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GOOD VIBE-A DEVICE FOR EARLY DETECTION AND PREVENTION OF VARICOSE VEIN

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Abstract—*We propose an inexpensive, light weight and wearable device for the early detection and prevention of varicose veins using non-invasive methods. The device includes 18650 battery for powering up the microcontroller, ESP32 microcontroller which acts as the client and Raspberry pi 3b+ which acts as the main server. The controller communicates wirelessly with the main server. NTC thermistors are used for measuring the temperature of the affected area as well as the normal body. A microcontroller pressure simulator is used for obtaining pressure variations and a compression stocking with micro motors are used for providing vibrations. The method includes continuous monitoring of blood pressure and temperature of the affected area. When the blood pressure exceeds the threshold value and when the temperature of the affected area becomes more than the normal body temperature, improper blood flow is detected and the information is sent to the application and vibrations are applied automatically to make the blood flow proper.*

Index terms—Varicose veins, non-invasive treatment, blood pressure monitoring, temperature monitoring

1. INTRODUCTION

Varicose veins can be considered as enlarged veins that have gotten enormous, swollen and turned. Normally they will happen quickly under our skin on legs. By and large they will bring about certain manifestations yet in barely any cases may encounter a torment around there. Draining can even happen in basic cases not withstanding thrombophlebitis. At the point when they happen close to the scrotum, they are named varicocele while those that happen around the anus is named as hemorrhoids. Specifically, there is no reason for it. Varicose veins are most commonly or likely to occur in people who used to stand a lot in their job such as teachers, nurses, policemen etc. It can happen in view of the absence of activity and furthermore because of stoutness. It can likewise be passed down with ages. They can likewise happen all the more regularly during pregnancy period. In some cases, it will occur because of basic vein inadequacy and it includes either a powerless or a harmed valve or valves. It can happen because of the activity of gravitational power on the blood streaming upwards. Blood in general, will aggregate at a specific valve because of this activity and can lead to the invert stream of blood.

The invasive treatments include laser therapy, sclerotherapy, radio frequency ablation and ambulatory phlebectomy. The existing non-invasive treatments are whole body vibration, using compression stockings and doing exercises. One of the greatest challenges faced by the medical industry is the early detection and prevention of varicose veins. When varicose veins go undetected, it gets aggravated and causes a lot of pain to the affected person as well as make them resort to surgical methods as a cure.

Our proposed solution includes continuous monitoring of blood pressure and temperature of the affected area. When the blood pressure rises above the threshold value [2] along.

with increase in the temperature of the affected region [3] above normal body temperature improper blood flow or less blood flow is indicated and this information is sent to the application and vibrations [1] are applied automatically. Vibrations can also be manually switched ON and OFF in the application. Pressure and temperature variations are obtained by using pressure simulator (for demonstration purpose only and later accurate pressure sensors can be used) and NTC thermistors respectively. These output variations are plotted graphically using raspberry pi and can be viewed in a webpage by the user.

The device includes 18650 battery for powering the microcontroller. ESP32 MCU is used since it has integrated WiFi and dual mode Bluetooth which enabled wireless communication between the main server and itself. A boost converter is used here to boost the voltage of the battery to make it compatible with the operating voltage of ESP32 MCU. NTC thermistors are used for measuring the temperature of the affected region as well as normal body temperature. A microcontroller pressure simulator is used in order to obtain pressure variations (for demonstration purpose only). Both these devices i.e., the thermistors and the simulator are 5V devices and are connected to ESP32 MCU via a voltage divider. Raspberry pi 3b+ is used which is the main server using which output graphs are plotted in the webpage and vibrations are turned on.

2. THEORY

Varicose veins are a venous disease that doesn't have early detection methods to date. Our project consists of two parts, a way to detect varicose veins early as well as a way to provide treatment. Based on the various journals we have referred to; we have come to the conclusion that early detection is possible by just monitoring two parameters: Pressure and temperature.

