International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 11 | Nov - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

IOT Based Varicose Vein Diagnosis System and Therapy

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Abstract - Varicose veins are a widespread vascular disorder, particularly impacting the lower limbs due to impaired blood flow and valve dysfunction, often resulting in pain, swelling, and potential complications if untreated. Conventional diagnosis demands clinical visits, advanced equipment, and skilled personnel, limiting accessibility for rural populations. This project presents an IoT-based varicose vein diagnosis and therapy system designed for continuous, real-time monitoring and automated intervention. By integrating sensors for heart rate, SpO2, temperature, and muscle activity with a Raspberry Pi Pico W controller, the system analyzes physiological data to detect symptomatic changes and initiate therapeutic responses such as vibration and cooling treatments. Real-time alerts via email enhance timely medical intervention. The system aims to enable early diagnosis, personalized symptom management, and improved patient outcomes, reducing reliance on hospital infrastructure and expanding access to care for affected individuals.

Keywords-Varicose veins, IoT, real-time monitoring, wearable sensors, Raspberry Pi Pico W, vibration therapy, cooling therapy, early diagnosis, automated treatment, health alerts, physiological sensors, muscle activity, blood circulation, telemedicine, remote patient monitoring.

1. INTRODUCTION

Varicose veins are dilated, swollen, and twisted veins that primarily affect the legs due to malfunctioning valves within the veins, which cause improper blood flow and venous hypertension. These veins appear prominently just under the skin's surface and are a common medical condition affecting a significant portion of the adult population, with higher prevalence among women and older individuals. The condition leads to symptoms such as aching, heaviness, swelling, and discomfort, and in severe cases can result in complications including skin ulcers, bleeding, and venous insufficiency.

Despite the high prevalence, conventional diagnostic methods for varicose veins, such as Doppler ultrasound, require costly equipment, clinical visits, and trained professionals, creating barriers in access to timely diagnosis and treatment, particularly in rural and underserved areas. Current management strategies such as compression therapy and surgical interventions, though effective, often suffer from limitations like poor patient compliance and limited accessibility.

This research proposes an innovative Internet of Things (IoT)-based system for the diagnosis and management of varicose veins. The system continuously monitors physiological parameters associated with varicose vein symptoms via wearable sensors measuring skin temperature, heart rate, SpO2, muscle activity, and movement. These data are analyzed in real-time using a Raspberry Pi Pico W controller to detect early signs of varicose vein complications and initiate therapeutic actions, including vibration and cooling therapy, to alleviate symptoms and improve blood circulation. The system also incorporates automated alerts to notify users and healthcare providers promptly, facilitating timely medical intervention.

2. LITERATURE REVIEW

Das et al. (2023) proposed an IoT-enabled embedded system for varicose vein detection that integrates sensors to continuously monitor physiological parameters. Their focus was on early diagnosis and symptom prevention using real-time data analysis, aiming to improve patient outcomes and reduce hospital visits.

Rathnam et al. (2024) developed a Body Area Network (BAN) based system that detects varicose vein disease in real-time and provides automated treatment using actuators. This system offers a comprehensive approach for both monitoring and managing the condition remotely.

Haritha et al. (2022) reviewed diagnostic and treatment options for varicose veins, including invasive methods such as laser therapy and sclerotherapy. The paper emphasizes the need for less invasive and more accessible treatment technologies.

Raetz et al. (2019) examined current therapies for varicose veins and highlighted limitations of traditional approaches. They proposed integrating new technologies like wearable sensors to enhance care delivery.

3. PROBLEM STATEMENT:

Current methods for diagnosing varicose veins are costly and time-consuming, limiting access in rural areas. There is a need for a low-cost, real-time IoT-based monitoring system for early detection and management.

4. METHOLOGY:

The proposed system begins with the integration of multiple physiological sensors, including a DS18B20 temperature sensor, MAX30102 for heart rate and SpO2 measurement, MPU6050 accelerometer for muscle activity, and a force sensor to assess muscle movements. These sensors are connected to a Raspberry Pi Pico W microcontroller, which continuously collects and processes the sensor data in real-time.

The developed system uses several components integrated to enable continuous monitoring and therapy for varicose veins:

DS18B20 Temperature Sensor: This sensor measures the skin temperature of the affected limb. Elevated skin temperature can indicate inflammation or poor blood circulation associated with varicose veins.

