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REVIEW ARTICLE

# Ultrasound for assessing paediatric body composition and nutritional status: Scoping review and future directions

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## Abstract

**Aim:** This scoping review aims to assess the utility of ultrasound as a prospective tool in measuring body composition and nutritional status in the paediatric population. We provide a comprehensive summary of the existing literature, identify gaps, and propose future research directions.

**Methods:** We conducted a systematic scoping review following the PRISMA Extension for Scoping Reviews guidelines. This involved screening titles and abstracts of relevant studies, followed by a detailed full-text review and extraction of pertinent data.

**Results:** We identified and synthesised 34 articles. The review revealed that while ultrasound has been used to assess body composition and bone properties in children, significant gaps remain in the literature. These include limited studies on ultrasound performance, insufficient attention to relevant sample characteristics, reliance on manual image measurements, and limited sample diversity.

**Conclusion:** Point-of-care ultrasound shows significant promise for assessing paediatric body composition and nutritional status. To validate and enhance its effectiveness, further research is needed. Future studies should include larger and more diverse patient cohorts and conduct longitudinal investigations to evaluate nutritional interventions. Additionally, developing artificial intelligence (AI) for standardising and automating data interpretation will be crucial in improving the accuracy and efficiency of ultrasound assessments.

KEYWORDS
artificial intelligence, body composition, growth and development, machine learning, nutrition, ultrasound imaging

**Abbreviations:** ADP, And air displacement plethysmography; AI, Artificial intelligence; BIA, Bioelectrical impedance analysis; BMI, Body mass index; CT, Computed tomography; CV, Coefficient of variance; DXA, Dual X-ray Absorption; ICC, Inter-class correlation of coefficient; PRISMA-ScR, Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for scoping reviews; SDI, Socio-demographic Index; SES, Socioeconomic status.

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# 1 | INTRODUCTION

Malnutrition poses a widespread challenge in the field of global public health. Undernutrition and overnutrition contribute to a significant proportion of deaths and health complications across all age groups.[1] Notably, malnutrition is a significant factor contributing to childhood mortality, and overnutrition can contribute to the development of many fatal conditions further in the life course.[2] Addressing malnutrition, however, presents several challenges, as conventional indicators of nutritional status may offer misleading or ambiguous insights into a patient's actual health status.[3] The standard measures for assessing nutrition and growth include anthropometric indicators, such as weight, height, and body mass index (BMI). These measures offer valuable information about nutritional status but lack specificity in distinguishing between, for example, healthy weight gain in muscle compared to unhealthy fat accumulation.[4]

Because anthropometric indicators have limitations in assessing optimal nutritional status, researchers are exploring innovative methods for assessing other pertinent biomarkers, such as body composition, to enhance the evaluation of nutritional status.[5] Body composition refers to the distribution of fat, muscle, bone, and other components within the body and thus provides a more nuanced understanding of an individual's physical makeup. This information is beneficial for assessing nutrition because it helps differentiate between healthy and unhealthy weight changes, which offers insights into the effectiveness of dietary patterns and overall nutritional well-being.[6]

Currently, the gold standard methods for examining body composition include bioelectrical impedance analysis (BIA), Dual X-ray Absorption (DXA), deuterium dilution ("doubly labeled water"), and air displacement plethysmography (ADP).[6–9] Among these, BIA and DXA are the most widely used. BIA is portable and cost-effective, measuring body composition based on the resistance of body tissues to a small electrical current. DXA, on the other hand, uses low-dose X-rays to differentiate between bone, fat, and lean tissue. Despite their utility, BIA may be influenced by hydration status, DXA involves radiation exposure, and both methods face challenges related to portability, cost, measurement time, applicability across different age groups, and reproducibility.[10] For these reasons, developing more accessible and improving approaches to measuring body composition are crucial.

