Liquid Crystal Display Equipment Development for Body Mass Index, Blood Pressure, Temperature and Sugar Level

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Abstract
Prevention is emphasized as a preferable strategy to cure, particularly for severe diseases that frequently develop gradually. Early diagnosis of abnormal health issues can lead to successful treatments and overall well-being improvement. Vital health factors such as BMI, blood pressure, temperature, and blood glucose levels all play an important part in a person's general wellness. In this work an health testing device was developed capable of assessing these critical indicators quickly and frequently at a single stand. The study focuses on the creation of a medical measuring device capable of measuring weights up to 100kg and heights up to 7 feet. A digital weighing scale, Sonar Ultrasonic height sensor, Medium Density Fibreboard, Liquid Crystal Display, blood glucose and pressure monitoring device and Microcontroller Arduino Board are among the components utilized. A Programmable Gain Amplifier (PGA) connects the weight output from the digital weighing scale and the height measurement from the ultrasonic sensor to an Arduino microcontroller. The Arduino Uno calculates the mass-to-body ratio and reads temperature using a non-contact thermometer. On the liquid crystal display (LCD), the output results (mass, height, temperature, and BMI) are presented. The medical measuring system that was created was calibrated against a precise digital weighing system and tape rule. For weight and height, it had 99% efficiency. The device was inexpensive and had a significant positive association with the standards (weighing scale and tape rule). Other instruments, such as blood pressure and glucose monitoring devices, were connected to the system but were not incorporated into the liquid crystal display, thus their results were provided separately. The presented unified health testing equipment provides an effective and easy method for evaluating critical health factors such as BMI, blood pressure, temperature, and blood glucose levels. Its precision and concordance with established measuring equipment are excellent. This device is recommended for usage in medical systems by healthcare practitioners due to its low cost and dependable performance.

Keywords: *Blood Pressure, Body Mass Index (BMI), Health Monitoring System, Liquid Crystal Display, Temperature*

I. Introduction

In the current globalized world, leveraging technology for improving human health has become essential. Timely monitoring of human health parameters using sensors and automation plays a vital role in the early detection and prevention of illnesses. This work focuses on developing a unified health testing device capable of accurately measuring BMI, blood pressure, temperature, and blood glucose level, all in one stand.

The world today is filled with advancement in technology capable of improving human health. Sensor measuring device can be used to monitor human health parameters. The measurement of blood pressure is done with the electronic version of Oscillometric device that is more accurate than sphygmomanometers and the Korotkoff methods, these methods required manual observation by doctors, nurses or other medical personnel. In a case where patients are admitted into the hospital's ward, nurses will only come at certain time intervals to monitor the patient's condition, including the patient's body temperature. If, by some misfortune, the patient experienced an attack of high blood pressure between these time intervals, there is nothing that could be use to alert the medical personnel which may lead to serious injury or even fatalities, hence the need for a dynamic system that could measure blood pressure, body mass index, temperature and blood sugar level at once on a single test thereby making the task less cumbersome and more efficient.

