Electronic System Design for Clinical Applications of Stunting Case

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Abstract **-** The problem of short children (stunting) is one of the nutritional problems faced in the world, especially in poor and developing countries. Stunting is a problem that's associated with an increased risk of morbidity and death, suboptimal brain till late motor development and stunted mental growth. Stunting is a condition of growth faltering due to accumulation of nutrient insufficiency that lasts from pregnancy to 24 months of age. This situation is worsed by not balanced catch up growth. In Indonesia, based on Riskesdas there was 30.8% stunted children in 2018. Measurement of children's length and weight becomes very important to determine normal or abnormal conditions by calculating anthropometry and Z-score. So far, the measurement is done manually. This study discusses the design of the Arduino microcontrooler-based children's length and weight measurements using ultrasonic and load cell sensors. Results data from sensors then processed in microcontroller and displayed on the LCD. The desaigned instrument could also connect to a smartphone via bluetooth.

Keywords - Stunting, z-score, ultrasonic, length measurement, body weight sensor, load cell.

INTRODUCTION

Smartphone in most communities have become a necessity devices for all people. The development of smartphone technology and internet networks has exceed from communication facilities to become a means of financial transactions, GPS, and other benefits. The present network technologies such as cloud computing, 3G, 4G, HSDPA, wireless, and the bluetooth data transfer process is becoming faster. The application of information technology that forms mobile applications on smartphones is one manifestation of the industrial revolution 4.0 era [1]. The future of the health sector affected by digital technology too. The impact of industrial revolution era 4.0 on the health sector is with many emerging health applications that can be easily accessed via smartphone or tablet devices [2] [3]. The development of this technology further supports the improvement of the quality of service in the health sector, because with the increasing sophisticated technology available, it will make us easier to obtain information needs in the health sector which will certainly impact on the better quality of health services.

Maternal and child health problems are one of the major problems in the health sector currently occurring in Indonesia. Until today there have been many health development programs in Indonesia for resolving it, even at the Ministry of Health there is a Directorate of Family Health was formed to improve their health status [4]. One of national health problem that is being highlight is the stunting problem. In Indonesia, around 30.8% (about 7 million) of children suffering stunting [5]. Indonesia is the country with the fifth largest prevalence of stunting. Children under two years (24 months) who suffering stunting will not have an optimal intelligence level, making children more vulnerable to disease and could risk of future decreasing productivity levels. In the end, stunting will be able to detain economic growth, increase poverty, and enlarge inequality [6] [7]. Stunting will occurs declining growth if not matched by catch-up growth. Stunting is a national health problem that is associated with increasing risk of morbidity, death, and obstacles to both motor and mental growth.

The condition of stunting can be determined when a child body weight and body height has measured, then compared with the reference value, and the results are below normal. Physically, stunted children will be shorter than normal children. This calculation uses WHO 2005 anthropometric standard determined by the Ministry of Health [8] [9] and calculated manually by health workers in health care facilities. The conditions Normal, Stunted and Severely Stunted status are declared by nutritional status based on Body Length index by Age (BL / A) or Body Height by Age (BH / A) in children age 0-24 months.

In this paper, an electronic instrument is designed and made in order to measure the combination of anthropometric values and body weight of children aged 0-24 months. The instrument works based on body length data obtained from ultrasonic sensors and body weight data obtained from the load sensor, and these value is compared with the age and sex of the child to obtain the Z-score. Next section explains the materials and methods used and the concept of system designed. In section results and discussion explain the experiments that have been designed to assess the validitation of the device. And at last section explain about the final conclusions about this research.

MATERIALS AND METHODS

Calculations Z-score

Stunting is a condition when a child has a body length (0-24 months) or body height (24-60 months) that is less when compared to the age. This condition is measured by the anthropometric method 2005 WHO standard. Stunting children have problems caused by many factors such as socioeconomic conditions, maternal nutrition during pregnancy, morbidity in infants, and lack of nutrition when infants. Stunting children will have difficulty achieving optimal physical and cognitive development in the future [10].

