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Infrared Radiation: A Non-Invasive Approach to Cholesterol Measurement

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Abstract

Cholesterol levels and Diabetes have become prevalent worldwide. People who are physically disabled or unresponsive need to have their glucose and cholesterol levels constantly checked because it is hard to get accurate readings through invasive procedures or blood samples. Based on the proposed model, Hyperglycemia and Cholesterol amounts might be found without touching or taking blood specimens. The Arduino UNO and basic infrared sensors are used to make this happen. Power LED sockets measure cholesterol and glucose while the patient's palms are on an infrared detector. The glucose and cholesterol levels of diabetic patients and pregnant women must be monitored regularly. Cardiovascular disease, which results in stroke and heart attack, is caused by the minimum level of cholesterol in the blood. Depending on how the energy from LED light bounces off of bloodstream cells, the Arduino UNO receives the values. Glucose and Cholesterol values are computed with the assistance of the Arduino UNO program. Furthermore, calculating Haemoglobin, LDL, and HDL values is an additional benefit. The proposed model is more cost-effective and saves more time. By utilizing the Internet of Things (IoT), this project can be further developed by transmitting virtual measurements. Nowhere else has a non-invasive technique for measuring glucose and cholesterol been used, which shows how new and different this approach is. No matter what, the model works well and is not affected by outside interruptions like various forms of light.

Keywords: Non-invasive monitoring, cholesterol, medical diagnostics, innovative healthcare solutions, diabetic patients, infrared sensors.

INTRODUCTION

The three most common risk factors for ischemic diseases are Hypertension, Dyslipidemia, and Diabetes. The prevention of these lifestyle diseases – with atherosclerosis receiving special attention – is gaining popularity. This is because hypercholesterolemia is the main risk factor for atherosclerosis [1–6]. It is deemed sufficient to define hypercholesterolemia in humans based on a total blood cholesterol level below 220 mg/dL. When cholesterol attaches itself to proteins, lipoproteins are created. This is because cholesterol does not dissolve well in water. Low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C) are the two forms of cholesterol in the bloodstream. It is significant to remember that LDL-C is directly linked to the development of atherosclerosis [7–9]. Regular testing for hypercholesterolemia should be done without the need for any invasive techniques. The prevention of ischemic diseases greatly depends on the early detection of atherosclerosis. Measurement of the cholesterol value in skin cells has been suggested as an easy monitoring process that is less invasive for atherosclerosis due to the high levels of cholesterol found in skin cells. Testing pads that can be purchased are applied to the palm to perform skin cholesterol tests. These pads are used to calculate skin cholesterol levels by measuring variations in

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skin pigmentation brought on by enzymatic reactions. Research has shown a significant correlation (correlation coefficient, 0.290.38) between this method's estimated skin cholesterol levels and the Framingham risk scores, total cholesterol levels, LDL-C, and ICAM-1 levels. These analysis outcomes have shown that they are useful in predicting coronary artery disease [10, 11]. Conversely, other investigations have failed to find a meaningful connection among blood cholesterol and skin cholesterol levels [12–16].

For this reason, it is uncertain whether skin cholesterol is a reliable indicator of serum cholesterol levels. A reduction in the deformability of red blood cells is correlated with an increase in blood cholesterol levels [17–19]. The cytoplasmic viscosity, cell morphology, membrane elasticity, and cell structure are some variables that affect deformability. Dyslipidemia and hypercholesterolemia cause a decrease in the elasticity of red blood cell membranes by raising blood viscosity and available cholesterol levels, which are components of red blood cell membranes [20]. The probability of developing anemia is also higher when red blood cell deformability keeps declining [21, 22]. A form of anemia known as catalytic anemia develops when there is a malfunction in the process by which cholesterol builds up in erythrocyte membranes [23, 24]. Red blood cells in the spleen that have become malformed are immediately destroyed.