II. LITERATURE REVIEW

A. BODY MASS INDEX (BMI)

Quetelet Index currently referred as Body Mass Index (BMI) is defined as a measure of nutritional status of adults. It is a function of an individual weight (kilogram) to the square of its height in metres (Flegal et al., 2012; Gallagher et al., 1996; WHO, 2000).
Body Mass Index is a critical measure for assessing nutritional status in adults, calculated as the ratio of weight to height squared. Accurate BMI measurement is essential in combating obesity and its associated health risks.
BMI measurement is a function of kgm^{-2}. The techniques is use for indicating the obesity status of human beings and in the long run, could contribute in warning against the surge of obesity and other related diseases (Gallagher et al.., 1996). Obesity is an essential risk factor for mortality from cancers, diabetes mellitus, cardiovascular diseases, and musculoskeletal disorders, causing the death of close to 3 million yearly basis worldwide (Prentice & Jebb, 2001; WHO 2000; Wolk et al., 2003; Flegal et al., 2013; Garrouste-Orgeas et al., 2004;). The accurate measurement of individual BMI will avail his nutritional status. This would enable such to take precautions to prevent the risk of obesity which may be associated with cardiac hypertrophy and impose adverse effects on coronary flow and eventually increase the likelihood of myocardial ischemia in human beings (Alpert, 2001).
The weight and height square ratio calculation known as the BMI method has, therefore, been favoured by clinicians, and different devices have been produced for this measuring technique. AKAS body mass index apparatus uses ultrasonic and load sensors to measure the height (m) and weight (kg), respectively (Quicklab, 2010). The AKAS system does more than BMI measurement: it shows several parameters within two minutes such as height, weight, BMI, Non-Invasive Blood Pressure (NIBP) in automatic and manual modes, temperature, blood oxygen saturation (SpO_2), and pulse rate adding to its costs. At a price equivalent of almost one million naira (Quicklab, 2010) during the cost of this study, it is quite expensive for personal use at home hence the need to develop a monitoring device within the populace reach.

B. TEMPERATURE MONITORING

Regular monitoring of body temperature aids in the early detection of fevers and other health abnormalities. The developed system incorporates a non-contact infrared thermometer to measure body temperature wirelessly, making the process efficient and convenient.

Temperature is the degree of coldness and hotness of a body. This is the measurement of the average heat in a body. The body is naturally built to be very good at maintaining its safe range of temperature. The inner part of the body will keep comparing and reacting to the temperature difference between it and its surrounding. The blood vessel under the skin will contract as a person in cold conditions to reduce the blood flow to the skin conserve heat and make the person shiver. While during hot situations, the blood vessel will expand to bring out excess heat through the skin's surface, thus causing the skin to start sweating (Parekh, 2010).
The most accurate part for measuring the body temperature is the rectum, currently the temperature is measure on the forehead using an infrared thermometer. According to Carl Wunderlich the normal benchmark body temperature is 98.6°F (36.9°C). He claimed this after collecting and analysing over a million armpit temperatures of 25,000 patients in hospitals. Human body temperature varies depending on activity, time of the day, and psychological factors (Parekh, 2010).

C. BLOOD PRESSURE MEASUREMENT DEVICE

Accurate blood pressure measurement is vital for diagnosing hypertension and other cardiovascular conditions. The instrument utilizes oscillometric methods to measure blood pressure automatically and display the results promptly.
Balestrieri and Rapuno (2010) discussed Oscillometric methods as a controlled air pressure pumped through the cuff wrist of the patient until it stopped the blood circulation. After that, the pressure will be deflated slowly while the device reads the blood pressure electronically during the inflation or deflation phase giving the systolic and diastolic value.
The Oscillometric methods have minor drawback from internal and external factors. For internal factors, these methods are somehow affected by uncertainty components due to the lacking of calibration on the air pressure sensing system and from the systolic and diastolic pressure (Balestrieri & Rapuno, 2010).
The external factor brings about uncertainty that could affect the measurement conditions, such as the patient's arm position during the test, and the patient physical condition. The author stressed that each of the blood pressure measurement devices has to be calibrated frequently to ensure the accuracy of reading a patient's blood pressure.
Another version of blood pressure measurement is based on the oscillometric method called as oscillometric morphology method. Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) are estimated via a signal-based approach and it is use to estimate the Mean Arterial Pressure (MAP). It clarified the derivation of Mean Arterial Pressure from systolic and diastolic peak pressure on the oscillometric waveforms,

$$(MAP = DBP + 1/3\,(SBP - DBP)). \qquad (1)$$

III. METHODOLOGY

A. MATERIAL AND METHOD

In the process of designing a functional machine, selecting the appropriate material and understanding its properties are crucial aspects. The material chosen should possess characteristics that align with the operational conditions of the machine. An ideal material fulfils the desired objectives of the machine being designed and modelled. Key considerations in the design process include strength, functionality, safety, reliability, utility, shape, ergonomics, aesthetics, and analysis and control.