TABLE I showed categories and threshold values for children's nutritional status based on Decree of the Ministry of Health number 1995 Year 2010 about Anthropometric Standards for Assessing Children's Nutrition Status.

TABLE I. Categories and Thresholds for Child Nutrition Status Based on Index

Indeks	Category Nutritional Status	Threshold (Z-score)
Body Weight according to Age (BW/A) Age 0 - 60 Months	Severely Underweight	< -3 SD
	Underweight	-3 SD s/d <-2 SD
	Normal	-2 SD s/d 2 SD
	More Nutritions	>2 SD
Body Lenght according to Age (BL/A) or Body Height according to Age (BH/A) Age 0 - 60 Months	Severely Stunted	< -3 SD
	Stunted	-3 SD s/d <-2 SD
	Normal	-2 SD s/d 2 SD
	High	>2 SD
Body Weight x according Body Length (BW/BL) or Body Weight x according Body Height (BB/TB) Age 0 - 60 Months	Severely Wasted	< -3 SD
	Wasted	-3 SD s/d <-2 SD
	Normal	-2 SD s/d 2 SD
	Fat	>2 SD

How to calculate the Z-score can be done as follows:

1, Body Weight or BH/BL Value > Median Value

$$Zscore = \frac{BW\ or\ BH/BL\ Value\ - Median\ Value}{Value\ (+1\ SD) - Median\ Value} \tag{1}$$

2. Body Weight or BH/BL Value < Median Value

$$Zscore = \frac{BW\ or\ BH/BL\ Value\ - Median\ Value}{Median\ Value - (-1\ SD)\ Value} \tag{2}$$

3. Body Weight or BH/BL Value = Median Value

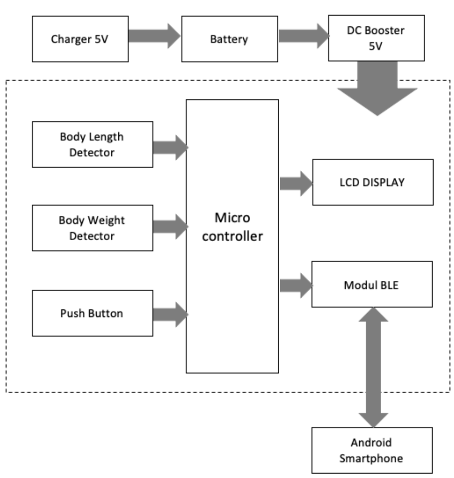
$$Zscore = \frac{BW\ or\ BH/BL\ Value\ - Median\ Value}{Median\ Value} \quad (3)$$

Hardware System

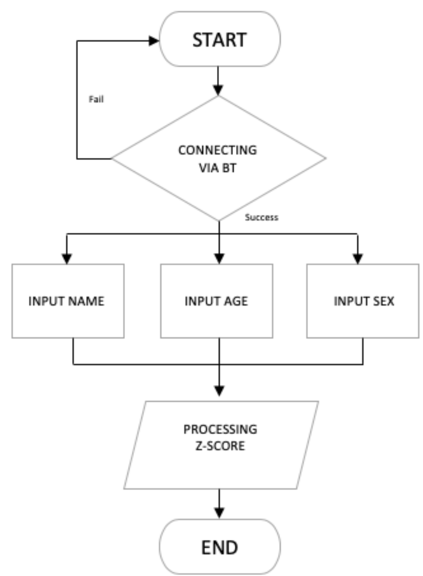
Body Length sensor used in this research is HC-SR04 ultrasonic sensor. This sensor works at 5V DC voltage and electric current 15 mA. Ultrasonic sensor HC-SR04 is a device used to measure the distance from an object. The range of distances that can be measured is around 2-400 cm [11]. This sensor uses two digital pins to read the distance for communicated. The work principle of this ultrasonic sensor by sending an ultrasonic pulse around 40 KHz, then reflected back the echo pulse, and calculate the time taken in microseconds.

