

The transformative potential of digital anthropometry in pediatric health: mapping a decade of innovations in anthropometric assessment (2014–2023)

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ABSTRACT

Pediatric health is crucial for global well-being, as growth and development indicators significantly influence long-term outcomes. Traditional anthropometric methods often face inaccuracies. Digital anthropometry that uses technology like 3D scanners offers precise, efficient solutions that promise to enhance pediatric health monitoring. This review aims to explore the current state of digital anthropometry in pediatric health. The authors sourced articles from EBSCO, PubMed, ProQuest, ScienceDirect, and Scopus between 2014 and 2023. The studies were reviewed based on set criteria, synthesizing data according to technology types, measurement capabilities, contributions to pediatric health, and adoption challenges and opportunities. The use of digital technologies was highlighted using 32 studies, most of which used a 3D scanner. These technologies made significant contributions to pediatric health. For instance, 3D scanners were used to assess cranial deformation in infants, detect facial features associated with Williams Syndrome, and monitor body composition to identify risks of obesity. Digital anthropometry enhances measurement capabilities, particularly in assessing diverse body dimensions. It contributes to improved nutritional and growth assessment, diagnosis and management of health conditions, medical device design, and home use applications. Despite challenges such as technical failures in scan processing and measurement inaccuracies caused by child movement or suboptimal conditions, the non-invasive, portable, and automated nature of these technologies presents significant opportunities for advancing pediatric health. This review highlights the transformative potential of digital anthropometry in pediatric health, addressing a critical gap in previous literature, which has predominantly focused on adult populations or single technologies. By synthesizing diverse applications across digital tools specifically for children, this review helps clarify how these innovations can improve growth monitoring and promote global health equity. Despite adoption barriers, its integration into healthcare is crucial, and future research needs to address challenges and ensure sustainability.

Keywords:

digital anthropometry, growth monitoring, nutritional assessment, pediatric health, 3d scanners, innovative healthcare, technology adoption challenges.

Citation:

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INTRODUCTION

Pediatric health is a cornerstone of global well-being, with growth and development during childhood serving as key indicators of future health outcomes.^{1,2} Routine monitoring of anthropometric measures—such as weight, height, and head circumference—is essential for assessing health status, ensuring adequate nutrition, and addressing global health issues.^{3,4} For instance, the threefold burden of malnutrition which includes stunting, wasting, and overweight, is among the most pressing health challenges faced by children worldwide,⁵ contributing to long-term physical and cognitive impairments.^{6–8} Ensuring precise and efficient measurement techniques is essential for addressing these challenges and improving pediatric health outcomes.⁹

The conventional techniques for anthropometric measurement, including manual procedures such as the use of measuring tapes, calipers, stadiometers and weight scales, are commonly used but often face limitations.¹⁰ These methods are susceptible to errors in measurement owing to various factors, including the anthropometric design, incorrect child positioning, and human error in reading or recording measurements.^{3,11} Importantly, errors in these measurements have the potential to impact the quality of the data, which can affect interpretation and lead to misclassification of nutritional status, intervention planning, and referrals.⁷

To address these constraints, improved anthropometric measurement technologies collectively referred to as digital anthropometry are being utilized. Digital anthropometry encompasses tools such as three-dimensional (3D) scanners, photogrammetry, and smartphone-based applications, which offer novel, technology-driven methods for capturing human body measurements with greater

precision. Although relatively new in healthcare, these technologies are increasingly being adopted to overcome the limitations of traditional manual methods. For some years, the technology has been employed to measure the 3D shape of objects; however, it now possesses the capability to accurately and precisely measure human body shapes.¹² This technology has been applied in diverse settings, from clinical to public health settings, enhancing health equity by providing access to precise, non-invasive pediatric measurements, such as using 3D scanners to detect stunting early in remote or low-resource communities where traditional tools and trained personnel are limited.⁹ This technique offers remarkable efficiency and reproducibility, providing highly detailed, and accurate measurements.¹³ As digital technologies become increasingly accessible, their integration into pediatric health systems holds promise for revolutionizing growth monitoring and promoting equitable healthcare access.

Previous reviews on digital anthropometry—such as the systematic review by Rumbo-Rodríguez et al. (2021)—have predominantly focused on specific technologies like 3D body scanners and have largely examined adult populations. As a result, there is limited synthesis of how digital anthropometric tools are applied across diverse technologies and settings to address pediatric health challenges. This scoping review aims to fill this gap by providing a comprehensive overview of the current state of digital anthropometry in pediatric health. Specifically, it explores digital anthropometry technologies, applications and adoption challenges. By uniquely synthesizing the breadth of digital anthropometry technologies and their applications in pediatric health—a focus often overlooked in prior research—this

scoping review establishes a novel foundation for the development of precise, and scalable tools that can significantly improve child health outcomes on a global scale.

METHODS

This study employed a scoping review methodology, in accordance with the standards set forth by the Joanna Briggs Institute (JBI) and Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines.^{14,15} This scoping review was performed according to the five-stage methodology initially proposed by Arksey and O'Malley.¹⁶ Ethical approval for this study was obtained from the Health Research Ethics Committee of the Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Yogyakarta (No. 087/EC-EXEM-KEPK FKIK UMY/IX/2024), approved on 17 September 2024.

