

DEVELOPMENT OF A UNIFIED HEALTH TESTING DEVICE FOR MONITORING BMI, BLOOD PRESSURE, TEMPERATURE, AND BLOOD GLUCOSE LEVELS

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Abstract

Prevention plays a critical role in healthcare, especially in addressing diseases that develop gradually. Early detection of health abnormalities, such as high blood pressure, body mass index (BMI) issues, temperature irregularities, and blood glucose imbalances, can significantly improve treatment outcomes and overall health. This study focuses on the development of a unified health testing device designed to measure these essential health parameters—BMI, blood pressure, temperature, and blood glucose levels—on a single platform. The device integrates several components, including a digital weighing scale, ultrasonic sonar height sensor, blood pressure and blood glucose monitoring systems, and a microcontroller (Arduino) for data processing. The system measures weight up to 100kg and height up to 7 feet with high precision. Additionally, a non-contact thermometer is used to measure body temperature. The results, including mass, height, BMI, and temperature, are displayed on a liquid crystal display (LCD). The device was calibrated and demonstrated 99% efficiency when compared to established methods, such as the digital weighing scale and tape measure. While the blood pressure and glucose monitoring devices were integrated into the system, their results are displayed separately. This unified health testing equipment offers an affordable, efficient, and precise solution for monitoring vital health parameters, making it particularly suitable for use in medical settings where quick and frequent assessments are necessary. The low cost and reliable performance of this device position it as a valuable tool for healthcare practitioners, with the potential for widespread adoption.

Keywords: Health testing device, BMI, blood pressure, temperature, blood glucose

Introduction

The rapid advancements in technology over the past few decades have led to significant improvements in various fields, particularly in healthcare. As the global population continues to grow and age, healthcare systems face immense challenges in providing timely, efficient, and effective care. One of the most critical challenges is the early detection and prevention of diseases, which is crucial for reducing healthcare costs and improving the quality of life for patients. Technological innovations, especially in sensor-based devices, have the potential to address these challenges by offering cost-effective solutions that can monitor and evaluate key health parameters

in real-time. As such, leveraging automation and sensors for health monitoring is no longer a futuristic concept, but rather an immediate necessity.

In the current healthcare landscape, early diagnosis is increasingly seen as the best strategy for preventing severe diseases that develop over time. Illnesses such as hypertension, diabetes, obesity, and other chronic conditions often develop slowly and are not immediately apparent to the patient. However, these conditions are some of the leading causes of death and disability globally. The ability to continuously monitor and assess critical health indicators such as blood pressure, body mass index (BMI), temperature, and blood glucose levels can lead to timely interventions that prevent the onset of these health conditions or mitigate their effects. Monitoring these parameters on a regular basis can also help healthcare providers make more informed decisions and improve the overall management of patient care.

The measurement of blood pressure is one of the most fundamental components of health monitoring, as hypertension is a leading cause of heart disease, stroke, and kidney failure. Traditionally, blood pressure has been measured using sphygmomanometers, which rely on manual observation and interpretation of sounds using a stethoscope. The Korotkoff method, developed by Dr. Nikolai Korotkoff in the early 1900s, involves listening to the arterial sounds as air is slowly released from an inflatable cuff. While this method is widely used and effective, it requires skilled medical personnel to accurately assess the blood pressure, and the results are often subject to human error. Furthermore, in a busy clinical environment, particularly in hospital wards, patients are often monitored at set intervals, which means that any sudden changes in blood pressure may go undetected until the next scheduled check. This delay can lead to severe complications, including organ damage or even death, especially if a patient experiences a hypertensive crisis or sudden blood pressure changes between checks.

