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Development of a remote multipurpose body fat analyser using Bluetooth technology

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Abstract
Weight and height are used to calculate a person's Body Mass Index (BMI), which measures the amount of fat in the body. Because of this, obesity has become the world's leading public health problem. Hypertension, type-2 diabetes, renal illness, respiratory issues, degenerative joint disease, cardiovascular disease, and others are all linked to this. When designing and fabricating a locally built Arduino-based automated BMI machine with LCD display, the goal was to use Hooke's law and acoustic ultrasound waves to make it inexpensive, accurate, robust, and accessible for anyone to check their obesity status on a regular basis. The goal of this project is to automatically compute a person's body mass index (BMI) based on their weight and height and preserve that information in the system's database. For this design project, the proponents created a circuit that integrated an ultrasonic proximity sensor with an optical weight sensor, as well as software for two microcontrollers that govern and operate the whole system. Arduino, SQL Server Management Studio, Microsoft Visual Studio (NET), and Gizduino ATMEGA328 were used in conjunction with the hardware tools of an ultrasonic proximity sensor and a weight sensor (software). Proponents of the gizDuino program released the software programs to Microcontroller Units after a series of tests (MCU). After the program had been uploaded, it was connected to the hardware and tested to see whether it worked. A number of experiments were carried out, and the results show that the automated BMI calculation yields accurate results. An ultrasonic sensor and four load cells are used to measure weight, and an Arduino microcontroller is used to calculate body mass index (BMI). The design has some limitations, such as not being able to accommodate more than one person at a time and not being able to accommodate more than 250 kilograms. Sixty randomly selected students from the FEDERAL POLYTECHNIC ILE OLUJI were utilized to calculate their BMI using the equipment. To serve as a baseline, the same kids' heights and weights were measured by hand. The standard errors for height, weight, and BMI are 0.01, 0.35, and 0.12, respectively, for manual and designed automatic BMI equipment. Formation of the communication system. It not only meet the document transmission needs of local area of a business, company, school and office data, it can also perform information exchange, storage and processing, provide voice, data and image synthesis in a country or even in the worldwide. The computer communication revolution brings the important facts as follows: There is no essential difference between data processing equipment (computers) and data (switching transmission equipment). There is no essential difference.

Keywords: Automated, body mass index, obesity, microcontroller, morbidity

Introduction
A person's BMI, or Body Mass Index, may be used to estimate the amount of fat in their body. A person's BMI is determined by their height and weight. Despite the fact that the BMI does not provide an accurate assessment of total body fatness, several studies have shown a correlation between the BMI and total body fat, as have methods like dual-energy x-ray absorptiometry and underwater weighing (Arduino, 2018) [1] The low cost and simplicity with which it may be used to calculate the health risks associated with obesity make BMI one of the most extensively used methods for detecting body fat. A load cell and an ultrasonic sensor were used to construct a body mass index machine in this study. The weight of a person is measured using a load cell or weighing mechanism, whereas the height of a person is measured using an ultrasonic height measuring device. The BMI standard formula is used to compute the person's weight in kilograms and height in meters (Carlene *et al.*, 2014) [2].

You may use the microcontroller-based automated BMI calculator to keep tabs on your weight and live a healthy lifestyle. The microcontroller may readily get electrical impulses after processing the computed weight of the individual via the load cell. Ultrasound sensors with built-in transmit and receive circuitry can measure a person's height by multiplying the ultrasound signal's speed and it's time to return to the sensor after it has passed through the transmitter and struck an object or person. This height can then be determined. Using a microcontroller, all of this data is processed and then presented on an LCD. We wanted to create a BMI unit that could be converted into a percentage that could be used to determine one's body fat percentage. If the number is less than 20, the individual is deemed underweight; if the number is between 20 and 25, the person is regarded healthy. Overweight is defined as a BMI of 25 or more, while Obesity is defined as a BMI of 35 or above. A precise device like an immersion tank is needed in this situation to quantify the percentage of body fat. Two persons of the same weight could not float on the same level because to the variation in body fat content. In circumstances when the danger of mortality is significant for the overweight individual, one additional pound might place them in a critical scenario, the BMI is a valuable tool for health-related experts and investigators. One of these groups includes those who suffer from coronary artery disease (CAD). Increased fat in the body causes venous blockage and a variety of other complications. Errors may be minimized with the use of an automated or computerized body mass calculator (BMC). Fat buildup that is abnormal or excessive may have a negative impact on health, such as obesity and overweight. It is usual to utilize the BMI, or body mass index, as a measure of relative weight and height. Overweight is defined by the WHO as having a BMI of 25 or more, while obesity is defined as having a BMI of 30 or more. Obesity globally has almost quadrupled since 1980, according to a World Health Organization paper published in August 2014. About 1.4 billion of those ages 20 and older were overweight in 2008. This group included approximately 300 million obese females and roughly 200 males. 60% of the global population lives in nations where obesity and overweight causes more deaths than underweight does. There were about 40 million obese or overweight children as young of five in 2012. These are the two top causes of death in the world. Overweight and obesity claim the lives of around 3.4 million persons each year. As an example, 44 percent of the diabetic burden, 23 percent of the heart disease burden, and between 7% and 41% of specific cancer burdens are all linked to obesity and overweight.