Ultrasound imaging has long been a standard tool in frontline healthcare, notably in fetal examinations, and is renowned for its ability to provide detailed, real-time images without ionising radiation. Building on its established success, ultrasound has emerged as a promising method for assessing body composition due to its unique advantages.[11] Ultrasound is non-invasive and provides real-time images that allow for detailed examination of tissues, muscles, and fat distribution.[12] As such, ultrasound has the capability to differentiate between fat and muscle in specific body areas, rendering it a desirable method for the accurate evaluation of body composition and nutritional status.[13] Unlike other imaging modalities, ultrasound does not use ionising radiation, making it a safer choice for repeatable measurements, especially important for the paediatric population, who are more sensitive to radiation due to their developing bodies and longer life expectancy post-exposure. Additionally, ultrasound's cost-effectiveness, portability, and ease-of-use make it suitable for various healthcare settings, including rural areas and resource-constrained environments.[14]

The primary objective of this scoping review is to describe technical aspects and clinical utility of ultrasound as a method to measure body composition and nutritional status in the paediatric population. By conducting a systematic scoping review of empirical literature that employed ultrasound techniques for assessing these factors, we aim to enhance the understanding of ultrasound as a prospective tool for evaluating body composition and nutritional status. This review also seeks to identify gaps in the literature and propose areas for further research on the intersection of ultrasound and nutrition. Ultimately, our goal is to explore how ultrasound could serve as an effective tool in preventing malnutrition and improving paediatric health outcomes.

**Key notes**

- Ultrasound imaging has the potential to assess body composition and nutritional status in children, but current research in this field is fragmented.
- This scoping review highlights the use of ultrasound in studies of paediatric body composition and nutritional status, identifying gaps such as limited performance testing and inadequate sample diversity.
- To validate ultrasound's effectiveness, further research is needed, including larger clinical studies, longitudinal analyses, and the development of artificial intelligence-based predictive models.

# 2 | METHODS

We utilised the Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for scoping reviews (PRISMA-ScR) to guide our review process.[15] A scoping review protocol was developed to steer the methodology, and it is available from the corresponding author upon request.

## 2.1 | Search strategy

With assistance of an experienced librarian, we conducted searches across four databases: PubMed, Embase, Compendex, and Web of Science. Our initial search utilised terms such as "paediatric," "infant," "ultrasound," and "measurement" and applied limits for full-text availability, human subjects, and publication date (≤10 years). Since this search did not yield enough articles, we broadened the search criteria to include a wider age range and both clinical and technical aspects of the ultrasound. The second search also removed the term "infant" and added the terms "adult," "adolescent," and "technology" and also extended the publication date to any years. The revised search strategy produced a sufficient number of articles. The search terms were tailored to the specific requirements of each database, with detailed search parameters outlined in Appendix S1. The initial search was performed in January 2023, the second search in February 2023, and a final search in March 2024 was conducted to identify any new publications since the previous searches.

### 2.2 | Inclusion and exclusion criteria

Articles were considered eligible for inclusion if they were an empirical, published research article that studied the use of ultrasound techniques in assessing growth and nutritional status in paediatric populations (birth to 18 years old). Articles were excluded if they were: (1) non-empirical studies (e.g., clinical summary, opinion pieces, or editorial comments/letters), (2) meta-analysis or systematic reviews, (3) studies without full-text availability, (4) lab-based studies without human subjects, (5) studies focused exclusively on foetuses, (6) studies assessing health outcomes unrelated to growth and nutrition (e.g., study used the ultrasound to evaluate the structure and function of the heart and associated vessels), and (7) studies including both children and adults without separate reporting for children.

### 2.3 | Data screening and extraction

To manage the data screening and extraction process effectively, we used Covidence (https://www.covidence.org), a specialised software platform designed for systematic reviews. All articles identified from our search were imported to Covidence, where three reviewers (AL, SK, and ML) conducted the screening. The screening process unfolded in two distinct phases. In the first phase, we screened the titles and abstracts of the articles to determine their initial relevance. For those that passed this initial filter, we proceeded to the second phase, where the full texts of the articles were reviewed in detail. Each article in both phases was reviewed by two independent reviewers. Any disagreements or discrepancies that arose during this process were resolved through consensus and discussion among the team.