Stage 1: Identifying the Research Question

The research team discussed and identified four guiding questions to frame the scope of this review: (1) Which digital anthropometry technologies are currently used in pediatric health? (2) What are their measurement capabilities? (3) How do these technologies contribute to pediatric health outcomes? and (4) What challenges and opportunities exist for their adoption? These questions guided the search strategy, inclusion criteria, and data extraction, ensuring a comprehensive examination of the role of digital anthropometry in pediatric healthcare.

Stage 2: Identifying Relevant Studies

The academic articles were sourced from EBSCO, PubMed, ProQuest, ScienceDirect, and Scopus. To ensure comprehensiveness, a Boolean search strategy was employed using a combination

of MeSH and Thesaurus keywords from three conceptual domains: digital (“digital,” “automated”), anthropometry (“anthropometry,” “body measure,” “body size,” “body composition”), and children (“children,” “pediatric”). Boolean operators (AND, OR) were applied to generate comprehensive keyword combinations. Example search strings included:

- “digital” AND “body size” AND “children”
- “automated” AND “anthropometry” AND “pediatric”
- “digital” AND “body composition” AND “children”

These combinations allowed for an exhaustive identification of studies related to digital anthropometry in pediatric populations.

Stage 3: Study Selection

Despite the application of the search terms, a considerable number of articles will remain irrelevant, particularly in answering the research questions posed. The authors established inclusion and exclusion criteria for the review.

Inclusion Criteria:

Publications that meet the following criteria were included:

- Studies published in English (2014-2023). This timeframe was selected to reflect the most recent advancements and developments in digital anthropometry technology, which has rapidly evolved over the past decade and increasingly been applied in pediatric health contexts.
- Studies involving digital anthropometry.
- Studies conducted in any setting.

Exclusion Criteria:

- Studies focusing on non-children populations (up to 18 years old).
- Studies in review designs.
- Studies lacking available full texts.

All references were exported to Rayyan (<https://www.rayyan.ai/>), a web-based tool for managing research, to

facilitate article screening. Two reviewers independently screened titles, abstracts, and full texts using Rayyan's blind mode to minimize bias, and duplicates were removed. The reviewers followed the PRISMA-ScR flow diagram during the selection process. Blind mode was then disabled to compare results. Discrepancies in article inclusion were resolved through structured discussion guided by predefined inclusion and exclusion criteria. If consensus could not be reached, a third reviewer was available for arbitration, although this was not ultimately required.

Stage 4: Charting the Data

The authors developed a tabulated data charting form in Microsoft Word to extract key variables, including author, year, country, technology, measurement capabilities, applications, and challenges/opportunities of digital anthropometry. The primary author extracted the data, and the secondary author verified it.

Stage 5: Collating, Summarizing, and Reporting the Results

This section outlines the characteristics of the included studies, including frequency by year, region, development status, and population. To analyze the extracted data, a thematic analysis was conducted following Braun and Clarke's (2006) six-phase framework: familiarization with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. Coding was conducted manually by the first author and verified independently by the second author to enhance reliability. Four main themes emerged from the data: (1) digital

anthropometry technology types, (2) measurement capabilities, (3) applications in pediatric health, and (4) challenges and opportunities in adoption. The results are presented using diagrams, tables, and descriptive formats, ensuring alignment with the objectives of the scoping review.

Limitations of the Methodology

This review is subject to certain methodological limitations. The exclusion of non-English studies may limit the comprehensiveness of the evidence base and potentially overlook relevant research conducted in other languages. Additionally, reliance on published databases may have excluded gray literature or unpublished studies, which can provide valuable insights into emerging or underreported research areas.

RESULTS

Included studies

As illustrated in the PRISMA-ScR flow diagram, a total of 1,771 records were identified across the five databases: EBSCO (526 records), Scopus (24 records), PubMed (914 records), ProQuest (165 records), and ScienceDirect (142 records). After the removal of 109 duplicate records, 1,662 unique records underwent screening. Of the 1,662 unique records screened, 92 were assessed for eligibility, and 32 were included. The most common reasons for exclusion were irrelevant study populations ($n=44$) and unsuitable study designs ($n=14$). See **Figure 1. PRISMA-ScR Flow Diagram for The Included Studies** for a detailed flow of study selection.

