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DEVELOPMENT OF NON-CONTACT DETECTION OF CHILD STUNTING USING ULTRASONIC SENSORS

TRI SISWATI*
Associate Professor, Department of Nutrition, Politeknik Kesehatan Kemenkes Yogyakarta, Indonesia.
Center of Excellence in Health Science and Research for Applied Technology Innovation in The Field of Public Health (PUI_Novakesmas), Politeknik Kesehatan Kemenkes Yogyakarta, Indonesia.
Corresponding Author Email: tri.siswati@poltekkesjogja.ac.id

YUNI KUSMIYATI
Associate Professor, Department of Midwifery, Politeknik Kesehatan Kemenkes Yogyakarta, Indonesia. Email: yuni_kusmiyati@yahoo.co.id

LUCKY HERAWATI
Professor, Department of Health Environment, Politeknik Kesehatan Kemenkes Yogyakarta, Indonesia. Email: lucky.herawati@poltekkesjogja.ac.id

YULIASTI EKA PURNAMANINGRUM
Lecturer, Department of Midwifery, Politeknik Kesehatan Kemenkes Yogyakarta, Indonesia.
Email: yuliasti.eka.purnamaningrum@gmail.com

BUNGA ASTRIA PARAMASHANTI
Department of Nutrition, Faculty of Health Sciences, Universitas Alma Ata. Yogyakarta, Indonesia.
Sydney School of Public Health, The University of Sydney, New South Wales 2006, Australia.
Email: bunga@almaata.ac.id

MUHAMMAD PRIMIAJI RIALIHANTO
Lecturer, Department of Nutrition, Politeknik Kesehatan Kemenkes Yogyakarta, Indonesia.
Email: primiaji@gmail.com

Abstract

Childhood stunting remains public health issue globally and in Indonesia. Thus, providing safe, affordable, and precise measurements of height or length is one important aspect of stunting detection in children. This study aims to develop an anthropometric tool using ultrasonic technology with the output of height or length, z-score, and stunting status of the children. We developed a comprehensive height/length measurement tool that generates measurement results in centimeter's, z scores, and nutritional status for toddlers. The Z-score calculation followed The Indonesian Ministry of Health Regulation Number 2 in 2020 about Child Growth Standards. The materials included HC-SR04 ultrasonic sensors, ESP32 microcontrollers, OLED 128x64 pixels, and fiber. To achieve a steady measuring value, we conducted measurement trials by observing the free area of the measure. The Ultrasonic HC-SR04 sensor was used in this tool to measure height, which was then processed by the ESP32 microprocessor to determine the measured height classification. The classification findings were then shown on a 128x64 pixel OLED display. The measurement results indicated that the ultrasonic sensor had a transmitting angle of 15^{o}. As conclusion this non-contact anthropometric measurement tool has the potential to be utilized through community empowerment since it is simple to use, easy to carry, and portable.

Keywords: Stunting, Ultrasonic, Sensor, Non-Contact Measurement, Anthropometry, Growth, Height, Length

1. INTRODUCTION

Stunting is a condition where a child's height is lower than standard [1]. Stunting is a form of malnutrition caused by repeated infections and long-term malnutrition. In addition, stunting under five reflects the social, sanitation, and economic problems of the region [2], [3]. Currently, stunting is still a major health problem in low- and middle-income countries, including Indonesia [3], [4]. Based on the 2022 Indonesian Nutritional Status Survey, the country is currently in the moderate stunting category [5] as many as 21,6% [6]. In fact, stunting greatly interferes with human quality and productivity and even increases the risk of morbidity and death [7]–[10].

Concerning the COVID-19 pandemic, amid efforts made to reduce stunting, the COVID-19 pandemic also increases the risk of decreasing the nutritional quality of vulnerable groups, including toddlers [11]–[14]. To prevent the pandemic, service activities at Posyandu (an integrated health post for child growth monitoring) stopped due to restrictions on mobilization and avoiding human contact. Restrictions and population mobilization also disrupt health services for pregnant women and other vulnerable groups in need of health services [11], [15], [16].

Several efforts have been made to reduce the risk of stunting under five and its severity including safe, inexpensive height or length measurements, and providing precise measurement results [17]. In toddlers, body mass measurements can provide information on the health status and well-being of toddlers, as well as detection of nutritional adequacy, impaired growth and development and health and well-being of toddlers [17], [18].

