Non-contact Measurement Using Ultrasonic Technology for Human Anthropometric: A Narrative Review

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Authors' contributions

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

Systematic Review Article

ABSTRACT

Introduction: Stunting is a public health priority in low- and middle-income countries. Thus, the validity and reliability of anthropometric measurement tools become critical for early stunting detection in children.
Objective: This article aims to review the use of ultrasonic sensors in human anthropometric and body measurements.
Methods: We conducted a narrative review of articles regarding the ultrasonic sensor for measuring anthropometrics in the human body between 2016 and 2022. We focused particularly on the use of ultrasonic sensors in children's anthropometrics, body size, and body measurements.

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Results: According to the findings, the majority of non-contact measurements using ultrasonic sensors were applied to adults, though several studies also involved pregnant women to measure foetus size. These studies showed that ultrasonic sensors were beneficial as they served as accurate, reproducible, affordable, and easy-to-use tools.
Conclusion: Future studies are warranted to understand the significance of the non-contact measurements for children's anthropometrics, especially for early stunting detection.

1. INTRODUCTION

Stunting is chronic malnutrition that occurs during pregnancy. Stunting is characterized by a shorter body size than normal. Currently, the problem of stunting is a priority problem for public health in global countries in the world and Indonesia, as stated in the Sustainable Development Goals Target 2 [1]. Following the mandate of the President of the Republic of Indonesia (RI) Jokowi, stunting under five is a priority public health problem with efforts to accelerate the decline in prevalence with a target of 14% by Presiden et al. [2]. To meet the demands of accelerating development in various health sectors, the Ministry of Health of the Republic of Indonesia seeks to make changes through health system transformation which focuses on six areas including primary service transformation, referral service transformation, health security system transformation, health financing system transformation, health HR transformation and health technology transformation.

Stunting is determined by measuring height or body length compared to age or HAZ, the measurement results are then compared with anthropometric standards. Toddlers are said to be stunted if the HAZ is less than the -2 Z-score. Standard measuring instruments, measuring expertise and compliance with how to take measurements are important factors that determine measurement [3]. The provision of appropriate data is an important aspect for further determination of stunting intervention programs, monitoring and evaluation.

Government efforts to optimize growth monitoring by determining measuring instrument standards are very important in maintaining the validity and reliability of measurement results [3] by doing it manually and body contact between the gauge and the measured. In fact, the practice of measuring by manual means has many deviations in the value/measurement results due to various things, including lack of knowledge, skills, compliance and motivation of the meter, cooperation between toddlers who are measured with fewer meters, limited human resources/cadres/officers, and complicated operations.

The use of ultrasonics is experiencing a very rapid development of technological advances in various fields including utilization in the health sector [4]. Ultrasonics is becoming a popular sensor for use including in the health sector [5]. Currently, several digital height measurement innovations by utilizing various technologies have been developed. For example, stadiometers with ultrasonic sensors such as in the study in Canada [6], Korea [7], France [8], United Kingdom [9], Argentina, Brazil, Democratic Republic of the Congo, Denmark, Egypt, France, Germany, India, Norway, and Thailand [10] also in Indonesia [11]. This article is a review of the use of ultrasonic sensors in anthropometry and body measurement in humans worldwive.

2. METHODS

This article is a literature review to discusses anthropometry tools using ultrasonic technology in humans. The source of review literature was a search engine on Google Scholar, PubMed, Science Direct and SCOPUS accessed in full text and published in 2016-2022 and followed the research question. The research design included all types of observational studies, such as cross-sectional, case-control and cohort, trials, and reviews. The reference source search keywords were Ultrasonic OR sensor AND anthropometry OR body measurement. Fig. 1 shows identified articles based on these criteria.

3. RESULTS AND DISCUSSION

The literature search obtained 46 articles, which were narrowed by the inclusion criteria. The final selection involved nine articles relevant to the review. Table 1 provides a summary of the ultrasonic sensor for human body measurement.

Table 1. Overview of the ultrasonic sensor for human body measurement evaluated in this study

No.	Country	Title	Research design	Participants	Outcomes	Results
1.	Canada	Test-retest Reliability and Validity of Body Composition Methods in Adults [6]	Cross-sectional survey	18-65 years old, 50 men and women	Weight, height, body mass	Ultrasonic technology could estimate body fat % and body circumference well, validly, and reliably with minimal expertise.
2.	NA	Ultrasound imaging, a stethoscope for body composition assessment [12]	A Review	NA	Body weight, body fat	Ultrasonic was a fast, close, low-cost, and widely available technology. Results were accurate so that they could be used for screening and clinical purposes. The use of ultrasonic technology tools was easy so that users could be trained quickly.
3.	Ten countries: Argentina, Brazil, Democratic Republic of the Congo, Denmark, Egypt, France, Germany, India, Norway, and Thailand	The World Health Organization Fetal Growth Charts: A Multinational Longitudinal Study of Ultrasound Biometric Measurements and Estimated Fetal Weight [10]	Cohort	1387 pregnant women aged 25-31 years with singleton pregnancies in the middle- and high-economic group	Fetal size	The estimation of baby weight using ultrasonic in female infants was smaller than in male infants. Maternal height and weight were related to fetal weight estimation
4.	Korea	Reliability and Validity of an Ultrasonic Device for Measuring Height in Adults [7]	Cross-sectional	120 adults	Body height	The ultrasonic stadiometer was reliable and valid for measuring adult height
5.	Indonesia	Development of a Multisensor-Based Non-Contact Anthropometric System for Early Stunting Detection [11]	Cross-sectional	Five under-five children	Body height, head circumference, body mass	The accuracy of measurements with ultrasonic sensors for height had an error rate of <5%.

