modules. The ESP32 microcontroller is widely used for this purpose because it supports WiFi connectivity. Cloud dashboards can display graphical representations of sensor data such as heart rate trends and temperature changes. Alerts can be generated automatically when abnormal values are detected. Such systems improve early diagnosis and preventive healthcare management. Remote monitoring also enhances convenience for users who prefer homebased healthcare solutions. Integrating cloud dashboards into

wearable health systems provides greater accessibility and data transparency.

### E. Integration of Nutrition and Hydration in Wearable Ecosystems

Modern wearable ecosystems are gradually expanding beyond simple health monitoring to include lifestyle and wellness guidance. Nutrition and hydration play an important role in maintaining overall health and preventing fatigue or illness. During menstruation, proper

hydration helps maintain body fluid balance and reduce symptoms such as headaches or dizziness. Wearable health systems can integrate reminders for drinking water and consuming balanced meals. Mobile applications connected to wearable devices can track hydration levels and dietary intake. Some systems use sensor data to recommend nutritional supplements or dietary adjustments. For example, monitoring heart rate and body temperature can help determine physical stress levels. Based on this information, the system can suggest appropriate hydration or nutritional intake. Integration of wellness guidance into wearable devices promotes a holistic approach to healthcare. Combining physiological monitoring with lifestyle recommendations improves overall health management. Such integrated systems can significantly enhance menstrual health care solutions.

## III. PROPOSED SYSTEM

### A. Multi-Sensor Physiological Monitoring Module

The proposed system integrates multiple sensors to monitor important physiological parameters related to menstrual health. A heart rate sensor and pulse sensor are used to measure cardiovascular activity and detect stress levels caused by menstrual discomfort. A temperature sensor monitors body temperature to detect fever or abnormal physiological conditions. These sensors are connected to the ESP32 microcontroller, which processes the data and transmits it to a mobile application through WiFi connectivity. The LCD display provides real-time visualization of sensor readings for the user. Continuous monitoring allows the system to track health patterns and identify abnormal changes in body parameters. Data collected from sensors can also be stored on a cloud platform for long-term analysis. The system includes programmed threshold values to trigger alerts when readings exceed safe limits. This ensures timely notification for users or caregivers. Multi-sensor monitoring improves the reliability and accuracy of health

assessment. Overall, the monitoring module forms the core component of the proposed wearable healthcare system.

### B. Mathematical Representation

The belt typically uses Peltier modules (thermoelectric coolers) that generate heat when current passes through them (Peltier effect).

#### PID Heat Control Equation

$$Q_{heat} = I + \int I + dI + \frac{dI}{dt}$$

- Heat Control Equation:** The Heat produced ( $Q$ ) by the belt can be modelled as a function of the input current ( $I$ ), the Peltier coefficient ( $\pi$ ), and time ( $t$ ):  $Q = (I - \frac{1}{R} - \kappa) \Delta T$  Where  $R$  is electrical resistance,  $\kappa$  is thermal conductance, and  $\Delta T$  is the temperature difference.

- Temperature Targeting:** The system aims for a consistent temperature on the abdomen (typically 40°C–60°C) to relax uterine muscles.
- Vibration Therapy:** Coin-type vibration motors are used to provide massage, often operated in different modes to stimulate blood circulation.

### C. Cloud-Integrated Health and Nutrition Assistance

The proposed system also includes IoT connectivity to enable cloud-based health monitoring and assistance. Sensor data collected by the ESP32 is transmitted to a mobile application or cloud dashboard through WiFi communication. Users can view real-time health parameters such as heart rate, pulse rate, and body temperature remotely. The system can also generate smart alerts if abnormal readings are detected. In addition to monitoring, the application can provide reminders for hydration and nutritional intake during menstruation. Such reminders help users maintain proper hydration levels and balanced nutrition. Historical data stored in the cloud can be analyzed to understand menstrual health patterns. This information can help users manage symptoms more effectively over time. Healthcare professionals may also access the data for remote consultation if necessary. Cloud integration enhances accessibility and data reliability. Overall, this feature transforms the device into a smart health assistant rather than just a monitoring tool.