The child's Body Weight (BW) measurement system is carried out through a loadcell that uses the principle of pressure utilizing and strain gauge as a sensor. Loadcell works by converting mechanical pressure into electrical signals. The electrical signal then processed in the HX711 module which converts the measured changes. The HX711 module also functions as an operating amplifier of loadcell when it works [12]. Next, the data results which are still in analog data are processed in a series of data processing and signal conditioners that will convert analog data into digital output. This digital data output then sent to the microcontroller.

For interfaces communication to smartphones, the BLE HM-10 module is used. Bluetooth Low Energy (BLE) is the latest energy saving wireless technology developed by the Special Interest Group (SIG) for close range control and used in application monitoring devices that are expected to be integrated into millions of devices in the future [13] [14] [15].



(a). Block Diagram System



(b) Flow chart software

FIGURE 1. (a) Block diagram system and (b) Flow chart software

Overall, the block diagram electronic system this instrument are contains 6 block as shown on **FIGURE 1(a)**, such as:

1. Body Length Detector; is an electronic circuit system that uses the HC-SR04 ultrasonic sensor which is used to detect the child's body length.

2. Body Weight Detector; is an electronic circuit system that use loadcell and HX711 module, used to measure the child's body weight.
3. Push Button; the input part of the system function as the input signal to the microcontroller to determine sex and age.
4. Microcontroller; the main device for data processor, using the Arduino Uno ATMega328 microcontroller.
5. TFT LCD Display; a device to display measurement results using liquid crystal as the main viewer.
6. BLE HM-10 Module; an interface communication to smartphone. This module works with voltage 3.3V or 5V.

Software System

There are two software for this research, they are Arduino IDE and App Inventor. Arduino IDE functions to make the Arduino program code. App Inventor is used to create data interface applications that will be communicated via smartphones. App Inventor is easy to use, because it is based on programming visual. User only need to drag and drop program code without having to write each line of program code. Android is a software and operating system developed for mobile devices. Android is Open-Source and is based on the Java programming language. The flow chart software for this instrument design as **FIGURE 1(b)**.