There are several kinds of toddler height measurement tools in the community such as microtoise, infantometer [19], measuring tape [20], growth mat (or *tikar pertumbuhan* in Bahasa Indonesia) [21] and growth sticker [22]. All of these tools are measuring instruments used with contact between the measured and the measuring so that the accuracy of the measuring data is very dependent on the knowledge, skills and motivation of the meter as well as good cooperation between the mother of the toddler and surveyor [23]–[25]. One way of measurement with the manual method is that it takes quite a lot of time, a lot of manpower/human resources involved and complex procedures [23], and suboptimal validity of measurement results [26]. The results showed that there was a difference between anthropometric measurements carried out by cadres with the results of meaningful statistical analysis, so the measurement results needed to be validated [27].

Non-contact height measurement with ultrasonic sensor technology is one of the efforts to reduce disease transmission, such as during the current COVID-19 pandemic [28]. Technology also facilitates measurement, improves data accuracy, saves resources and supports stunting intervention programs [29][26]. Previous research reported that the use of sensors can provide accurate anthropometric measurement results of up to 95%[30]. Thus, this study aims to develop anthropometric tools using ultrasonic technology with the output of height or length, z-score and the state of toddlers whether stunting or normal.

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2. METHODS

2.1 System Block Diagram

At this stage, we developed a comprehensive height/length measurement tool to produce output in the form of measurement results in centimetres, z score, and children's nutritional status.

2.2 Design

The input of anthropometric tools developed included the date of birth of toddlers, measurement dates, sex, and measuring positions. In this tool, anthropometric standards were included based on the 2005 WHO Anthropometry. The measurement data were categorized based on the Z-score as per The Indonesian Ministry of Health Regulation Number 2 in 2020 about Child Growth Standards. Toddlers were categorized as severe stunting if the Z-score was <-3 standard deviations, stunting if the Z-score was < -2 standard deviations, normal if -2 to 3 standard deviations, and >3 standard deviations were high [31].

2.3 Materials

The materials used were 4 AAA batteries, buttons, HC-SR04 Ultrasonic sensors, ESP32 microcontrollers, OLED 128x64 pixels and fiber for the case.

2.4 Measurement Trials

Measurement trials were carried out to determine the measurement results. This test was carried out by observing the free area of the measure to produce a stable measuring value.

3. RESULTS

3.1 Prototype

This tool used the Ultrasonic HC-SR04 sensor to measure height which later was processed by the ESP32 microcontroller to determine the measured height classification. Then, the tool displayed the classification results on a 128x64 pixel OLED display. Figure 1 describes how the tool works.

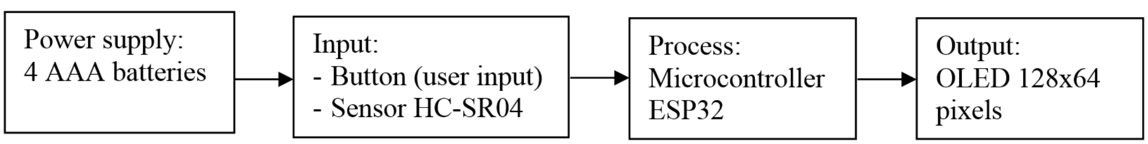

Figure 1: Prototype and how the tool works

This tool was divided into three parts, namely electronic, mechanical, and program. The electronic part included microcontrollers, PCBs, and some components. The mechanical part included the casing design of this tool. Meanwhile, the program part was code embedded in the microcontroller using the Arduino language. Figure 2 describes parts of this tool.

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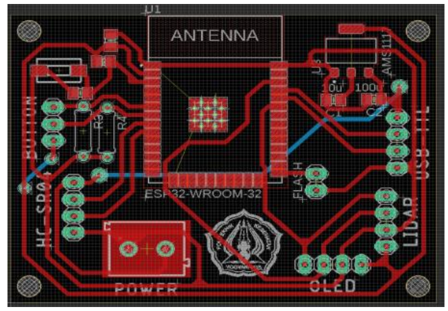
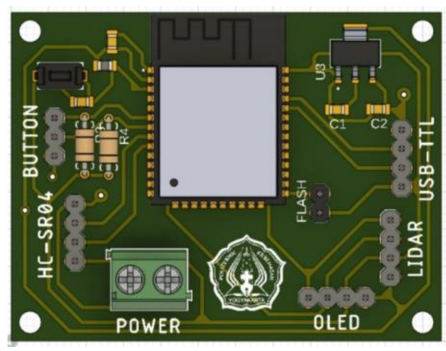
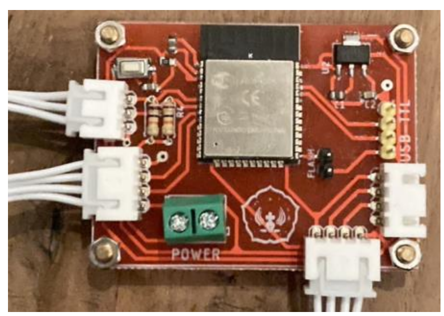
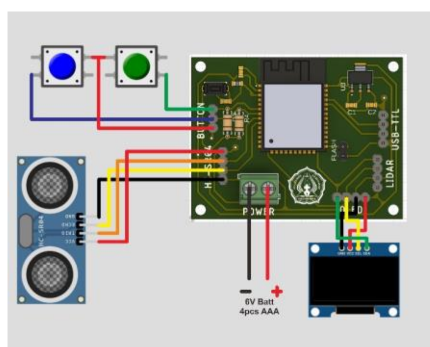
No	Design	Figure
1.	Preview PCB	
2.	3D Preview PCB	
3.	PCB results	
4.	Wiring diagram	