To overcome these limitations, advancements in electronic blood pressure measurement devices have become a focal point in healthcare technology. One such technology is the oscillometric method, which electronically detects the oscillations in the artery as the cuff deflates. This method has been shown to be more accurate and reliable than traditional manual methods, as it reduces the potential for human error. Furthermore, oscillometric devices can continuously monitor blood pressure, providing real-time data without requiring the intervention of a healthcare professional for each reading. This real-time monitoring is especially critical in emergency care and intensive care units (ICUs), where patients require constant observation due to the severity of their conditions. In addition to blood pressure, body temperature and BMI are also essential indicators of a person's overall health. Body temperature serves as an indicator of potential infections or inflammations, and abnormal readings can signal the presence of a fever or hypothermia. Historically, temperature has been measured using thermometers, with oral, rectal, and axillary measurements being the most common methods. However, traditional thermometers can be time-consuming and require close contact with the patient, which may not be ideal in certain settings, such as in ICU or pediatric care.

Similarly, BMI is an important measure used to assess whether a person is underweight, overweight, or obese. Obesity is a significant risk factor for various health problems, including diabetes, heart disease, and joint

problems. Traditional methods of calculating BMI involve manually measuring a patient's weight and height, and then applying the formula: $BMI = \text{weight (kg)} / \text{height (m}^2\text{)}$. While this method is relatively simple, it can be cumbersome, particularly in busy healthcare settings where quick measurements are essential.

The need for an efficient and dynamic health testing system that can measure blood pressure, BMI, body temperature, and blood glucose levels simultaneously on a single platform has become evident. The ability to consolidate these measurements into a single, unified device would simplify the monitoring process for healthcare practitioners, improve the frequency of checks, and reduce the burden of multiple separate tests. Moreover, it would allow for real-time data collection, which can be crucial in emergency and routine care situations. The advent of such a system would lead to greater accuracy, reduce the chances of human error, and help healthcare workers make faster, more informed decisions.

This paper presents the development of a unified health testing device capable of measuring BMI, blood pressure, temperature, and blood glucose levels in one stand. The proposed device integrates various sensor technologies, including a digital weighing scale for weight measurement, an ultrasonic sensor for height measurement, and electronic sensors for blood pressure and blood glucose monitoring. By combining these technologies into a single unit, the device aims to provide an all-encompassing solution for healthcare providers, reducing the need for multiple devices and streamlining the process of patient monitoring. Furthermore, the use of automated systems ensures that the readings are both accurate and timely, which is particularly important in preventing and managing chronic diseases. Through this development, the goal is to provide healthcare systems with an affordable, efficient, and effective tool for continuous health monitoring, enabling earlier diagnosis and better patient outcomes.

In conclusion, as the healthcare industry continues to evolve, embracing technological advancements will be crucial to addressing the increasing demands of patient care. The development of a unified health testing device represents a significant step forward in the integration of health monitoring technologies, improving the quality and efficiency of healthcare delivery. By enabling the simultaneous measurement of key health indicators, this device has the potential to revolutionize the way healthcare professionals monitor and manage patients' health, ultimately contributing to improved health outcomes globally.

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 meters (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 $k g m^{-2}$. 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 (SpO₂), 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 analyzing 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, $(MAP = DBP + 1/3 (SBP - DBP))$. (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 Fiberboard (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

D. 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 electromechanical 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.