Traditional methods of determining blood sugar and cholesterol levels involve puncturing the skin to access a vein to collect an appropriate blood sample. This method is deemed more irritating since it is more painful for patients, particularly children. A fluctuation in blood sugar levels is frequently observed in pregnant women and diabetics. Consequently, it is imperative to puncture the skin each time. Next to glucose, cholesterol is the most prevalent disease. A blood sample is also required to measure total cholesterol, LDL, and HDL cholesterol. Cardiovascular disease, which results in strokes and heart attacks, is caused by low blood cholesterol levels. Table 1 sets the source value for overall cholesterol in the circulatory system [25]. This study resolves the issue of non-invasively measuring critical glucose and cholesterol levels. This method does not necessitate a blood sample to assess cholesterol and glucose levels. To measure blood sugar levels and lipids, use the LED power indicator.

Table 1. Standardized level of total cholesterol.

Category	**LDL (mg/dl)**	**Total (mg/dl)**
Optimal	<100	
Desirable		<200
Above or close to the optimum	100–129	
On the edge of high	130–159	200–239
High	160–189	>240
Very High	>190	

MATERIALS AND METHODS

Experiment Overview

Blood irradiation was carried out using the wavelength on various body tissues, including the fingers and the earlobe, to measure cholesterol levels in the blood using non-invasive methods. By developing near-infrared spectroscopic sensors that employ infrared LEDs and photodiodes, blood constituents, including SPO_2, glucose, hemoglobin, and heartbeat, have been determined. Findings from earlier studies were encouraging. One way to determine whether something transmits or reflects energy is to measure how much of different wavelengths of light it absorbs. Infrared spectroscopy is a type of spectroscopy that uses wavelengths in the infrared part of the electromagnetic spectrum. Non-invasive methods are used to look at absorption ratios across different wavelength sets.

The initialization process, which includes processing signals from infrared LED sensors to convert analog signals to digital signals. This study's flow chart starts with putting sensors at person's fingertips,

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sending light into body tissues so that the bloodstream can absorb it, and then taking in light that the photodiode does not absorb. When the light-emitting diode sends voltage to the ADC, the 'microcontroller' uses a logarithmic formula to ascertain the total cholesterol level. After that, measurements are sent to the user's phone and shown on the LCD screen.

Invasive Technique

An invasive method for blood cholesterol testing entails using a needle to extract a blood sample from a vein, typically in the arm. A venipuncture is a procedure that entails the insertion of a needle into a vein to collect blood in a vial or syringe. The sample is subsequently sent to a laboratory for analysis to determine total cholesterol levels, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and triglycerides. The process is relatively quick and routine; however, it may result in minor discomfort, bruising, or bleeding at the puncture site.

Non-Invasive Techniques

Non-invasive methods for measuring blood components such as blood glucose using near-infrared (NIR) sensors with an emitter LED 1550E and an FGA10 photodiode with a wavelength of 800–1800 nm and NIR radiation in the 700–1100 nm range. Blood cholesterol is measured using optical sensors with IR LED photodiodes of 800–1800 nm wavelengths. It is necessary to develop straightforward measuring tools with non-invasive methods to track total blood cholesterol. The chemical formula for cholesterol is $C_{27}H_{46}O$. It is a small biological molecule, similar to wax, mixed with blood plasma. Cholesterol is nearly insoluble in water (0.095 mg/L at 30°C), meaning the bloodstream contains very little. Hydrophilic proteins bind to cholesterol to form lipoproteins necessary for cholesterol to circulate in the bloodstream. This lipoproteins build up and can lead to clogged arteries. Atherosclerotic lipoprotein is the kind that causes atherosclerosis. There are two types of lipoproteins: high-density lipoprotein (HDL) and low-density lipoprotein (LDL).