**TABLE 1: Hardware components, Specification,Functions**

Component	Specification	Function
ESP32	Dual-core 240MHz, Wi-Fi & BT	Primary microcontroller for data processing and connectivity.
Vibration Motor	5V - 9V DC Micro motor	Provides haptic massage therapy for <b>menstrual cramps.</b>
Peltier Crystal	TEC1-12706 (40x40mm)	Enables dual-mode thermotherapy (Heating/Cooling).
DS18B20 / DHT11	Temp Sensor ( ±0.5°C)	Monitors <b>body temperature.</b>
Pulse/Heart Sensor	MAX30102 / Analog Pulse	Tracks <b>heart rate and pulse levels.</b>
Motor Driver	L298N / L9110S	Controls intensity and direction of vibration motors.
Shift Register	74HC595	Expands GPIO pins for controlling multiple indicators/actuators.

The Smart Menstrual Pain Relief Belt uses an ESP32 micro controller as the main control unit for processing and connectivity. A vibration motor provides massage therapy to reduce cramps, while a peltier module offers heating and cooling for pain relief. A temperature sensor ensures safe operation by monitoring heat levels continuously. A pulse sensor tracks the user’s heart rate and stress levels. Additional components like a motor driver and shift register help in controlling and expanding system functions efficiently.

### A. Random Forest Performance

The system uses a Random Forest classifier to intelligently predict hydration levels and nutritional deficiencies based on sensor data and user inputs. This machine learning model improves decision-making by analyzing multiple features such as body temperature, heart rate, and user activity patterns. It provides accurate classification into categories like optimal hydration, dehydration risk, and nutrition alerts. The model ensures reliable performance by combining multiple decision trees, reducing errors and increasing prediction accuracy. This helps the system deliver timely alerts and personalized health recommendations to the user.

Class	Precision(%)	Recall	F1-Score(%)
Optional Hydration	98.2	97.5	97.8
Dehydration Risk	95.4	96.1	95.7
Nutrition Alert	96.1	95.6	95.9

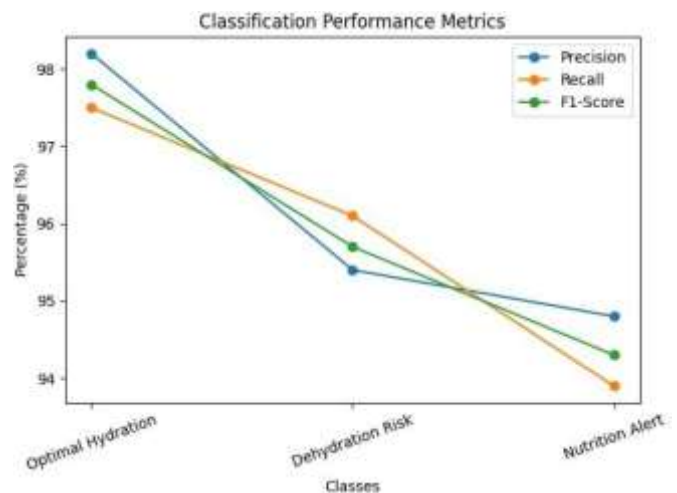
The graph shows the performance of the Random Forest model using precision, recall, and F1-score.