Literature Review

Calculating someone's weight requires a load cell or some other kind of weighing machine, whereas determining their height requires an ultrasonic height measuring device. Employing the BMI standard formula, the person's weight and height are computed in kilograms and meters, respectively (Carlene *et al*., 2014) [2]. When it comes to managing your weight and leading a healthy lifestyle, the microcontroller-based automatic BMI calculator comes in handy. By converting mechanical force into electrical impulses using a load cell, a microcontroller may readily determine a person's weight. Using the ultrasound sensor's built-in transmit and receive circuitry, the sensor measures a person's height by multiplying the ultrasound signal's speed by its return time to the sensor. This is accomplished by sending an ultrasonic signal through the sensor, which returns an ultrasound signal to the receiver. A microcontroller manipulates all of this data, and an LCD shows the final outcome. We wanted to create a BMI unit that could be converted into a percentage that could be used to determine one's body fat percentage. If the number is less than 20, the individual is deemed underweight; if the number is between 20 and 25, the person is regarded healthy. Overweight is defined as a BMI of 25 or more, while Obesity is defined as a BMI of 35 or above. A precise device like an immersion tank is needed in this situation to quantify the percentage of body fat. The body fat content of two persons of the same weight may cause them to float at different heights. In circumstances when the danger of mortality is significant for the overweight individual, one additional pound might place them in a critical scenario, the BMI is a valuable tool for health-related experts and investigators. One of these groups includes those who suffer from coronary artery disease (CAD). Increased fat in the body causes venous blockage and a variety of other complications. Errors may be minimized with the use of an automated or computerized body mass calculator (BMC). Fat buildup that is abnormal or excessive may have a negative impact on health, such as obesity and overweight. It is usual to utilize the BMI, or body mass index, as a measure of relative weight and height. Overweight is defined by the WHO as having a BMI of 25 or more, while obesity is defined as having a BMI of 30 or more. Obesity globally has almost quadrupled since 1980, according to a World Health Organization paper published in August 2014. About 1.4 billion of those ages 20 and older were overweight in 2008. This group included approximately 300 million obese females and roughly 200 males. 60% of the global population lives in nations where obesity and overweight kills more people than underweight does. There were about 40 million obese or overweight children under the age of five in 2012. These are the two top causes of death in the world. Overweight and obesity claim the lives of around 3.4 million persons each year. Overweight and obesity are also responsible for 44% of diabetes cases, 23% of heart disease cases, and anywhere from 7% to 41% of cancer cases.

Methodology

Load cells are used in a Wheatstone bridge design to measure the weight of the subject, which may range from 2 to 150 kg. Wheatstone bridges' electrical resistance varies when a force is applied directly to the load cell, resulting in millivolts of electrical output (mV). Using an instrumentation amplifier, the calibration circuit amplifies the modest output signal, which is then sent to Arduino Uno (an AT mega 328p microcontroller) where it is processed as a digital signal for further analysis. Equation 1 is used to determine the object's weight, which is expressed in kilograms (kg), millivolts (mm), and the offset voltage (VV oo) in millivolts. The output voltage (VV mm) and offset voltage (VV oo) are both expressed in millivolts. 525.05mV is the value obtained.