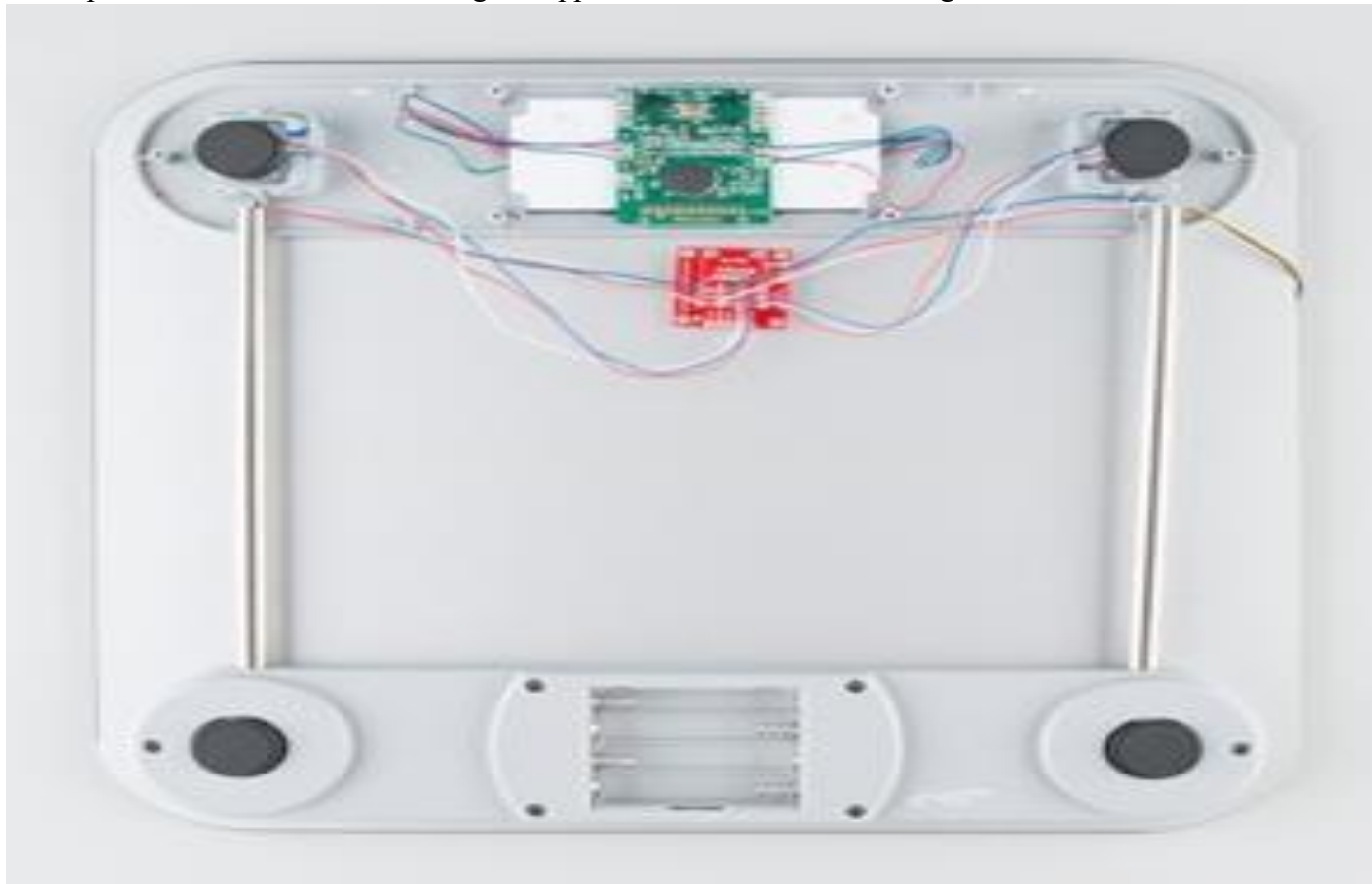


Fig. 1: Application of Load Cell.

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).

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

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).

