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DEVELOPMENT AND EVALUATION OF AN AUTOMATED BODY MASS INDEX MACHINE

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ABSTRACT

This study designed, developed and evaluated an automated Body Mass Index computational machine. The machine is sub divided into three top sub-system unit (Height Measurement Unit, central sub-system and base sub-system unit. The units work together to

INTRODUCTION

In 2016, over 1.9 billion adults aged 18 and above were overweight, with over 650 million obese. According to the World Health Organization (WHO), around 13% of the adult population (11% of men and 15% of women) is obese, and 38.2 million children under the age of five are predicted to be overweight or obese in 2019. Obesity and overweight are on the rise in practically all countries, regardless of their economic growth. Since 2000, the number of overweight children under five has climbed by about 24%. (WHO 2021). In recent decades, there has been a worldwide increase in mortality due to

fat-rich food consumption, which has led to overweight and obesity. Obesity is responsible for more than 35 million deaths worldwide, or 2.3% of all deaths, according to the World Health Organization (WHO). Chronic disorders such as diabetes, hypertension, and heart attacks are all linked to fat-rich meals. Obesity is caused by the difference between the number of calories consumed and the amount expended (WHO 2021).

The types of jobs available, the lack of time for exercise, and the current COVID 19 pandemics have all contributed to the growth in obesity and overweight, which are both categorized as uncharacteristic or

compute the height, weight, BMI and send the result with interpretation to the end users. Results obtained were compared with manual compilation of the BMI. The Manual and automated data comparison for 55 adults showed very minute deviation traceable to parallax error in manual computations. The 55 respondents received text messages of the BBMI value on their mobile phones. Three (3) of the subjects had overweight, one (1) had underweight while fifty-one (51) had normal weight. Text messages were sent to pre-registered health practitioners for the overweight and underweight for proper advice, counselling and follow up. It was concluded that the machine is accurate, easy to operate and cost effective with minimum error tolerance and therefore recommended for use in various medical centers.

Keywords: Obesity, Body Mass Index machine, Microcontroller, Serial communication Interface, Short Message Service.

unnecessary fat buildup that can be detrimental to one's health. The mathematical expression showing the proportion among an individual's weight in kilograms and the square of his height in meters is generally referred to as Body Mass Index (BMI). BMI is the most appropriate population-level index of overweight and obesity because it is the same for both sexes and all ages of individuals. Individuals must be aware of their health situation and check their BMI regularly. A score of fewer than 18.5 indicates being underweight, a value between 18.5 and 24.9 shows average weight, 25 – 29.9 shows overweight, and a value of more than or equal to 30 shows obesity. Because of its consistency, the BMI was developed to connect weight and height to do population research as a demographic research tool. It is most commonly used for the anthropometric study (Zierle-Ghosh 2020). Baladad (2016) worked on an automated BMI Calculation machine that uses the combination of ultrasonic sensor, weight sensor, and a microcontroller with a software requirement of SQL Server Management Studio, Microsoft Visual Studio, and Arduino; however, the system cannot accommodate weight that is greater than 90 kg and cannot transmit the result over to health practitioners.

Kim and Youm (2020) developed a model that categorizes many types of obesity, which was simple to diagnose and manage health concerns by receiving and updating obesity information quickly and accurately without traditional, expensive equipment. However, in most developing countries, BMI is measured manually using mathematical relationships and body weight and height information, which is considered strenuous and time-consuming. Thus, the design of an automated BMI machine with the aid of a microcontroller sending SMS alerts will help reduce the stress of health practitioners with easy measurement, computation, analysis, and transmission of patient data with a high degree of effectiveness hence the need for this study.

Materials and Method

Machine Description

The machine automatically measures the BMI of an individual and stores the information in a database. At the onset, the user need to register and input user Information including name and phone number after which he has push the start button, step on the weighing scale platform where the weight and height is determined, the system then calculates the BMI, displays the weight, height, BMI and its interpretation on a Liquid Crystal Display (LCD) screen and stores in an SD Card Memory with the aid of a Microcontroller. The BMI is connected to a computer system via a USB interface that runs a proprietary C# data-logging application. A deep cycle battery was used to power the BMI, which was charged via a utility supply. Also, a microcontroller continuously monitors the BMI value and interprets the result as either normal, overweight, underweight or obese. The overweight, underweight and obese results are transferred to health practitioner which must have been previously registered in the system.