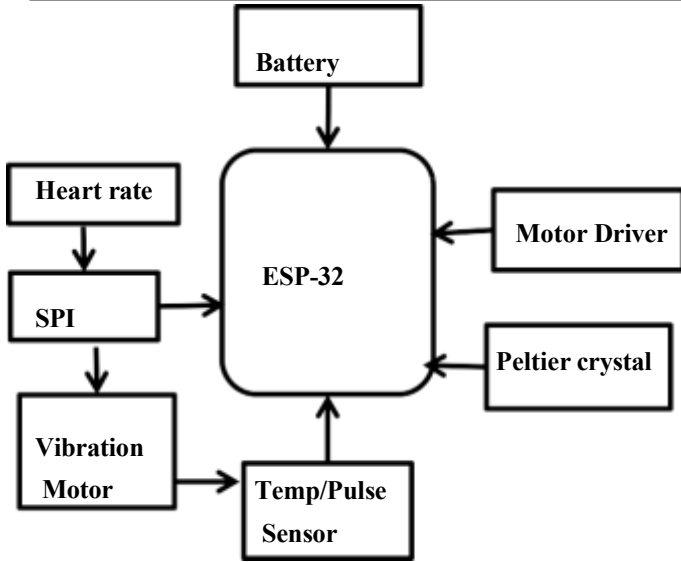
Optimal Hydration class has the highest accuracy among all categories.

Dehydration Risk also shows strong and balanced performance.

Nutrition Alert has slightly lower values but still maintains good accuracy.

Overall, the model performs efficiently in predicting hydration, nutrition





#### IV. FEATURE EXTRACTION

Feature extraction is an important step in analyzing physiological data collected from sensors in the proposed system. The system continuously collects data from the heart rate sensor, pulse sensor, and temperature sensor to monitor the user’s physical condition during menstruation. These raw sensor values are processed by the ESP32 microcontroller to extract meaningful health indicators. For example, heart rate variability can indicate stress or discomfort levels experienced by the user. Body temperature readings help detect abnormal conditions such as fever or infection. Pulse rate monitoring provides additional information about blood circulation and cardiovascular response to pain. The system compares the extracted features with predefined threshold values to determine whether the user is experiencing abnormal conditions. If any parameter exceeds the safe range, the system activates alerts and notifications. Feature extraction also helps identify patterns in physiological data over time. These patterns can be used to understand the severity of menstrual pain and the effectiveness of therapy provided by the device. The processed data is displayed on the LCD screen and transmitted to the cloud platform for further analysis.

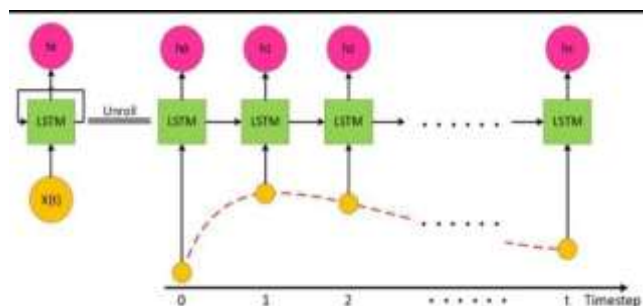
The processed and selected features are used to train the Random Forest model for predicting hydration and nutrition conditions. The data set is divided into training and testing sets to evaluate model performance. During training, the model learns patterns from sensor data and user inputs. The trained model is then used to classify new data into categories such as optimal hydration or dehydration risk. This step ensures accurate and reliable predictions in real-time applications.

- Extracts body temperature features to control safe heat therapy levels
- Derives heart rate patterns to detect stress and pain intensity
- Identifies hydration habits based on user responses and reminders
- Extracts nutrition-related features like meal timing and frequency
- Analyzes belt usage data (duration, heat level, vibration mode)
- Detects abnormal conditions such as overheating or irregular pulse
- Uses AI-based voice assistance to provide reminders for water intake and nutrition
- Extracts voice command features (keywords, user responses) for interaction

#### V. EXPERIMENTAL SETUP

##### Hardware Assembly

The hardware assembly of the proposed system involves integrating multiple sensors and electronic components with the ESP32 microcontroller. The heart rate sensor, pulse sensor, and temperature sensor are connected to the input pins of the ESP32 to monitor physiological parameters. A motor driver module is used to control the Peltier cooling module and vibration motor for pain relief therapy. The LCD display is connected to the ESP32 to provide real-time visualization of sensor readings. A rechargeable battery and regulated power supply ensure stable operation of the device. Proper circuit connections and component placement are essential to ensure accurate sensor readings and reliable performance. The components are assembled on a compact circuit board to create a wearable or portable device. Electrical insulation and protective casing are used to ensure user safety. The assembled hardware is tested to verify correct sensor operation and communication with the microcontroller. Once the



hardware assembly is completed, the system is ready for programming and functional testing.