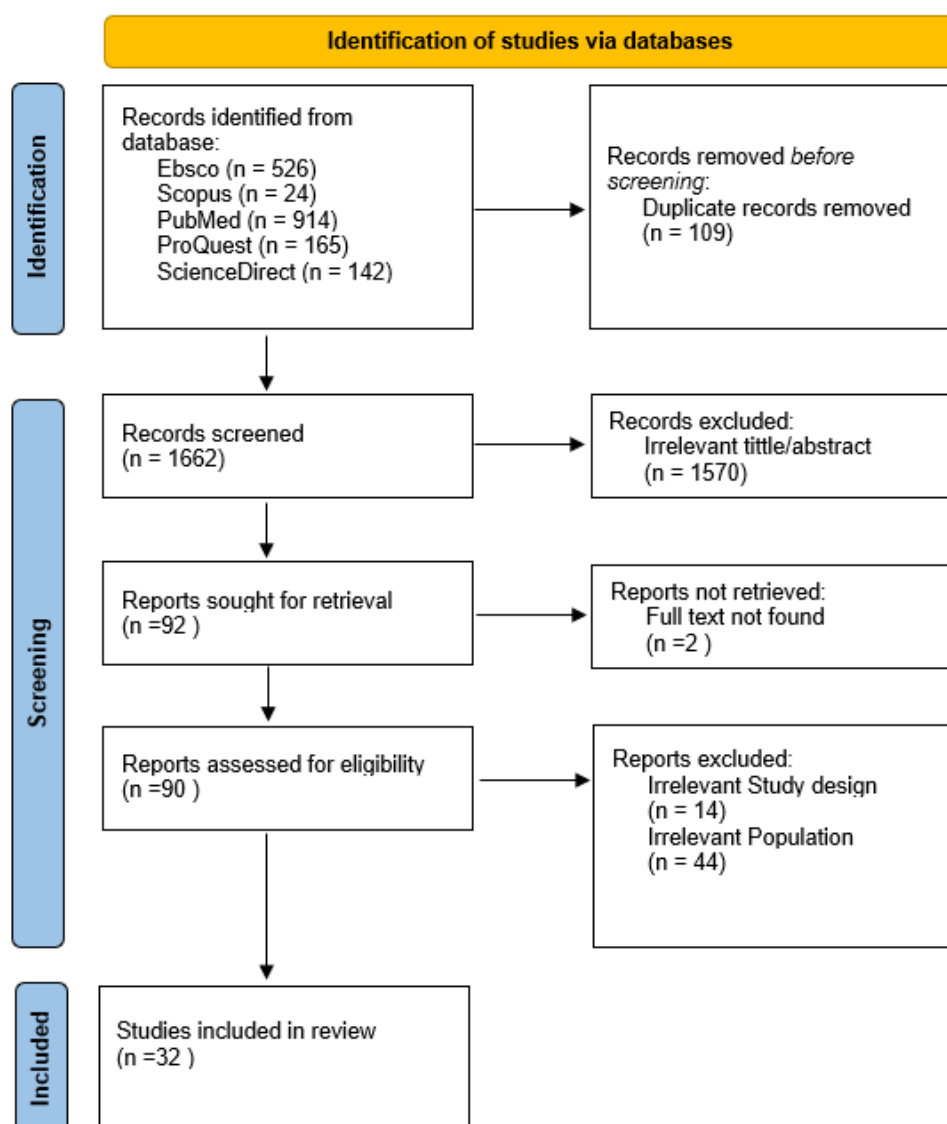


Figure 1. PRISMA-ScR Flow Diagram for The Included Studies

Characteristics of the included studies

Publication by Year

Figure 2. *Publication by Year (2014-2023)* presents the characteristics of the thirty-two publications included in the final review. Research interest in digital anthropometry for pediatric health from 2014 to 2023 has revealed notable fluctuations. Publication peaks occurred in 2018, 2019, and 2022, each with five studies. These peaks may reflect growing global attention to technological advancements such as the wider availability of 3D scanners and smartphone-based health tools, as well as heightened public health awareness about child growth

monitoring, especially following key global initiatives targeting childhood malnutrition and digital health transformation. Conversely, 2021 recorded the fewest publications (n=1), which may be attributed to disruptions caused by the COVID-19 pandemic that affected research activities, funding, and fieldwork globally. Despite this dip, interest has grown in recent years, with consistent publications noted in both 2022 and 2023. This overall trend highlights an increasing acknowledgment of digital anthropometry's role in improving pediatric health, while also signaling the need for more sustained and regionally

diverse research efforts in this evolving field.

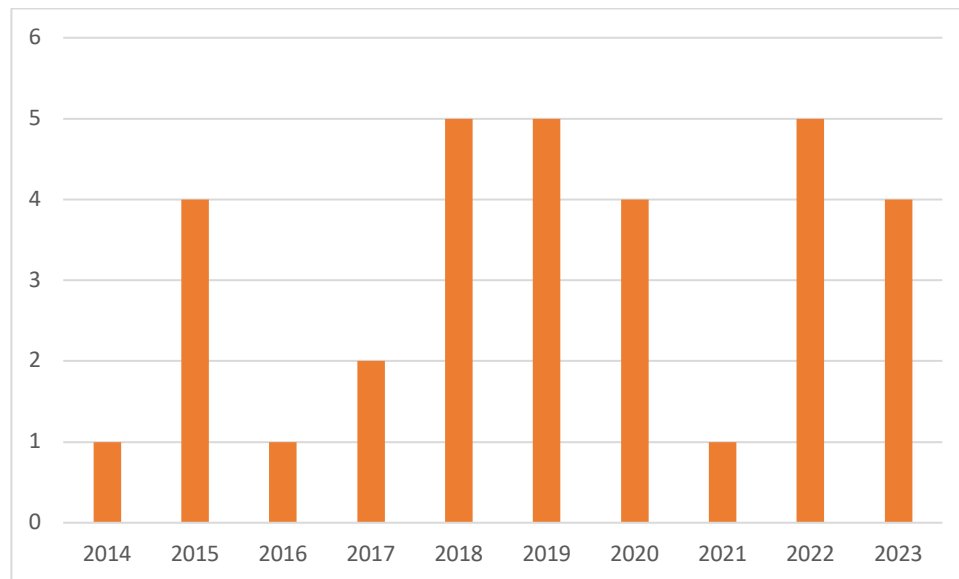


Figure 2. Publication by Year (2014-2023)

