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Effectiveness of Digital Anthropometric in Early Detection of Stunting Systematic review

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Abstract

Stunting, a critical and serious public health issue, hinders child development. Accurate and timely stunting detection is essential for effective interventions. Traditional anthropometric measurements face limitations like human error and resource scarcity. Digital anthropometry presents a potential solution by offering precise and efficient data collection. This study aimed to assess the effectiveness of digital anthropometry tools in early stunting detection. This study employed a systematic review method compiled based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Six databases (PubMed, Scopus, ProQuest, Medline, ScienceDirect, and others) were searched for articles published between 2019 and 2023. The Rayyan platform facilitated literature management. Among 1048 articles, eight studies demonstrated that digital anthropometry is a reliable and efficient tool for early stunting detection. Advantages include enhanced accuracy, reduced measurement time, and potential for remote monitoring. However, challenges such as cost, technical expertise, and data privacy require careful consideration for widespread implementation. By harnessing the potential of digital anthropometry, we can significantly improve early stunting detection and interventions, ultimately fostering better child health and development outcomes.

Keywords: *Stunting; Antropometry; Childreen*

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1. Introduction

Stunting, a chronic childhood nutrition problem, continues to be a global concern. It is characterised by stunted body growth and cognitive development due to chronic malnutrition in the womb and during childhood (WHO, 2022). As a result, stunting can adversely affect the health, productivity and quality of life of individuals and communities. Based on the results of the Indonesian Nutrition Status Survey (SSGI) (SSGI, 2022), the prevalence of stunting in Indonesia decreased from 24.4% in 2021 to 21.6% in 2022 with the hope of a sharper decline, which decreased to 14% by 2024. Early detection of stunting is critical to prevent serious long-term impacts (Kemenkes, 2022).

Stunting monitoring in Indonesia is carried out by anthropometric measurements on toddlers at posyandu services and uploaded in SISFO Gizi (Nutrition Information System). The government stresses the importance of accurate height and weight measurements for determining the prevalence of various health conditions rate of stunting (Jefferds et al., 2022). However, conventional methods of anthropometric measurement often face obstacles such as limited human resources, varying levels of accuracy, and delays in obtaining results and reporting. However, conventional Methods of anthropometric measurement often face obstacles such as limited human resources, varying levels of accuracy, and delays in obtaining results as well as in reporting errors and inaccuracies in measurements, so there will be possible errors in diagnosing healthy children as stunted. Errors may arise from inappropriate measurement techniques, changes in measurement results, or errors in analysis. Potential sources of inaccuracy can arise from the use of measuring equipment and challenges encountered during the measurement process (Smith et al., 2023).

The emergence of digital technology offers a promising solution to overcome these challenges. Digital anthropometry systems have the potential to improve the accuracy, efficiency, and coverage of anthropometric measurements, thus enabling more effective early detection of stunting (sri winarni, sugeng iwan, 2019) herefore, the purpose of this study is to determine the effectiveness of digital anthropometry measurement tools in early detection of stunting in children. Specifically, this study will: Review the existing literature on the use of digital anthropometry for stunting detection, Analyse the methodology and findings of previous studies, related to digital anthropometry, provide recommendations.

2. Method

The design of this study was a literature review conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021). As this was a literature review of publicly available data, ethical approval was not required.

An electronic literature search was used to locate relevant literature for this study. The researcher conducted a systematic search on electronic databases, including Scopus, ProQuest, Medline, Sciencedirect and PubMed. In accordance with the research question, relevant generic keywords from the PICO Framework and Medical Subject Headings (MeSH) were used to conduct a systematic search of relevant studies in the specified databases. the keywords used were Population: "children," OR "under five years," OR "toddlers" OR "children," OR "stunted children," OR "stunted children," OR "stunted toddlers," OR "stunted children," "Intervention: AND "Effectiveness" OR "Comparative Effectiveness Study" AND "Anthropometry" OR "anthropometric measurements" OR "digital anthropometry," OR "electronic anthropometry," OR "portable anthropometry" Used to identify related literature.

The search was limited to articles published between January 2019 and January 2023. To avoid confusion and facilitate translation, only articles published in English were selected for review. In conclusion, the inclusion and exclusion criteria for the literature search were as follows: Literature search inclusion criteria: Studies on the efficiency of digital anthropometry with anthropometric conventions, Population of children aged 0-8 years, Full test articles, Articles published from 2019 to 2023. Literature search exclusion criteria: Studies on child population>8 years old and Articles written in languages other than English.

All references identified from all databases were exported to Rayyan, a free web-based application designed to manage literature reviews. This was done to facilitate detection of article duplication and pre-screening of titles and abstracts. to check for article duplication and pre-screening of titles and abstracts. Seven researchers independently conducted the screening by activating Rayyan's blind mode. The results of each screening were verified by disabling blind mode in Rayyan. Any disagreements were resolved through discussion between researchers. All retrieved quotes were then screened for full text to determine eligibility. Dissenting opinions were discussed by the reviewers to reach a final decision.

The research team collectively developed a data extraction form in Microsoft Word and determined the variables to be extracted to answer the research questions. Data extracted included author, year, country, purpose of the study, study design, data collection, population and sample size, and results. All members of the research team independently extracted data from the included studies using the data extraction form and discussed their approach to data extraction to ensure consistency with the research questions and objectives.

3. Results and Discussion

The researchers identified 1043 articles through their literature search. After 104 duplicate articles were eliminated, the titles and abstracts of the remaining 849 articles were scrutinised according to the inclusion standards defined by their titles and abstracts. Articles that failed to fulfil the inclusion requirements were eliminated during the title and abstract screening process. To ensure relevance, 103 full-text papers underwent independent screening and discussion. The flow of article research through final paper identification is represented in Figure

Based on the findings from reviewing research articles, this analysis compares eight studies that investigate the development and effectiveness of digital anthropometry compared to conventional anthropometric methods. The research focused on various applications, including early detection of stunting. There are three themes of findings in the research, including device characteristics, advantages of digital systems, challenges and improvements.