Operational procedure of SMS unit and Height Measuring Device

The automatic BMI records and transmits readings to the bearer using a pre-registered SIM card from any network provider. Subjects' heights are measured using ultrasonic, receivers, and transmitters. The receiver was positioned on the foot side, while the transmitter was placed on the head side, and a micro controller was built to control their activities with the help of Arduino.

Operational Procedure and Analysis of the weight sensor using fingerprint

Electrical forces are converter to various correspondent signals with the help of load cell transducers (Ma et al. 2016). Two major processes

required for the conversion are the dealignment of the gauge by the producing force exacted on the system and the measurement of the deformation with aid of electrical signal due to variation on the resistance connected to the system (Naresh et al. 2016). A wheat stone bridge used in the development of load cell. It is categorized full, half or quarter bridge type when the arms strain gauges are four, two or one respectively (Wheatstone Bridge 2020). Lower voltages are produced in the output of the strain gauges, hence required amplification circuit to boost the millivolts to higher voltages necessary to evaluate the transducer's exerted force (Amcells 2018). Figure 1-4 shows the basic circuit diagrams of load cell

Mechanical Design

Stainless steel was used to design machine components. The weight sensor was positioned at the bottom while height sensor was placed on top. A load cell was installed at the foot covered with foam materials. The ultrasonic sensor (2m long) was mounted to the metallic materials near the top as shown in Figure 5-6.

Application of BMI

In the realm of medicine, schools, medical centers, clinics, sport pavilions, pharmaceutical halls, gymnastic centers, hotels, and other terminals, the automatic BMI calculator can be used to determine a person's level of obesity, weight gain and loss. The standard reading of BMI is as stated below:

Table 1: Categorizations of overweight and obesity in adults

Categorization	$BMI = (kg/m^2)$	Threat of Symptomatology
Severely underweight	< 6.5≥	Very low
Underweight	< 18.5	Low
Average	18.5 - 24.9	Normal

Overweight	25 - 29.9	Augmented
Obesity I	30 to 34.9	Temperate
Obesity II	35 to 39.9	Stringent
Obesity III	≥ 40	Very Stringent

Machine Evaluation

After the numerous analyses were completed, the modules were individually tested, and the overall circuit was also checked to guarantee appropriate functionality before packing and use, utilizing a digital multi-meter, jumper wires, and software application, as well as Proteus Lite. In evaluating the entire system, 55 subjects comprising of 30 male adults and 25 female adults within ages 20 to 50 years were used for the machine evaluation. The weight and height of the subjects were obtained manually using electronic digital platform scale (31.5 x 40.5 cm) and meter rule respectively. The results obtained from the BMI machine and manual compilation of the BMI were compared.