Data extraction was carried out through a structured approach. We began by developing a preliminary data extraction tool in the form of a matrix table. Each member of the research team independently used this initial tool to code a sample of the articles. This process was followed by a team discussion, which allowed us to refine and finalise the extraction variables. The finalised data extraction tool was then implemented in Covidence to systematically chart data from the eligible studies. We extracted a range of variables, including: study characteristics (year of publication, country where the study was conducted), study purpose, study participants (inclusion/exclusion criteria, sample size, child age at the time of measurement, sex, race/ethnicity, medical diagnoses, and any relevant maternal information), study design (cross-sectional or longitudinal design, for longitudinal studies, the timing and frequency of measurements), ultrasound utilisation (types of growth and nutritional parameters assessed by ultrasound, anatomical regions used for ultrasound scans), accuracy and/or reliability of ultrasound measures (methods employed to ensure the accuracy and reliability of ultrasound measurements, such as inter-rater or intra-rater reliability), main findings of the study related to the performance of ultrasound in evaluating growth and nutritional status. For the data extraction phase, two reviewers (AL and SK) worked independently to extract data from all eligible articles. Any inconsistencies or disagreements were resolved through team discussions to ensure accuracy and completeness.

## 3 | RESULTS

### 3.1 | Study selection

The results of the literature search are summarised in Figure 1. Since the initial search did not yield a sufficient number of articles, here we report the combined results from the second and third searches. The search resulted in 405 articles after duplicates between the databases were removed. In the title and abstract screening phase, we excluded 303 articles. We then reviewed 102 articles in full text, from which we excluded 68. This process resulted 34 articles eligible for data extraction. A complete list of these 34 studies is available in Appendix S2.

### 3.2 | Study characteristics

We identified 34 unique articles published across various journals. Notably, 11 articles were authored by the same primary authors: seven articles by Gridneva et al.,[16–22] three articles by van Beijsterveldt et al.,[23–25] and two articles by Nagel et al.[26,27] The number of articles on this topic has gradually increased since 2013 (Figure 2). The studies were conducted in 13 different countries, with the highest representation from Australia ($n=8$, 23%), the Netherlands ($n=6$, 17%), the United States ($n=4$, 12%), and Brazil ($n=4$, 12%). Other countries included Germany ($n=2$, 6%), Japan ($n=2$, 6%), South Africa ($n=2$, 6%), Belgium ($n=2$, 6%), Italy ($n=1$, 3%), France ($n=1$, 3%), China ($n=1$, 3%), and Nigeria ($n=1$, 3%).

### 3.3 | Study purposes

The studies reviewed had various purposes. The majority aimed to explore the association between ultrasound-measured growth outcomes and other factors such as other growth or health outcomes, or early nutrition ($n=27$, 79%). For instance, one study examined whether early growth of leg muscle and subcutaneous fat measured by ultrasound imaging are related to later motor development in neurologically healthy preterm infants.[28] Another

FIGURE 1 PRISMA flow chart of search results. N, number of studies.

