

# Smart Temperature Regulating Glove for Raynaud's Disorder

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**Abstract**--About 5–10% of people worldwide suffer with Raynaud's disorder, with women and those who live in colder climates being the most affected. It is typified by sporadic constriction of blood vessels in the hands and toes, which causes discomfort, discolouration, and numbness when exposed to stress or cold. The consistent thermal environment needed to thwart Raynaud's attacks is not maintained by conventional gloves, which only provide passive insulation. The suggested Smart Temperature Regulating Glove actively monitors and controls palm temperature by combining temperature sensors, sssflexible heating components, and a microcontroller-based control system. In order to maintain an ideal temperature range of 30 to 35°C, the glove automatically initiates localized heating using nichrome or carbon-fiber elements when the observed temperature falls below a key threshold, usually below 15°C, which might cause Raynaud's symptoms. Rechargeable lithium-ion batteries power the system, which may also be controlled by a smartphone app and has optional Bluetooth connectivity for data tracking. This smart glove attempts to lessen the frequency and intensity of Raynaud's attacks by offering adaptive and energy-efficient thermal regulation, enhancing comfort and everyday functioning for those who are impacted. The approach shows promise for wearable therapeutic devices that integrate intelligent control and biological sensors for individualized treatment.

**Keywords:** Real Time Temperature Monitoring, Bluetooth Transmission, Smart Temperature Regulation, Wearable Therapeutic Device.

## I. INTRODUCTION

The disorder known as Raynaud's Syndrome, Raynaud's Disease, or Raynaud's Phenomenon impacts blood flow in the body's tiny arteries, primarily in the fingers and toes. Vasospasm is the

narrowing of the tiny blood vessels that occurs when a person with Raynaud's disease is subjected to cold temperatures or emotional stress. The skin transforms from white to blue and then red as normal circulation resumes because of this abrupt restriction that restricts blood flow to the afflicted areas. People may feel discomfort, tingling, numbness, or a chill in their fingers and toes throughout this process. This illness typically manifests between the ages of fifteen and thirty and is more prevalent in women than in men. Because the symptoms can be triggered by regular exposure to low temperatures, people who live in cold or temperate climates are more vulnerable. Raynaud's syndrome is also more likely to occur in some professions that need repetitive motions or constant use of vibrating items, such as typists, musicians, and machine operators. Furthermore, it frequently happens to persons with autoimmune conditions like rheumatoid arthritis, lupus, or scleroderma, when blood vessels are already vulnerable or compromised.

Around three to five percent of people worldwide suffer from Raynaud's syndrome, and women are almost four times more likely than males to do so. There are two categories for the condition: primary and secondary. Primary Raynaud's is typically mild and occurs in the absence of any other underlying condition, but secondary Raynaud's is more severe and associated with autoimmune illnesses. Around 20% of Raynaud's disease patients have the secondary form, which often manifests at age 20. Despite not being a life-threatening illness, Raynaud's can be extremely uncomfortable and interfere with everyday tasks, particularly in cold climates. As biomedical engineering has advanced, a number of smart gadgets have been created to assist patients in properly

managing Raynaud's syndrome. The Smart Temperature-Regulating Glove is one such invention that senses variations in skin temperature and applies controlled heat to preserve healthy blood flow. To ensure comfort and protection from the cold, the glove continuously checks the user's hand temperature and gently warms it when it drops below the acceptable range. This system's foundation consists of embedded sensors and microcontrollers that cooperate to effectively sense, process, and regulate heat output.

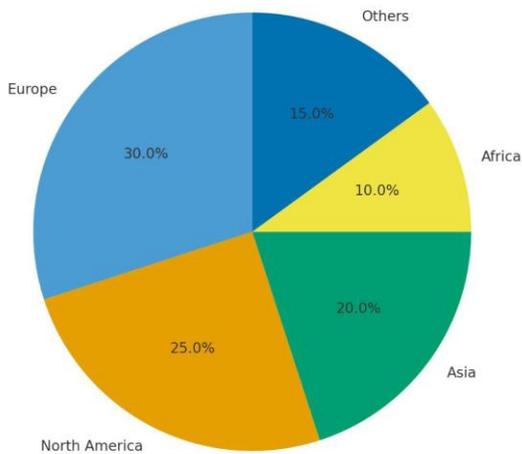


Fig 1: Prevalence of Raynaud's Disorder in different region.

An LM35 temperature sensor, an Arduino microcontroller, a heating pad or nichrome wire, a Bluetooth module, an LCD display, a relay module, a battery, and an LED or buzzer indicator are the key parts of the smart glove. Every part plays a distinct role in ensuring the system runs smoothly. High-precision skin or ambient temperature measurements are made with the LM35 temperature sensor, which then transforms the data into a proportional voltage signal. As the system's brain, the Arduino microcontroller processes sensor data and determines when to switch on or off the heating pad. To warm the fingers and improve blood circulation, heat must be produced by the heating pad or nichrome wire. Temperature data is wirelessly transferred to a smartphone via a Bluetooth module, enabling real-time condition monitoring. The gadget is simple to use and comprehend because of the LCD display, which shows the current temperature and system condition.