$$W = gain * (V_m - V_0) \quad \text{equation (1)}$$

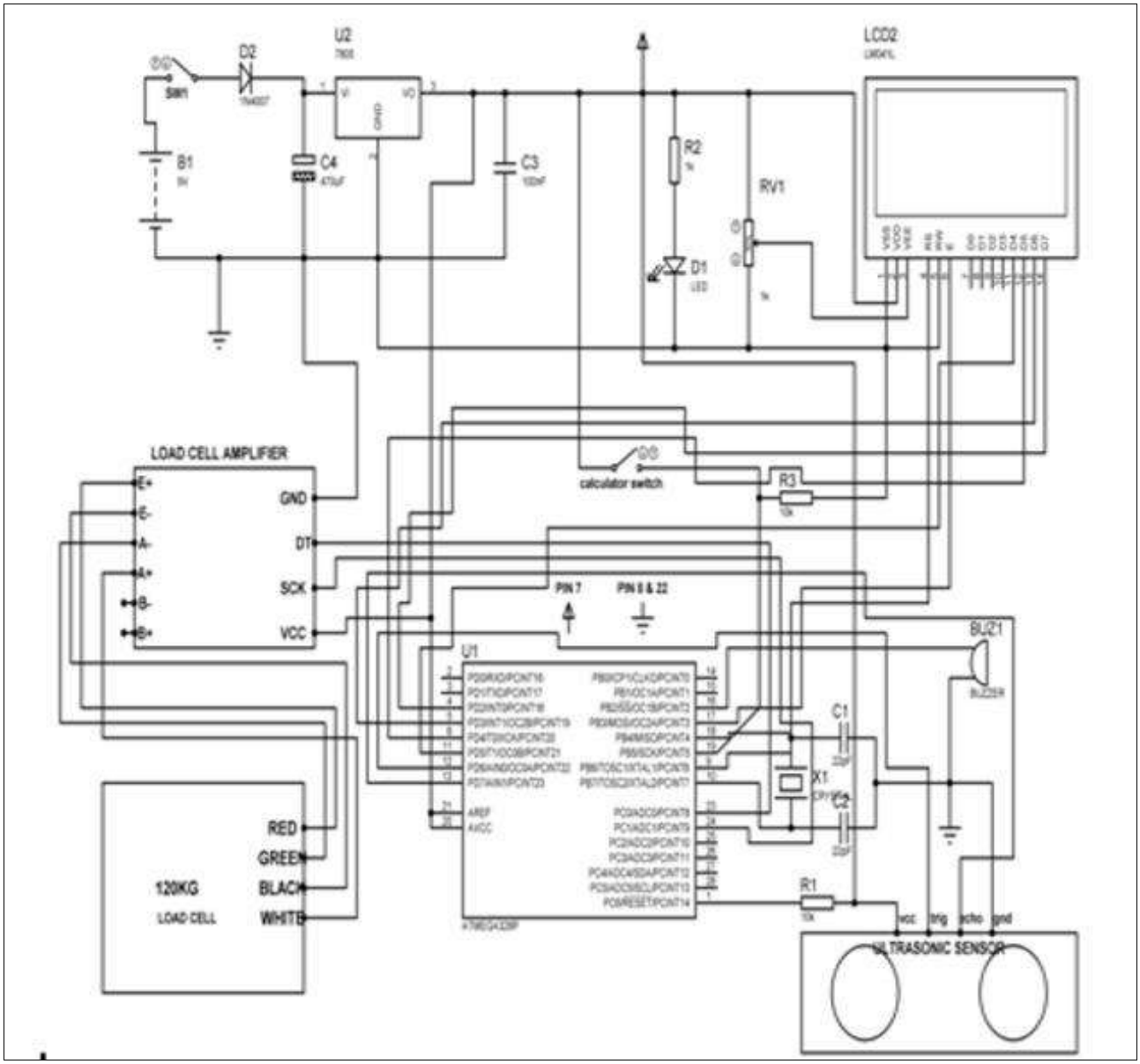

Fig 1: The circuit diagram

An ultrasonic sensor (PING ultrasonic sensor) is attached to the microcontroller's RC1 and RC2 pins to measure the subject's height. When a strong pulse is sent to the sensor trigger input, ultrasonic waves are transmitted from the sensor, causing an echoed signal to be generated. Sensor-head distance is computed using Equation (2) by microcontroller utilizing the time it takes for echo pulse to return to sensor after reflection from the object's head.

$$\text{dos} = t * (0.0174) \qquad \text{equation (2)}$$

aaoooo is the distance in meters, whereas t represents the time in seconds. It is 2.135 meters from the load cell to the ultrasonic sensor. Assuming that the object's height is expressed in meters and that the distance between its head and an ultrasonic sensor is known, equation 3.2 may be used to determine its height. Equation 3.3 was used to obtain the height in meters, and the BMI was derived using equation (2)

$$h(m) = 2.135 - \text{dos} \qquad \text{equation (3)}$$

The microcontroller connects a Liquid Crystal Display (LCD) to the relevant port and displays the calculated BMI, together with the user's height (in meters) and weight (in kilograms) on the LCD. A commercial floor-type manual weighing equipment was used to test the accuracy of the new instrument. Sixty healthy, randomly chosen Federal Polytechnic, Ile oluji Polytechnic, Nigerian students aged 16 to 50 years were surveyed for the study. The connection between the automated and manual measurements of height, weight, and BMI was determined using MATLAB programming, while the statistical analysis for the 60 students was carried out using MS-Excel. The flowchart for these computations may be seen in Figure 2.