MAX30102 Pulse Oximeter Sensor: It captures heart rate and blood oxygen saturation (SpO2). Irregular heart rate or reduced oxygen levels may signal compromised vascular health.

MPU6050 Accelerometer and Gyroscope: This sensor monitors muscle activity and limb movement. Detecting unusual muscle movements can help identify vein dysfunction or swelling.

Force Sensor: This sensor detects muscle contractions and pressure applied, providing additional data on muscular health and blood flow dynamics.

Raspberry Pi Pico W Microcontroller: Acts as the central controller gathering data from all sensors. It processes the sensor inputs through programmed algorithms to detect abnormalities indicating varicose vein symptoms.

Vibration Motor: Upon detection of symptoms, the microcontroller activates the vibration motor to promote blood circulation and alleviate discomfort.

Peltier Cooling Module: This module provides cooling therapy to reduce inflammation and pain by cooling the skin surface in affected areas.

Relay Circuits: Relays are used to switch the therapeutic devices (vibration motor and cooling module) on and off based on microcontroller commands.

Communication Module (Wi-Fi or GSM): Enables real-time alerts to be sent via email or messages to patients or healthcare providers, facilitating timely intervention.

Power Supply and Wearable Assembly: All components are integrated into a compact wearable device powered by portable batteries, enabling ease of use and continuous monitoring for patients.

Together, these components enable a real-time, automated system that diagnoses early varicose vein symptoms, provides immediate therapy, and sends alerts to emergency contacts, improving patient care outside conventional clinical settings.

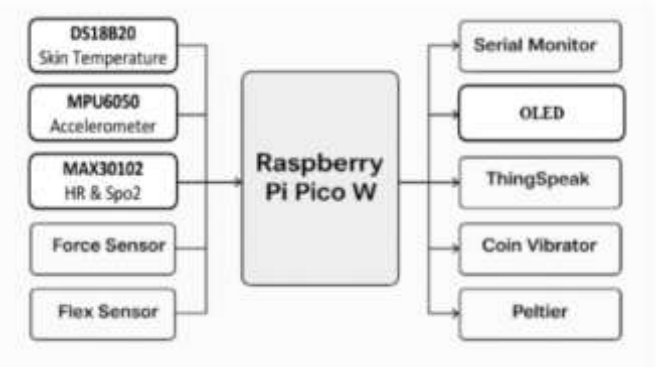

Fig -1: Block Diagram of the proposed system.

5. OBJECTIVES :

The main objectives of the study are as follows:

(a) To develop a real-time IoT-based monitoring system for detecting early symptoms of varicose veins using wearable sensors.

(b) To implement automated therapeutic responses, such as vibration and cooling therapy, activated upon abnormal symptom detection.

(c) To enable remote health monitoring by integrating communication modules for instant alerts to healthcare providers.

(d) To reduce dependence on traditional diagnostic methods by providing an accessible and cost-effective alternative.

(e) To improve patient quality of life through continuous symptom management and early intervention strategies.

APPLICATION:

Continuous Health Monitoring at Home: The system enables patients to monitor their varicose vein condition continuously without hospital visits. Real-time tracking helps in managing symptoms early and effectively, reducing complications and improving quality of life.

Remote Patient Management by Healthcare Providers: Through wireless connectivity and alert systems, the project facilitates remote monitoring by doctors. Healthcare providers can receive real-time updates and intervene sooner, providing telemedicine support, especially useful in rural and underserved regions.

Early Detection and Prevention: By detecting physiological anomalies such as abnormal temperature, heart rate, or muscle activity, the device aids in early diagnosis of varicose vein progression. Preventive therapy through automated vibration and cooling reduces symptom severity and potential .

Automated Therapeutic Intervention: The device's ability to automatically apply vibration and cooling therapy provides on-demand symptom relief. This reduces reliance on medication or manual physical therapy, improving patient convenience and adherence to treatment.

Data-Driven Research and Personalized Treatment: Collected physiological data can be used for long-term analysis, enabling personalized treatment plans. Researchers and clinicians can leverage this data to understand varicose vein progression better and tailor therapies based on individual patient responses.