Device characteristics

Based on these research sources, the devices used in digital anthropometric measurement research for children are as follows: The main components used Senor which includes weight sensors (Load cell, HX711) and height sensors include Ultrasonic sensors (HC-SR04), body temperature sensors (MLX90614-DCI), Sharp IR GP2Y0A21 sensors. Microcontrollers include arduino nano, arduino uno, ESP32. Communication modules include bluetooth, wifi. Display LCD (20x4), OLED. Software AutoAnthro, special software for 3D data processing. System used AutoAnthro 3D imaging system used to automatically measure body dimensions. Multi-sensor 3DO system that combines multiple sensors to obtain more accurate data. Internet of Things (IOT), used to connect devices to the internet and allow remote monitoring of data. The above devices are used to build a digital anthropometric measurement system that is more accurate, efficient and easy to use compared to conventional methods.

Advantages of digital anthropometry system

Digital systems, especially those using multisensory approaches, have been shown to be more accurate and reliable in measuring height, weight, and waist circumference than conventional methods. Based on the findings of the literature review above which states that it has high accuracy and reliability in 5 studies out of eight research reviews which include research (Kennedy et al., 2022), (Lensoni et al., 2023) (Leidman et al., 2022)

(Ludya et al., 2023a) (Umiatin et al., 2022) (Ardianto et al., 2022). Accurate measurement results can be used to determine the nutritional status of children under five and detect stunting early on. One finding states that the results of the accuracy and reliability test of the tool are still within the tolerance limit, namely (Sofie et al., 2023) meaning that the measurement results produced by the tool are still acceptable and considered valid. Although there may be a slight difference between the measurement results of the tool and the actual value, the difference is still within the permitted or tolerated range. While there is 1 study that does not appear to test the insurance of the tool, only the results of the study state that the tool is effective in research (Lensoni et al., 2023) while there is 1 study (Siswati, 2023) testing the insurance and reliability of anthropometric digital devices with ultrasonic sensors compared to stadiometer devices produces the same valid or accurate results so that there is no difference from the two results of the insurance test on the tool.

Non-physical contact measurement reduces child discomfort and allows remote monitoring, which is suitable for areas with limited access to health services. Based on the literature review that measurements without physical contact reduce discomfort in children are found in research (Siswati, 2023) (Ludya et al., 2023a) (Leidman et al., 2022) (Kennedy et al., 2022) (Umiatin et al., 2022). Digital anthropometric measurement without physical contact is a method of measuring the dimensions of the human body, such as height, head circumference using sensors without the need to directly touch the body of the subject being measured. This anthropometric system is one of the innovations in non-contact anthropometry (Lensoni et al., 2023).

The measurement process is faster and easier, reducing the time and errors that may occur in manual measurements. The findings from the literature review that 7 studies conveyed the use of digital anthropometric tools that are fast, easy to use, minimise errors. which includes research (Umiatin et al., 2022) (Siswati, 2023) (Ludya et al., 2023b) (Leidman et al., 2022) (Kennedy et al., 2022) (Ardianto et al., 2022) (Sobhiyeh et al., 2021). Measurements with 3D non-contact, ultrasonic sensors, Authoanthro, multi 3D and OIT measurements can be done quickly thereby reducing waiting time and measurement data can be directly displayed and sent to other devices in real time, data can also be monitored by health workers from different locations so as to reduce fear in children. Digital systems can reduce subjectivity bias that may occur in manual measurements, this is found in research (Leidman et al., 2022). Which states the AutoAnthro 3D imaging system (third generation) the average bias value of measurements in cm is -0.5 (95% CI - 2.0 to 1.0) for height/length and 0.7 (95% CI 0.4-1.0) for MUAC, it can be concluded that the tool has a high insurance value.

Data can be monitored and controlled in real-time through various devices connected to the cloud. This is found in the findings in 7 studies (Leidman et al., 2022) (Ludya et al., 2023a) (Kennedy et al., 2022) (Siswati, 2023) (Umiatin et al., 2022) (Sofie et al., 2023) (Ardianto et al., 2022). which in the study explained that measurements using sensors without physically touching the child produce data that will be displayed directly and sent to other devices in real time (Leidman et al., 2022).

In research (Sofie et al., 2023) by adding an ESP32 MCU node to the digital baby scale; so that the data read by the scale is directly recorded in the central database. Scales are connected to the database and web page via WiFi network. The measurement data will be processed in the cloud to get a classification of nutritional status. This makes the process of determining nutritional status faster. development of an automatic height measuring instrument using an HC-SR04 ultrasonic sensor based on Arduino R3. The general description of the application in the study (Ardianto et al., 2022). includes the data input process (measurement), data processing using Arduino sent to a smartphone using bluetooth. To facilitate data retrieval is done by looking at the results of numerical data at the time of measurement using electronic devices so that the data taken can be displayed in the form of numbers on LCD and android smartphones. Arduino nano microcontroller which has this I/O pin to read the value of height, age, and weight sent by the circuit and accompanied by serial communication between bluetooth so that it can display data in the form of numbers into a smartphone.(Halimah, 2024).