Proposed System

The proposed system block is illustrated in (Figures 1 and 2), which illustrates the Arduino utilized in our investigation. The system comprises 940 nm IR LED sensors that emit infrared light. Photodiode detectors either absorb or receive light. When a detector is put on the hand, the tissue takes in the LED light. At the same time, the photodiode detector receives the remaining light. A load resistor on the anode converts the light attenuated by the photodiode into an electric current and voltage. The voltage of the photodiode increases as light is received, with a range of 0 V to 5 V. Voltage fluctuations are less apparent due to the photodiode's inadequate voltage. In order to resolve this issue, the sensor's voltage is increased by an IC circuit for an amplifier LM358N. An ADC microcontroller with 10 bits reads the photodiode voltage in the sensor circuit and changes it to voltage. After that, this is put into a linear equation to find the total cholesterol in the blood. The results of measuring LCD and smartphone screens at the same time, LC with a micro-controller and an i2c LCD 16 x 2 screen is put on pin 4 of the main board for the micro-controller.

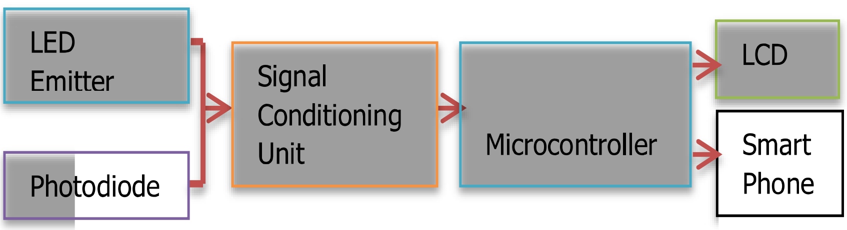

Figure 1. Blockage of the blood cholesterol sensor.

RESULTS

Sixty-four individuals, aged twenty to seventy, were recruited to evaluate the device. There were both male and female participants. After collecting total blood cholesterol data with invasive devices, the next step was to use the NIR sensor to measure voltage, which was created a few minutes later. Five times, each person was tested to get information on the sensor voltage output values. The sensor output voltage was checked before a blood sample was taken for an invasive method assessment and was measured twice at the commencement of the data collection process. Subsequently, it was measured three times after the blood sample was collected. Average output voltage values were obtained by placing the sensor on the finger for approximately twenty to forty seconds. This guaranteed that the output voltage of the sensor was consistent. Figure 3 and Table 2 illustrate the data collection methods and the results of the measurements, respectively.

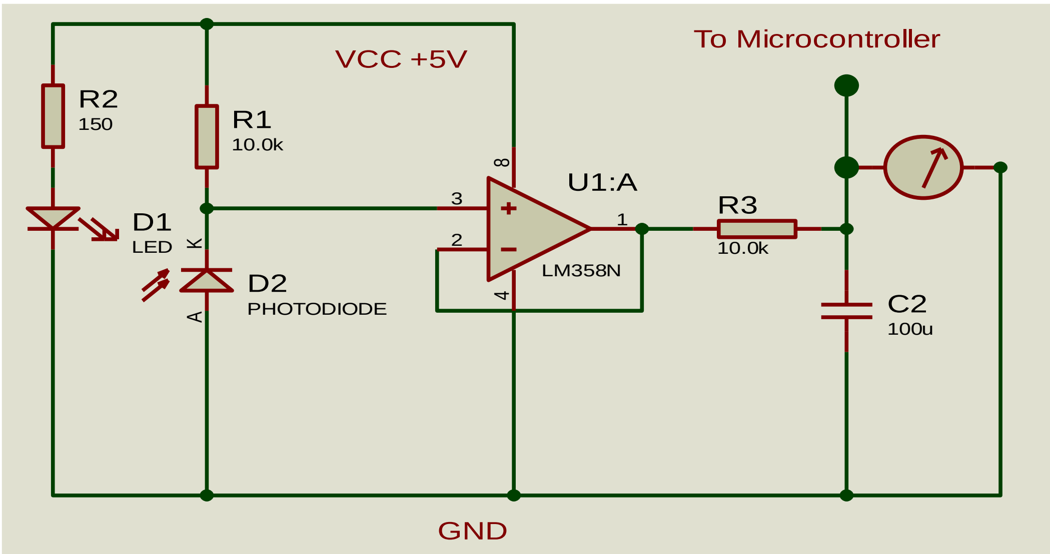

Figure 2. Transmission circuit.