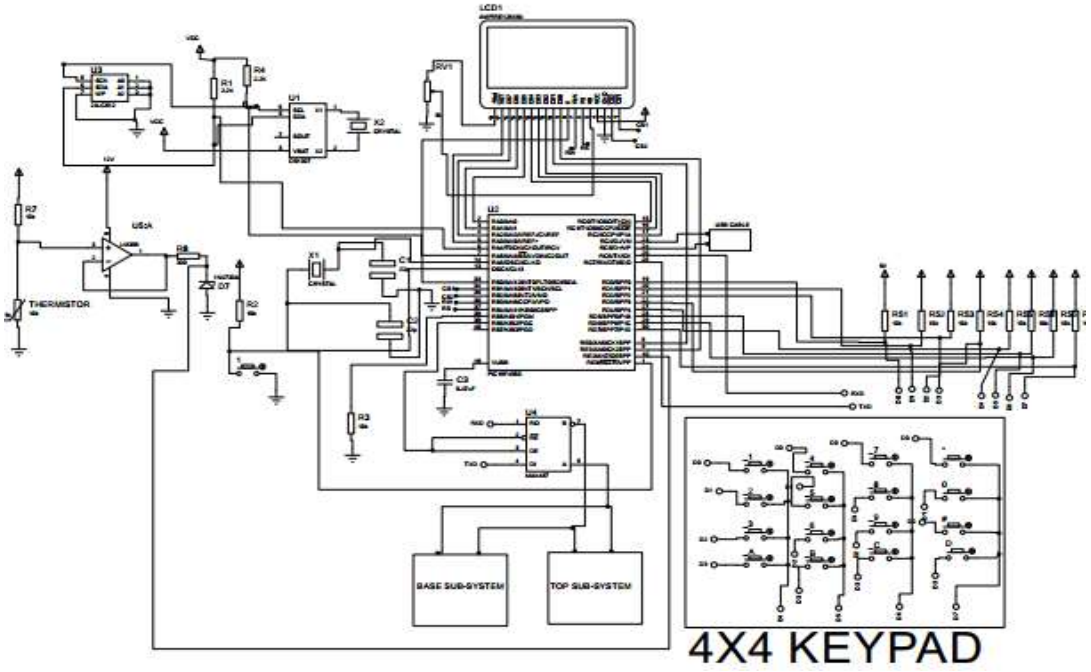
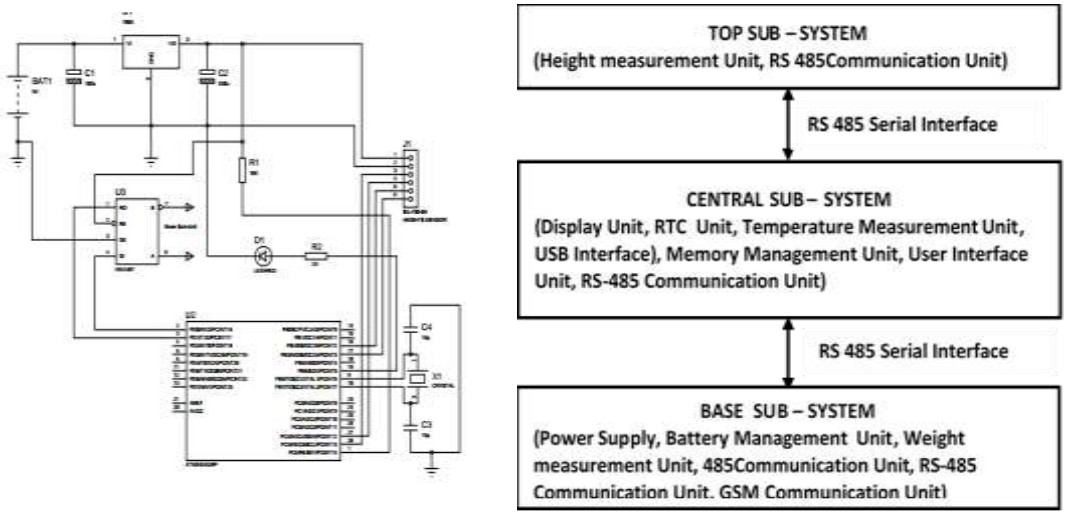


Figure 1: Central Sub System Circuit Diagram



(a) (b)

Figure 2: Overview of: (a) - Upper Sub Unit Circuit Diagram; (b) - Body Mass Index (BMI)