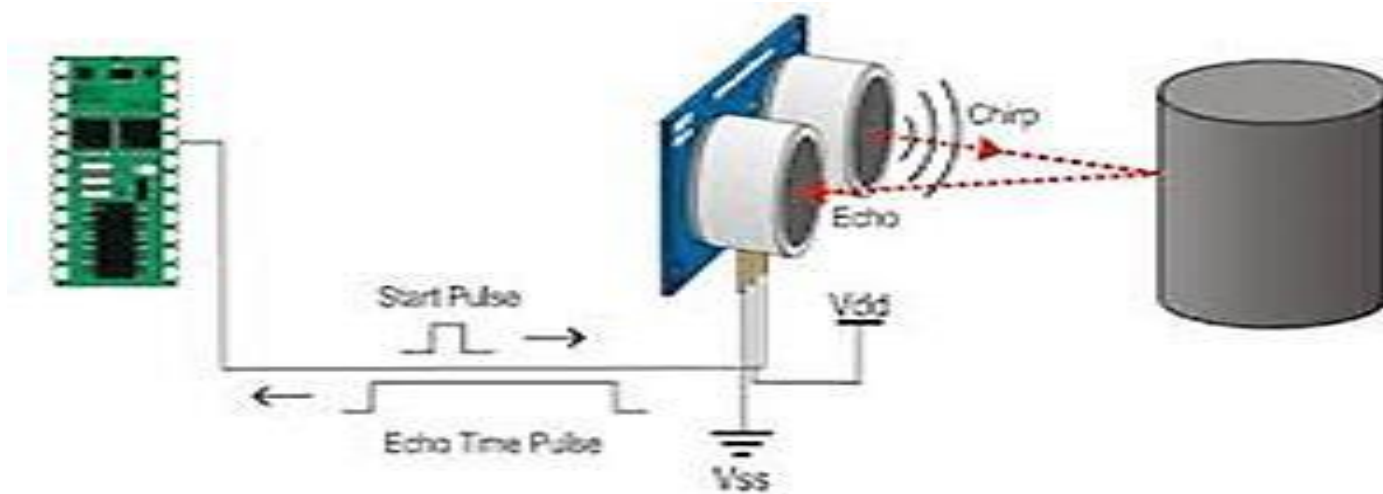


Fig. 2: Ultrasonic Distance Sensor and Its Operation.

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/m³, and an average density of 680 kg/m³. 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 8 are 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, $W = \text{Density, } \rho \times \text{Volume, } V \times \text{Acceleration due to Gravity,}$

$g = \rho Vg$ (3)

Assumed 15 % Factor of safety

The weight is 60N

Research Article

The maximum weight of a man is 1200 N (120 kg), and the average weight of a man as male and female is 9500N (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

W_{max}

$$RA = RB = \frac{1260}{2} \quad (4)$$

W_{max}

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

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,

$W L$

$$M_{max} = \frac{1260 \times 0.5}{4} \quad (5)$$

$W L$

$$M_{max} = \frac{1260 \times 0.5}{4} = 157.5$$

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,

Maximum Load

$$\sigma_c = \frac{P_{max}}{A} \quad (6)$$

Cross-Sectional Area

$$\sigma_c = \frac{1260}{5 \times 0.4} = 6.3kN/m^2$$

Compressive Stress, σ_c is 6.3 kN/m²

The maximum deflection occurs at the mid-point as given in equation 7 with moment of inertia as given in equation 8 Maximum deflection,

$W L^3$

$$\delta = \frac{1260 \times 0.5^3}{48E I} \quad (7)$$

$48E I$

Where; modulus of elasticity of mild steel is 210Gpa (KN/mm²) (Adewuyi et. al., 2021; Ejiko et al., 2018a)

$$I = \frac{b l^3}{12} \quad (8)$$

12

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

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

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

3

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

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

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 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). 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/s^2 (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)

$$\text{Volume} = \text{Length} \times \text{Breadth} \times \text{Thickness} = V = l \times b \times t \quad (9) \quad \text{mass} = \rho \times V \quad (10) \quad \text{Weight} = m \times g \quad (11)$$

The Base

$$\text{Volume} = \text{Length} \times \text{Breadth} \times \text{Thickness} = V = l \times b \times t \quad l = 152 \text{ mm} = 0.152 \text{ m}; b = 457 \text{ mm} = 0.457 \text{ m}; t = 2.5 \text{ mm} = 0.0025 \text{ m}$$

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

$$\text{Volume, } V = 0.0001736 \text{ M}^3 \quad m = \rho \times V \quad m = 7850 \times 0.0001736 = 1.36 \text{ kg}$$

$$\text{Mass, } M = 1.36 \text{ kg} = 1360 \text{ g}$$

$$W = m \times g$$

$$W_1 = 1.36 \times 9.81 = 13.34 \text{ N}$$

$$\text{Weight, } W = 13.34 \text{ N}$$

$$\text{The Height Volume} = \text{Length} \times \text{Breadth} \times \text{Thickness} = V = l \times b \times t \quad l = 2200 \text{ mm} = 2.200 \text{ m}; b = 50 \text{ mm} = 0.05 \text{ m}; t = 2.5 \text{ mm} = 0.0025 \text{ m}$$