Publication by Region

The map in **Figure 3. *Global Distribution of Included Studies*** illustrates the global distribution of studies on digital anthropometry in pediatric health, with the United States ($n=8$) and China ($n=3$) emerging as leading contributors. This dominance likely reflects their substantial investments in research and development, robust infrastructure, and access to cutting-edge digital health technologies. High-income countries benefit from well-established funding mechanisms, interdisciplinary research ecosystems, and stronger institutional capacity, enabling greater innovation and large-scale studies. In contrast, low- and middle-income countries (LMICs) remain significantly underrepresented in the literature, despite

bearing a disproportionate burden of child malnutrition and growth-related health issues. Barriers such as limited funding, insufficient infrastructure, restricted access to digital tools, and a shortage of trained personnel hinder the production and implementation of research in these settings. While some progress is visible—such as collaborative efforts involving Kenya and Guatemala—the overall disparity highlights a critical technological gap. Bridging this divide requires sustained international collaboration, targeted capacity-building initiatives, and context-appropriate innovations to ensure that the benefits of digital anthropometry are equitably accessible across diverse healthcare systems.

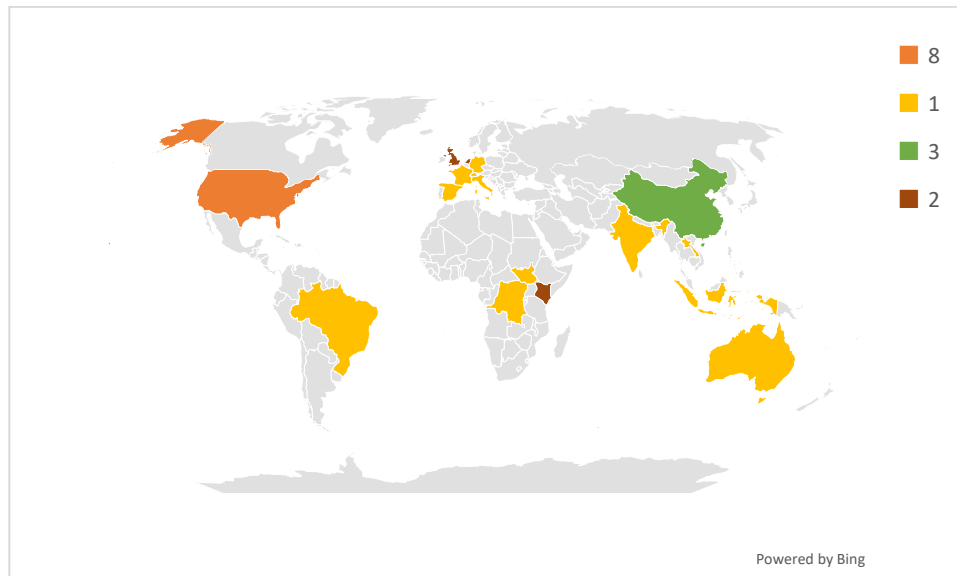


Figure 3. Global Distribution of Included Studies

Publication by Population

The pie chart in **Figure 4. Target Age Groups of Study Populations** illustrates that the research publications demonstrate a pronounced emphasis on early childhood, with 16 studies specifically targeting the 0-5 age group. Depicted as well are studies that include

both children and adults in the same sample, which total 12 publications. In contrast, studies focusing solely on children between the ages of 5 and 17 are comparatively rare, with only four publications. This trend underscores the significant research emphasis on early childhood development.