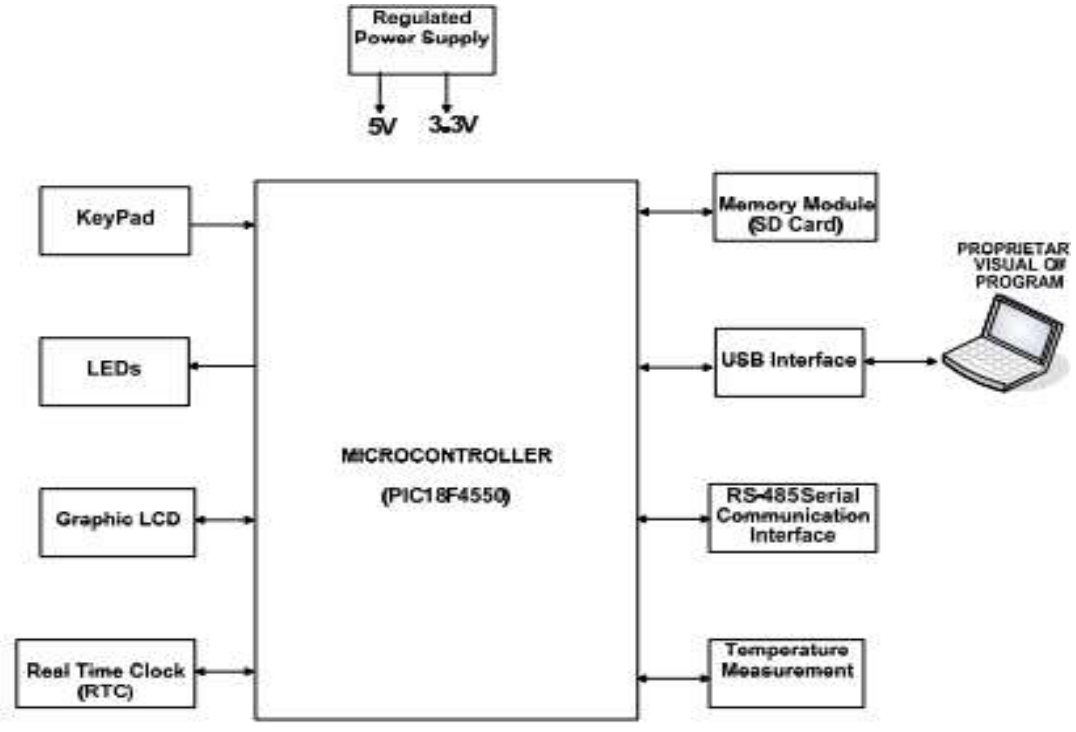


Figure 3: Block Diagram of Central Sub System Circuit Diagram

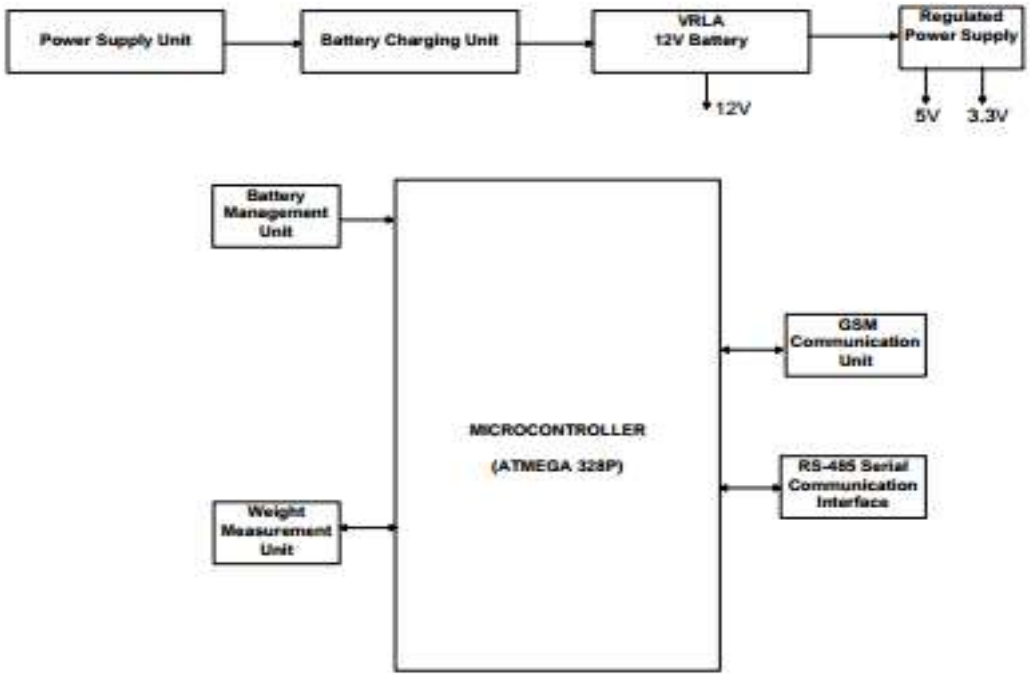
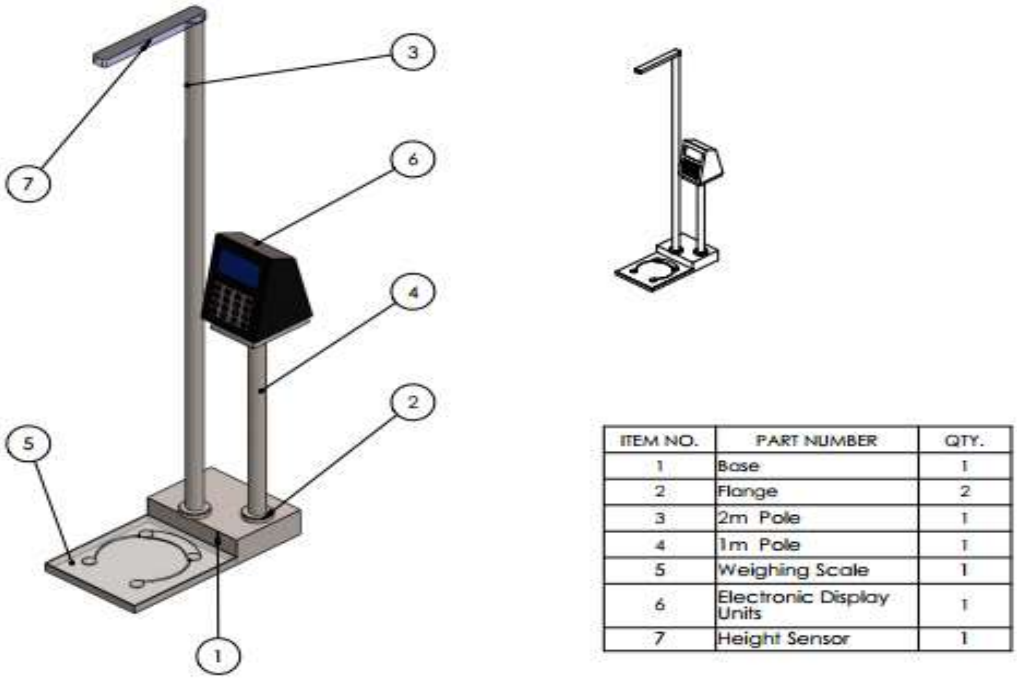