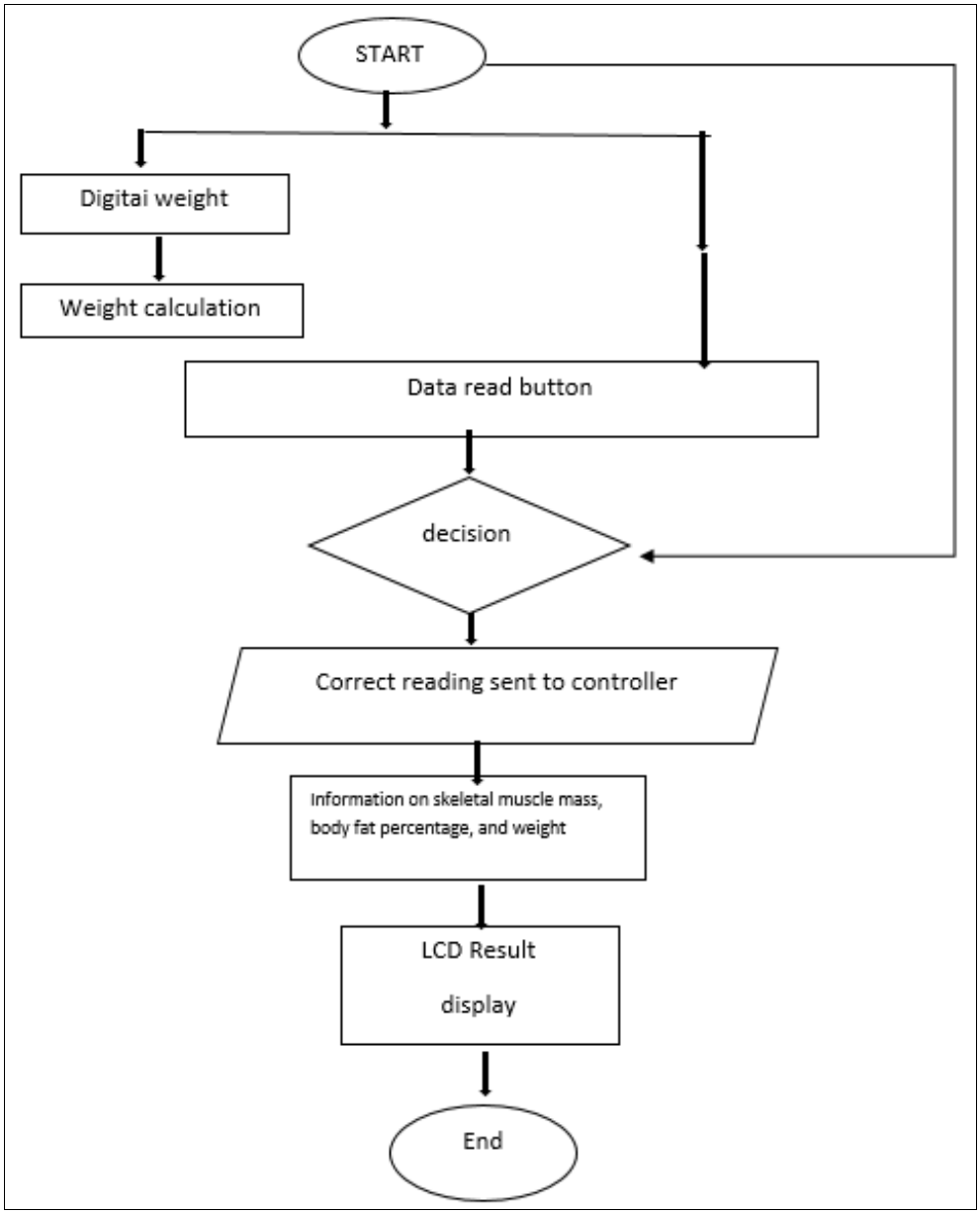

Fig 2: Flow chart of the design and calculations

The BMI (body mass index) is a useful tool for gauging a person's general health. A higher BMI puts a person at greater risk for serious health problems, such as increased blood pressure (hypertension), cardiovascular disease, gallbladder disease, and type 2 diabetes, to name just a few. Patients' chances of developing COVID-19 are also increased when they are obese. The body mass index (BMI) is a formula for calculating a person's weight in relation to their height in meters squared. It is based on the adult's height and weight, and is used to measure the mass of the tissue. Temperature compensation for body mass index (BMI) has been discussed in this article. For accurate and exact mass measurement, the proposed BMI measuring system utilizes a strain gauge-based load cell, an ultrasonic sensor, a temperature sensor, and a microcontroller, as well as associated electronics, software, and a display system. Weight and height can be accurately measured with a 0.01 kg and 0.01 m precision, respectively, using the BMI technique created by the researchers. 2.8 mm of height measurement inaccuracy has been calculated. These variables are used to calculate BMI, which is then shown with a 0.1-point accuracy. It is the first time that temperature correction has been applied to height measurement using an ultrasonic sensor. Additionally, the system has been developed for its very exact and accurate readings at a cheaper cost than the commercially available systems now on the market. For the project's hardware, we employed a weighing machine to determine an individual's weight and an LDR to determine their height. The weighing machine is used to determine an individual's weight and the LDR is used to determine their height. Weight and height are measured using the BMI standard formula, which calculates the individual's BMI (Vinay, 2021) [6]. When it comes to managing your weight and leading a healthy lifestyle, the microcontroller-based automatic BMI calculator comes in handy. After processing by a microcontroller, the mechanical force of the person's weight is converted to electrical impulses that may be readily retrieved. When the LDR is exposed to dim light, the resistance value lowers, resulting in a higher output voltage. Using a microprocessor, all of this data is processed and then shown on the LCD and a GSM message is delivered to the user about his BMI and the recommendations linked to it. In terms of theoretical research, many publications were