B. MATERIAL

The materials required for the design and development of the linear variable liquid crystal display for indicating body mass index, blood pressure, temperature, and sugar levels include the following:

1. Digital weighing scale used in measuring body mass.
2. Sonar with Ultrasonic Sensors was used for the measurement of distances and depths.
3. Infrared thermometer was employed to measure body temperature without making contact...
4. Blood pressure monitor: Used to measure blood pressure levels accurately.
5. Blood glucose meter: Utilized to measure sugar levels in the blood.
6. Liquid Crystal Displays (LCD): Display panels to present the measured values and information.
7. Medium Density Fibreboard (MDF): Material used for constructing the body and framework of the equipment.
8. Rubber Mounting: Absorbs shocks and vibrations, providing stability to the components.
9. Microcontroller Arduino Board: The main processing unit that controls and manages data from various sensors and displays the results.
10. Battery: Provides power supply for the equipment's operation.
11. Various other Accessories: These include connectors, wires, resistors, capacitors, and other electronic components necessary for the proper functioning of the equipment.

The combination of these materials allows for the creation of a sophisticated and functional device capable of indicating and displaying body mass index, blood pressure, temperature, and sugar levels accurately.

C. DESIGN ANALYSIS OF THE SYSTEM

The design analysis of the system involves a quantitative assessment of various components to determine the functionality, efficiency, and safety of the designed system.

The system's design includes load cells, vibrating wire sensors, and ultrasonic distance sensors to ensure precise and reliable measurements. Medium Density Fibreboard (MDF) is selected as the construction material for the body and framework due to its strength, durability, and ease of use.

(i) Load Cells:The system incorporates electronic compression load cells, which are electro-mechanical weight sensors used to measure force or weight. These load cells rely on the transference principle between an applied force, material deformation, and the flow of electricity (Erinle et al., 2020). They offer accurate and robust performance across a wide range of applications, as illustrated in Fig. 1.

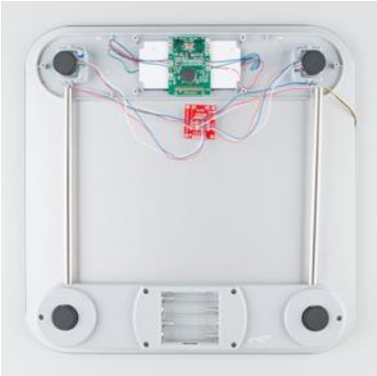

Fig. 1: Application of Load Cell.

When gravitational force is applied to an elastic element due to the body being measured, it produces a measurable deflection in the load cell. The load cell serves as a sensing element with an input of change in forces and an output of change in length (elastic deformation) (Flintec, 2020; Erinle et al., 2020).

(ii) Vibrating Sensor: The system also incorporates a vibrating wire sensor, which comprises a wire kept vibrating at its resonant frequency by a variable-frequency oscillator. The resonant frequency of the wire under tension is determined by equation (2) proposed by Morris in 2001; as cited in Erinle et al., 2020. By measuring the output frequency of the oscillator, the force applied to the wire can be calculated, thus assisting the load cell in its function (Morris, 2001; Erinle et al., 2020).

$$F = \frac{1}{2L}\sqrt{\left(\frac{M}{T}\right)} \qquad (2)$$

where;
M is the mass per unit length of the wire,
L is the length of the wire, and
T is the tension due to the applied force.

These components, the compression load cells, and the vibrating wire sensor work together to enable precise measurements of weight, force, and other essential parameters in the designed system. The integration of these elements ensures the accurate and reliable functioning of the equipment for the intended applications.