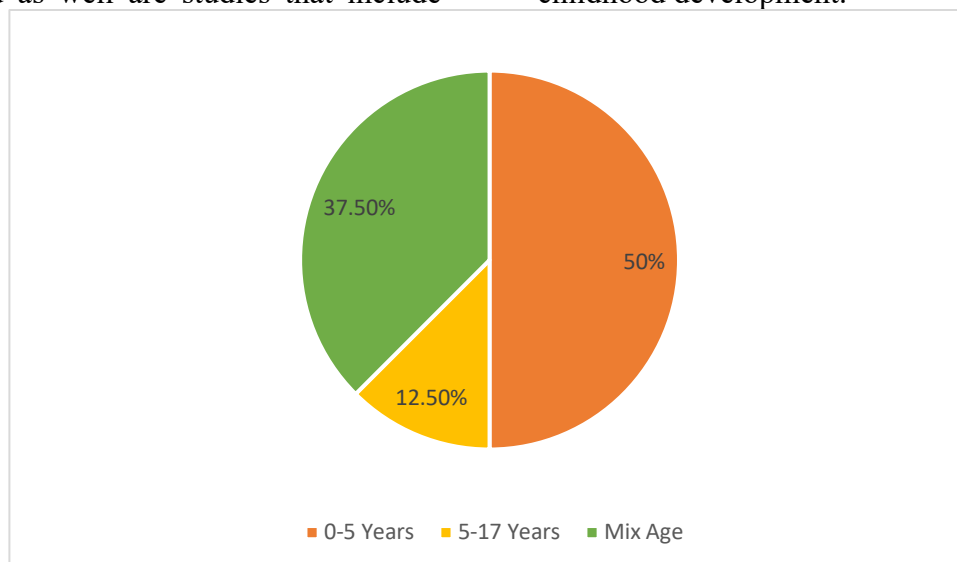


Figure 4. Target Age Groups of Study Populations

Pediatric Digital Anthropometry

Pediatric digital anthropometry uses advanced technologies to assess children's physical characteristics. This review

explores its tools, measurement capabilities, contributions to pediatric health, and adoption challenges and opportunities.

Technology Used in Digital Anthropometry**Table 1.** Digital Anthropometry Technologies Used in Pediatric Health Studies

Category	Author
3D scanner	Gupta et al ¹⁷ , Sacco et al ¹⁸ , Zhang et al ¹⁹ , Bougma et al ²⁰ , Jefferds et al ²¹ , Kennedy et al ²² , Leidman et al ²³ , Wu et al ²⁴ , Ji et al ²⁵ , Kennedy et al ²⁶ , Wong et al ²⁷ , Amirav et al ²⁸ , Andrews et al ²⁹ , Pleuss et al ³⁰ , Conkle et al ³¹ , Ganesan et al ³² , Loeffler-Wirth et al ³³ , Santos et al ³⁴ , Soileau et al ³⁵ , Wells et al ³⁶
Photogrammetry	Burini et al ³⁷ , Penders et al ³⁸ , Affuso et al ³⁹ , Penders et al ⁴⁰ , Sokolover et al ⁴¹
Smartphone	Barbero-Garcia et al ⁴² , Wetzel et al ⁴³ , Fletcher et al ⁴⁴
Multisensor	Umiatin et al ⁴⁵
Laser	Bauman et al ⁴⁶ , Mayol-Kreiser et al ⁴⁷
Ultrasound	Huang et al ⁴⁸

Table 1. *Digital Anthropometry Technologies Used in Pediatric Health Studies* identifies the studies that present various digital anthropometry technologies used in pediatric health. 3D scanners (n=20) are highly accurate and capable of capturing body circumferences and craniofacial dimensions^{24,34}. However, they often require stable power sources, and lack portability, which limits their practicality in low-resource or field settings²⁶. Photogrammetry (n=5) allows non-contact measurement by analyzing digital images to estimate body proportions such as body length and width based on anatomical landmarks^{38,40}, although its accuracy can depend on image quality and positioning^{37,41}. Smartphone-based tools (n=3) though relatively novel, stand out for their accessibility and potential for scalability. Equipped with machine vision, these

applications streamline measurements and are promising for remote or home-based health monitoring²⁶. However, these tools may face challenges in accuracy, especially in cases where lighting, positioning, or camera quality is suboptimal⁴³. Multi-sensor devices (n=1) integrate multiple sensors to simultaneously collect diverse anthropometric data, but they can be complex to calibrate and operate⁴⁵. Laser (n=2) and ultrasound devices (n=1) are typically more portable and user-friendly, suitable for measuring basic dimensions such as height and length in field conditions, but they may not capture detailed body composition⁴⁸. The diversity of technologies reflects both the innovation in digital anthropometry and the need to match tools with specific clinical and operational contexts.

Digital Anthropometry Measurement Capabilities**Table 2.** Measurement Capabilities of Digital Anthropometry Tools

Category	Explanation
Head and facial	Head shape, head circumference, cranial circumference, craniofacial (intercanthal width, biocular width, nose height, nose width, mouth width, face height, ear length, and ear width)

Category	Explanation
Body length and width	Stature (height or length), upper arm length, lower arm length, hand length, sitting height, arm span, biacromial width, biiliac width, waist width, abdomen width
Body circumference	Mid-upper arm, waist, hip, seat, wrist, chest, abdomen, thigh, knee, calf, neck, biceps
Body composition	Fat mass, free mass, lean mass, and bone mass
Foot and ankle	Foot and ankle length, height, grith, width
Complementary measurement	Body mass index, body weight, body temperature

Table 2. *Measurement Capabilities of Digital Anthropometry Tools* presents a wide range of measurement capabilities offered by digital anthropometry tools, highlighting their advanced functionality compared to traditional methods. Among these, 3D imaging systems stand out for their ability to capture detailed body circumferences^{17,20,23,31,34}—as well as body composition parameters—including fat mass, lean mass, and bone mass.^{26,27,30} These metrics are challenging to obtain through manual techniques, underscoring the unique value of 3D technology in pediatric assessment.^{24,34} In addition to basic measurements like body length and width,^{38,40} digital tools also enable the precise evaluation of complex anatomical

structures, including craniofacial dimensions and foot geometry.^{18,25} Such comprehensive data collection has important implications for pediatric health. For instance, body circumference and body composition analysis support early detection of malnutrition, while craniofacial and foot measurements facilitate the diagnosis of developmental anomalies such as cranial deformations or syndromic features and clubfoot deformations.⁴⁵ By offering a non-invasive, efficient, and scalable approach to anthropometric assessment, digital tools provide critical support for monitoring growth, guiding clinical interventions, and designing custom medical devices for children with unique health needs.