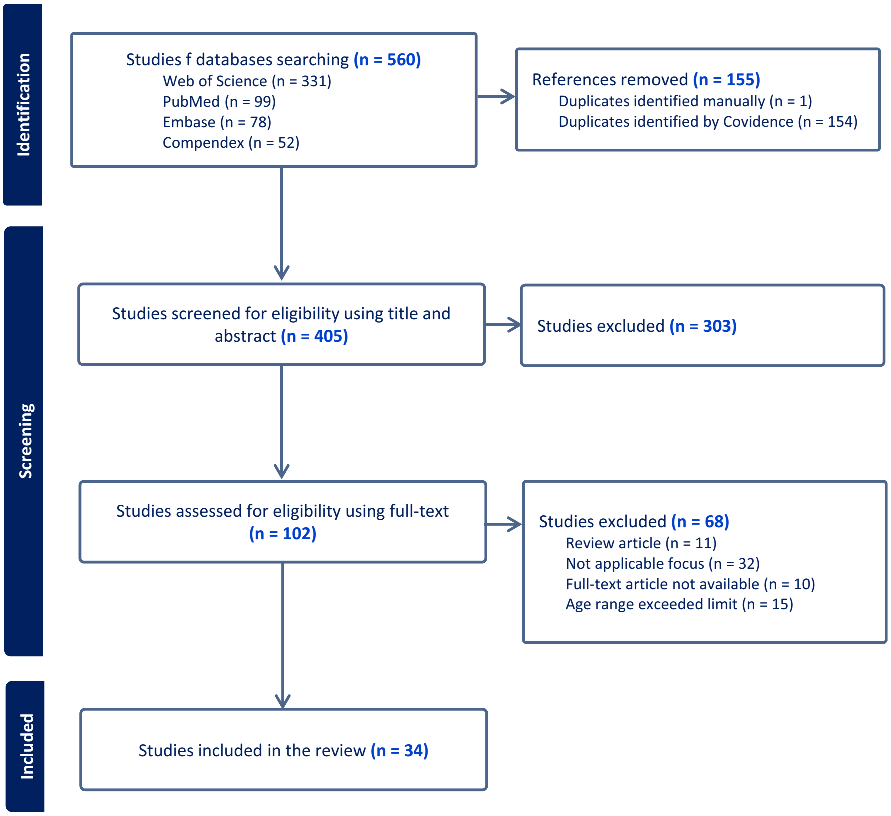
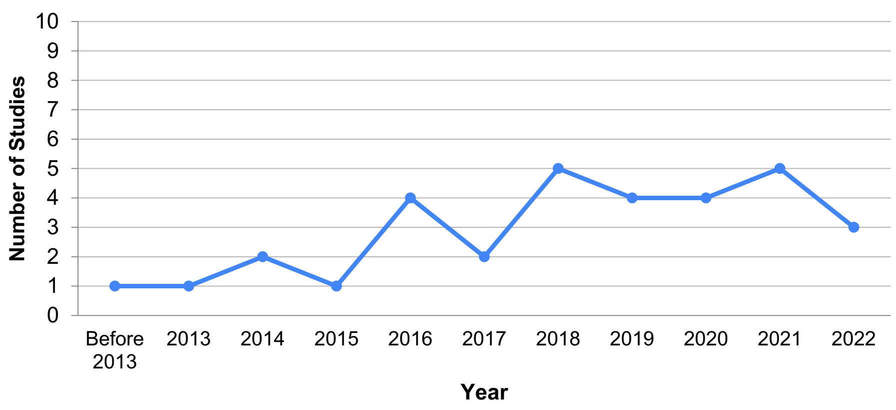



FIGURE 2 Number of publications over time.




study investigated the relationship of human milk micronutrition composition and infant body composition and abdominal fat in the first 6 months of life.[29] The remaining studies ($n=7$, 21%) focused on evaluating the performance of ultrasound in measuring various growth and nutritional parameters compared to other methods. For example, one study assessed the agreement between ultrasound and DXA for measuring body fat percentage in adolescents.[30]

## 3.4 | Study participants

### 3.4.1 | Child age

Of the 34 studies, 25 studies reported either the median or the mean age of their sample (median = 3.7 years, range = 0–14.9 years). When we further analysed the child's age according to the common age categories: 0–1 year (infant), 1–3 years (toddler), 3–5 years (preschooler), 5–12 years (school-aged child), and 12–18 years (adolescent), most studies focused on children under 1 year old ($n=16$, 48%) or those between 6 and 12 years old ($n=7$, 21%). The detailed age distribution is presented in Appendix S3.

### 3.4.2 | Sample size

The studies varied widely in sample size, with a median of 68 participants and a range from 10 to 6178. Most studies had relatively small sample sizes: 68% had a sample size of 150 or fewer participants, and 65% of these had fewer than 50 participants. The breakdown of sample sizes is detailed in Appendix S4.