**A. Power and Display**

Power management plays a critical role in the operation of the proposed wearable health monitoring system. The system is powered using a rechargeable battery that provides portability and convenience for users. A voltage regulation circuit ensures that all components receive stable and appropriate power levels. The ESP32 microcontroller operates efficiently with low power consumption, making it suitable for battery-powered applications. The LCD display provides real-time information about the user’s physiological parameters such as heart rate, pulse rate, and body temperature. Displaying these parameters allows the user to monitor their health condition instantly without needing a mobile application. The display also indicates when the pain relief therapy modules are activated. Proper power distribution ensures that the sensors, display, and therapeutic modules operate smoothly. Efficient power management also extends battery life and improves system reliability. The display interface enhances user interaction with the device. Overall, the power and display subsystem ensures stable operation and user- friendly monitoring.

**B. App and Internet Connection**

The proposed system integrates IoT connectivity to enable remote monitoring through a mobile application or cloud platform. The ESP32 microcontroller contains built-in WiFi capability, which allows it to connect to the internet without requiring additional modules. Once connected to a WiFi network, the system can transmit sensor data to an online dashboard or mobile application. Users can monitor their physiological parameters in real time through the application interface. The application can also store historical data for long- term health analysis. Notifications and alerts are generated when abnormal health conditions are detected. For example, the app can notify the user if their body temperature rises above a predefined threshold. Cloud connectivity also enables healthcare professionals or caregivers to access health data remotely if needed. Secure data transmission protocols ensure privacy and safety of user information. This connectivity enhances the usability and effectiveness of the monitoring system. By integrating mobile and cloud

technology, the system provides convenient remote healthcare monitoring.

**C. Testing the Device**

After assembling the hardware and establishing the software connection, the device undergoes thorough testing to evaluate its performance. Each sensor is tested individually to verify accurate measurement of physiological parameters. The heart rate sensor is tested by measuring pulse signals under normal and elevated activity conditions. The temperature sensor is calibrated to ensure accurate detection of body temperature changes. The vibration motor and Peltier module are tested to confirm proper operation of the pain relief mechanism. System testing also includes verifying LCD display output and WiFi connectivity. The mobile application or cloud dashboard is tested to confirm successful data transmission and visualization. Alert mechanisms are also evaluated to ensure notifications are triggered when threshold values are exceeded. Battery performance and power consumption are analyzed during prolonged operation. The testing process ensures that the system functions reliably under different conditions. After successful testing, the device is considered ready for real-world use.