The Contribution of Digital Anthropometry to Pediatric Health

Table 3. Key Contributions of Digital Anthropometry to Pediatric Health

Category	Explanation
Nutritional and growth assessment	• Nutritional status assessments in healthy and deceased children under five • Health risk assessment related to obesity • Early detection of stunting • Monitor body type
Diagnosis and management of health condition	• Cranial deformation assessment • Diagnosis and management of clubfoot deformities • Identifying facial features of children with Williams Syndrome (WS) • Analyzing body proportions in children with CHARGE syndrome
Medical device design	• Supporting the design of medical devices tailored for children • Designing customized helmets for infants with abnormal head shapes

Category	Explanation
	• Designing customized footwear and orthotic device for specific foot deformities
Home use application	• Monitoring weight loss or fitness program results over time

Table 3. Key Contributions of Digital Anthropometry to Pediatric Health highlights several key contributions of digital anthropometry to pediatric health, with particularly impactful applications in nutritional and growth assessments. Digital anthropometry plays a critical role in evaluating nutritional status, especially in early childhood where accurate measurements are essential for guiding interventions against stunting and malnutrition. For instance, 3D scanners have been used effectively to assess the nutritional status of both healthy and deceased children under five, providing vital data for understanding child health outcomes and mortality risks.¹⁷ Moreover, multi-sensor devices support early stunting detection by monitoring key growth indicators in a non-contact and efficient manner.⁴⁵ The technology also facilitates early identification of obesity risks by monitoring body types and proportions over time.³³ Beyond growth assessment,

digital anthropometry supports diagnosis and management of health conditions, such as using photogrammetry to evaluate cranial deformities or 3D imaging to monitor clubfoot and analyze facial features in children with genetic syndromes like Williams Syndrome and CHARGE syndrome.^{25,38} Importantly, these technologies have also been utilized to enhance medical device design: for example, 3D scanners have enabled the development of customized helmets for infants with cranial deformities, improving therapeutic outcomes through better fit and comfort.²⁴ Likewise, digital measurements inform the design of child-specific face masks and orthotic footwear.²⁸ In addition to clinical use, digital anthropometry empowers home-based monitoring, where families can track changes in children's weight, BMI, and body shape, supporting proactive health management and lifestyle improvements.²⁶

Challenges and Opportunities to Adopting Digital Anthropometry in Pediatric Health

Table 4. Challenges and Opportunities in the Adoption of Digital Anthropometry

Challenges	
Category	Explanation
Technology	• Technical failures in scan processing, connectivity, and power issues. • Devices design optimized for adults lead to errors in pediatric measurements. • Lack of immediate scan results.
Data quality	• Missing measurements due to infant or children's movement or incorrect positioning. • Need for extensive training to manage devices and interpret data accurately. • Requirements for specific lighting and space. • Requires internet & adequate speed for uploading scans for review and calculations.

Challenges

Category	Explanation
	• Problem with clothing affected the measurement process.
Opportunities	
Category	Explanation
Technology	• Non-invasive. • Contactless. • Lower costs. • Automated. • Lightweight and portable systems. • Faster data acquisition and processing. • Digital storage facilitates longitudinal tracking.
Data quality	• High accuracy and precision. • Enabling to capture of complex measurements.

Table 4. *Challenges and Opportunities in the Adoption of Digital Anthropometry* presents a clear overview of the challenges and opportunities associated with the adoption of digital anthropometry in pediatric health. However, the challenges merit deeper exploration, particularly in relation to data quality. Several studies reported that child movement during scanning procedures led to incomplete or missing measurements, which was especially common with 3D scanners and laser-based tools where children were distracted by the projected beams or dots.^{20–22,24,27,36} For instance, some children looked down to follow the laser dot, compromising posture and scan accuracy.⁴⁷ Clothing also emerged as a significant barrier; loose or bulky garments interfered with surface detection, and while form-fitting attire could mitigate this, its use may not be feasible in colder climates or among children with body image sensitivities.^{21,26,36} In addition, environmental requirements—such as adequate lighting and internet connectivity—are often unmet in low-resource settings, impacting scan accuracy and the ability to upload data for remote analysis.^{17,20,21,23,24,31} Extensive training is also required to operate these tools correctly and interpret the data, which can limit scalability.^{3,23,31,32,48}

Conversely, the opportunities presented by digital anthropometry are

substantial. The non-invasive and contactless nature of technologies like 3D scanners, photogrammetry, and laser devices enhances patient comfort and safety. In real-world scenarios, such as high-risk neonatal care, these features are especially beneficial—contactless measurements help reduce infection risks for immunocompromised infants, and allow for anthropometric assessment without disturbing the child.²⁷ For example, photogrammetric tools have been used to measure head dimensions of infants in incubators without the need for physical handling.^{29,41} Beyond clinical accuracy, the growing availability of lightweight, portable, and automated systems significantly improves accessibility in remote or under-resourced areas, addressing barriers related to cost, limited infrastructure, and scarcity of trained personnel. These portable technologies reduce the need for specialized facilities, enabling community health workers to conduct high-quality anthropometric assessments in field conditions. Digital tools further allow for high-precision data capture and longitudinal tracking through digital storage, facilitating more informed and timely clinical decision-making.²⁶

Collectively, these advancements position digital anthropometry as a critical innovation for enhancing pediatric health monitoring and outcomes worldwide.