Those patients suffering from varicose veins were found to have a temperature difference in the affected region compared to the temperature of the rest of the body [1]-[2]. Since varicose veins occur due to the malfunctioning of the valves in the veins, blood gets accumulated in the veins [2]. Thus, blood flow decreases, and as a result the temperature increases in the affected area. From the medical journals we have referred to, this increase in temperature is found to be about two degrees from the normal body temperature of the patient [2]. Another parameter that can be used to detect varicose veins is by monitoring the blood pressure in the veins. As mentioned above, the accumulation of blood in the veins also leads to an increase in the blood pressure in the affected vein. This increase in venous pressure, if properly measured can be used to detect varicose veins before it is visible superficially [3].

Since early detection is now possible with the above-mentioned methods, the next part of our research was focused on how to treat the condition. Compression stockings are a common treatment prescribed during the early stages of this disease. These stockings apply graduated pressure on the affected area and improve the blood flow back to the heart from the leg region [5]-[6]. Another prescribed treatment in the early stage is by providing vibrations in the affected region. This produces a milking sensation in the veins and promotes the blood flow back to the heart [4].

Combining the various conclusions, we have reached from our research, we have designed our proposed idea into a prototype. The prototype we designed has a pressure and a temperature module to detect varicose veins. We chose the long saphenous vein as our target area because this vein is more commonly affected by this condition [2]. The pressure sensing module consists of a cuff that inflates and digitally measures the vein pressure in the targeted area. If the value of blood pressure is higher than the threshold value for pressure, this information is sent to the micro-controller. The temperature module consists of a few temperature sensors kept in the targeted area and continuously measures the temperature in that area. Another temperature sensor is used to measure the normal body temperature of the subject. The temperature values received from these sensors are compared and once a variation of two degrees from the normal body temperature is detected, this information is then sent to the micro-controller. When both criteria are satisfied, the micro-controller switches on the vibrator modules attached to the compression stockings. The combined action of the stockings and the vibrator modules prevents blood from being accumulated in the veins and thus improves the blood flow. The speed of vibrations provided can be controlled by means of a web-page which also displays the temperature and pressure values measured.

3. BLOCK DIAGRAM

The primary server used in the device is the Raspberry Pi 3 Model B+. It is powered using an adapter. The secondary server used to connect the actuator with the sensors is ESP 32 MCU. It is powered using a 18650 power supply module. They are also known as Li-ion batteries. The output given by 18650 is step up to 5V using a DC Boost Converter. The sensors include the NTC thermistors. A total of six thermistors are used to sense different regions of the vein. Five sensors are placed in a strip on the calf region just below the knee where initial symptoms of varicose are observed. The other one is placed in the upper body part near the chest to measure the difference between the normal body temperature and the temperature of the calf affected by varicose. Pressure simulator is used in our case to show the variations in pressure with the onset of varicose veins. The value can be varied by rotating the simulator. It is attached to the secondary server by using a PWM Counter. An inbuilt ADC converts the analog output of thermistors to a digital value and there are six 10 k resistors used for voltage dividing purpose corresponding to six thermistors. 33k and 22k resistors are used in pressure simulator for the same purpose. Micromotors are used to provide necessary sequential vibrations to pump the accumulated blood back to the heart. The micromotors are placed in a strap and in our case, we are using four motors for demonstration purposes. Two switches are used - One is a slide switch for making the device ON and OFF. The other one is the Push button which when pressed for more than 2 seconds will increase the temperature by 2 degrees Celsius. This is done to show the defected case.