#### 3.4.3 | Target group

Among the studies, 25 studies (74%) did not focus on specific medical conditions, meaning they included healthy children or children with no known medical condition. The remaining studies (*n*=9, 26%) targeted children with specific medical conditions such as prematurity (*n*=4), asthma (*n*=1), obesity (*n*=1), Prader-Willi syndrome (*n*=1), liver transplant (*n*=1), and critically ill children admitted to paediatric intensive care unit (*n*=1).

#### 3.4.4 | Reported participant characteristics

All 34 studies reported the child's sex; 32 studies included both males and females, one study included only males, and one study included only females. Although all studies reported the child's sex to describe their sample, only 50% of the studies (*n*=17) included sex in their analyses as a factor affecting the outcomes measured. Nine studies (26%) reported racial and ethnic backgrounds, with the majority of participants being White (66%–90%). None of these studies considered race/ethnicity in their analyses. Fifteen percent (*n*=5) of the studies reported socioeconomic status (SES) descriptors, including household income, parent education or employment status, and family size; however, only one study included SES information in its analyses. Ten studies (29%) also reported maternal health information and considered them in the analyses as a factor that may affect the child's growth outcomes. These variables include maternal age, maternal anthropometric measurements during pregnancy (e.g., pregnancy weight gain and BMI), health history during pregnancy (e.g., smoking history, medical diagnoses, and medications taken during pregnancy), and delivery mode (vaginal vs caesarean birth).

### 3.5 | Study design

Half of the studies (*n*=17, 50%) employed a cross-sectional design, while the other half used a longitudinal study design. In the longitudinal studies, the measurements were taken at 2–8 times over follow-up periods ranging from 2 weeks to 24 months.

### 3.6 | Use of ultrasound for measuring growth and nutritional status

Most studies (*n*=30, 88%) used ultrasound to measure body composition. Within these, 16 studies (53%) assessed whole-body composition, 13 studies (43%) focused on regional body composition, and one study (4%) measured both types. For regional body composition, the most commonly assessed areas included the abdomen (*n*=10) and extremities such as thighs, lower legs, or upper arms (*n*=3). Whole-body composition studies typically utilised a combination of various body regions, such as abdomen and upper/lower extremities or shoulder and upper extremities. Detailed descriptions of the anatomical regions used for whole-body measurement are provided in Table 1. All studies measuring body composition utilised ultrasound images from these anatomical regions to gauge the depth of muscle and/or adipose tissue. Sixteen studies (53%) reported muscle and adipose tissue thickness in centimetres or millimetres, while 14 studies (47%) converted these measurements to standardised body composition indices such as fat mass, fat-free mass, percentage of fat mass, and percentage of body fat.

In addition to body composition, ultrasound was also used to measure bone properties in four studies (12%). The body regions assessed for bone properties included the feet (*n*=2), hand (*n*=1), and calf (*n*=1). These studies analysed parameters derived from sound waves passing through cortical and trabecular bone, including speed of sound, bone transmission time, bone stiffness, and bone mineral density.

### 3.7 | Strategies for ensuring accuracy and reliability of ultrasound

Ensuring the accuracy and reliability of growth and nutritional parameters measured using ultrasound is crucial, given that these measurements depend heavily on image quality. It is essential that measurers are well-trained and that their performance remains consistent across study participants and time points, especially in longitudinal studies. Among the 34 studies reviewed, 18 studies (53%) implemented strategies to address potential variability in measurement performance throughout the study period. The most frequently employed strategy involved using a single trained measurer who demonstrated good intra-rater reliability. Additionally, some studies took multiple measurements (in duplicate or triplicate) and averaged these values to enhance accuracy. For only eight studies, formal inter-rater reliability statistics were reported, such as interclass correlation of coefficient (ICC) or coefficient of variance (CV) as an indicator of the degree of discrepancies between the repeated measurements taken by the same measurer. In addition, although many studies used more than one measurer, only six studies (18%) reported inter-rater reliability using a second or third person who took all or part of the measurements again.