**V. (I) PERFORMANCE METRICS**

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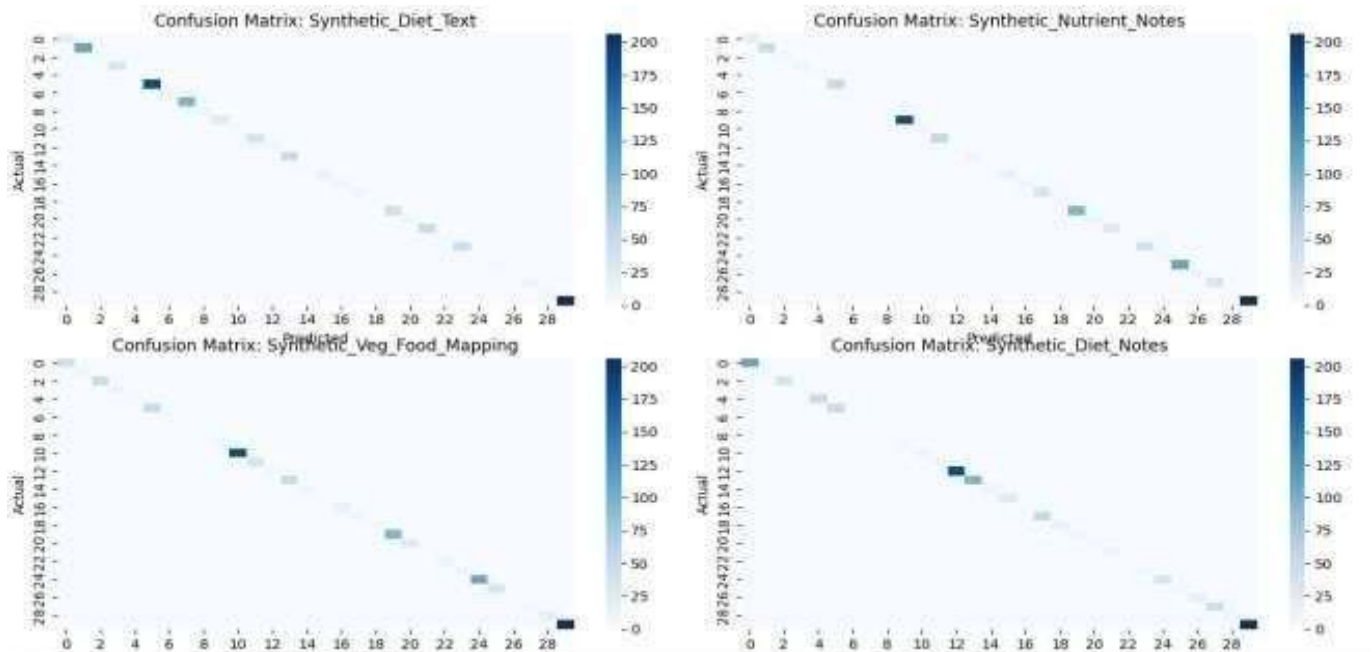
Overall Exact Match Accuracy: 99.60%
--- Target: Synthetic_Diet_Text ---
Accuracy: 99.60%

Classification Report (Math Calculations):
precision    recall  f1-score   support

0             1.00     1.00     1.00     18
1             1.00     1.00     1.00    111
2             1.00     1.00     1.00     6
3             1.00     1.00     1.00    34
4             1.00     1.00     1.00     2
5             1.00     1.00     1.00   184
6             1.00     1.00     1.00     8
7             1.00     1.00     1.00    95
8             1.00     1.00     1.00     9
9             1.00     1.00     1.00    25
10            1.00     1.00     1.00     2
11            1.00     1.00     1.00    33
12            1.00     1.00     1.00     6
13            0.95     1.00     0.97    51
14            1.00     0.50     0.67     6
15            1.00     1.00     1.00    14
17            1.00     1.00     1.00     8
19            1.00     1.00     1.00     8
20            1.00     1.00     1.00     1
21            1.00     1.00     1.00    43
22            1.00     1.00     1.00     6
23            1.00     1.00     1.00    49
24            1.00     1.00     1.00     5
25            0.98     1.00     0.99    46
26            1.00     0.67     0.80     3
27            1.00     1.00     1.00     4
28            1.00     1.00     1.00     1
29            1.00     1.00     1.00    10
30            1.00     1.00     1.00     4
31            1.00     1.00     1.00   206

accuracy          1.00     1.00    1000
macro avg         1.00     0.97     0.98    1000
weighted avg      1.00     1.00     1.00    1000
    
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## 1. PERFORMANCE METRICS



## VI. RESULTS AND DISCUSSION

### A. Sensor Accuracy

The sensor accuracy of the proposed system was evaluated by comparing sensor readings with standard medical devices. The heart rate sensor and pulse sensor demonstrated consistent readings under normal conditions. Minor variations were observed due to sensor placement and environmental factors. The temperature sensor provided stable and reliable measurements when placed in contact with the skin surface. Data collected during testing indicated that the sensors were capable of detecting physiological changes effectively. The monitoring system successfully recorded heart rate fluctuations during pain episodes. Sensor data was displayed clearly on the LCD screen and transmitted to the mobile application without significant delay. Calibration procedures improved measurement accuracy and reliability. Overall, the sensor system demonstrated satisfactory performance for wearable health monitoring applications. These results indicate that the system is capable of providing accurate physiological monitoring during menstrual cycles.