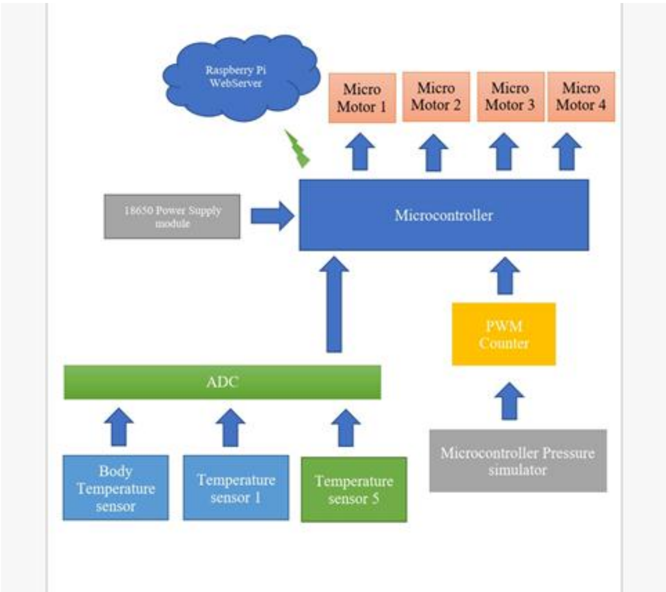

FIGURE 1 Block Diagram

3.1. Raspberry Pi

This is the primary server used for demonstration purpose and it helps in the wireless transmission of information from the sensor to the webpage. The webpage enables us to view the temperature and pressure variations in the affected area using graphs. The device can be turned on by the person on seeing a considerable change from normal body temperature and pressure. No other components are attached to the primary server except the secondary server. The secondary server, ESP 32 MCU is connected to the temperature sensor, actuator, and pressure simulator. The general specifications include 64 – bit SOC, 1 GB Media-2 RAM, GB LAN Port, HDMI 4 USB Port, and micro SD card slot. It is powered using an adapter.

3.2. *ESP 32 MCU*

ESP32 is fit for working dependably in modern conditions, with a working temperature going from – 40°C to +125°C. Fueled by cutting edge adjustment hardware, ESP32 can progressively evacuate outside circuit blemishes and adjust to changes in outer conditions. Engineered for cell phones, wearable gadgets, and IoT applications, ESP32 accomplishes ultra-low force utilization with a mix of a few kinds of restrictive programming. ESP32 likewise incorporates best in class highlights, for example, fine-grained clock gating, different force modes, and dynamic force scaling. ESP32 can proceed as a total independent framework or as a slave gadget to a host MCU, diminishing correspondence stack overhead on the fundamental application processor. ESP32 can interface with different frameworks to give Wi-Fi and Bluetooth usefulness through its SPI/SDIO or I2C/UART interfaces.

ESP32 is exceptionally coordinated with in-constructed receiving wire switches, power enhancer, low-commotion get intensifier, channels, and force the board modules. ESP32 adds extremely valuable usefulness and adaptability to your applications with negligible Printed Circuit Board necessities. It is powered using a 18650 power supply. Four micro motors are attached to the four output pins. These comprise the actuators. Six temperature sensors are also attached. The analog output of thermistors is converted to digital values using the inbuilt ADC in this module. The microcontroller pressure simulator is attached to the module using a PWM counter. This module is wirelessly connected to raspberry pi and the readings and actuator control can be seen by the viewer through the webpage.

The 18650 is a kind of battery-powered lithium-particle battery. Lithium-particle batteries have altered compact gadgets. They're in all things, from our cell phones and cameras to infant screens, wellness devices, and flashlights. A 18650 battery is a cell that is 18mm x 65mm in size. The name, 18650, alludes solely to the size of the lithium-particle battery cell. They offer the presentation of a lithium-particle cell, a limit in the scope of 1800mAh to around 3500mAh, and a yield of 3.7 volts. They're utilized in an immense scope of gadgets from workstations to laser pointers, and camera adornments like gimbals and sliders. The output 3.7 V should be stepped up to 5 V to power 32 MCU. And therefore, we use a DC boost converter as seen in figure 1.

3.3. Thermistors

In total we use six thermistors and these are the sensors used to measure the localized variation of temperature of the affected region. One thermistor is placed in the upper body part to measure the normal body temperature and five other thermistors are used in the region below the calf and are placed in a strip. The average value of all the outputs from the five NTCs are taken and is compared with the value from the upper body part. The difference is noted and the Kelvin value is converted to degree Celsius.

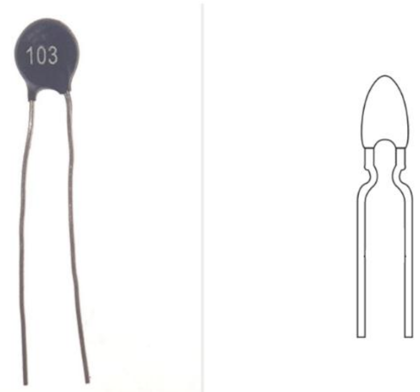

FIGURE 2
Thermistor

The strip is placed in the region below the knee just over the superficial veins where the chances for the onset of varicose veins are maximum. The individual component and its PINOUT are shown in. figure 2.