(iii) Sonar with Distance Ultrasonic Sensor: The system incorporates ultrasonic waves for distance measurement, commonly known as sonar. Two ultrasonic devices are employed to accurately measure distances ranging from 1 to about 50 meters. An ultrasonic transducer is utilized to convert energy into ultrasonic vibrations. The process involves emitting a pulse of energy from the transmitter, which travels to an object and is reflected to the receiver. The time taken for this pulse to travel and return is measured, enabling the calculation of distance based on the known speed of ultrasonic waves, which is approximately 340 meters per second (Beyer, 2009; Erinle et al., 2020.

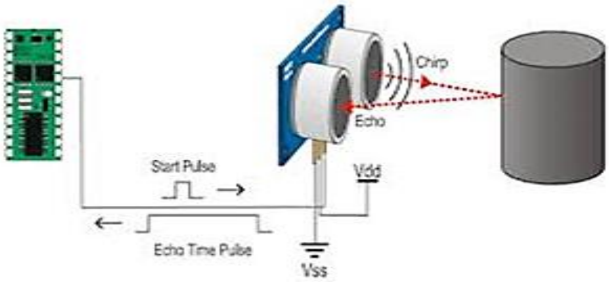

Fig. 2: Ultrasonic Distance Sensor and Its Operation.

The ultrasonic waves transmitted by the sensor reflect off the surface of the object and are detected by the receiver. By measuring the time delay, the distance between the transmitter and the object's surface can be determined, considering the velocity of ultrasonic waves. This feature allows the system to accurately measure distances, an essential capability for various applications.

(iv) Medium-Density Fibreboard (MDF):Medium-Density Fibreboard (MDF) is chosen as a material for the construction of the equipment. MDF offers numerous advantages over natural wood, including dimensional stability, uniform strength, resistance to splitting, panel form, and decorative value, along with thermal and sound insulating properties as shown in Table 1.

MDF is highly versatile and adaptable, making it suitable for various applications. It boasts excellent surface qualities, strength, and durability. The available thickness ranges from 6 to 40 mm, with a density range of 517 to 834 kg/m^3, and an average density of 680 kg/m^3. The speed of sound in wood longitudinally falls within the range of about 3500 to 5000 m/s (Erinle et al., 2020).

By utilizing MDF for the body and framework of the equipment, the design ensures stability, strength, and aesthetic appeal, contributing to the overall functionality and durability of the system.

Table 1: Mechanical Properties of Medium-Density Fibreboard (MDF)

Properties of Medium-Density Fibreboard	**Parameters Value**
Density	680 kg/m^3(Average)
Modulus of Elasticity	105 N/mm^2
Modulus of rigidity	12280 N/mm^2
Tension stress(Transverse)	5.5 N/mm^2
Compression stress(Transverse)	9.1 N/mm^2
Toughness	36.7 Nm
Hardness	6.0 KN

SOURCE: (Dinwoodie 1996, Haygreen and bowyer 1996)

The size of the MDF to be used on the load cell as the platform is:
Length = 0.5 m, Width = 0.4 and Thickness = 0.04 m
Equations 3 to 8are used to determine the integrity of the weight-measuring system platform (Khurmi et. al. 2005; Ejiko et al., 2015, 2022; Oigbochie and Ejiko, 2020)
Weight, W = Density, ρ × Volume, V × Acceleration due to Gravity,

g = ρVg (3)
Assumed 15 % Factor of safety
The weight is 60N
The maximum weight of a man is 1200 N (120 kg), and the average weight of a man as male and female is9500N (95 kg) and 764 N (83.9 kg) respectively (stats.areppim.com, 2018).
The total weight that will act on the MDF is 1260 N

$RA = RB = \frac{Wmax}{2}$ (4)

$$RA = \frac{Wmax}{2} = \frac{1260}{2} = 630N$$

The shear force is 630 N
The maximum bending moment of the MDF under load as given by (Ejiko et. al., 2020; Oigbochie and Ejiko, 2015) in equation 5
Maximum Bending Moment,

$Mmax = \frac{WL}{4}$ (5)

$$Mmax = \frac{Wl}{4} = \frac{1260 \times 0.5}{4} = 157.5$$

The maximum bending moment is 157.5 Nm.
The compressive stress induced due to the load to undergo during the operation as given in equation 16 Compressive Stress,