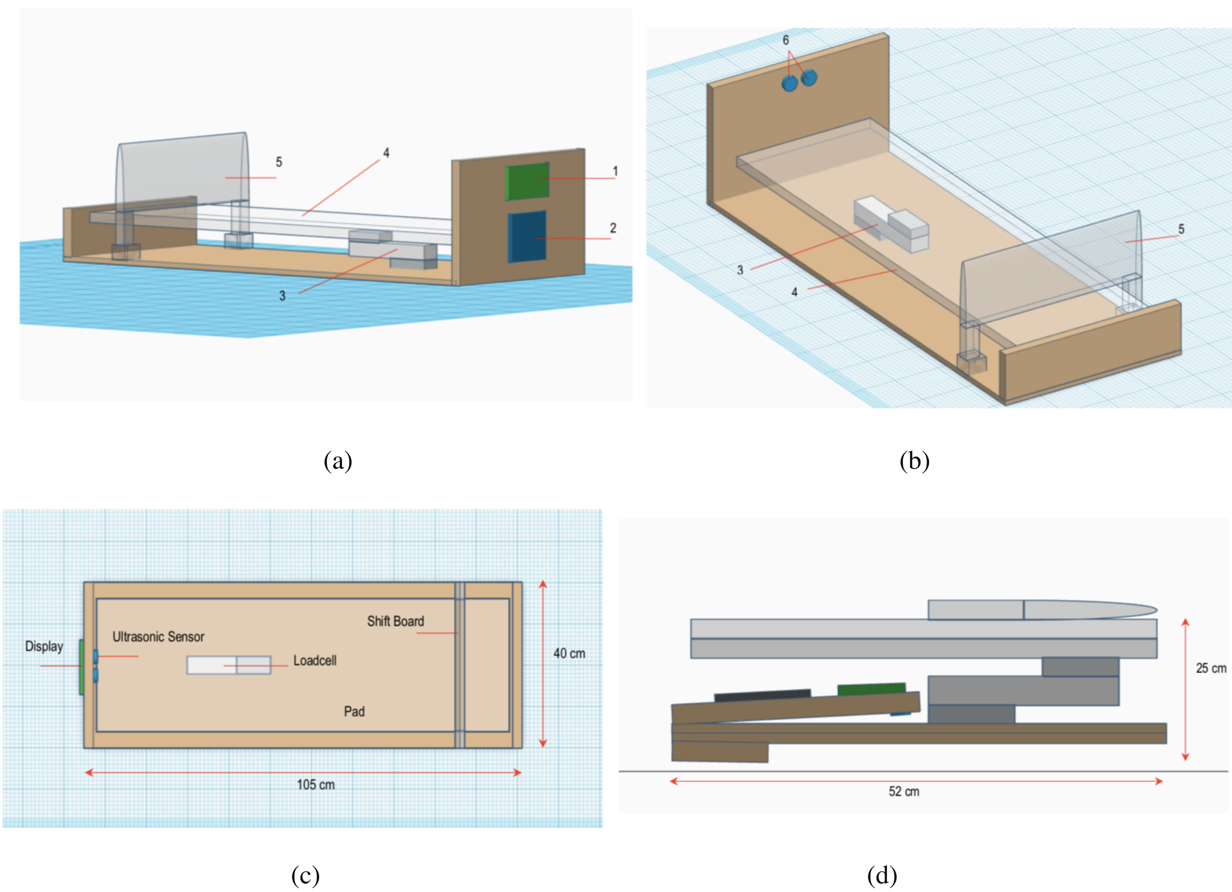


FIGURE 2 (a) Front left view, 1. LCD Display 2. Keypad 3. Loadcell sensor 4. Pad 5. Sliding plate 6. Ultrasonic sensor (b) Rear side view (c) Top view (d). Fold condition.

Mechanical System

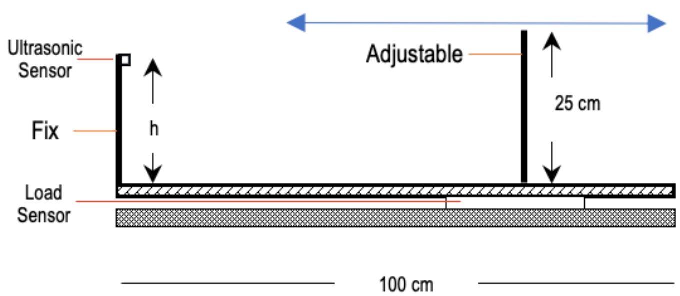
The mechanical system is designed in such a way that function as a length measuring and body weight detector system (the scales). It is equipped with a sliding plate in the middle. The design of a mechanical system can be seen in **FIGURE 2**. The mechanical system designed to be folded into 2 parts also, so it is portable and compact enough to be lifted up and move by user to carry.

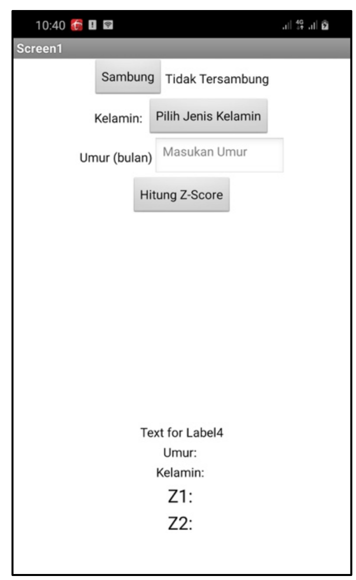
RESULTS AND DISCUSSION

Electronic system instruments for clinical applications of stunting case consist of mechanical and electronic parts. The mechanical part is made from acrylic, the electronic parts consist of ultrasonic, load sensor, microcontroller, BLE module, LCD Display and buttons for instrument setting functions. To determine overall system performance it needs testing and validations.