7. RESULTS – SYSTEM DEMONSTRATION

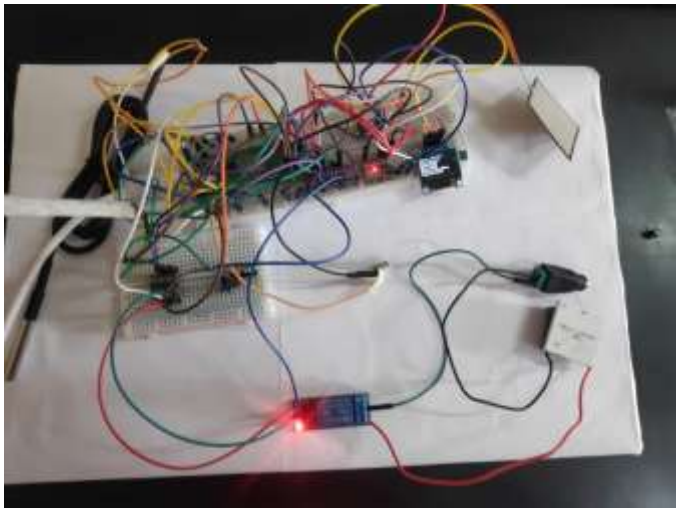

Fig -2: Hardware setup.

TThe developed IoT-based prototype successfully monitored key physiological parameters, including skin temperature, heart rate, blood oxygen saturation (SpO2), flex sensor values, and posture detection, in real time. Measurements such as body temperature (26.63°C), heart rate (107 bpm), SpO2 (64.9%), and posture (standing) were accurately displayed on the device's OLED screen, enabling clear and immediate feedback for both patients and healthcare providers. Flex sensor readings provided additional insight into muscle and limb activity, contributing to the overall assessment of varicose vein status.During testing, the prototype consistently differentiated between normal and abnormal vein conditions based on real-time sensor data analysis. The system's capability to activate alerts and therapeutic interventions, including vibration and cooling, demonstrated effective symptom management. Initial detection focused on temperature and flex values; as development progressed, features such as heart rate and SpO2 measurement were integrated to enhance early warning and intervention accuracy.

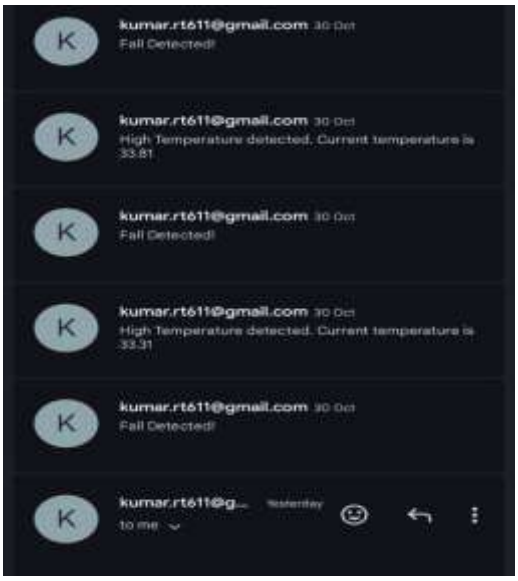

Fig -3: result outcome.

The integration of mobile and cloud communication allowed remote monitoring and notification, reinforcing the system's utility for home-based patient care and telemedicine applications. These results validate the feasibility of the proposed approach for real-time varicose vein monitoring and management, suggesting potential for improved patient outcomes and accessibility in clinical and home settings

8. CONCLUSIONS

The developed IoT-based varicose vein monitoring and therapy system demonstrates effective real-time detection and management of key physiological parameters relevant to vein health, including skin temperature, heart rate, SpO2, and muscle activity. The integration of wearable sensors with automated therapeutic responses and remote alert functionalities provides a comprehensive and accessible solution for continuous patient monitoring, early symptom detection, and prompt intervention. Prototype validation confirmed reliable measurement accuracy and successful symptom assessment, highlighting the system's potential to reduce hospital dependency and improve patient outcomes, especially for those in remote or resource-limited settings. Future enhancements, such as expanded sensor integration and cloud analytics, can further personalize care and enable data-driven treatment strategies for chronic vein disorders

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