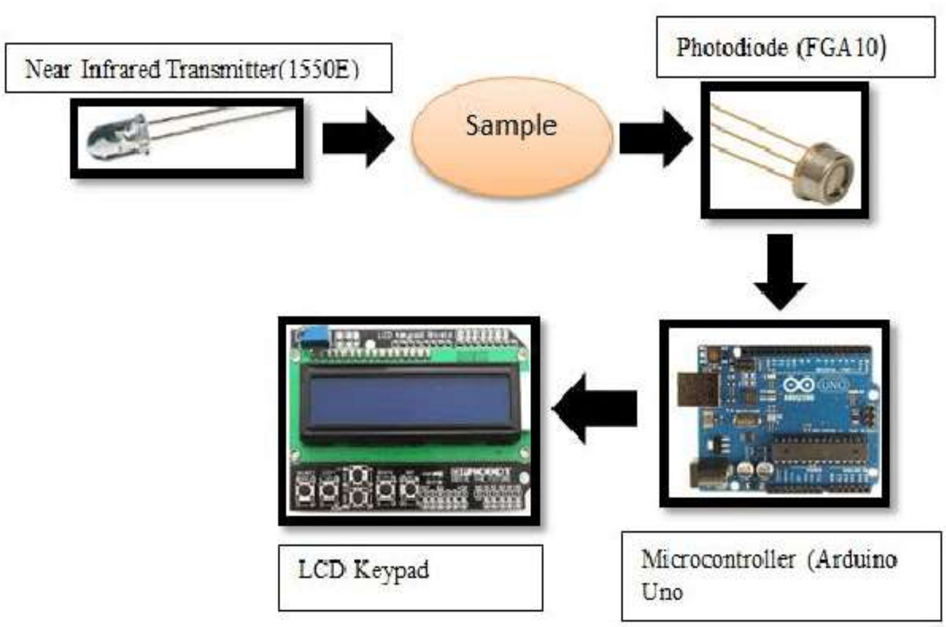

Figure 3. System process flowchart.

Statistical Analysis

- *P-value (0.0047):* Since the p-value is much less than 0.05, we conclude that there is a statistically significant relationship between the non-invasive and invasive cholesterol measurements.
- *Regression equation:* Y^ = 106.4876 + 0.6181 ·X\hat{Y} = 106.4876 + 0.6181 \cdot XY^ = 106.4876 + 0.6181 · X. This means, for every unit increase in the non-invasive measurement, the invasive measurement increases by approximately 0.6181 units.
- Linear regression has the equation *R2R^2R2 (0.9303):* This high R2R^2R2 value suggests that the non-invasive measurements can explain approximately 93.03% of the variance in invasive measurements. This indicates a very strong relationship between the two sets of measurements.

Table 2. Invasive and voltage with non-invasive sensor measurements.

Set	Non-Invasive (mg/dl)		Invasive (mg/dl)	Non-Invasive (mg/dl)		Variance	*P-value*
	1	*2*	*3*	*4*	*5*		
A	151	157	155	159	158	3,16	0.0047
B	224	221	229	228	222	3,78	
C	251	260	254	252	256	3,57	
D	274	271	269	282	281	5,85	
E	295	296	292	290	297	2,91	
F	302	311	307	303	308	3,70	

DISCUSSION

The Figure 4 shows the end outcome of the tests done on both male and female. People took part in a link between the voltage generated from the sensor in both total cholesterol levels and invasive measurement methods. It was found that the variance in voltage at the sensor's result was due to varied light patterns and light absorption in the body tissues. This difference was caused by the cholesterol levels in each individual's blood. A straightforward correlation between the total cholesterol levels and the voltage coming from the sensor was determined using the algorithm equation Y = 59.7805 + 0.7963·X. The regression correlation coefficients R^2 = 0.9303 were also utilized. The voltage at the output of the NIR sensor is not linear, with the values of blood checking for cholesterol using invasive method. One of the factors that can affect the measurement outcome is the inconsistency of the sensor installation. Other things that can affect the amount of light taken by the finger tissue are the thickness of the skin and the likelihood that the sensor is receiving other light, which could lead to the reflection of non-pure light.