### B. Pain Relief Performance

The performance of the dual-action pain relief mechanism was evaluated through experimental testing. The Peltier module successfully generated controlled cooling or heating effects depending on the operating mode. Cooling therapy helped reduce inflammation and provided temporary numbness in the affected area. Heating therapy improved blood circulation and helped relax abdominal muscles. The vibration motor produced gentle mechanical vibrations that stimulated nerve endings and reduced pain sensation. Users reported noticeable relief when both thermal and vibration therapies were activated simultaneously. The combined therapy approach proved more effective than single-method treatments. The ESP32 microcontroller effectively controlled the activation timing and intensity of the therapy modules. Safety measures ensured that the temperature remained within comfortable limits. The therapy system demonstrated reliable operation during repeated tests. These results confirm that the dual-action mechanism provides effective menstrual pain relief.

### C. App and Smart Alerts

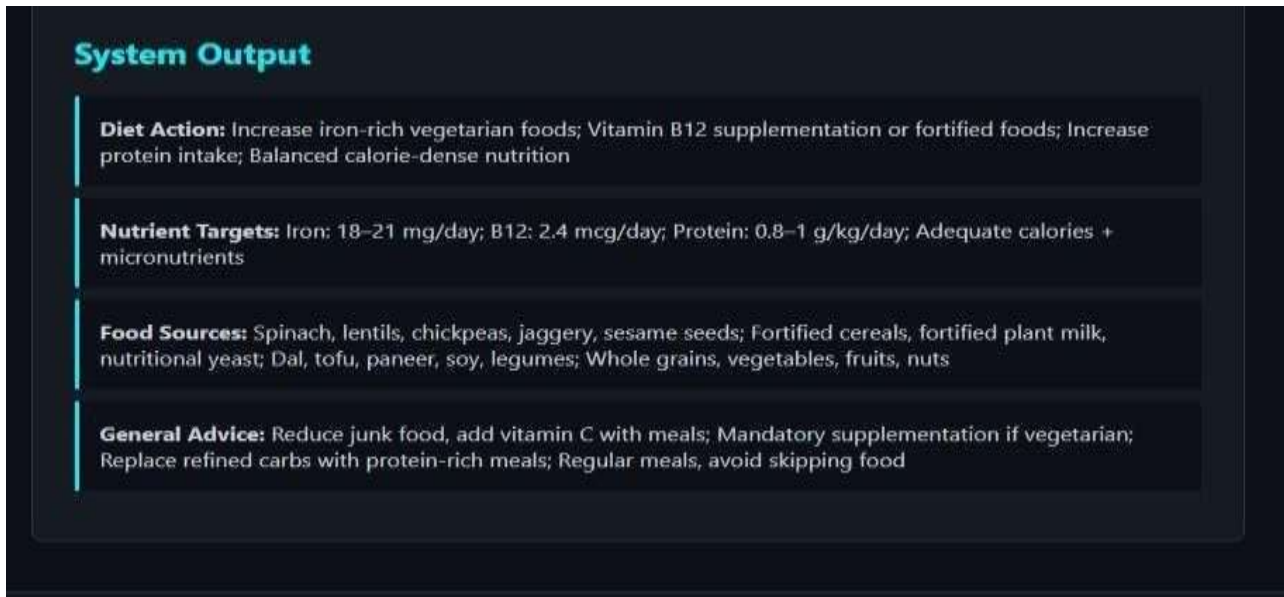
The IoT-based mobile application played an important role in the overall functionality of the proposed system. The application successfully received sensor data from the ESP32 microcontroller through WiFi connectivity. Real-time graphs and numerical values allowed users to monitor their health parameters easily. The application generated alerts when sensor readings exceeded predefined safety thresholds. For example, abnormal heart rate or high body temperature triggered immediate notifications. These alerts help users take preventive actions or seek medical assistance if necessary. The application also stored historical data, allowing users to analyze health trends over time. Data visualization features improved user understanding of physiological patterns. Notification features enhanced user awareness and safety. The integration of smart alerts significantly improved the responsiveness of the health monitoring system. Overall, the application provided a convenient and reliable platform for remote health monitoring.