Challenges and improvements

Some systems still experience a fairly high failure rate, especially in data processing. Where 6 studies state that the Hc-SR04 ultrasonic sensor and environmental disturbances of dust, water vapour or foreign objects that can block the ultrasonic path can cause inaccurate readings or even no readings at all, changes in temperature can affect the speed of sound so that it affects the accuracy of distance measurements, ultrasonic signals can be disturbed by noise from other electronic devices so as to produce invalid data. Data processing errors by the ESP32 microcontroller: Errors in writing programme code or calculation algorithms can cause inaccurate measurement results, overflow or underflow if the value of the calculation results exceeds the maximum or minimum limit that can be accommodated by the variable, an error will occur, interference with the microcontroller operating system or interference with other components can cause the programme to stop working or produce unexpected results, a damaged OLED screen can cause the display of measurement results to be incomplete or unclear, an error in the display driver can cause the display to not match the data sent by the microcontroller (Ardianto et al., 2022) (Kennedy et al., 2022) (Sofie et al., 2023) (Siswati, 2023), the system is highly dependent on

Unstable Internet Connectivity Dependence on the internet to access data, perform computations, or store data can be hampered if the internet connection is unstable. This resulting in failure to upload data to cloud storage due to intermittent connections. Electrical noise can interfere with the load cell output signal, Load cells can be damaged due to overload or impact. The bluetooth signal can be interfered with by other signals around causing the data sent to be incomplete or damaged, the distance between the microcontroller and the smartphone is too far can cause the signal to bee or cut off, not all android devices are compatible with the bluetooth module used. System performance may vary depending on device design and environmental conditions. The system needs to be calibrated periodically to ensure the accuracy of the measurement results. If the sensor is not calibrated correctly at the time of use all subsequent measurements will have systematic errors, the characteristics of the sensor can change over time so it needs to be done periodically. The cost of developing and implementing digital systems is higher than conventional methods (Leidman et al., 2022) (Ludya et al., 2023a) (Umiatin et al., 2022).

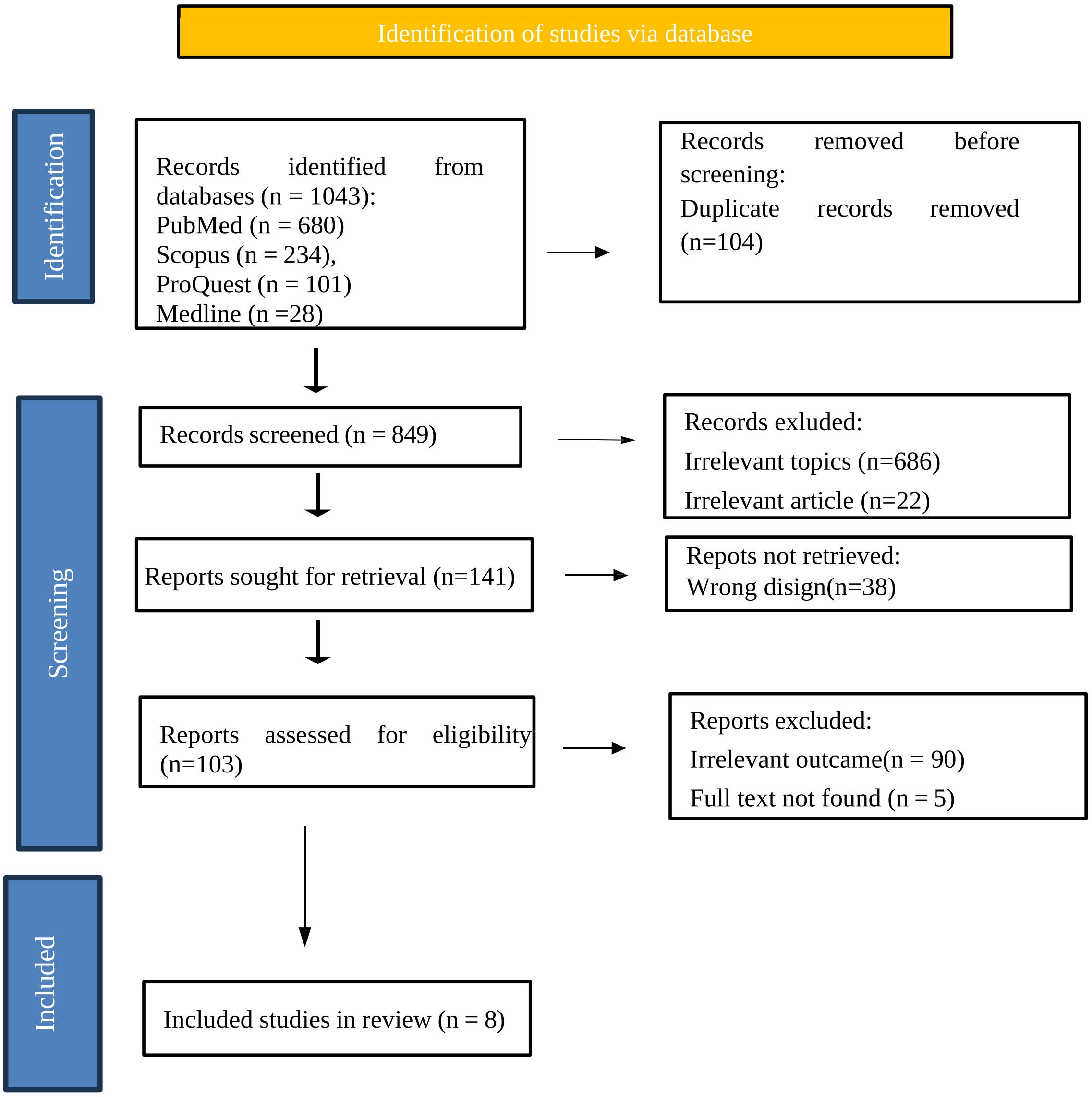

Figure 1
PRISMA DIAGRAM

From the choice of results, eight articles were obtained that were in accordance with the research objectives, inclusion criteria, and exclusion criteria so that they could be included in this study and could proceed to the quality research stage.