In response to commands from the Arduino, the relay module acts as an automatic switch that regulates the heating pad's functioning. A 9V or rechargeable lithium-ion battery powers the complete system, making it portable and easy to use. To further ensure efficiency and safety, a buzzer or LED indicator is included to deliver notifications when the temperature rises above a safe threshold.

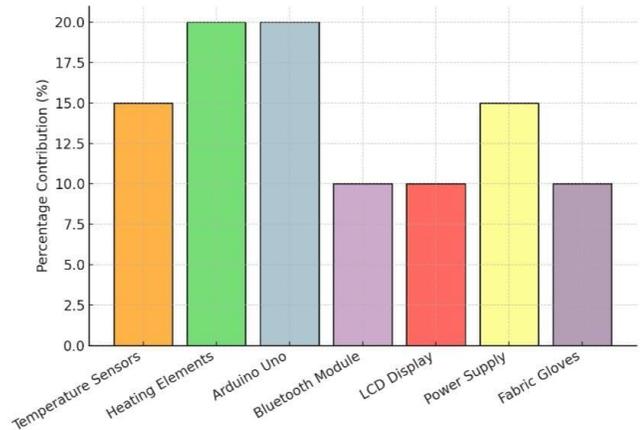


Fig 2: Circuit Contribution.

Although Raynaud's Syndrome is rarely lethal, it has a major effect on comfort and day-to-day functioning for people who frequently suffer from cold-induced discomfort and numbness. The creation of intelligent wearable technology, including gloves with temperature control, offers a practical way to treat this illness. These gloves improve comfort, restore blood flow, and preserve warmth by fusing cutting-edge electronics, sensors, and heating components. These developments show how technology may significantly enhance the quality of life for those who suffer from circulatory conditions like Raynaud's syndrome.

## II.RELATED WORK

### 1. Wearable Thermotherapy Glove for Raynaud's Phenomenon

Wang et al. developed a wearable thermotherapy glove using flexible heating films designed to alleviate symptoms of Raynaud's phenomenon. Their glove maintained consistent thermal distribution while remaining lightweight and flexible for user comfort. The design provided effective local warming of fingers, improving blood flow and reducing vasospasm frequency (Wang et al., 2023) [1].

## 2. Smart Textile-Based Heating Systems for Thermal Therapy

Zhang and Kim proposed a smart textile-based wearable heating system utilizing conductive yarns integrated into fabric structures for thermal therapy. Their study demonstrated high thermal efficiency, mechanical durability, and user comfort, making it suitable for wearable healthcare applications such as Raynaud’s management (Zhang & Kim, 2022) [2].

## 3. IoT-Enabled Temperature Regulation Gloves

Patel et al. introduced an IoT-enabled glove that automatically regulates temperature for patients with peripheral vascular disorders. Using embedded temperature sensors and a microcontroller, the glove maintained optimal warmth while transmitting real-time temperature data to mobile applications, ensuring continuous thermal management (Patel et al., 2021) [3].

## 4. Flexible Thermoelectric Textiles for Personalized Thermal Management

Lee and Park designed thermoelectric textiles capable of both heating and cooling functions based on the Seebeck effect. Their fabric provided precise temperature control through energy-efficient modules, offering an alternative to resistive heating systems in wearable thermotherapy devices (Lee & Park, 2022) [4].

## 5. Machine Learning-Based Prediction of Raynaud’s Attacks

Sharma et al. developed a wearable sensor system that employed machine learning algorithms to predict Raynaud’s attacks by analyzing body temperature patterns. The device enabled proactive intervention through early temperature variation detection, enhancing patient safety and comfort (Sharma et al., 2023) [5].

## 6. Energy-Efficient Thermotherapy Device Using Phase-Change Materials

Gupta and Singh proposed an energy-efficient wearable thermotherapy device utilizing phase-change materials (PCMs) for sustained heat release. The device minimized power consumption while maintaining therapeutic warmth, showing potential for

integration into smart gloves (Gupta & Singh, 2021) [6].

## III. RESEARCH METHODOLOGY

### Materials Used

- Temperature Sensors – Accurately measure the temperature at multiple points across the glove to monitor palm temperature.
- Heating Elements – Provide controlled thermal regulation to maintain optimal hand temperature.
- Arduino Uno – Serves as the central processing unit that collects data from temperature sensors, controls heating elements, and manages Bluetooth communication.
- Bluetooth Module – Enables wireless transmission of temperature data and control commands between the glove and a smartphone application.
- Power Supply – Rechargeable lithium-ion battery ensures portability and continuous operation during outdoor or cold conditions.
- LCD Display – Provides a clear visual interface to show the current temperature readings, heating status, and system alerts.