referred to and their approach to calculating the BMI and taking into consideration their drawbacks, an effective method for measuring BMI was brought up. Shinya, Microcontroller-based automated BMI calculator with LCD was the goal of the project. It was the goal of the project to create a microcontroller-based automated BMI calculator with an LCD display, which calculates the BMI based on weight and height. The display's hardware, which uses weight and height to determine the body mass index (BMI). For the project's hardware, we employed a weighing machine to determine an individual's weight and an LDR to determine their height. The weighing machine is used to determine an individual's weight and the LDR is used to determine their height. When a person's height is measured using an LDR sensor, the sensor calculates their weight as well. To determine a person's BMI, a person's weight is measured in kilograms and their height is measured in meters. Automated Body Mass Index (BMI) calculation using a microcontroller and height in meters. For Vinay's weight management and healthy living, the microcontroller-based automated BMI calculator is a helpful tool (2021). When it comes to keeping a healthy weight and living a healthy lifestyle, a tool like the Mass Index calculator comes in handy. Weighing machines transform mechanical force into electrical signals that may be processed by a microprocessor, allowing the estimated weight of the individual to be retrieved. When the LDR is exposed to dim light, the resistance value lowers, resulting in a higher output voltage. The microprocessor processes all of this data, and the resistance value reduces, resulting in a higher voltage at the output. Microcontroller manipulates this data and then sends a message via GSM to the person to inform them of their BMI and provide suggestions. The finding is displayed on the LCD and a message is sent via GSM to the person to inform them of their own personal BMI and the recommendations that go along with it. Measuring the BMI is the name given to this endeavor. 'Measurement of Body Mass Index is a statistical tool, to calculate the Health Risk of various statistics tools, to calculate the Health Risk of various illnesses,' reads the title of the project. In the early stages of sickness, theoretical research was conducted. As a health indicator, BMI's importance was studied theoretically before a project began. Olajide *et al*., year of publication 2020 [4]. Automatic Body Mass Index System Development, Implementation, and Use. Weight and height are used to calculate a person's Body Mass Index (BMI), which measures the amount of fat in the body. Because of this, obesity has become the world's leading public health problem. Hypertension, type-2 diabetes, renal illness, respiratory issues, degenerative joint disease, cardiovascular disease, and others are all linked to this. When designing and fabricating a locally built Arduino-based automated BMI machine with LCD display, the goal was to use Hooke's law and acoustic ultrasound waves to make it inexpensive, accurate, robust, and accessible for anyone to check their obesity status on a regular basis. While the Arduino microcontroller circuitry conducts the automated BMI calculating, the project's hardware consists of four load cells and an ultrasonic sensor for height measuring. Sixty randomly selected students from the FEDERAL Polytechnic ILE OLUJI were utilized to calculate their BMI using the equipment. To serve as a baseline, the same kids' heights and weights were measured by hand.

Result and conclusion

1. Download and install the In Body App from the iPhone App Store or Google Play Store before testing. (IOS 8, or newer. Android 5.0, or newer.)
2. Once the download is complete, open the In Body App and register as a new user
3. Keep the Bluetooth ON to use the In Body H20N
4. Pairing In Body