Table 1. Extraction Data

Author and country	Aim	Study Design	Data collection	Participants	Results
(Umiatin et al., 2022) Indonesia	Develop an integrated and contactless anthropometric system to measure body mass, height, and head circumference in children aged 12-60 months	Exsperiment al study	Development and testing design	n=100 Children aged 2-5 years	The multisensory approach to anthropometric measurements demonstrated significant improvements in accuracy and reliability, reducing measurement error to 5%. By eliminating the need for physical contact, this non-contact system alleviates child discomfort and enables remote monitoring, particularly beneficial in areas with limited healthcare access. Additionally, the system's user-friendly design offers a quicker and easier alternative to traditional methods
(Kennedy et al., 2022)	Evaluation of the accuracy and precision of digital anthropometric measurements compared to conventional anthropometry in children for stunting detection	experimental study	Data was collected from a group of racially and ethnically diverse children aged 5 to 8 years old who participated in the Shape Up! Kids program. Participants were recruited through various channels, including online advertisements, flyers, and word-of-mouth.	N=64 children aged 5-8 years	A significant number of scans (33.1%) could not be processed due to technical issues. The accuracy of 3D optical (3DO) devices in measuring circumference differed across systems and anatomic sites. The performance of 3DO devices varied widely, with some systems demonstrating better accuracy than others. Existing 3DO devices were not designed specifically for young children, leading to potential limitations in their accuracy and applicability.
(Leidman et al., 2022) Sudan Selatan , Malaka	Objectives: To evaluate accuracy of child stature (height/length) and mid-upper arm circumference (MUAC) measurements produced by the AutoAnthro 3D imaging system developed by Body Surface Technology Inc following improvements to the software algorithm to improve accuracy and support automated processing, and hardware changes aimed to reduce cost	Randomised Controlled Trial (RCT)	The data collection process involves manual measurements and 3D scanning to enable comparison and evaluation of technology performance.	N= 539 children aged 6-59 months	The 95% LoA for stature and MUAC measurements indicate the accuracy is high compared to manual measurements.The accuracy of measurements varied considerably across different teams.That the scan-derived measurements produced by AutoAnthro were not of sufficient accuracy for widespread adoption. Time is still needed for tool development. There was a slight negative bias for stature measurements and a positive bias for MUAC measurements. Enumerators communicated an overall interest in the device performing well given t h a t the scan capture generally took less time than manual measurement and eased field work
(Ardianto et al., 2022) Indonesia	Evaluate the validity and reliability of digital anthropometry anthropometry android application system for status	System Development Life Cycle Experimental study	The stages of planning, analysis, design, implementation, testing, and management are applied to the design of anthropometric detection systems in children under five	N=5 Children	The audiovisual system is a valid and reliable digital-based anthropometric measuring tool that can be used to measure height, weight and head circumference. The system identified an error on the sensor weight of 0.25% and the distance sensor of 0.5%. Android-based system can make cadres and health workers identify and record measurement results easily, but it still needs to be developed into a more specific identification system

Author and country	Aim	Study Design	Data collection	Participants	Results
(Sofie et al., 2023) Indonesia	designing an IoT- based baby scale by adding an ESP32 MCU node to a digital baby scale; so that the data read by the scale is directly recorded in the central database.	Randomised Controlled trial (RCT)	Modifications are made by adding IoT technology to baby scales, so that the telemetry data retrieval process will be faster and the percentage of human error can be reduced.	none	Sensitivity and specifications of IOT-based scales produce insurance rates still within tolerance limits compared t o conventional methods. Easy to use, faster nutritional status determination results, reduced errors and increased time efficiency. Monitor and control things in real-time through remote locations, resource availability anywhere, various devices can connect and interact with the cloud
(Siswati, 2023) Indonesia	to obtain a stable measurement value, we conducted a measurement trial by observing the measuring free area.	Experimental study	System block diagram, device design, measurement test	N=30 Children aged 2-5 years	There is no significant difference between the ultrasonic sensor and the stadiometer when measuring children's height. The measurement results of both are equally valid and accurate. Optimal measurement results in a free area with an angle of 15 degrees can detect stunting early. Contact methods are safe and efficient, easy to use, portable or portable
(Lensoni et al., 2023) Indonesia	Increase awareness and skills of targets in early detection of stunting independently using anthropometric stunting meter	Experimental study	Measurement with anthropometric stunting meter compared to conventional anthropometry	N= 30 Aged 24-59 months	ASM tool shows effective results High enthusiasm from respondents
(Ludya et al., 2023a)	Find a system, a type of height and w e i g h t measuring instrument that is practical and accurate, with visualisation, product ergonomics, and features that are in accordance with the characteristics of toddlers, so that the measurement process can be more accurate, comfortable, safe, and fun with the design thinking method and ergonomics approach.	Quasi EXperimental study	Qualitatively, literature study, emphatize (validation) stage,ideate (concept design), validation testing in accordance with the prototype.	None Aged 2-5 years	Showing that digital anthropometry that combines a stadiometer and ultrasonic sensor has a high level of accuracy in measuring height and weight compared to conventional anthropometry. The product uses crem, beige and brown colours to provide a safe, comfortable and warm psychological impression on children. The selection of fox stilation shapes and the addition of detachable plush toys can attract children's attention to stay focused and feel happy during the measurement process. The addition of a monitor screen and keypad can help posyandu cadres read results and enter data.

Discussion

Based on the findings in the research above, the devices used in digital anthropometric measurement research for children The main components used include: Senor Load cell and HX711 to measure body weight where the Load cell can change the mechanical force (load) into an electrical signal, while the HX711 functions as an amplifier to strengthen the weak signal from the load cell and convert it into digital data that can be read by the microcontroller (Graybeal et al., 2023).

Ultrasonic Sensor (HC-SR04) serves to measure height by emitting ultrasonic sound waves and measuring the time it takes for the waves to reflect the object (human body) and return to the sensor based on the travel time the distance (height) can be calculated. MLX90614-DCI sensor to measure body temperature by means of this infrared sensor measures infrared radiation emitted by the human body to determine temperature, Sharp IR GP2Y0A21 sensor to measure shorter distances by emitting infrared light and measuring the time it takes for the light to bounce off the object and return to the sensor. 2) Microcontrollers include arduino nano, arduino uno, ESP32 this is the brain of the system, receiving data from senor, processing data and sending data to the device (LCD or smartphone) (Gubawa & Abuzairi, 2020).