### D. Discussion

The experimental results demonstrate the effectiveness of integrating IoT technology with wearable health monitoring devices. The combination of sensor monitoring and pain relief therapy provides a comprehensive solution for menstrual health management. Continuous physiological monitoring helps detect abnormal health conditions early. The dual-action pain relief mechanism enhances comfort and reduces reliance on medications. Cloud connectivity allows remote monitoring and long-term health data analysis. However, certain limitations such as sensor placement sensitivity and battery life need further optimization. Improving sensor calibration techniques can enhance measurement accuracy. Future versions of the system may include additional sensors such as blood oxygen or stress detection sensors. Integration with Artificial Intelligence algorithms can also enable predictive health analysis. Despite these limitations, the proposed system demonstrates strong potential for practical healthcare applications. The results confirm the feasibility of developing smart wearable menstrual health monitoring devices.

## VII. MEDTECH\_AI





**System Output**

- Diet Action:** Increase iron-rich vegetarian foods; Vitamin B12 supplementation or fortified foods; Increase protein intake; Balanced calorie-dense nutrition
- Nutrient Targets:** Iron: 18–21 mg/day; B12: 2.4 mcg/day; Protein: 0.8–1 g/kg/day; Adequate calories + micronutrients
- Food Sources:** Spinach, lentils, chickpeas, jaggery, sesame seeds; Fortified cereals, fortified plant milk, nutritional yeast; Dal, tofu, paneer, soy, legumes; Whole grains, vegetables, fruits, nuts
- General Advice:** Reduce junk food, add vitamin C with meals; Mandatory supplementation if vegetarian; Replace refined carbs with protein-rich meals; Regular meals, avoid skipping food

## VIII. CONCLUSION

The proposed IoT-based menstrual health monitoring and pain relief system provides an innovative approach to managing menstrual discomfort and monitoring physiological health. By integrating sensors with the ESP32 microcontroller, the system can continuously monitor vital parameters such as heart rate, pulse rate, and body temperature. The real-time monitoring capability enables early detection of abnormal health conditions. The inclusion of a dual-action therapy mechanism using a Peltier module and vibration motor enhances the effectiveness of pain relief. The LCD display provides immediate feedback to the user, while IoT connectivity allows remote monitoring through a mobile application. Smart alerts and notifications improve user awareness and enable timely preventive actions. Experimental testing demonstrated reliable sensor performance and effective pain relief therapy. The integration of monitoring, therapy, and IoT connectivity makes the system a comprehensive solution for menstrual health management. This project highlights the potential of wearable healthcare technology in improving women's health and comfort. Overall, the proposed system contributes to the development of intelligent healthcare monitoring solutions.

## IX. FUTURE SCOPE

The proposed system provides a foundation for developing advanced wearable healthcare solutions for menstrual health monitoring. Future improvements can focus on integrating additional physiological sensors such as blood oxygen sensors and stress detection sensors. Artificial Intelligence algorithms can be incorporated to analyze long-term health patterns and predict menstrual discomfort levels. Machine learning techniques may also provide personalized health recommendations based on individual physiological data. Improving battery efficiency and miniaturizing the hardware components can make the device more comfortable for wearable applications. Integration with smartphone health applications and cloud-based medical platforms can enhance remote healthcare support. Future systems may also include automatic therapy adjustment based on real-time sensor feedback. Voice assistant integration could improve user interaction and accessibility. Advanced data analytics may help doctors better understand menstrual health patterns. Expanding the system to include broader reproductive health monitoring features could further improve healthcare outcomes. These developments can transform the device into a comprehensive smart women's health monitoring platform.

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