$\sigma C = \frac{\text{Maximum Load}}{\text{Cross−Sectional Area}} = Pmax\ A$ (6)

$$\sigma C = \frac{1260}{0.5 \times 0.4} = 6300N/m2 = 6.3kN/m2$$

Compressive Stress, σ_C is 6.3 kN/m^2
The maximum deflection occurs at the mid-point as given in equation 7 with moment of inertia as given in equation 8
Maximum deflection,

$\delta = \frac{WL^3}{48EI}$ (7)

Where; modulus of elasticity of mild steel is 210Gpa (KN/mm^2) (Adewuyi et. al., 2021; Ejiko et al., 2018a)

Moment of inertia $I = \frac{bl^3}{12}$ (8)

Where; l= 0.5m=500mm, b= 0.4m = 400mm

$$I = \frac{bl^3}{12} = \frac{400 \times 500^2}{12} = 4166666667mm^2$$

Deflection of the MDF under concentrated load as given in equation 7

Deflection, $\delta = \frac{WL^3}{48EI}$

$$\delta = \frac{WL^3}{48EI} = \frac{1260 \times 500^3}{48 \times 210000 \times 4166666667} = 0.0000035m$$

Deflection, δ is **0.0000035 m**

Frame

The size of the frame completely depends on the needs. A frame will be used to carry all the other parts of the weight and height measuring system. Equations 9 to 11are used to determine the mass and weight of the frame with other aesthetic parts of the weight and height measuring system (Khurmi and Gupta, 2005). A mild steel angle bar was used to construct the frame. The density of mild steel is 7850 kg/M^3. The density of medium-density fibreboard (MDF) is 800 kg/M^3, and acceleration due to gravity is 9.81 m/s2 (Khurmi and Gupta, 2005).
The frame and base of the instrument are constructed using mild steel angle bars to provide stability and durability. The weight of these components is calculated to ensure optimal load handling and operational efficiency.

Determination of the Mass and Weight of the Frame

Equations 9 to 11 are used to determine the mass and weight of the frame with other aesthetic parts of the weight and height measuring system (Khurmi and Gupta, 2005; Ejiko et al, 2018b, 2020)

Volume = Length × Breadth × Thickness =

$V = l \times b \times t$ (9)

$\text{mass} = \rho \times V$ (10)

$\text{Weight} = m \times g$ (11)

The Base

Volume = Length × Breadth × Thickness = $V = l \times b \times t$

l = 152 mm = 0.152 m; b = 457 mm = 0.457 m; t = 2.5 mm = 0.0025 m

$V = 0.152 \times 0.457 \times 0.0025 = 0.0001736\ M^3$

Volume, $V = 0.0001736 M^3$

$m = \rho \times V$

$m = 7850 \times 0.0001736 = 1.36$ kg

Mass, M = 1.36 kg = 1360 g

$W = m \times g$

$W_1 = 1.36 \times 9.81 = 13.34$ N

Weight, W = 13.34 N

The Height

Volume = Length × Breadth × Thickness = $V = l \times b \times t$

l = 2200 mm = 2.200 m; b = 50 mm = 0.05 m; t = 2.5 mm = 0.0025 m

$V = 2.200 \times 0.05 \times 0.0025 = 0.000275\ M^3$

Volume, $V = 0.000275 m^3$

$m = \rho \times V$

$m = 7850 \times 0.000275 = 2.16$ kg

Mass, M = 2.16 kg = 2160 g

$W = m \times g$

$W_2 = 2.16 \times 9.81 = 21.18$N

Weight, W = 21.18 N

The Top

Volume = Length × Breadth ×Thickness = $V = l \times b \times t$

l = 457 mm = 0.457 m; b = mm = 0.05 m; t = 2.5 mm = 0.0025 m

$V = 0.457 \times 0.05 \times 0.0025 = 0.000057\ M^3$

Volume, V = $0.000057M^3$
m = ρ × V
m = 7850×0.000057 = 0.45 kg
Mass, M = 0.45 kg = 450 g
W = m × g
W_3 = 045 ×9.81 = 4.40N
Weight, W = 4.40 N