The difference from arduino nano and uno has similar capabilities but ESP32 has integrated Wi-Fi capabilities that allow direct internet connection. Bluetooth, Wi-Fi as a communicationmodule between microcontroller devices and smartphones. The difference is that Bluetooth has a shorter range but lower power consumption while Wi-Fi has a wider range but higher power consumption. LCD (20x4), OLED functions to display measurement data in real time while the difference in OLED has better image quality wider viewing angle and lower power consumption than LCD. The system used in digital anthropometry includes: AutoAnthro system by using a 3D camera or 3D scanner to take 3D measurements (Gupta et al., 2023), capturing images of the human body from various angles, the software will process the images to generate a 3D model of the body and then calculate the dimensions of the body (height, girth, circumference). Arm and waist circumference). So the measurement becomes more accurate because it is done automatically by computer reducing human error, can reduce various body dimensions simultaneously, does not require direct physical contact 2). Multi-sensor 3DO: A system that combines multiple sensors to obtain more accurate data, collect more complete data, and produce more in-depth data analysis. Internet of Things (IoT), used to connect devices to the internet and enable remote monitoring of data. This is in line with research (Putra et al., 2024).

NodeMCU is an ESP8266-based development module that provides Wi-Fi connectivity, ideal for Internet of Things (IoT) applications. The module supports open-source software and is compatible with the Arduino IDE, making programming easy. The NodeMCU has an analogue input with a maximum voltage of 3.3 volts and works as a complete control system. The reason for choosing NodeMCU ESP8266 is because of its ease of programming, completeness of I/O pins, and its ability to access the internet to send or receive data.(Fatullah, 2024).

Digital systems, especially those using multisensory approaches, have been shown to be more accurate and reliable in measuring height, weight, and waist circumference than conventional methods Equivalent to the findings in the study (Beckmann et al., 2019) 3DO sensors can yield radiating results and accuracy of measurements obtained from 3D scanning against manual measurements in 474 children aged 0-5 years Atlanta, Georgia, USA. The mean child age was 26 months, and 48% of children were female. Based on reported race and ethnicity, the sample was 42% Black, 28% White, 8% Asian, 21% dual race, other race or race not reported; and 16% Hispanic. The reliability of repeated 3D scan measurements was within 1 mm of manual measurements for height, head circumference, and arm circumference. We found systematic bias when analysing accuracy-the 3D imaging mean overestimated height and head circumference by 6 mm and 3 mm, respectively, and underestimated arm circumference by 2 mm (Halimah, 2024).

The 3D imaging system used in this study is reliable, inexpensive, portable, and can handle movement making it ideal for use in routine nutritional assessment. However, additional research, particularly on accuracy, and further development of scanning and processing software are needed before making policy and clinical practice recommendations on the routine use of 3D imaging for paediatric anthropometry. IOT can accurately detect stunted toddlers, This closely resembles the findings of previous studies. (Widodo & Sulistiyanti, 2022) to manage child medical record data, intelligent applications for early detection of stunting using Support Vector Machine (SVM), and finally graphical applications to integrate anthropometric data of toddlers. Smart applications developed using the Support Vector Machine (SVM) method can be used as a model for detecting stunting status in children. It is known from the average accuracy value obtained of 86%. To get the accuracy value is done by comparing the classification results by the system with the groundtruth (midwife) (Gómez-Campos et al., 2021).

The method used to calculate accuracy is the Receiver of Characteristic (ROC) method. The ROC method will produce four values, each of which is true positive, false negative, false positive, and true negative. Stunting status that is correctly identified according to its class is indicated by True Positive (TP). Stunting status that should be correctly identified in its class, but in the classify cation process is incorrectly identified is indicated by Positive Phrase (FP). True Negative (TN) is a stunting status that is not a member of the identified class and is identified as not a member of that class. False Negative (FN) indicates stunting status that should not be a member of the class and is identified as a member of the class. Based on these four values, the true positive rate (TPR) value is obtained, known as sensitivity. To test the accuracy of the developed application, three tests were conducted using 50 test data. The first test is testing the stunting detection method based on age and weight. The second test is testing based on age and body length. While the third test is testing stunting status based on age, body weight, body length simultaneously (Gupta et al., 2023).

This scenario is used to see the effect of feature selection in this case age, weight and body length on the performance of the developed stunting detection method. The first test results showed an accuracy rate of 85.1%. The second test results showed an accuracy rate of 86%%. The third test results showed an accuracy rate of 82.3.6%. This shows that the method used by using training data can detect very accurately. multifunctional anthropometric measuring device based on ultrasonic sensor arduino nano as the basis for measuring the length and weight of the baby and metlin as a head circumference measuring device displays three measurement results in one measurement that appears on the LCD monitor screen. Electrical and electromedical experts say that the design, safety, and effectiveness of the device are up to standard. The components contained in the MODAS Baby tool can provide accurate results, an attractive tool shape, safe, easy to use and the results of the tool are no different from measurements using manual tools. Proven when testing with midwives and village health cadres (Hapsari, 2024).

Contactless measurement reduces child discomfort and enables remote monitoring, which is suitable for areas with limited access to healthcare. Contactless digital anthrometry measurement is a method of measuring the dimensions of the human body, such as height, head circumference using (Ba-Saddik & Al-Asbahi, 2020).

Sensors without the need to directly touch the body of the subject being measured is very suitable for children, where children feel afraid or uncomfortable when touched, especially when being measured, this anthropometric system is one of the most popular anthropometric systems. Innovations in non-contact anthropometry (Fatullah, 2024). Non-contact technology in medical devices plays an important role, especially in the era of the COVID-19 pandemic. Minimising contact can minimise the risk of transmitting infections during anthropometric measurements. The use of this non-contact anthropometric measuring instrument can detect stunting early, easy to use, easy to carry or portable so that it has the potential to be used by ordinary people through community empowerment at Posyandu. Challenges and improvements regarding digital anthropometry include Sensor Failure and Environmental Influences such as The sensitivity of ultrasonic sensors to environmental disturbances such as dust, water vapour, and temperature changes is indeed a major obstacle (Gaskin et al., 2020).