However, gaps remain—particularly the limited research on older pediatric populations (ages 5–17) and the absence of studies evaluating long-term clinical outcomes. Future studies should explore the scalability of smartphone-based solutions and address data quality issues in dynamic pediatric environments to ensure broader applicability and sustained impact.

DISCUSSION

The findings from this scoping review underscore the transformative potential of digital anthropometry in advancing pediatric health. The review synthesizes insights from 32 studies, spanning technological innovations, measurement capabilities, health applications, and adoption challenges and opportunities. Together, these findings offer a comprehensive understanding of how digital anthropometry is reshaping the landscape of pediatric healthcare.

To ensure alignment with the study's objectives, this discussion revisits the four research questions outlined in the methodology. First, regarding the types of digital anthropometry technologies used in pediatric health, the review identified six main categories – 3D scanners, photogrammetry, smartphone-based applications, multi-sensors, laser, and ultrasound devices. Among these, 3D scanners were the most frequently utilized because of their ability to provide rich anthropometric data.^{13,49} While earlier reviews such as Rumbo-Rodríguez et al. (2021) focused primarily on the use of 3D body scanners in adult populations and compared manual versus scanner-based measurements, our review distinctly contributes to the literature by synthesizing a broader spectrum of technologies and emphasizing their applications specifically within pediatric contexts.¹² This focus on children not only addresses a critical gap in existing literature

but also highlights how these digital tools can support child-specific health needs such as early detection of stunting, craniofacial anomalies, and the design of pediatric medical devices. By moving beyond the adult-centric scope of previous reviews, this study offers a novel and more inclusive perspective on the role of digital anthropometry in addressing global pediatric health challenges. However, our findings highlight a broader range of technologies and their multifaceted applications in pediatric health such as photogrammetry, smartphone applications, multi-sensors, lasers and ultrasound devices. This comprehensive approach enhances our understanding of how digital anthropometry can be leveraged to address global health challenges, especially in pediatric populations

Second, on measurement capabilities, the findings demonstrate a broad range, from head and craniofacial dimensions to body composition and circumferences, many of which are difficult to capture using traditional methods. Major et al. (2024) corroborated similar findings by emphasizing the advantages of 3D scanning. The study found that this technique enables the patient's face to be modelled with the highest possible accuracy, making it ideal for mapping soft tissue and areas with complex morphologies such as ears, noses, and lips.⁵⁰ Similarly, a study by Abdel-Alim et al (2023) demonstrated that utilizing photogrammetry technology for cranial measurements can rapidly and securely obtain high-dimensional data that surpasses conventional parameters.⁵¹ Additionally, studies by Smith et al. (2023) proved that combining the 3D scanner and mobile application technology is capable of providing precise and accurate body circumference measurements that are a gateway to many other anthropometrically derived body shape and composition

measures.⁵² Another study by Mueller et al. (2023) used 3D scanning for foot shape measurement.⁵³ Besides these complex measurements, our study found the use of laser and ultrasound devices to measure simple parameters such as body height, which was also reported by Sørensen et al. (2020) and Cho et al. (2021).^{54,55}

Third, in terms of contributions to pediatric health outcomes, digital anthropometry supports early detection of stunting, malnutrition, craniofacial abnormalities, and obesity risks, while also aiding medical device design and home health monitoring. The role of these technologies in detecting stunting aligns with Sofie et al. (2023), who developed a different technology from our research. They used the Internet of Things (IoT) by connecting baby scales to the database and web page via a Wi-Fi network.⁷ Lo et al. (2022) provided evidence for the utility of 3D photographs in evaluating the development of the craniofacial region in healthy infants and analyzing asymmetry patterns in the first year of life, findings that complement this review.⁵⁶ Our study found that digital anthropometry can contribute to supporting medical device design, especially for children. A study by Goto et al (2021) mapped the size and shape variation of Dutch children's heads and faces using a 3D scanner to investigate possible implications for the design of a ventilation mask.⁵⁷ Furthermore, consistent with our findings, a study by Yafie et al. (2020), highlighted the importance of accessible tools for home-use health monitoring using the Multi-Sensor-Based Non-Contact Anthropometric System, a mobile application designed to empower parents to track the nutritional status of children under the age of five.⁵⁸