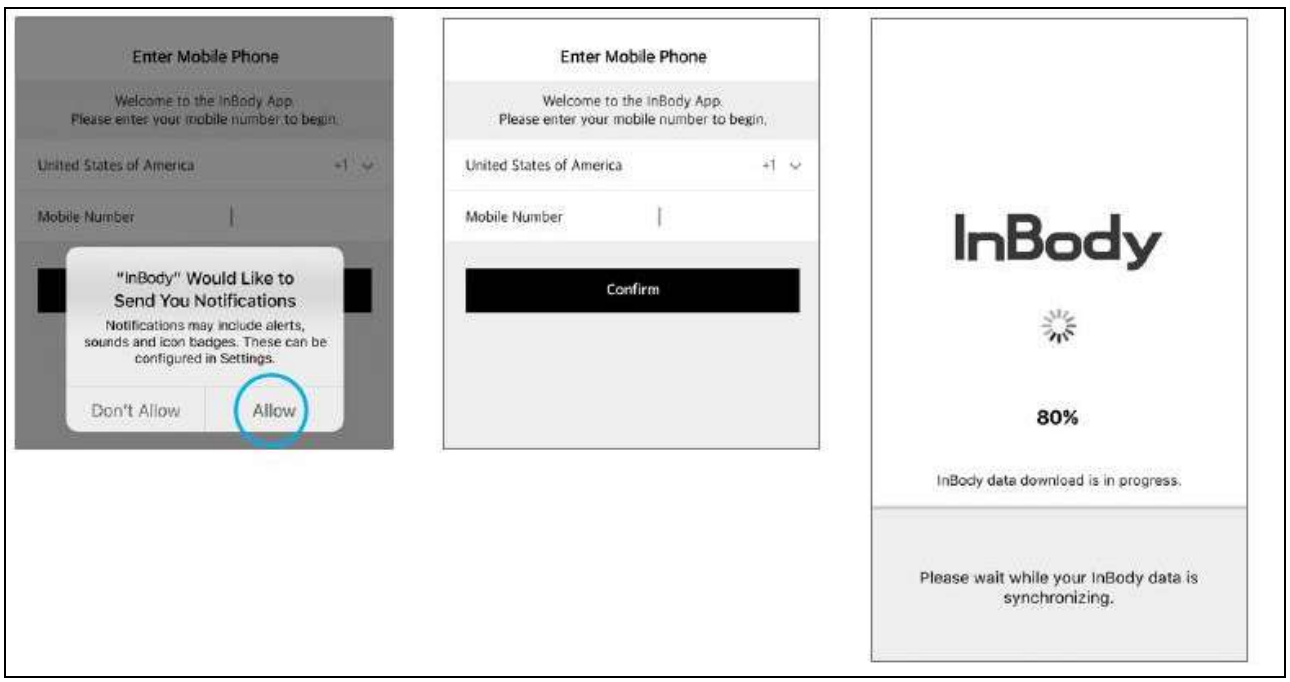

Fig 3: Bluetooth Configuration

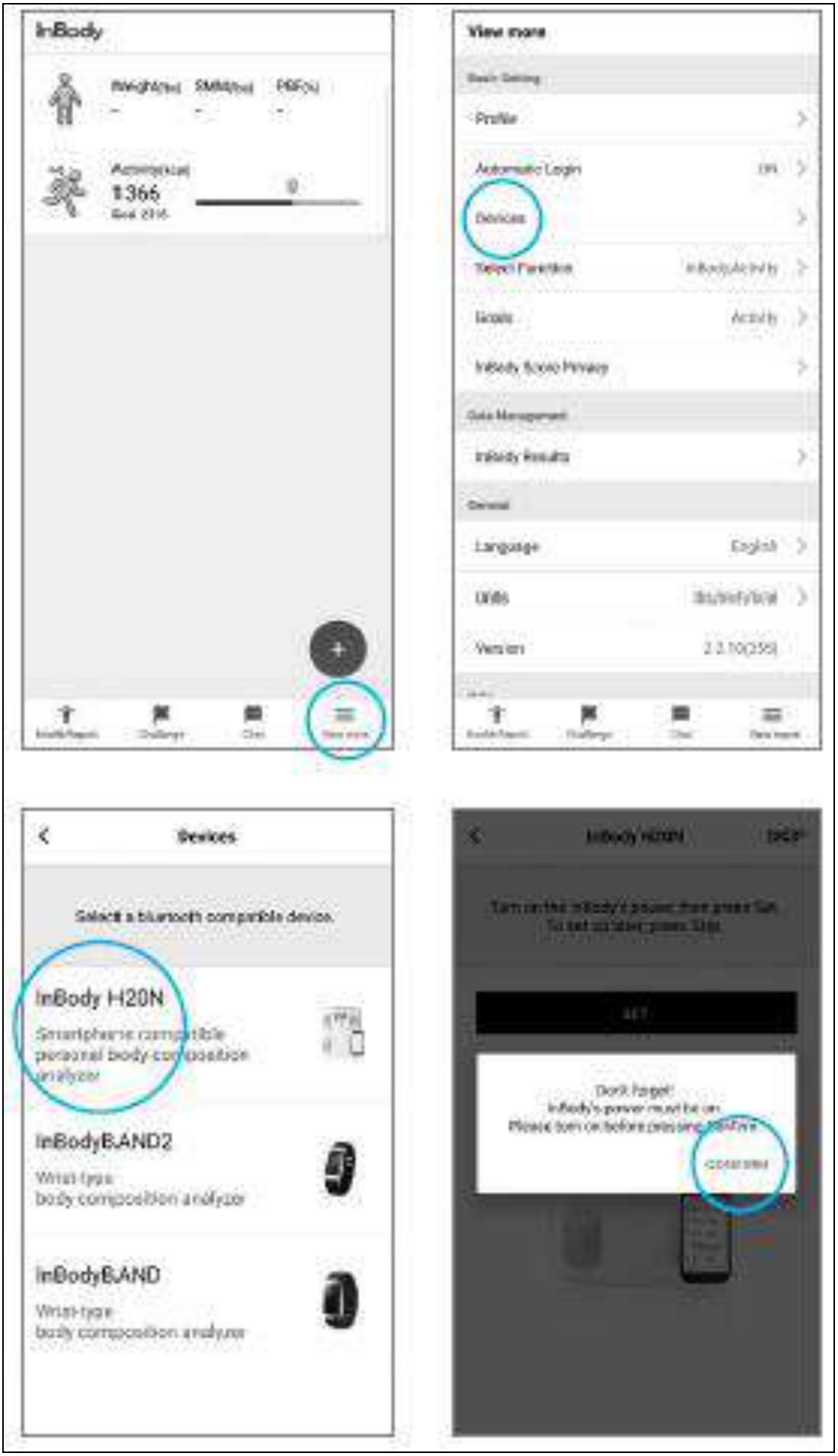

Fig 4: Pairing of Bluetooth

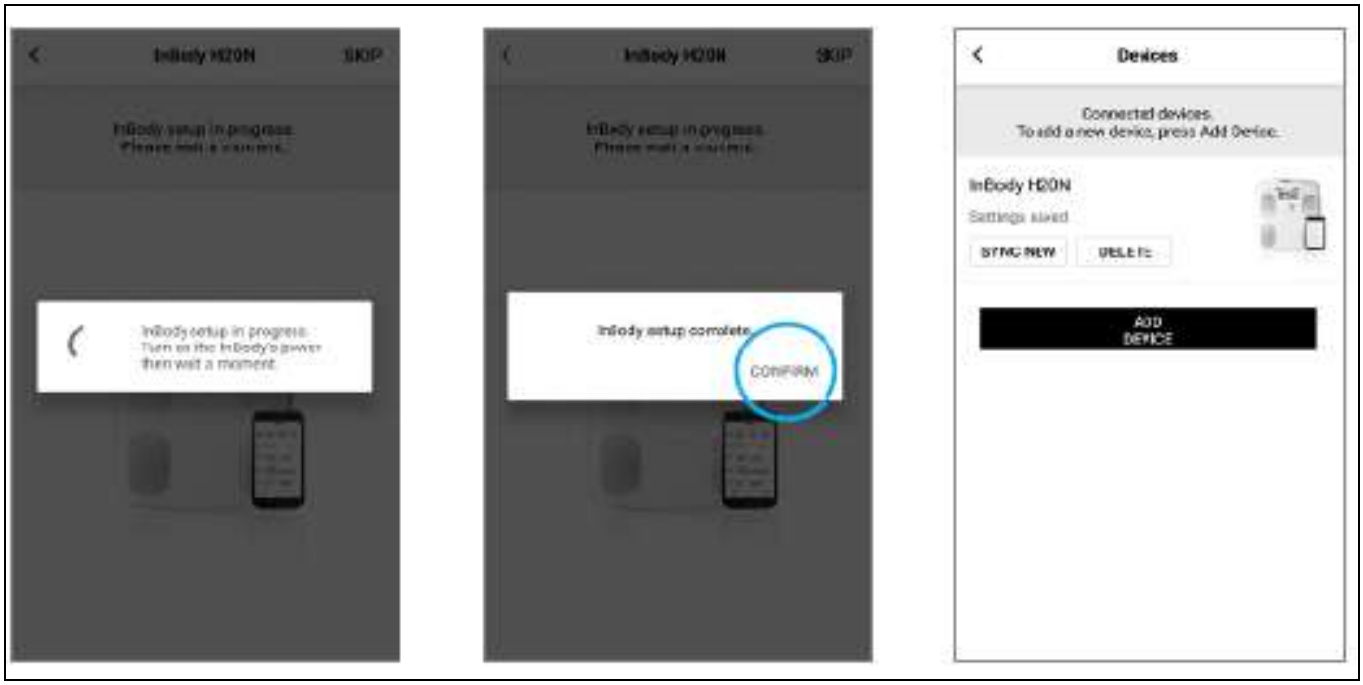

Fig 5: Device Synchronisation

Weight Measurement

To measure weight only

1. Tap the footplate to turn the power on, and step on the footplate
   when 0.0 is displayed on the screen
   Figure 4.3: Tapping of the footplate