Physical damage and electrical noise can also affect the performance of the load cell, making the weight data obtained unreliable. Improper calibration or not done regularly will cause systematic errors in measurements. That Install a shield on the sensor to reduce the influence of dust and dirt. Use a temperature compensation algorithm to improve the accuracy of the meter (Gubawa & Abuzairi, 2020). Perform calibration regularly to ensure sensor accuracy. The development of a multifunctional anthropometric measuring device based on ultrasonic sensors can help reduce measurement errors. Better tool design, such as the use of rectangular boxes that can measure various parameters (body weight, body length, and head circumference) in one action, can improve measurement efficiency and accuracy (Graybeal et al., 2023).

Calibration is an important step to ensure measurement accuracy. The calibration process can be done by comparing the digital output of the sensor with a known standard value (Hapsari, 2024).This is in line with the findings of (Putra et al., 2024) putra. The test results show that the accuracy of the ultrasonic sensor decreases as the measurement distance increases. In addition, environmental conditions such as temperature, humidity, and the surface of the object also affect the accuracy of the measurement. Therefore, additional calibration is required to ensure measurement accuracy under varying environmental conditions. This study concludes that the NodeMCU 8266-based ultrasonic sensor can be used as an effective solution for distance measurement applications, but calibration and customisation are required to guarantee the accuracy of the data under various conditions. These results make an important contribution towards the development of more intelligent and responsive automation systems (Hijrawati et al., 2021).

Data processing errors in digital anthropometry are caused by various factors including inaccuracies in measuring instruments, human error and problems in data processing such as errors in writing program codes or calculation algorithms can cause inaccurate results. The limits of the values that can be processed by the microcontroller need to be considered to avoid calculation errors. Disturbances in the operating system or other components can cause the system to work unstable that conduct thorough testing of the system before use. the use of algorithms that are resistant to noise and errors. Conduct regular monitoring to detect and solve problems that arise. In line with research (Putra et al., 2024) that routinely calibrating measuring instruments is very important to ensure the accuracy and precision of measurements. calibration can be done by comparing the measurement results of tools with predetermined standards such as recognised weighing or manual measuring instruments (Hapsari, 2024) this process helps detect and correct systematic errors in measurements. Developing an anthropometric digitisation system integrated with mobile applications and monitoring dashboards can increase the efficiency of recording and analysing data by using digital anthropometry kits that combine various measuring instruments in one platform, the data recording process can be done automatically, reducing the risk of human error and speeding up data transmission to the database (Halimah, 2024). Providing adequate training to users of measuring instruments such as posyandu cadres is very important to minimise errors in the measurement process. A good understanding of how to use the tool and the correct measurement technique will reduce the possibility of errors due to human error (Hijrawati et al., 2021).

Conducting validation tests on measuring instruments by involving experts in the field of electro and electromedical technology can ensure that the tools can function properly and meet insurance standards. Product trials are also important to evaluate the consistency of measurement results and the effectiveness of the tool. Creating new prototypes with more advanced sensor technology can improve measurement assurance such as the use of ultrasonic sensors or more sensitive load cells can help reduce errors in measurement. Implementing an effective data analysis system to process measurement results is also very important. The use of analytics software can help identify error patterns or anomalies in the collected data so that corrective actions can be taken immediately (Jensen et al., 2023).

Dependence on Internet Connectivity Network Stability Heavy dependence on the internet can be a problem if the connection is unstable, especially for systems that require real-time data transfer. So it is necessary to store data locally as a backup and synchronise periodically so developing a measuring lat that can operate offline is an important first step for this tool. It can store local data and upload it to the server when an internet connection is available in this way measurements. can still be taken without depending on connectivity (Kustiawan et al., 2022). Mesh network implementation can improve connectivity in hard-to-reach areas. This network allows devices to communicate with each other directly, extending signal coverage without the need for a strong internet infrastructure. Creating a mobile application that is integrated with measuring instruments can help in local data collection. The application can store measurement results and perform preliminary analyses before sending the data to the server when an internet connection is available. Using a buffering system within the measuring instrument so that data is collected and stored until the internet connection is restored, helps to ensure that no data is lost during periods of network instability. Providing training to users on how to handle situations without an internet connection is essential (Mocini et al., 2023).

Users should know how to manually save data and upload it when the network becomes available again. Developing alternative technologies such as the use of Bluetooth or other short-range communication to transfer data to other internet-connected devices reduces internet dependency. Implement a network quality monitoring system to evaluate the availability and stability of the internet connection so t h a t users can have the right time to take measurements. If possible, use a more stable local network for communication between devices (Sains & Vol, 2023).

Cost and Implementation The development and implementation of a digital anthropometry system requires considerable investment. It takes experts with adequate skills to design, develop, and manage the system. With the use of open source Technology (Soller et al., 2023) : Using open source hardware and software to reduce costs. Building partnerships with various parties to share resources and knowledge.

Study Limitations

a. Limited Scope of Studies Reviewed: This review mainly focused on anthropometric measurement tools for early detection of stunting.
b. Timeframe Limitation: Study inclusion is limited to studies published between 2019 and 2023. This may include relevant earlier studies that may provide a broader historical context or different intervention outcomes.
c. Geographical Bias: Most of the research originated in certain regions, especially in developed countries, as well as in low or underdeveloped regions.
d. Exclusion of Specific Populations: The review required studies that focused on children aged 6-96 months However, the assessment downloaded studies related to children aged >96 months
e. Variability in Study Design: The included studies used different designs, such as cross-sectional studies and retrospective cohort analyses. RCT, experimental studies, Variations in study design may introduce bias in the synthesis and comparison of results.
f. Inconsistent Data Reporting: Some studies had inconsistent or incomplete reporting of intervention details, making it difficult to compare the effectiveness of digital anthropometry

4. Conclusions and Suggestions

Conclusions

Based on the literature review that has been carried out, it can be concluded that the anthropometric digital system offers anumber of significant advantages over conventional methods of anthropometric measurement, especially for early detection of stunting. Key Advantages include Higher Accuracy and Precision in digital systems, especially those using a multisensor approach are able to produce more accurate and consistent measurement data. This is due to the use of technologies such as 3D sensors, sophisticated data processing algorithms, and regular calibration.