Total weight of the frame
W= $W_1 + W_2 + W_3$ = 13.34 + 21.18 + 4.40 = 38.92N

D ALGORITHM OF THE DESIGN
The Body Mass Index algorithm describes the computation process involving the measurement of weight and height parameters and their application from the system as shown in Fig. 3.

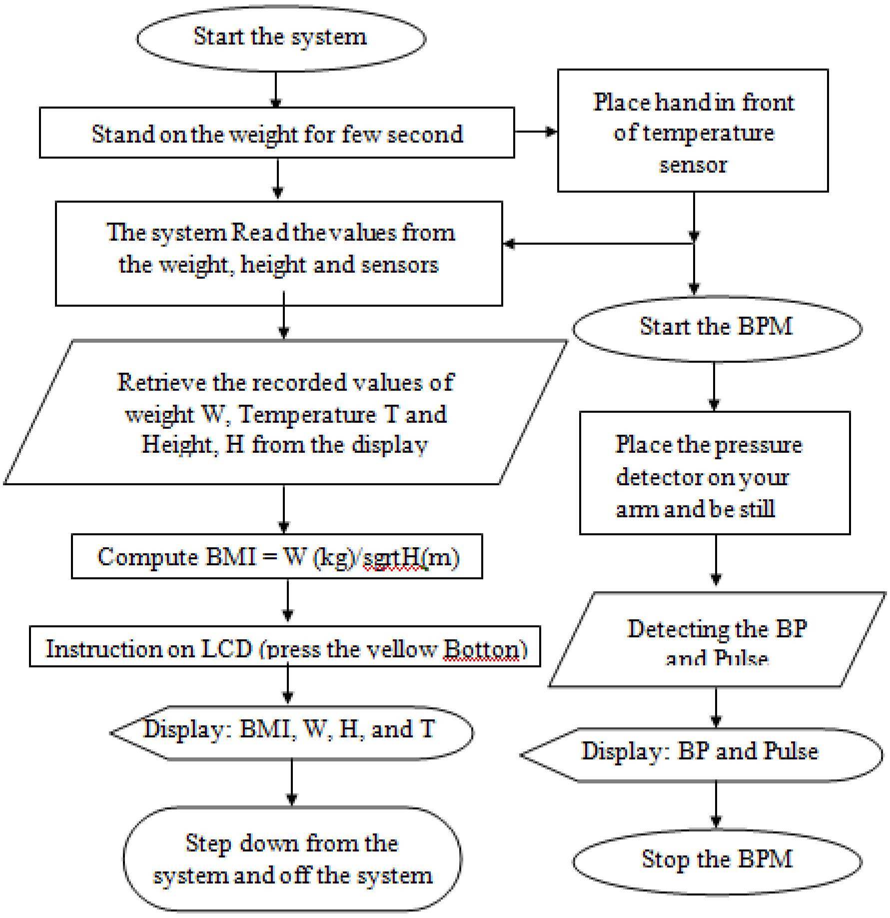

Fig. 3: Algorithm for the Body Mass Index Computation

IV. RESULT AND DISCUSSION

A. FABRICATION OF THE SYSTEM

The fabrication process comprises cutting parts for the equipment and welding all the parts needed. All the parts are joined by using a welding machine. After cutting the component is assembled according to the specification and welded together then some of the parts of the angular iron bar will be drilled to make provision for screwing the MDF to the system have been drilled and joined together by screw, washer, and nut.

The process of manufacturing the equipment is broken into five major parts which include, the frame made of angular bar, painting of the frame, the platform stand made of MDF, fixing of equipment, and programming.