Figure 2: Electronic parts of the tool

The mechanical part included the creation of the casing design for this tool. The prototype casing of this tool was made with PLA material using 3D Print. Figure 3 describes the design of the case.

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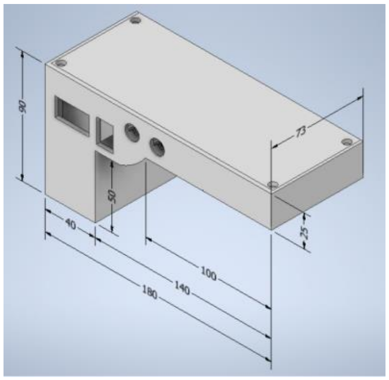
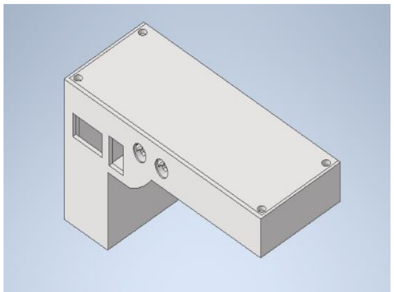
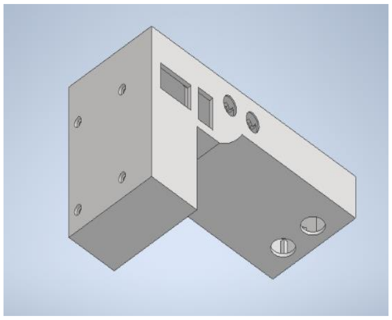
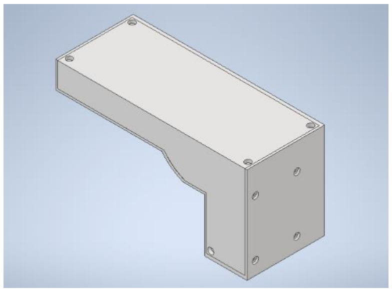
No.	Parts	Figure
1.	Size preview	
2.	Front-top view	
3.	Front-down view	
4.	Back-top view	

Figure 3: Mechanical parts of the tool

The following is the program (code) section containing commands poured on the microcontroller. This program used Arduino language and used Arduino IDE software. The detailed flowchart of the program is shown in Figure 4.

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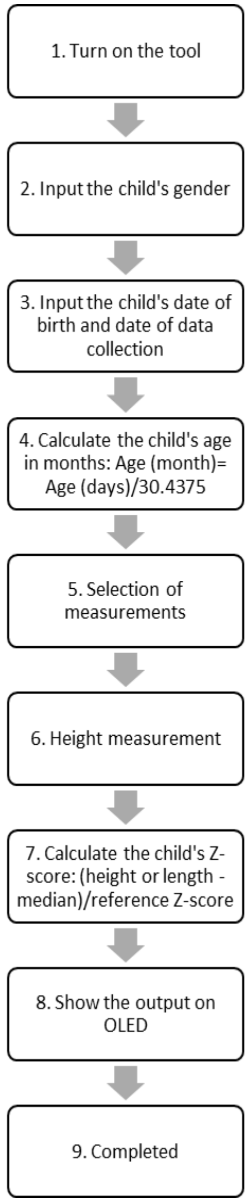

Figure 4: Program Flow Diagram

The calculations were carried out by the ESP32 microcontroller, including calculating the child’s age. The child’s age in months was obtained. by calculating the number of days from the input date of birth and the current date, then the result is divided by 30.4375. In addition, another process that occurs is to get the median value and Z-score reference based on age and measurement method. Finally, the calculation of the Z-score with the following formula:

$$Z - \text{score} = \frac{\text{Observed height or length} - \text{reference median}}{\text{reference standard deviation}}$$