The measurement process becomes faster and more efficient, enabling the examination of more children in less time. Automation of the measurement process reduces potential errors that often occur with human measurements. Digital systems can collect more complete data, not only height and weight, but also other parameters such as head circumference and body composition. Integration with IoT enables real-time and remote monitoring of data, making decision-making easier. Measurement without physical contact makes children more comfortable and reduces the risk of infection. Challenges and improvements include Development and implementation of digital systems require considerable investment. Hardware or software glitches can disrupt the measurement process. Improper calibration can affect measurement accuracy.

Expert labour is required to operate and maintain the system. Reliance on the internet network can be an obstacle in areas with limited access. Recommendations for Further Development: There needs to be clear standards for the development and use of anthropometric digital systems. The system needs to be designed to be easily used by health workers with various levels of expertise. Efforts are needed to reduce the cost of system development and implementation. Anthropometric digital systems need to be integrated with existing health information systems.

Research continues Continuous improvement is required to enhance the accuracy, efficiency, and effectiveness of the system. Digital anthropometry systems have enormous potential to improve early detection of stunting and monitoring of child growth. However, there needs to be a concerted effort to overcome the existing challenges and ensure that this technology is accessible to all communities, especially in areas of need. By continuing to develop and improve digital anthropometry systems, we can make a significant contribution to improving child health and nutrition.

Suggestions

Conduct a broader comparative study to compare various types of anthropometric digital systems. Conduct a cost-benefit analysis to assess the economic feasibility of using anthropometric digital systems. Develop a user- friendly mobile application to facilitate data collection and analysis. Apply artificial intelligence algorithms to analyse data more deeply and provide more personalised recommendations.

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6. References

Ardianto, E. T., Elisanti, A. D., & Husin, H. (2022). Arduino and Android-Based Anthropometric Detection Tools for Indonesian Children. Proceedings of the 2nd International Conference on Social Science, Humanity and Public Health (ICOSHIP 2021), 645. https://doi.org/10.2991/assehr.k.220207.043

Ba-Saddik, I. A., & Al-Asbahi, T. O. (2020). Anthropometric measurements of singleton live full-term newborns in Aden, Yemen. International Journal of Pediatrics and Adolescent Medicine, 7(3), 121–126. https://doi.org/10.1016/j.ijpam.2019.08.003

Beckmann, C., Aldakak, L., Eppenberger, P., Rühli, F., Staub, K., & Bender, N. (2019). Body height and waist circumference of young Swiss men as assessed by 3D laser-based photonic scans and by manual anthropometric measurements. PeerJ, 2019(12). https://doi.org/10.7717/peerj.8095

Fatullah, A. (2024). Perbandingan Nilai Ukur Sensor Load Cell Single-Point Dan Load Cell Half-Bridge Sebagai Parameter Monitoring Massa Badan Pada Sistem Antropometri Balita. https://doi.org/10.21009/03.1201.fa20

Gaskin, P. S., Chami, P., Nancoo, T., Warner, P., Barrett, P., & Mayers, Y. (2020). Electronic based reported anthropometry—A useful tool for interim monitoring of obesity prevalence in developing states. PLoS ONE, 15(12 December). https://doi.org/10.1371/journal.pone.0243202

Gómez-Campos, R., Vidal-Espinoza, R., Marques de Moraes, A., Lázari, E., Andruske, C. L., Castelli Correia de Campos, L., Urzua-Alul, L., Cossio-Bolaños, W., & Cossio-Bolanõs, M. A. (2021). Comparison of Anthropometric Indicators That Assess Nutritional Status From Infancy to Old Age and Proposal of Percentiles for a Regional

Sample of Chile. Frontiers in Nutrition, 8(December), 1–13. https://doi.org/10.3389/fnut.2021.657491

Graybeal, A. J., Brandner, C. F., & Tinsley, G. M. (2023). Evaluation of automated anthropometrics produced by smartphone-based machine learning: a comparison with traditional anthropometric assessments. British Journal of Nutrition, 130(6), 1077–1087. https://doi.org/10.1017/S0007114523000090

Gubawa, A., & Abuzairi, T. (2020). EasyChair Preprint Electronic System Design for Clinical Applications of Stunting Case Electronic System Design for Clinical Applications of Stunting Case.

Gupta, P. M., Sivalogan, K., Oliech, R., Alexander, E., Klein, J., Addo, O. Y., Gethi, D., Akelo, V., Blau, D. M., & Suchdev, P. S. (2023). Impact of anthropometry training and feasibility of 3D imaging on anthropometry data quality among children under five years in a postmortem setting. PLoS ONE, 18(9 September). https://doi.org/10.1371/journal.pone.0292046

Halimah, N. N. (2024). Karakterisasi Sensor Hy-Srf05 Dan Load Cell Single-Point Sebagai Parameter Pengukuran Antropometri Pada Sistem Pemantauan Status Gizi Bayi. https://doi.org/10.21009/03.1201.FA10

Hapsari, J. P. (2024). Perancangan Modifikasi Alat Antropometri sebagai Solusi Ketepatan Pengukuran Berbasis Sensor Ultrasonik. 2(4), 110–117. https://doi.org/10.61722/japm.v2i4.2129

Hijrawati, Usman, A. N., Syarif, S., Hadju, V., As'ad, S., & Baso, Y. S. (2021). Use of technology for monitoring the development of nutritional status 1000 hpk in stunting prevention in Indonesia. Gaceta Sanitaria, 35, S231–S234. https://doi.org/10.1016/j.gaceta.2021.10.028

Jefferds, M. E. D., Mei, Z., Palmieri, M., Mesarina, K., Onyango, D., Mwando, R., Akelo, V., Liu, J., Zhou, Y., Meng, Y., & Bougma, K. (2022). Acceptability and Experiences with the Use of 3D Scans to Measure Anthropometry of Young Children in Surveys and Surveillance Systems from the Perspective of Field Teams and Caregivers. Current Developments in Nutrition, 6(6), 1–14. https://doi.org/10.1093/cdn/nzac085

Jensen, N., Lepariyo, W., Alulu, V., Sibanda, S., & Kiage, B. N. (2023). Assessing Mbiotisho: A smartphone application used to collect high-frequency health and nutrition data from difficult-to-reach populations. Maternal and Child Nutrition, 19(3). https://doi.org/10.1111/mcn.13496

Kemenkes. (2022). Buku Saku Hasil Survei Status Gizi Indonesia (SSGI) 2022.