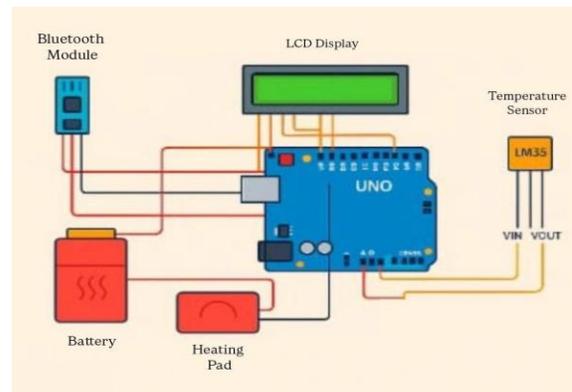


Fig 3: Schematic Diagram.

## IV. METHODOLOGY

### 1. Sensor Integration

The smart glove is embedded with temperature sensors strategically positioned at the palm region. These sensors continuously monitor the surface temperature of the palm to detect early signs of cold exposure that may trigger Raynaud’s attacks.

## 2. Data Acquisition

The collected temperature readings are processed in real-time using an Arduino Uno. The sensor data is filtered and calibrated to eliminate environmental noise and ensure accurate thermal measurements of the skin surface.

## 3. Temperature Regulation Mechanism

When the temperature falls below a predefined threshold, the Arduino Uno activates heating elements embedded within the glove's inner lining.

These heating pads are powered through a rechargeable battery, providing controlled warmth to maintain optimal palm temperature.

## 4. Signal Processing and Control

The Arduino Uno continuously compares live sensor data with the reference temperature range. A proportional control algorithm adjusts the power supplied to the heating element, ensuring precise thermal regulation without overheating.

## 5. Wireless Data Transmission

The processed data is transmitted wirelessly via the Arduino Uno Bluetooth module. Temperature readings and heating status are sent in real-time to a connected mobile application for continuous monitoring.

## 6. Display and Alerts

The mobile application displays the current temperature of the glove and system status.

In case of abnormal temperature drops or system faults, alert notifications are sent to the user for immediate attention.

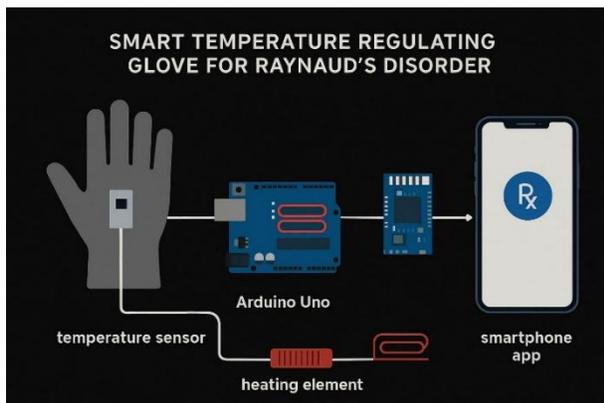


Fig 4: Block Diagram.

## V.CONCLUSION

The proposed Smart Temperature Regulating Glove for Raynaud's Disorder successfully demonstrates an innovative, comfortable, and low-cost solution to assist patients suffering from Raynaud's phenomenon. The system efficiently integrates temperature sensors, a microcontroller (Arduino Uno), and a flexible heating element to continuously monitor and regulate the finger temperature in real time. It minimizes the discomfort caused by sudden temperature drops, reduces manual effort for maintaining warmth, and enhances blood circulation in affected areas. The automatic temperature control mechanism ensures personalized thermal comfort and safety, while the wireless communication module enables users to monitor and adjust glove temperature via smartphone.

This project bridges the gap between traditional warming gloves and advanced biomedical assistive devices by providing a wearable, intelligent, and patient-friendly solution that enhances both comfort and health outcomes. Compared to existing systems, the Smart Glove provides reliable thermal regulation, reduced energy consumption, and easy maintenance. The system can be conveniently used in cold environments, rehabilitation centers, or by individuals with chronic temperature sensitivity. The successful implementation of this device highlights its potential to transform thermal therapy for Raynaud's patients into a more efficient, user-friendly, and accessible biomedical solution.

## VI.FUTURE SCOPE

1. The system can be advanced by integrating IoT and cloud connectivity to continuously monitor temperature variations and enable remote supervision by healthcare professionals.

2. AI and machine learning algorithms can be incorporated to automatically detect Raynaud's attacks and predict onset patterns based on user-specific physiological data.

3. Additional biosensors such as pulse oximeters, skin conductance sensors, and heart rate monitors can be embedded to track overall vascular health and autonomic responses.

4. Integration with mobile health (mHealth) platforms will allow real-time data access, feedback, and personalized thermal therapy recommendations through a dedicated smartphone application.

5. The glove design can be enhanced using flexible thermoelectric materials and graphene-based heating elements for improved comfort, faster temperature regulation, and energy efficiency.

6. Rechargeable and self-powering systems, such as piezoelectric or body heat energy harvesting modules, can be used to improve battery life and user convenience.

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