The tools used in the fabrication process include:

1. measuring tape for measurement,
2. scriber for marking out the measured part,
3. cutting machine for cutting the iron according to specifications,
4. welding machine for welding the components together,
5. grinding machine for smoothing the face of the welded part
6. spraying machine for painting the component
7. drilling machine for drilling the holes on the bar for fitness of the platform (MDF)
8. screwdriver for screwing the platform into the frame and fixing all other components.

The specification of the equipment include: total height 2200mm,the width is 75mm the base is 457mm long, the height of the base is 152mm, and the width of the base is 310mm an image of the system is shown in Plate 1.

Plate 1: The Fabricated Device

B. PERFORMANCE EVALUATION OF THE SYSTEM

An evaluation of the system performance is needed to measure the system functionality and the result produced on each operation.

BMI & Temperature Evaluation Of The System.

The process of determining the BMI & temperature involves the person being measured will stand upright on the digital weighing scale properly, while the ultrasonic sensor which measures the height must focus on the centre of the head of the person being to be measured, while the person places his or her thumb in front of the infrared temperature for temperature reading. Then wait for a few seconds before pressing the yellow button and the system will

display the readings on the liquid crystal Display. Although the person is being measured mustn't take the reading him or herself to get an accurate reading.
An image of the BMI & temperature test as shown in Plate 2

Plate 2: An image of BMI & temperature Reading

The test was performed on three different people and the result is tabulated in Table 2 and Table 3 shows the status.

Table 2: BMI Test and Result

Temperature(0_C)	Weight(kg)	Height(cm)	BMI(kg/m^2	STATUS
30	63.13	171	21.6	Normal
25.80	65.16	184	19.2	Normal
28.35	50.60	167	18.1	Underweight (mild thinness)

Table 3: BMI Ranges & Status

Below 18.5	Underweight
18.5 – 24.9	Normal weight
25.0 – 29.9	Overweight
30.0 – 34.9	Obesity Class I
35.0- 39.9	Obesity Class II
Above 40	Obesity Class III

Efficiency of Device

The efficiency can be evaluated base on the accuracy, ease of use and reliability of the device.

$$\text{EFFICIENCY},\eta = \frac{BMI\ CALCULATED\ MANUALLY}{BMI\ DISPLAYED\ ON\ LCD} \times 100$$

To get the efficiency correctly one person was measured on the equipment and all the value was taken, then that same person was measured using different scale and height then the readings were taken and calculated using the above BMI equation, Table 4 shows the result of the reading from the test on the device and standard equipment.

Table 4: Result Comparison

BMI readings from the device			Manually calculated BMI results soured locally		
Weight from device(kg)	Height from device (cm)	BMI from device	Weight from scale(KG)	Height from tape (cm)	Manually calculated BMI
65.16	184	18.82	64.38	185.9	18.62

$$BMI = \frac{Weight(kg)}{Height(m^2)}$$

$$BMI = \frac{64.38(kg)}{1.859^2(m^2)} = 18.62$$

Therefore efficiency = $\eta = \frac{BMI\ CALCULATED\ MANUALLY}{BMI\ DISPLAYED\ ON\ LCD} \times 100$

$$\eta = \frac{18.62}{18.82} \times 100 = 99.26\%$$

The Blood Pressure Test Evaluation

The blood pressure monitor device is mounted on the system, therefore anyone who wants to take the test has to move close to the system stand all through the test and be close to the system and remain silent and calm all through the testing process. An image of the blood pressure testing operation is shown in Plate 3.

Plate 3: Blood Pressure Monitoring

The test was performed on three different people and the result is tabulated in Table 5.

Table 5: Blood Pressure Test Result

Pulse/min	SBP (mmHg)	DBP (mmHg)	Category
76	142	114	High bp
100	121	77	Normal
79	126	78	Normal

A chart of blood pressure range is shown in Table 6.