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

$$\text{Volume, } V = 0.000275 \text{ m}^3$$

$$m = \rho \times V$$

$$m = 7850 \times 0.000275 = 2.16 \text{ kg}$$

$$\text{Mass, } M = 2.16 \text{ kg} = 2160 \text{ g}$$

$$W = m \times g$$

$$W_2 = 2.16 \times 9.81 = 21.18 \text{ N}$$

Weight, $W = 21.18 \text{ N}$

The Top

Volume = Length $\times$ Breadth $\times$ Thickness = $V = l \times b \times t$ $l = 457 \text{ mm} = 0.457 \text{ m}$; $b = \text{mm} = 0.05 \text{ m}$; $t = 2.5 \text{ mm} = 0.0025 \text{ m}$

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

$$\text{Volume, } V = 0.000057 \text{ M}^3$$

$$m = \rho \times V$$

$$m = 7850 \times 0.000057 = 0.45 \text{ kg}$$

$$\text{Mass, } M = 0.45 \text{ kg} = 450 \text{ g}$$

$$W = m \times g$$

$$W_3 = 0.45 \times 9.81 = 4.40 \text{ N}$$

$$\text{Weight, } W = 4.40 \text{ N}$$

Total weight of the frame

$$W = W_1 + W_2 + W_3 = 13.34 + 21.18 + 4.40 = 38.92 \text{ N}$$

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.