### 3.8 | Main findings of the studies related to the performance of ultrasound

There were seven studies that specifically examined the performance of ultrasound in assessing growth and nutritional status in paediatric populations. Of these seven studies, five studies tested the performance of ultrasound in measuring body composition indices by comparing with other available methods, such as DXA, BIA, ADP or skinfold, however their findings were conflicting. Nagel et al.[26] found that ultrasound measurements of muscle and adipose tissue thickness at anatomical sites including the abdomen, biceps, and quadriceps did not show a high correlation with whole-body

TABLE 1 Anatomical regions used for whole body composition assessment.

| Author, Year of Publication | Age Group[a] | Body Side | Specific Anatomical Regions |
|---|---|---|---|
| Midorikawa et al., 2009 | 6–12 years | NR | Lateral forearm, anterior and posterior upper arm, abdomen, subscapular, anterior and posterior thigh, and anterior and posterior lower leg |
| Gridneva et al., 2019 | 0–1 year | Left | Triceps, subscapular, biceps, suprailiac |
| Gridneva et al., 2018 | 0–1 year | Left | Triceps, subscapular, biceps, suprailiac |
| Gridneva et al., 2018 | 0–1 year | Left | Triceps, subscapular, biceps, suprailiac |
| Liccardo et al., 2021 | 13–18 years | Right | Triceps, subscapular |
| Ripka et al., 2016 | 13–18 years | NR | Triceps, subscapular, abdominal, suprailiac, midaxillary, chest, thigh sites |
| Gridneva et al., 2017 | 0–1 year | Left | Triceps, subscapular, biceps, suprailiac |
| Reus et al., 2014 | 1–3 years | Left/ Right | Left biceps brachii, right forearm flexors, right quadriceps, left tibialis anterior muscle |
| Kelso et al., 2020 | 3–5 years | Right | Upper abdomen, lower abdomen, lateral thigh, erector spinae, distal triceps, brachioradialis, front thigh, medial calf |
| Perteet-Jackson et al., 2022 | 6–12 years | NR | Anterior upper arm, anterior upper leg |
| Nagel et al., 2021 | 0–1 year | Right | Abdomen, biceps, quadriceps |
| Kojima et al.,2018 | 13–18 years | NR | Forearm, upper arm, trunk, thigh, lower leg |
| Ngaji et al.,2019 | 3–5 years | Left | Left upper arm (midway between the tip of the acromion process and the olecranon for triceps adipose tissue, subscapular adipose tissue below the inferior angle of the left scapula), the abdominal adipose tissue (2 cm to the left of the umbilicus) |
| Gridneva et al., 2021 | 0–1 year | Left | Triceps, subscapular, biceps, suprailiac |
| McLeod et al., 2013 | 0–1 year | Left | Mid-arm, mid-thigh, abdomen |
| Gridneva et al., 2018 | 0–1 year | Left | Triceps, subscapular, biceps, suprailiac |
| Gridneva et al., 2017 | 0–1 year | Left | Triceps, subscapular, biceps, suprailiac |

Abbreviation: NR, not reported.

[a]Studies were categorised into the age groups based on the reported mean or median value of the study sample. For four studies, the reported range was used as the mean or median value was not available.

composition measured by ADP in preterm infants. Liccardo et al.[31] reported that body composition measurements, including muscle and adipose tissue thickness and % body fat obtained through skinfolds and ultrasound, were highly correlated. Otitoola et al.[32] assessed the accuracy of mid-upper arm circumference and ultrasound triceps skinfold thickness methods in predicting obesity and overweight in children. They found strong correlations between these methods and BMI, indicating their accuracy in predicting obesity and overweight. Gridneva et al.[16] found that % fat mass measured by ultrasound and BIA were not significantly different in breastfed term infants, but the measurements were variable within and between the methods, with the degree of variation affected by infant age and sex. Not a single method or equation was consistent with the distribution of reference values for all age and sex groups, although higher number of matches were seen in the ultrasound-based equation. Ripka et al.[30] found that ultrasound methods tended to underestimate % body fat in female participants relative to DXA but still showed a strong overall correlation with DXA measurements in adolescents. The other two studies, Midorikawa et al.[33] and Kelso et al.,[34] evaluated whether ultrasound data collection protocols and prediction equations developed for adults are applicable to children and adolescents. They concluded that these methods, originally used in adults, were relatively reliable for the paediatric population. These studies illustrate the variability and complexity of using ultrasound for assessing growth and nutritional status, highlighting both strengths and limitations compared to other measurement methods.