Table 6: Blood Pressure Range

Blood Pressure Ranges		
Blood pressure category	Systolic (mmHg)	Diastolic(mmHg)
Healthy	Less than 120	less than 80
Elevated	120-129	Less than 80
Stage 1 hypertension	130-139	80-89
Stage 2 hypertension	140 or higher	90 or higher
Hypertension crisis	Over i80	Over 120

(Kimberly Holland, 2023)

Blood Glucose Test Evaluation

The blood glucose machine is use to test the collected blood samples in comparison with the blood glucose level chart as shown in Table 7.

Table 7: Blood Glucose Chart

Blood Glucose Chart			
Mg/Dl	Fasting	After Eating	2-3 hours After Eating
Normal	80 – 100	170 -200	120 - 140
Impaired glucose	101 – 125	190 - 230	140 - 160
Diabetic	126 +	220 - 300	200 +

(Natalie Stein, 2022)

V. DISCUSSION

The body mass index, blood sugar level, blood pressure, and temperature indicating the device was fabricated and put to test which the result is shown in Table 2 and Table 5. The

BMI shows that two out of the three people tested had normal value while the third person is below the normal which is as a result of his small body weight. The blood pressure was established to be normal of two persons tested as against one with high blood pressure who was among those with normal BMI. The reading shows that the greater the weight the more liable to high blood pressure. The blood glucose level is expected to be carried out by medical practitioners due to the sensitivity involve in analyzing blood samples. The developed system was designed to easily determine the temperature, BMI, Blood pressure and glucose level in one stand. The manually estimated value is closely related to the system value with a maximum error of 0.74%. The developed system possesses an efficiency of 99.26% indicating its reliability and dependability.

VI. CONCLUSION

The creation of the linear variable liquid crystal display for displaying body mass index, blood pressure, temperature, and blood sugar levels is a big step forward in the field of health monitoring. Individuals can use the unified health testing gadget to examine vital health indicators in a comprehensive and fast manner. Its capacity to assess BMI, blood pressure, temperature, and blood glucose levels rapidly and reliably in one stand makes it a vital tool for early identification and prevention of health conditions.

Fabrication and testing of the device showed its functioning and dependability. The findings from the system are consistent with established criteria, confirming its precision and accuracy. Furthermore, the integration of numerous sensors and the application of automation enable real-time measurements, making it easier for healthcare practitioners to properly monitor patients' health.

The advantages of this equipment go beyond its performance. Its low-cost design makes it more accessible to a larger population, especially in low-resource situations such as Nigeria. It encourages individuals to take proactive efforts towards preserving their well-being and taking essential safeguards to address any possible health hazards by giving current health data.

To guarantee accurate and safe testing, it is critical to emphasise that the blood glucose monitor component should only be handled and used by certified medical personnel.

Finally, the unified health testing equipment shown here shows potential as a significant tool in healthcare settings. The equipment utilization is recommended for early diagnosis in order to prevent health disorders arising from manual errors. It is cost-effective and has the capacity to evaluate numerous health indicators concurrently. This technology, with additional validation and improvement, has the potential to greatly contribute to improved health outcomes and general well-being for individuals.

VII. RECOMMENDATION

Based on the development and performance evaluation of the linear variable liquid crystal display health monitoring system, the following recommendations are suggested:

i. This technology is advised for use in hospitals or clinics to perform tests on patients, and the individual being examined should not collect readings for himself or herself.

ii. Only medical professionals should use the blood glucose metre.

iii. Before wide-scale implementation, the system should go through extensive clinical testing and validation to assure its accuracy and consistency across a broad population. Collaborating with medical institutes and healthcare specialists to conduct validation studies would boost the system's credibility.

iv. Appropriate user training and guidelines should be provided to guarantee that healthcare practitioners can use the system effectively and properly interpret the data. Clear instructions on device operation and data interpretation will aid in the system's successful deployment.

v. To maintain accurate and dependable measurements throughout time, the system's components, particularly the sensors and measuring devices, should be subjected to regular maintenance and calibration. Implementing a maintenance program will assist to keep the system running smoothly.

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