For demonstration purposes the push button is pressed for two seconds and there will be a two-degree Celsius difference in temperature between the affected region and the upper body. The output of the thermistor will be 5 V and it needs to be converted to 3.7 V to connect to 32 MCU. Hence a voltage divider is required and we use six 10k resistors for each of six 10k thermistors. A slide switch is also used to ON and OFF the device. The strip is shown in. figure 3.

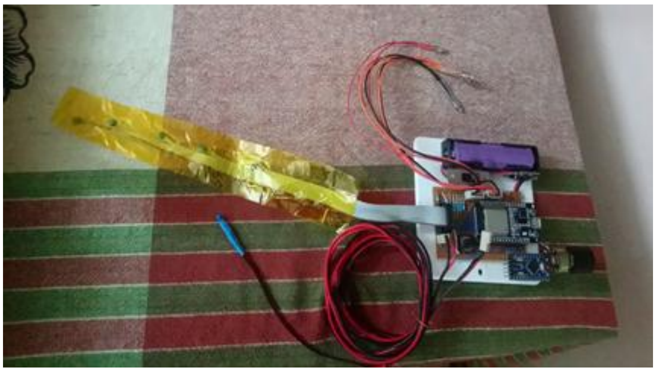

FIGURE 3
Strip of Thermistor

3.4. Pressure Simulator

Arduino pro mini along with a potentiometer is used for varying pressure of the affected region. A considerable rotation of the knob changes the diastolic and systolic values of pressure. The average increase in pressure being 20 % more than the normal pressure. It is attached to 32 MCU using a PWM counter. A voltage divider circuit is introduced by using two resistor values of 22k and 33k after designing. The simulator when rotated gives a considerable change in pressure. Pressure along with temperature variation will give us the details regarding varicose veins and we could switch on the vibration by viewing through the webpage.

3.5. Micromotor vibrator

These are the actuator modules and here four are used to show sequential vibration. They are attached to the output ports of 32MCU. Their specifications include 2 V 10 mA and are 5 mm in size. Each one is given to four different output ports and each port can accommodate 40 mA of power. The sequential vibration provided will pump the blood accumulated in the affected region back towards the heart. More number of vibrator modules can be attached to 32 MCU. In further future scope, pulse triggering can be imparted under proper medical conditions and tests. The information regarding the variations of pressure and temperature is stored in Raspberry pi. The vibrators here used are less costly and are strictly for demonstration purposes. Under further medical approval nerve pulse stimulations can be given to the affected person.

3.6. Webpage communication

The webpage is developed to show the readings of each of the five thermistors and it also shows the normal body temperature. The webpage was developed to get a better understanding of the defected case and to compare it with normal value. It displays the variations using line graphs for better understanding. The user can get a better understanding of whether to switch ON the device by checking the values. The continuous variation from normal values can also indicate the onset of the varicose vein to a normal individual. The systolic and diastolic pressure values simulated using the microcontroller can also be seen on the webpage.