Figure 4: Block Diagram of Base Sub System



ITEM NO.	PART NUMBER	QTY.
1	Base	1
2	Flange	2
3	2m Pole	1
4	1m Pole	1
5	Weighing Scale	1
6	Electronic Display Units	1
7	Height Sensor	1

Figure 5: Conceptual sketch of the Body Mass Index (BMI)

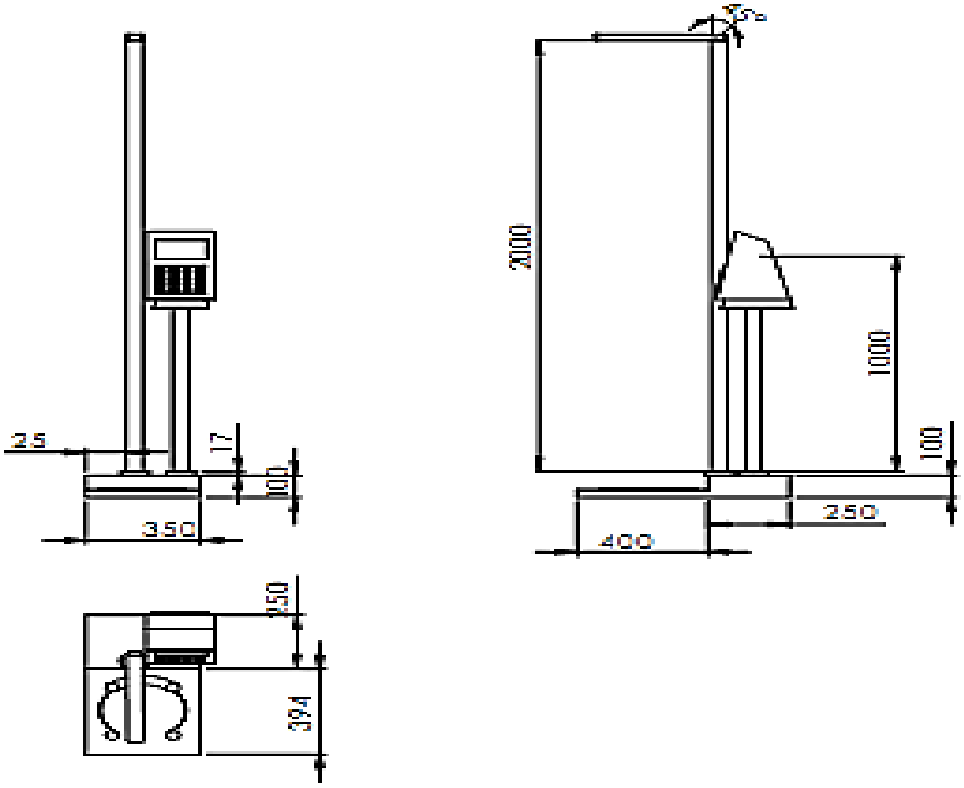


Figure 6: Assembly Drawing of Body Mass Index (BMI)