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This value was then classified based on the Indonesian Ministry of Health Regulation No. 2 in 2020 about the Child Anthropometric Standard. The categorization was severe stunting (if Z-score <-3 SD), stunting (if Z-score <-2 SD), normal (if -2 to +3 SD), and tall (if >3 SD) [31]

3.2 Measurement trials

Measurement trials were carried out to determine the sensitivity of the tool by placing objects around the tool. The measurement results indicated that the ultrasonic sensor had a transmitting angle of 15^o. This sensor utilized objects as ultrasonic sound reflectors in reading the distance to the object so that the area was the reading area of the tool. To produce a valid measuring value, the area should be free as shown in Figure 5.

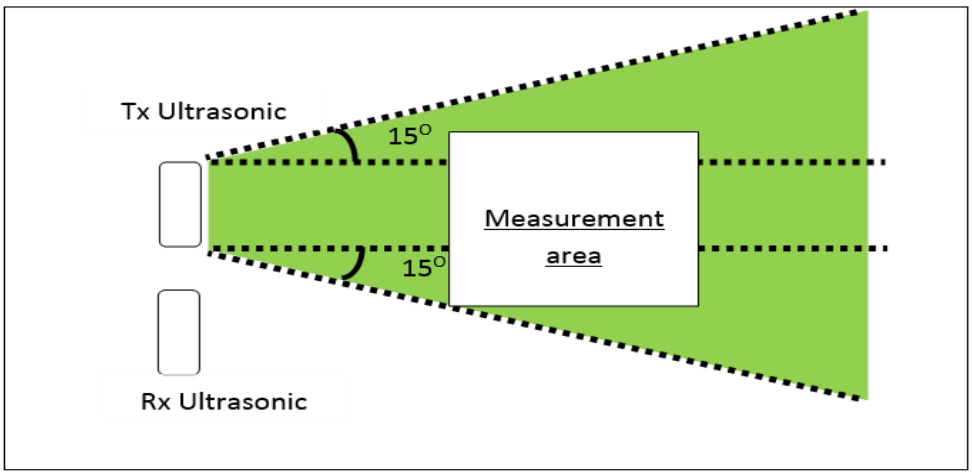

Figure 5: Tool reading area using an ultrasonic sensor

4. DISCUSSION

Changes in height are very important parameters to determine nutritional adequacy, especially nutritional adequacy in the long term [32]. Toddler height also reflects general social conditions including household economic conditions, sanitation, education, parental knowledge, policies and other social factors [3], [33], [34]. Children who are stunted often experience developmental disorders [9][7], obesity, morbidity, mortality and other non-communicable diseases [35]–[38]. The main way to detect stunting is to measure height or length correctly and regularly, especially at toddler age [17]. Measuring height or length by automatic methods is an easy way to do and save resources [29], [39]–[43]. The use of sensors also has sufficient accuracy [44], [45][30]. In previous research, the development of automatic and non-contact height measuring instruments with ultrasonic sensor technology has been successfully developed, but the measurement output is centimeters [30]. Meanwhile, for the benefit of the intervention, the nutritional status of toddlers determined through measuring height or length in centimeters is still being processed through calculations by comparing the

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measurement results with WHO anthropometric standards of 2005[46] and then categorized into normal growth or stunting.

In this study, we have succeeded in developing a height/length measurement tool with a centimeter, z-score and toddler status whether stunting or normal growth. This tool is one of the technological innovations that support health transformation pillar 1, namely primary health services with a priority to overcome stunting under five and pillar 6, namely health technology transformation. This tool has the advantage of being easy to use, with a reading area with an angle of 15%. This measuring tool is useful for stunting prevention programs, and preventing disease transmission such as during the COVID-19 pandemic and other special conditions.

5. CONCLUSION

The design of a non-contact height/length measurement instrument has been successfully made, because the sensor reads objects by reflecting ultrasonic sounds, to have optimal measurement results, a free area with an angle of 15^{o} of its. The use of this non-contact anthropometric measurement tool can detect stunting early, easy to use, easy to carry or portable so it has the potential to be used by ordinary people through community empowerment at Posyandu.

6. AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

7. CONSENT

Not applicable.

8. ETHICAL APPROVAL

Not applicable.

9. COMPETING INTERESTS

We don't have any competing interests.

10. ACKNOWLEDGEMENT

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