Validation of Body Length Detector Results

Body length measurement this validation is a measurement the body length of children aged 0-24 months from head to toe. The measurement is done by placing the ultrasonic sensor on a fixed position and shifting the barrier as the object measured as shown in **FIGURE 2(a)**. In this research, an experiment with the position of the ultrasonic sensor is conditioned with 3 (three) different heights on 11 cm, 17 cm and 23 cm systematically to decide the best resonance position for sensor.

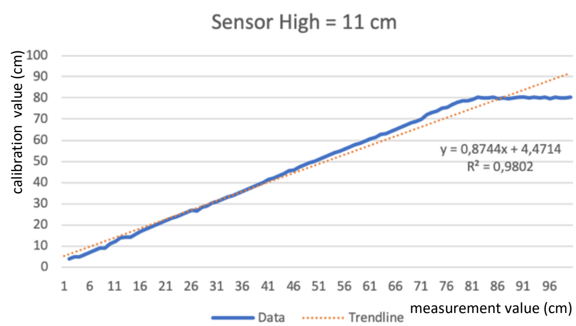




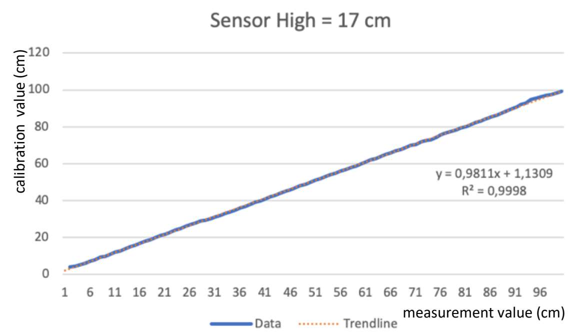
(a) Validation instrument (b) GUI smartphone

FIGURE 2. (a) Illustration of body length data validation (b). Application interface

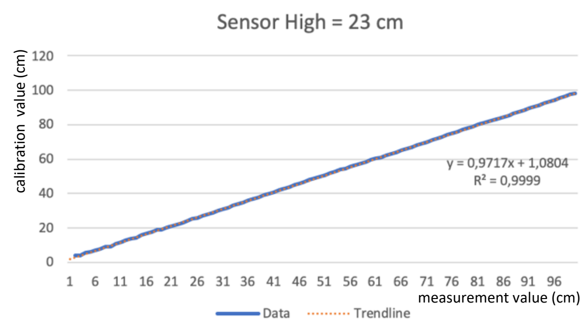
The result of measurements body length detector with a comparison using a ruler is presented in **FIGURE 3** (a), (b), (c). The test starts from the point of 2 cm to 100 cm.



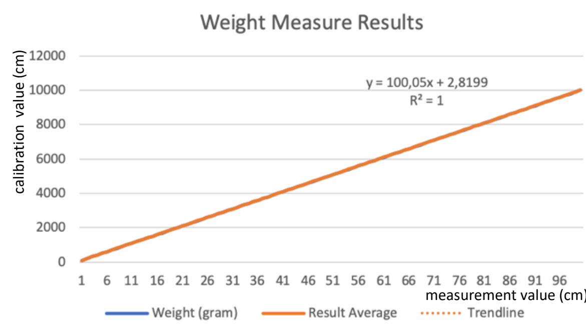
(a)



(b)



(c)



(d)

FIGURE 3. Test results of body length sensor with sensor height (a) 11 cm, (b) 17 cm, (c) 23 cm. (d) Body Weight Sensor

Trendline results of three times measurements with different sensor height showed that HC SR04 ultrasonic sensor readings are suitable with distance measurements made using a ruler. The findings of the result for this experiment are: 1) distance measurement using an ultrasonic sensor is influenced by the height of sensor because the signal is spread by waves directed at an angle of 30^{O} [16]. Therefore, if the sensor position is too low, it will have an impact to the floor reflecting area which causes wave interference. This condition is supported by measurement data that shows variations for each measurement on the same scale with different sensor height positions. On height 11 cm the saturation value is at a distance of 80 cm. That so, the sensor position height correction factor needs to be consider; 2) Further experiments are needed to see the results of variations in sensor height and type of sensor used to test the accuracy of the sensor's detection range; 3) Sensor stability is also affected by the surface position of the object relative to the sensor [17]. The value generated from this test is the measured child's body length value.