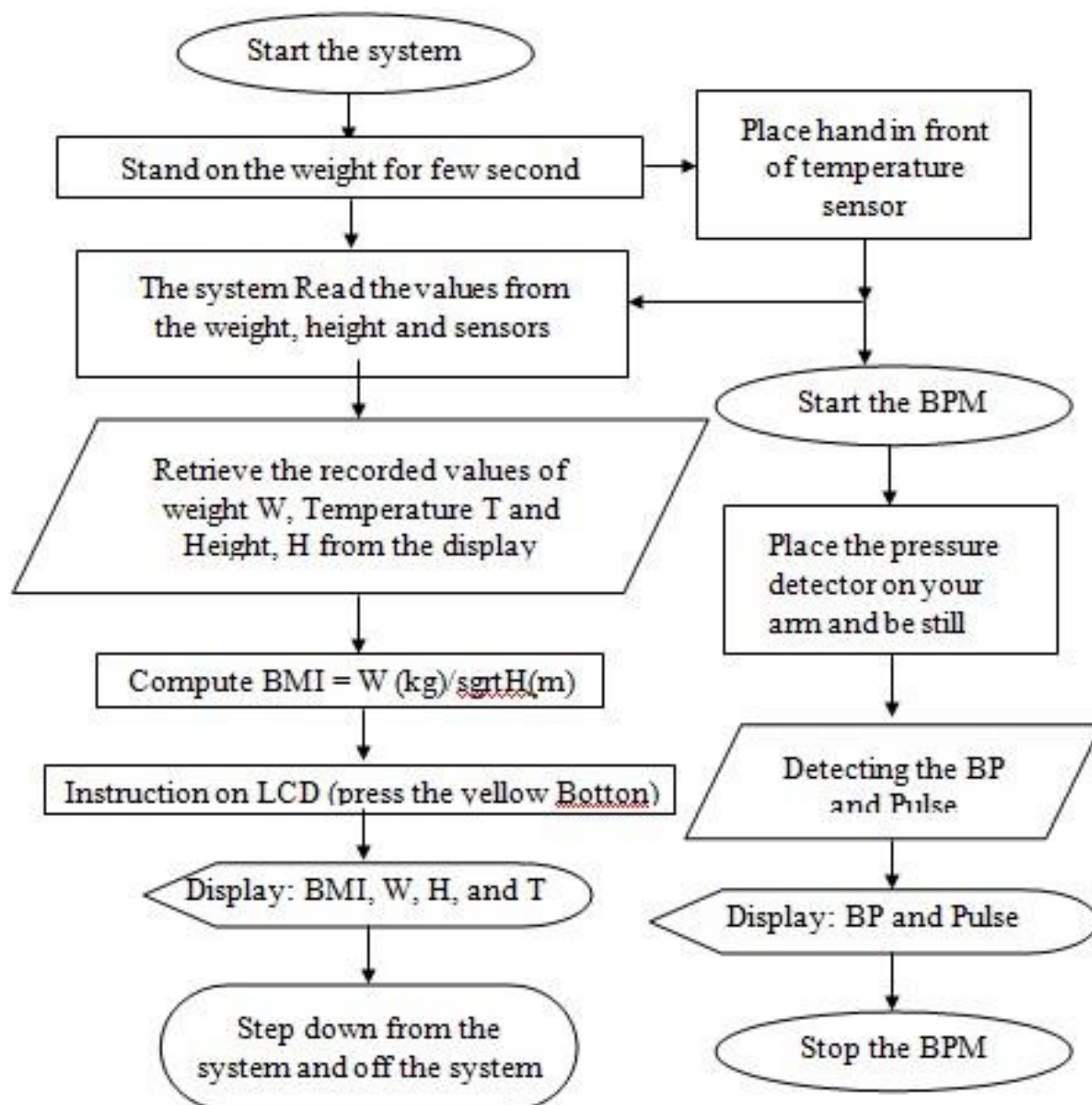


Fig. 3: Algorithm for the Body Mass Index Computation

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. scribe 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 center 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($0c$)	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.

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

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 sourced 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

Weight(kg)

$$BMI = \frac{Weight}{Height^2}$$

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

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

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

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

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 meter.

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- 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.

REFERENCES

- Adewuyi, R. A., Ejiko, S. O., & Oladebeye, D. H. (2021). Design and fabrication of amusement park train powered with electricity. *European Journal of Materials Science and Engineering*, 6(1), 52–64. <https://www.ejmse.ro>
- Alpert, M. A. (2001). Obesity cardiomyopathy: Pathophysiology and evolution of the clinical syndrome. *The American Journal of Medical Sciences*, 321(4), 225–236.
- Balestrieri, E., & Rapuno, S. (2010). Instruments and methods for calibration of oscillometric blood pressure measurement device. *IEEE Transactions on Instrumentation and Measurement*, 59.
- Beyer, R. T. (2009). Sonar. *Microsoft Encarta Premium*. Microsoft Corporation.
- Daniels, S., Khoury, P., & Morrison, J. (1997). The utility of body mass index as a measure of body fatness in children and adolescents: Differences by race and gender. *Pediatrics*, 99(5), 804–807.
- Dinwoodie, J. M. (1996). *Timber: Structure, properties, conversion and use* (7th ed.). H. E. Desch.
- Ejiko, S. O., Adewuyi, R. A., & Filani, O. A. (2019). Development of a household biogas digester. *International Journal of Modern Studies in Mechanical Engineering*, 5(4), 23–32. <https://doi.org/10.20431/2454-9711.0504003>
- Ejiko, S. O., Adu, J. T., & Osayomi, P. (2015). Design and fabrication of groundnut shelling machine. *GRIN Research Journal*, 1–23. <https://m.grin.com/document/306848>
- Ejiko, S. O., Ajayi, I. S., & Omojogberun, Y. V. (2022). Development of mobile block molding machine to ameliorate shelter challenges in Nigeria. *Journal of Engineering & Earth Sciences*, 15(1), 56–69. <https://www.iosrjournals.org>
- Ejiko, S. O., Ejiko, S. O., & Filani, A. O. (2021). Mathematical modelling: A useful tool for engineering research and practice. *International Journal of Mathematics Trends and Technology*, 67(9), 46–60. <https://doi.org/10.14445/22315373/IJMTT-V67I9P506>