Kennedy, S., Smith, B., Sobhiyeh, S., Dechenaud, M. E., Wong, M., Kelly, N., Shepherd, J., & Heymsfield, S. B. (2022). Digital anthropometric evaluation of young children: comparison to results acquired with conventional anthropometry. European Journal of Clinical Nutrition, 76(2), 251–260. https://doi.org/10.1038/s41430-021-00938-x

Kustiawan, T. C., Nadhiroh, S. R., Ramli, R., & Butryee, C. (2022). Use of mobile app to monitoring growth outcome of children: A systematic literature review. Digital Health, 8. https://doi.org/10.1177/20552076221138641

Leidman, E., Jatoi, M. A., Bollemeijer, I., Majer, J., & Doocy, S. (2022). Accuracy of Fully Automated 3D Imaging System for Child Anthropometry in a Low-Resource Setting: Effectiveness Evaluation in Malakal, South Sudan. JMIR Biomedical Engineering, 7(2), e40066. https://doi.org/10.2196/40066

Lensoni, L., Elmiyati, E., Yulinar, Y., Yahya, M., & Hanum, U. (2023). Effectiveness of Using the Anthropometric Stunting Meter in Children Aged 24-59 Months at the Lageun Health Center, Aceh Jaya District. Jurnal Penelitian Pendidikan IPA, 9(9), 6952–6956. https://doi.org/10.29303/jppipa.v9i9.5015

Ludya, M., Herlambang, Y., & Yunidar, D. (2023a). Produk alat ukur tinggi dan berat badan pendeteksi stunting dengan fitur hiburan untuk anak usia 2-5 tahun. Productum: Jurnal Desain Produk (Pengetahuan Dan Perancangan Produk), 6(1), 51–62. https://doi.org/10.24821/productum.v6i1.7685

Ludya, M., Herlambang, Y., & Yunidar, D. (2023b). Produk alat ukur tinggi dan berat badan pendeteksi stunting dengan fitur hiburan untuk anak usia 2-5 tahun. Productum: Jurnal Desain Produk (Pengetahuan Dan Perancangan Produk), 6(1), 51–62. https://doi.org/10.24821/productum.v6i1.7685

Mocini, E., Cammarota, C., Frigerio, F., Muzzioli, L., Piciocchi, C., Lacalaprice, D., Buccolini, F., Donini, L. M., & Pinto, A. (2023). Digital Anthropometry: A Systematic Review on Precision, Reliability and Accuracy of Most Popular Existing Technologies. In Nutrients (Vol. 15, Issue 2). MDPI. https://doi.org/10.3390/nu15020302

Putra, R. A., Fatoni, G. A., Rifai, M. H., Ahsani, E. W., & Danendra, R. D. (2024). Validasi Akurasi Pengukuran Terhadap Benda Menggunakan Sensor Ultrasonik Berbasis NodeMCU 8266. 2(3), 188–195.

Sains, F.-J., & Vol, T. (2023). [Design And Construction Of Digital And Portable. 7(2), 98–110.

Siswati, T. (2023). Development of Non-Contact Detection of Child Stunting Using Ultrasonic Sensors. Researchgate.Net, 19–29. https://doi.org/10.17605/OSF.IO/6GFAP

Smith, M. K., Staynor, J. M. D., El-Sallam, A., Ebert, J. R., & Ackland, T. R. (2023). Longitudinal concordance of body composition and anthropometric assessment by a novel smartphone application across a 12-week self-managed weight loss intervention. British Journal of Nutrition, 130(7), 1260–1266. https://doi.org/10.1017/S0007114523000259

Sobhiyeh, S., Dunkel, A., Dechenaud, M., Mehrnezhad, A., Kennedy, S., Shepherd, J., Wolenski, P., & Heymsfield, S. B. (2021). Digital anthropometric volumes: Toward the development and validation of a universal software. Medical Physics, 48(7), 3654–3664. https://doi.org/10.1002/mp.14829

Sofie, M., Kusi Olla, P., Kusumaningtyas, P., & Maduratni Chambali, F. (2023). Stunting Monitoring in Indonesia. Indonesian Journal of Electronics, Electromedical Engineering, and Medical Informatics, 5(4), 217–223.

Soller, T., Huang, S., Horiuchi, S., Wilson, A. N., & Vogel, J. P. (2023). Portable digital devices for paediatric height and length measurement: A scoping review and target product profile matching analysis. PLoS ONE, 18(7 JULY). https://doi.org/10.1371/journal.pone.0288995

sri winarni, sugeng iwan, D. (2019). modifikasi pengukuran TB &BB.

SSGI. (2022). Buku Saku Hasil Survei Status Gizi Indonesia (SSGI) 2022.

Umiatin, U., Indrasari, W., Taryudi, T., & Dendi, A. F. (2022). Development of a Multisensor-Based Non-Contact Anthropometric System for Early Stunting Detection. Journal of Sensor and Actuator Networks, 11(4). https://doi.org/10.3390/jsan11040069

WHO. (2022). Stunting prevalence among children under 5 years of age (%) (model-based estimates). Global Health Observatory Data Repository, 5, 35. https://www.who.int/data/gho/data/indicators/indicator-details/GHO/gho-jme-stunting-prevalence

Widodo, S., & Sulistiyanti, A. (2022). Development Of Intelligent Software For Early Detection Of Stunting In Toddlers Based On Anthropometry.