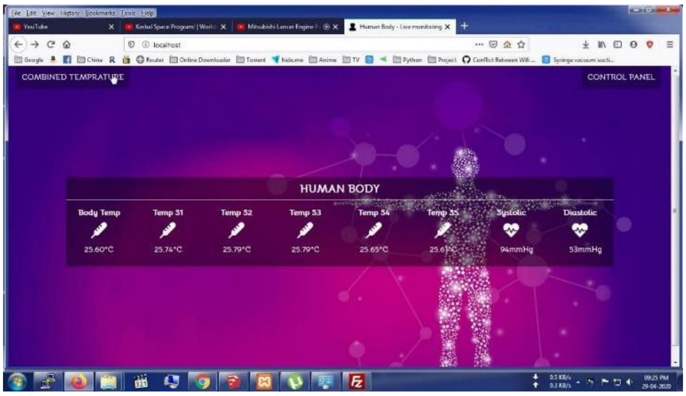

FIGURE 4
Screenshot of Webpage

4. MEASUREMENTS

The measurements taken are that of temperature and pressure. the basic theory is to calculate the temperature of the affected region and compare it with the normal body temperature. The temperature of the varicose affected calf region is calculated in kelvin and is converted to degree Celsius. The temperature changes can vary with exercise and fever. Therefore, it is suggested to use the system under optimal body conditions. Since we could not test directly on the human body and due to the cost constraints for a more precise temperature sensor, we apply the defected case condition by simulation. The average value of the thermistors in the patch is taken and compared with the temperature measured by the sixth thermistor. If the difference is greater than two degrees Celsius it indicates the chances of onset of the varicose veins.

```
float tcalc(int a)
{
  float tempcalc;
  tempcalc=(4095.0/a) - 1;
  tempcalc=tempcalc*10000;
  tempcalc = log(tempcalc);
  tempcalc = (1.0 / (A + (B * tempcalc) + (C *
tempcalc * tempcalc * tempcalc)));
  tempcalc = tempcalc - 273.15;
  return tempcalc;
}
```

FIGURE 5
Screenshot of code (to measure the temperature)

Similarly, the normal pressure values are set as shown in the figure. When the knob of the potentiometer is rotated there will be a change in resistance which correspondingly imparts a change in systolic and diastolic pressure values. A twenty percent change in pressure value is usually considered when there is an onset of varicose. When there is a change in both pressure and temperature values simultaneously, it indicates the chances of obstruction in blood flow. The vibrator modules can be switched ON and further treatment can be done as prescribed by a doctor.

```
void bp()
{
  int val = pulseIn(pres, HIGH);
  val=val-1000;
  sbp=map(val, 0, 1000, 90, 200);
  dbp=map(val, 0, 1000, 50, 120);
}
```

FIGURE 6
Screenshot of code (to measure the pressure)

5. RESULT

Each of the thermistor values can be observed using line graphs as seen on the webpage. Whenever the temperature of the normal body falls two degrees Celsius less than the average of the other five thermistor values, the temperature will be shown in red color indicating the onset of the varicose vein. The pressure values can be simulated using the knob as seen in figure 7. The temperature readings of the default atmosphere are shown in figure 8.

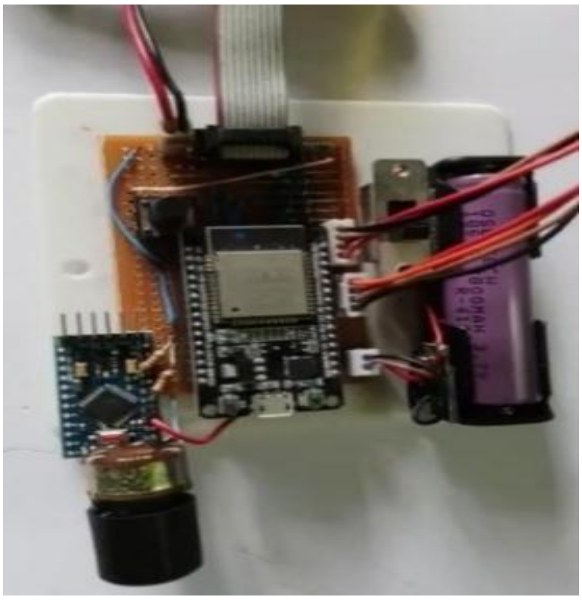

FIGURE 7
Pressure simulator connected to the body of device

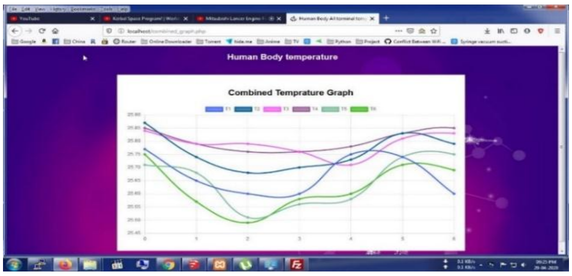

FIGURE 8
Temperature measurement demonstration using line graphs

6. CONCLUSION

This paper proposes a novel method for early detection as well as a treatment to prevent the onset of varicose veins. For the detection of the disease, we continuously monitor both the temperature and pressure in the targeted area. Once both values are found to be more than the threshold values, the vibrator modules fixed to the compression stockings switch on. Their combined action will enhance the blood flow in that region and prevent the accumulation of blood. The future work for this project includes measuring the blood flow for more accurate detection of varicose veins.

Ultrasound also can be used to detect the variations in blood pressure but we couldn't incorporate it into our project because of cost constraints.

7. REFERENCES

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