Results and Discussion

The component units of the BMI machine tested separately before machine evaluation. A multimeter was used to check that all of the Vcc pins in the circuit were receiving 5Vdc and that all of the GND pins were kept at 0V. Only three pins were utilized to validate the output before incorporating it into the main circuit because the sensor unit was operated in analog mode. Although the sensor unit was unable to measure the maximum distance indicated, it was afterwards programmed to detect as measured. The controller unit was also put to the test by developing a basic instruction program to display "hello world" on the microcontroller. BMI is the designation given to the ratio of a person's height and weight that measures body fat proportion. A higher BMI indicates a larger fat content in the body.

Machine Evaluation Results

The BMI system was developed, tested, and utilized effectively for data capture and system authentication. The manual and automated data comparison for 55 adults showed very minute disparity from the manual data compilation which was traceable to parallax error in manual compilation. The 55 respondents received text messages of the BMI value on their mobile phones. The weight, height and BMI value of the subjects used is presented in Figures 7, 8 and 9 respectively.

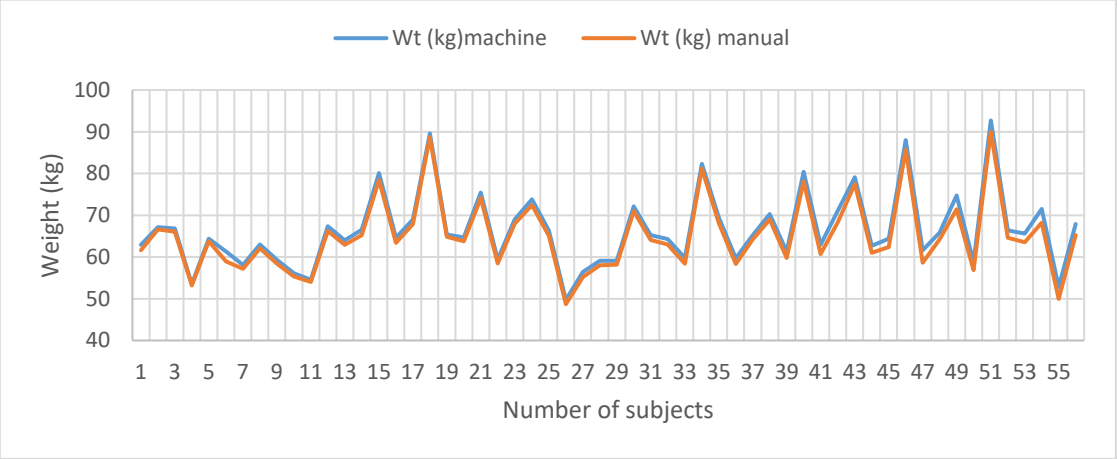


Figure 7: Weight of Subjects

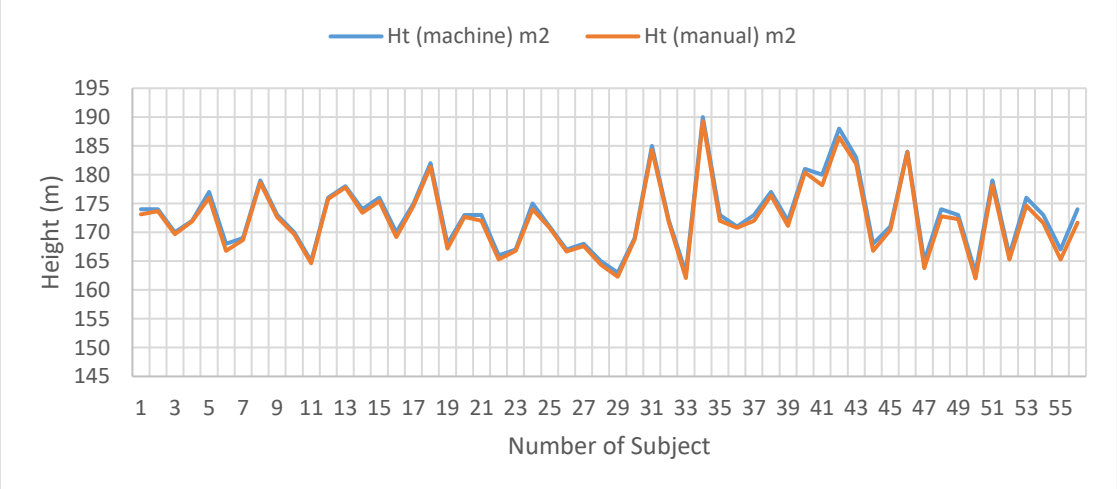


Figure 8: Height of Subjects

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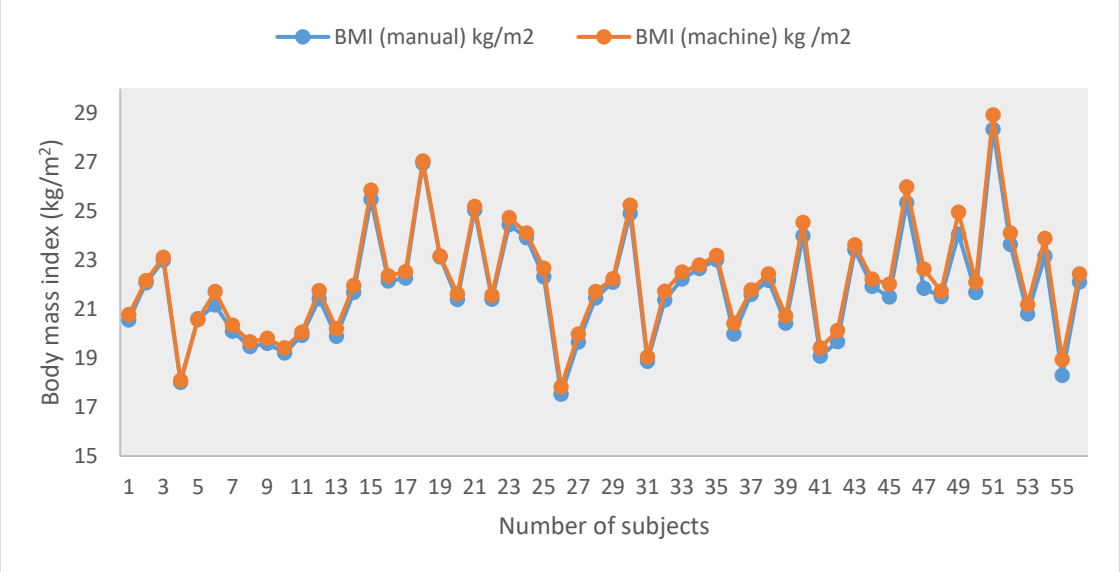

Figure 9: BMI measurement of the Subjects