Validation of Body Weight Detector Response Results

Measurement and testing of body weight detector is testing the load cell sensor and HX711 module circuits which equipped with acrylic mechanics as a base and pad. The test is carried out by performing a calibration procedur to determine the deviation of the conventional value measuring instrument. In this case, value of calibration factor is 208.8. Calibration methode is done by compare results of the weight load between digital scales and load cells. Next step is to measure and test the load cell by comparing the weight of the load received between the system created with a sample that has been determined by digital scales. Data from the Body Weight detector test results are presented in **FIGURE 3(d)**. From the test results, it can be concluded that the load weight reading is appropriated with the actual value. In order to get a stable point, the system need 2 seconds for calculating. The data generated shows that the load sensor can be used in this research.

Validation GUI Smartphone

The Android application used is designed using App Inventor. It is easy to use, because user just input aplication data request, they are name, gender and age of the child. The Arduino microcontroller program code sent to the smartphone contains the measured Child's Length and Body Weight data. When the pairing process is successful, microcontroller Arduino will sent data to smartphone, it's controlled by pressing virtual button 'measurement' at GUI display on the smartphone screen. The interface design shown on **FIGURE 2(b)**.

Validation Overall System Design

Basicly, the system designed consists of Body Length Detector with an HC SR04 ultrasonic sensor detecting a child's body length up to 100 cm, Body Weight Detector with load cell sensor and HX711 module detecting a maximum weight of 10 kg, an Arduino Uno ATMega328 microcontroller as a data processor, and LCD Display as a data viewer for each measurement. The overall system of this tool includes mechanical parts and electronic devices that have been tested. The output of loadcell is an analog signal, therefore HX711 module convert it to digital data. It is also functions as an ADC (analog-to-digital converter), and sent to the microcontroller. The microcontroller will read the value given to find the appropriate load value. With the arduino program given, instruction to get the child's body length and body weight measured could be obtain. Then all data received is process in a mathematical calculation of the Z-score. Furthermore data of body length, body weight, Z-score could be send to a smartphone via the Bluetooth BLE HM-10 interface.

From the result of the overall system validation, it can be seen that the instrument created testing have measurement results close to the calculation results manually. Factors that affected of measurement results are: 1. Installation of ultrasonic sensors for the body length detector must be set at a certain height and perpendicular to the reflecting plate because affect to the deviation of the body length measurement results. Therefore, the installation of ultrasonic sensors in the holder must be in the right position. 2. The result of body weight detector testing with loadcell sensor when the measurement is ideal. 3. The child's condition when measured should be stable / constant so that you can get an accurate value of Body Length and Body Weight. 4. Z-score calculation can be programmed in Arduino Uno.

CONCLUSIONS

Based on research that has been done during the process of designing, manufacturing and testing process, it can be concluded that this instrument can be used to measure a child's body length (cm), child's body weight (grams), and calculate the Z-score.

Measurement of a child's body length using an ultrasonic sensor produces a saturation value on a scale of 80 cm if the sensor mounted at a height of 11 cm. Therefore we decided to install the sensor with a height of 25 cm to produce a linear measurement. Measurement of a child's body weight using a loadcell reaching a maximum value of 10 kg, is considered ideal because the results have a regresion value = 1. Overall the process of the electronic system for clinical application of stunting case is functioning properly.

This instrument is intended to facilitate user, especially health workers in remote areas when measuring body length and body weight of children aged 0-24 months. The Arduino microcontroller program code enable calculate Z-score data correctly and display it on the smartphone screen via bluetooth. With connected instrument to smartphone and stunting application installed on Android platform, user could easily find out the child's Z-score automatically.

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