| No.	Country	Title	Research design	Participants	Outcomes	Results
6.	France	Prediction of per cent total body fat in adult men using ultrasonic and anthropometric measurements versus DXA [13]	Cross-sectional	63 men	Body fat	Ultrasonic techniques could provide an estimated value of per cent body fat in an easy way to apply in the community
7.	Nigeria	Development of a Digital Body Mass Index (BMI) measuring device for low-resource settings [14]	Operational research	8 persons	Body weight, body height	The designed digital device automatically measures weight, height, calculates BMI, and shows the user's nutritional condition on LCD screen based on BMI.
8.	NA	Current knowledge on the use of ultrasound measurements of fetal soft tissues for the assessment of pregnancy development [15]	Review	NA	Fetal size	Measurements by ultrasound in the subcutaneous tissue in different parts of the body could be a strong predictor of fetal weight, which was useful for sonography assessment of pregnancy.
9.	United Kingdom	Birth weight to placenta weight ratio and its relationship to ultrasonic measurements, maternal and neonatal morbidity: A prospective cohort study of nulliparous women [9]	Prospective studies	3311 women	Birth weight	The birth weight to placenta weight (BWPW) ratio was related to the results of measurements of neonatal health and maternal morbidity so the BWPW ratio became a biomarker of a person's health.
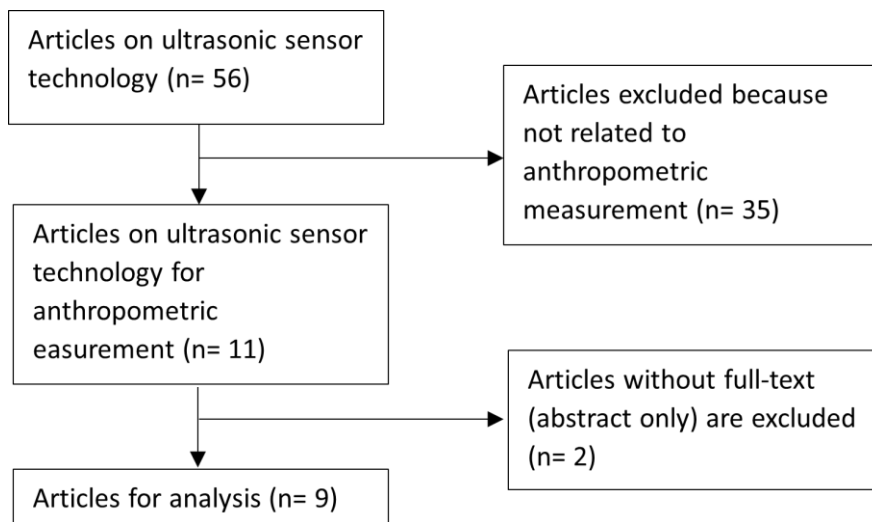
Fig. 1. Flow diagram of database search and article eligibility

Height is an indicator that reflects the adequacy of meeting long-term nutritional needs [16,17]. If someone is stunted, they are likely to experience intergenerational malnutrition [18,19] and social problems such as the economy, education and sanitation. Height is also closely correlated with growth and development. The results of the study stated that children who were stunted in parallel had developmental disorders [20].

One way to prevent and overcome stunting is to measure and detect growth regularly [21,22]. In general, measuring a child's height is done through traditional or manual methods, both standard and non-standard. The standard measuring instruments for height include a length board and a microtoise [23], while those that are not standardized include a measuring tape [24], height stickers [25] and growth mats [26]. All of these tools are carried out using physical contact between the child and the meter. In some conditions, it is sometimes impossible to measure height in the traditional way with human-to-human contact, such as the condition of COVID-19 which limits people from meeting and prevents disease transmission [27]. For this reason, digital technology using sensors is an option [28].

Several studies have reported various methods of non-contact anthropometric measurements using ultrasonic sensors [12,13,27,28]. It is believed that ultrasonic is a cost-effective height measurement tool compared to other sensors [29,30]. In addition, the height measuring sensor also has the advantage of being easy to use, having fewer human resources involved and having valid measurement results [8,27,29]. In several previous studies, measurement of body height with ultrasonic sensors was mostly applied to adult subjects [6,12,28,31], while estimation of fetal length and weight has been widely used by obstetricians through examinations of pregnant women [10].

4. CONCLUSION

The use of ultrasonic sensors to measure anthropometry provides optimal benefits in terms of cost-effectiveness, measurement results, minimal amount of power, minimal expertise, ease to carry and non-contact measuring and measuring to reduce the possibility of disease transmission. Anthropometric measuring instruments with ultrasonic sensors to measure the height or length of toddlers with centimetres, Z-score and nutritional status of toddlers do not yet exist, so it is necessary to design tools to detect stunting easily, cheaply, quickly and accurately with ultrasonics.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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