Finally, the fourth question addressing adoption challenges and opportunities revealed barriers such as scan inaccuracies due to child movement and technical limitations, counterbalanced by opportunities including non-invasive use,

high accuracy, portability, and automation. Despite its many advantages, the adoption of digital anthropometry faces challenges such as data inaccuracies caused by child movement, and specific environmental requirements for optimal operation such as adequate lighting and internet connectivity, which are critical in low-resource settings. These issues are consistent with the findings of Soller et al. (2022), who assessed portable digital anthropometry in children through a scoping review⁹. Addressing these challenges calls for practical strategies such as standardizing form-fitting clothing during scans, developing more intuitive interfaces tailored for pediatric use, and implementing comprehensive training programs for healthcare workers to ensure accurate operation and data interpretation. However, the opportunities offered by digital anthropometry, including high accuracy, reduced time requirement, non-invasiveness, and cost-effectiveness, position it as a transformative tool for pediatric healthcare. Devices are becoming increasingly lightweight, automated, and portable, which enhances their feasibility in community-based or remote care settings. As technology advances, cost reductions and scalable innovations—such as smartphone-based applications, could further support implementation in under-resourced areas. Importantly, digital anthropometry enables longitudinal data collection, allowing for continuous growth monitoring and early detection of developmental issues. Mocini et al. (2023) also highlighted these attributes, particularly its potential to enhance clinical practice.¹⁰ Moreover, digital anthropometry offers reduced contact measurement, exemplified by innovations made by Pereira-da-Silva et al (2024), who used a laser-based length-measuring board to externally assess body length from the incubator, thereby minimizing the risk of microbial contamination and thermal instability for premature neonates.⁵⁹

Moreover, integrating these technologies into community health initiatives could empower local healthcare providers and caregivers, enabling decentralized, yet accurate, growth assessments that support timely interventions. These advancements underscore the transformative potential of digital anthropometry in improving pediatric health outcomes globally.

The study exhibits strengths, including its comprehensive synthesis of diverse current technologies, measurement capabilities, contributions to pediatric health, and the challenges and opportunities for its adoption. This study effectively addresses the gap in the literature concerning the pediatric population. The incorporation of a variety of tools, including 3D scanners, photogrammetry, smartphone-based applications, multi-sensors, lasers and ultrasound devices, highlights the extensive exploration of innovative methods. The study also identified challenges to data accuracy arising from environmental factors like lighting and internet connectivity, which can limit generalizability in low-resource settings. However, integrating digital anthropometry into public health programs presents a potential for mitigating global health disparities by enabling accurate, non-invasive assessments-especially in the areas of stunting prevention and nutritional monitoring. If designed for scalability and local adaptability, digital anthropometry could bridge the gap between high- and low-resource settings, promoting more equitable access to pediatric health surveillance and intervention. The exclusion of non-English studies may have omitted relevant research, particularly from regions where digital anthropometry is being tested in resource-limited settings. Future reviews should include multilingual studies to ensure broader global representation. Additionally, the predominance of studies focused on younger children (0–5 years)

highlights a gap in understanding the use of digital anthropometry for older pediatric populations. Future studies should address this demographic to explore broader applications. To strengthen the recommendations, future research directions should be more specifically articulated. Priority areas may include the development of low-cost, portable digital anthropometry tools that can be effectively used by community health workers, particularly in low-resource or remote settings. Additionally, longitudinal studies are needed to evaluate the long-term impact of digital anthropometry on pediatric health outcomes, including growth, nutritional status, and early disease detection. Further exploration into the integration of digital anthropometry with artificial intelligence could also enhance its utility, enabling automated analysis, predictive modeling, and more efficient clinical decision-making.

RECOMMENDATIONS

Digital anthropometry offers transformative potential for pediatric health by enhancing growth monitoring, nutritional assessment, and health condition management through precise, efficient, and non-invasive methods. To maximize its benefits, recommendations must be tailored to specific stakeholder groups. For researchers, future studies should focus on addressing identified gaps such as the lack of longitudinal evidence on the effectiveness of digital anthropometry and limited cost-effectiveness data compared to traditional methods. Policymakers should prioritize investments in low-cost, portable technologies that can be feasibly deployed in LMICs, coupled with supportive policies including subsidies and infrastructure development to reduce geographic disparities in adoption. For technology developers, improving device usability for

pediatric populations is critical, particularly in accommodating movement and variable positioning among children; integrating artificial intelligence and machine learning may further enhance measurement accuracy and automate error correction. Healthcare providers should receive standardized, hands-on training that includes culturally sensitive approaches and context-specific practices to ensure proper device usage and data interpretation. Establishing data standards is vital to guarantee measurement consistency and interoperability across devices and systems, while robust data privacy frameworks are needed to protect sensitive pediatric health data, particularly in cloud-based environments. To ensure long-term sustainability, multi-sectoral collaboration is necessary—engaging caregivers and community health workers to raise awareness and build trust, while co-designing technologies with end-user input ensures cultural relevance and practical functionality. Policy-level efforts must support integration into national growth monitoring frameworks and facilitate the scaling up of digital anthropometry through sustainable funding models and infrastructure development. Collectively, these actions will strengthen the adoption and impact of digital anthropometry in improving pediatric health worldwide.

AUTHORS' CONTRIBUTIONS

UA: Conceptualization, Software, Formal analysis, Investigation, Data curation, Visualization, Writing—original draft preparation, Writing—review and editing and Supervision. TH: Methodology, Software, Data curation, Supervision and Project administration.

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CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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