2. A "beep" will indicate when the measurement is complete.
   The power turns off automatically when you step off the footplate
   Figure 4.4: Beep Measurement
3. Zero-Point Adjustment

When the device is being calibrated, a scrolling rectangle will appear on the screen.

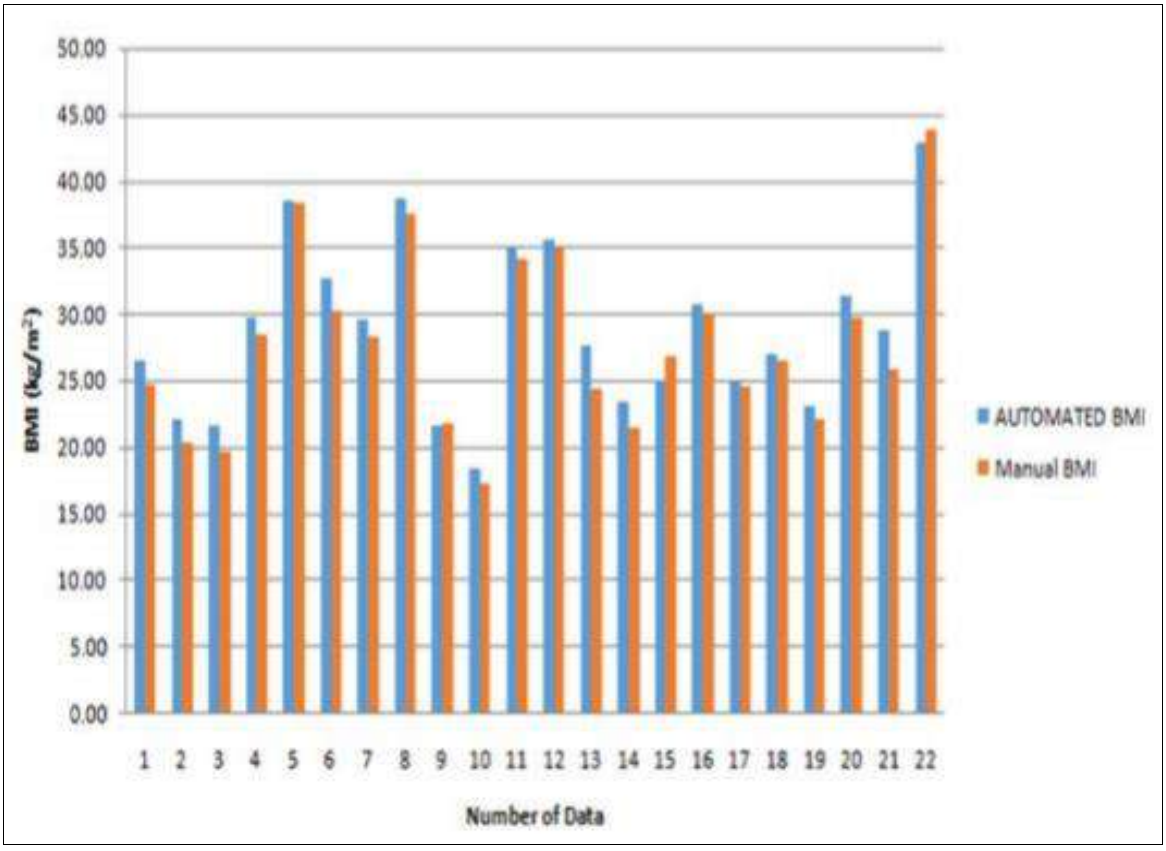

Fig 6: Bar graph of BMI for 22 male students of Federal Polytechnic Ile oluji, Nigeria, using both automated and manual methods