Research Article

- Ejiko, S. O., Oigbochie, D., & Adewuyi, R. A. (2018a). Development of an engine block polishing machine using locally sourced material. *International Journal of Scientific Engineering and Science*, 2(5), 32–36. <http://ijses.com>
- Ejiko, S. O., Oigbochie, D., & Emmanuel, A. A. (2018). Design of a semi-mechanized gari fryer. *IOSR Journal of Mechanical and Civil Engineering*, 15(2), 23–30. <https://doi.org/10.9790/1684-1502042330>
- Ejiko, S. O., Omojogberun, Y. V., & Aluko, A. O. (2021). Development of a pedal-powered water pump (PPWP). *Journal of Engineering & Earth Sciences*, 14(1), 85–89.
- Erinle, T. J., Oladebeye, D. H., & Ademiloye, I. B. (2020). Parametric design of height and weight measuring system. *Research in IJIREEICE*, 8(7), 27–29.
- Flegal, K. M., Carroll, M. D., Kit, B. K., & Ogden, C. L. (2012). Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999–2010. *Journal of the American Medical Association*, 307(5), 491–497. <https://doi.org/10.1001/jama.2012.39>
- Flegal, K. M., Kit, B. K., Orpana, H., & Graubard, B. I. (2013). Association of all-cause mortality with overweight and obesity using standard body mass index categories: A systematic review and meta-analysis. *Journal of the American Medical Association*, 309(1), 71–82. <https://doi.org/10.1001/jama.2012.113905>
- Flintec. (2020). Weight sensors load cells: The technology of a load cell. <https://www.flintec.com>
- Gallagher, D., Visser, M., Sepulveda, D., Pierson, R. N., Harris, T., & Heymsfield, S. B. (1996). How useful is body mass index for the comparison of body fatness across age, sex, and ethnic groups? *American Journal of Epidemiology*, 143(3), 228–239.
- Garrouste-Orgeas, M., Troché, G., Azoulay, E., Caubel, A., de Lassence, A., Cheval, C., Montesino, L., Thuong, M., Vincent, F., Cohen, Y., & Timsit, J. F. (2004). Body mass index. *Intensive Care Medicine*, 30(3), 437–443. <https://doi.org/10.1007/s00134-003-2095-2>
- Haygreen, J. G., & Bowyer, J. L. (1996). *Forest products and wood science: Wood structure, properties, and technology of major forest products* (3rd ed.).
- Khurmi, R. S., & Gupta, J. K. (2005). *A textbook of machine design* (14th ed.). Eurasia Publishing House.
- Kimberly, H. (2023). Everything you need to know about high blood pressure (hypertension).
- Morris, A. S. (2001). *Measurement and instrumentation principles*. Butterworth-Heinemann.

- Natalie, S. (2022). Blood sugar chart.
- Oigbochie, D., & Ejiko, S. O. (2015). Modification of a motorized quadcycle. *International Journal of Scientific & Engineering Research*, 6(9), 87–95.
- Oigbochie, D., & Ejiko, S. O. (2020). Design and performance evaluation of 0.2 tonne maize dual layer solar dryer. *International Advanced Research Journal in Science, Engineering, and Technology*, 7(5), 53–60. <https://doi.org/10.17148/IARJSET.2020.7508>
- Parekh, D. (2010). Designing heart rate, blood pressure, and body temperature sensors for mobile on-call system.
- Prentice, A. M., & Jebb, S. A. (2001). Beyond body mass index. *Obesity Reviews*, 2(3), 141–147.
- Quicklab. (2010). AKAS BMI with 7 parameters. <https://m.indiamart.com/proddetail.php?i=18766255162>
- Stats.areppim.com. (2018). Weight survey of maximum weight of man & woman. <https://stats.areppim.com>
- WHO. (2000). Obesity: Preventing and managing the global epidemic. *WHO Technical Report Series*.
- Wolk, R., Berger, P., Lennon, R. J., Brilakis, E. S., & Somers, V. K. (2003). Body mass index: A risk factor for unstable angina and myocardial infarction in patients with angiographically confirmed coronary artery disease. *Circulation*, 108(18), 2206–2211.