The machine calculates the BMI automatically and displays the weight, height, BMI, and health status interpretation on the LCD. Three (3) of the participants were obese, one (1) was underweight, and fifty-one (51) were of normal weight. For the overweight and underweight, text messages were sent to pre-registered health practitioners for suitable counselling and follow-up. Similar findings were found by (Abana et al. 2020, Olajide et al. 2020). The adoption and use of an automated BMI machine will reduce the stress associated in manual measurement and prevent human errors that may occur throughout the set-up of a manual mechanism and calculation. Statistically, the BMI can also be used to determine a person's health status

Conclusion

The Body Mass Index is measured manually using mathematical relationship from the information of body weight and height in most developing countries which is considered strenuous and time

consuming. Thus, the design of an automated BMI machine with the aid of a microcontroller sending SMS alert will help reduce the stress of health practitioners with easy measurement, computation, analysis and transmission of patient's data with high degree of effectiveness. The data obtained from the machine showed no deviation from the manual compilation. The mechanism calculated the Body Mass Index automatically and displayed the weight, height, BMI and the interpretation of the health status on the LCD. Three (3) of the subjects had overweight, one (1) had underweight while fifty-one (51) had normal weight. Text messages were sent to pre-registered health practitioners for the overweight and underweight for proper advice, counselling and follow up.

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Conflict of Interest

The Authors declare that there is no conflict of interest whatsoever.

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