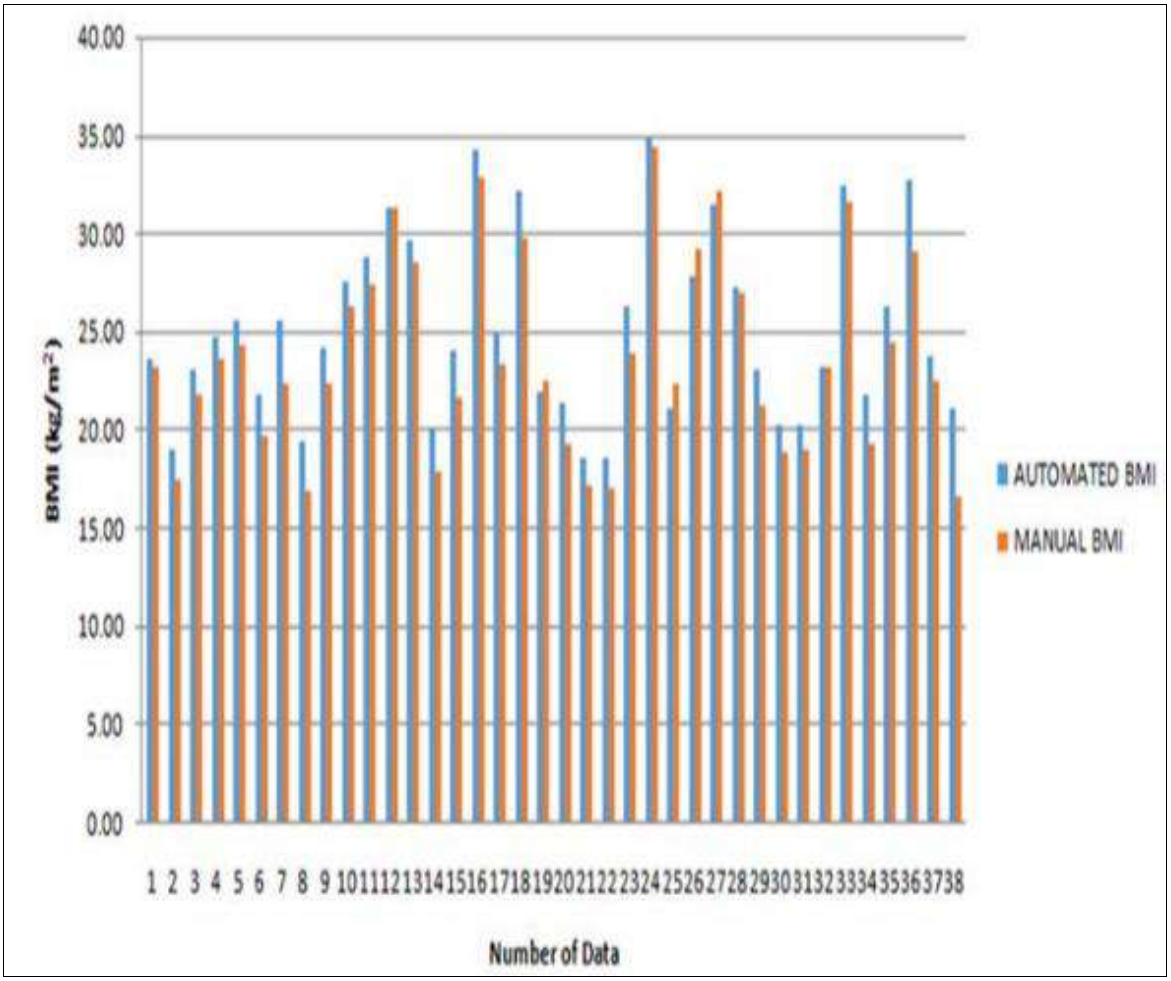

Fig 7: Bar chart of automated and manual BMI for 38 female students of Federal Polytechnic Ile oluji

The BMI system has been built, tested, and used effectively to gather data and compare it for system authentication. Using the graphs above, we were able to compare the results of 60 pupils, 22 men and 38 women. The discrepancy in the correlation between the manual and automated values for each data point is due to the human mistake in reading the stadiometer and weighing balance, as well as incorrect placement of the item.

Conclusion

The body mass index (BMI) is a useful tool for gauging a person's overall health and identifying potential health problems. According to several studies, a person's BMI is a good determinant of health. Because it has been put to use and compared to a manual approach, the design has shown to be quite accurate. The hustle and mistakes that may be caused by people while using manual devices and computations will be reduced if electronic principles of machines are adopted and used. An additional use for the ABMI is in the field of human health statistics.

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