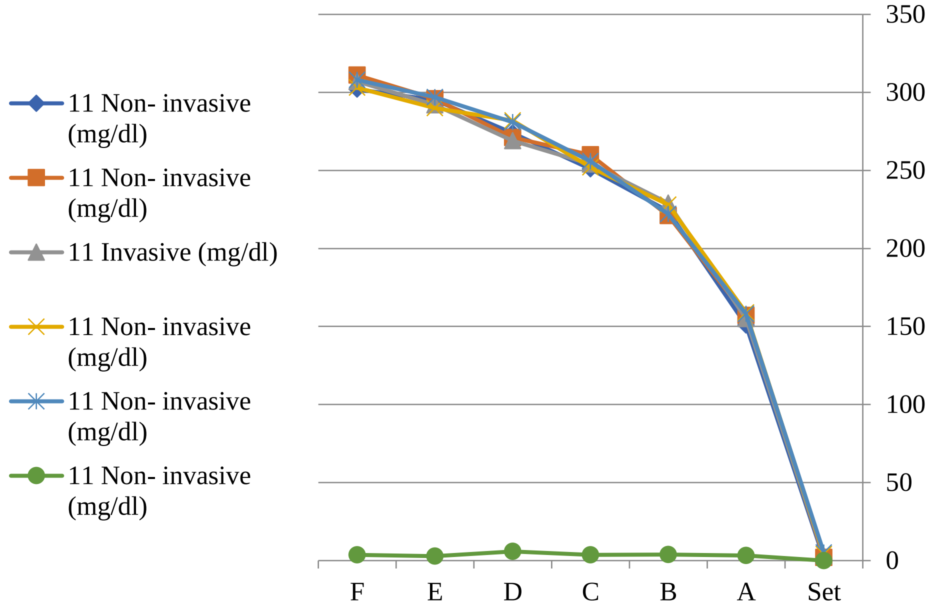

Figure 4. System process flowchart for infrared radiation blood cholestrol measurement.

The Table 3 results of the mean cholesterol levels, standard deviations (S.D.), and standard errors (S.E.) of the different age groups were consistent. The mean cholesterol level was 239.5 mg/dl at 61 to 70. This suggests that the range of cholesterol levels is broader within this age group. These results demonstrate that near-infrared (NIR) sensors can effectively provide non-invasive and precise blood cholesterol measurements. This could be particularly advantageous in clinical environments, enabling routine monitoring without invasive procedures. The results of this study have substantial implications, as they indicate that non-invasive techniques can transform patient care by enhancing compliance with cholesterol monitoring recommendations and reducing discomfort.

Table 3. Cholesterol levels by age group: mean values, standard deviations (S.D.), and standard errors (S.E.) across different age groups.

Age	**No. of Individuals**	**Result**	**Mean**	**SD**	**SE**
20–30	11	151-192	171.5	11.83	3.56
31–40	14	151-198	174.5	13.57	3.63
41–50	12	165-200	182.5	10.10	2.92
51–60	22	160-235	197.5	21.65	4.61
61–70	9	168-311	239.5	41.29	13.76

Note: SD: standard deviations; SE: standard errors.

CONCLUSION

The results of non-invasive cholesterol measurements are presented in this paper, which was made possible by sensors that consist of infrared LED producers and collectors for photodiodes. These measurements were pitted against the results of invasive techniques. This device has the potential to generate innovations in the field of cholesterol measurement that are painless, user-friendly, and cost-effective, as it does not rely on cholesterol strips. The tool's precision has become reliable and well-developed.

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