## 4 | DISCUSSION

We conducted a scoping review to deepen our understanding of ultrasound as a tool for measuring body composition and nutritional status, with the goal of improving paediatric health outcomes and addressing challenges related to malnutrition. Our review included 34 studies and highlighted both significant opportunities and notable gaps in the literature concerning the use of ultrasound in paediatric populations. These findings inform recommendations for further research to enhance our knowledge and application of ultrasound in nutritional assessment and growth monitoring.

Our review revealed that research on ultrasound for nutritional assessment is concentrated in a limited number of countries, with a noticeable absence of studies from low Socio-demographic Index (SDI) countries. These regions face a high burden of malnutrition[35] and expanding research to include diverse populations could provide a more representative dataset and address global nutrition challenges more effectively.

In regards to study purpose, most studies (79%) focused on using ultrasound to examine growth outcomes, while only seven studies (21%) assessed its performance compared to other methods. Of these, some studies did not use gold standard measures: one compared ultrasound to BIA and two compared it to skinfold thickness. The inconsistency in comparison methods has led to mixed results regarding the performance of ultrasound for body composition, with some studies showing a high correlation to other methods, and others showing low correlation. Moving forward, additional studies with larger and more diverse patient cohorts is needed to further validate ultrasound as a nutritional assessment tool. Future studies should aim for consistent use of gold standard measures (e.g., DXA, ADP) to further validate the accuracy and reliability of ultrasound-based body composition predictions.

When considering study design, many studies were limited by sample size, with 65% having a fewer than 50 participants. Furthermore, even though half of the studies used a longitudinal design and focused on growth outcomes, very few studies directly evaluated the effectiveness of nutritional interventions, such as different forms of supplementation, on body composition and nutritional status. To address this gap, future research should pursue longitudinal studies that use ultrasound to track changes in body composition and nutritional status in response to various nutritional interventions. This approach could enhance the utility of ultrasound as a tool for assessing and improving paediatric growth and development.

Considering sex as a biological variable in research design, data analysis, and reporting is increasingly important. However, while all studies reported sex to describe their sample, only 50% incorporated it into their analysis and interpretation of findings. Additionally, many studies lacked sufficient information about their sample, such as a child's race/ethnicity, SES, or maternal information. Even when such data were reported, they were rarely integrated into the analysis and interpretation. Incorporating these variables could significantly enhance future research, leading to more accurate predictions and a better understanding of factors affecting growth and nutritional status in children.

In the studies that assess ultrasound for growth and nutrition status, we noted that 53% of the studies used ultrasound to predict whole-body composition, rather than a regional prediction, and only 12% of studies assessed bone properties. As shown in Table 1, there was a huge variability in body regions scanned, highlighting the need for standardising how ultrasound scans should be performed for body compositional assessment. In addition, when predicting body composition, we note that all studies relied on manual measurements for estimating fat and muscle thicknesses, which introduce potential inconsistencies in data analysis.

Overall, ultrasound has significant potential to improve clinical outcomes for individuals experiencing growth, nutrition, and developmental challenges. By establishing a more accurate ultrasound approach, healthcare providers can gain detailed insights into body composition, which is crucial for addressing nutritional challenges. Early detection of nutritional problems through ultrasound can facilitate timely and targeted interventions, promoting optimal body composition and overall health. Ultrasound may become a powerful diagnostic tool that significantly improves clinical outcomes and carries profound implications for healthcare providers and their patients.

One possible path forward involves developing deep learning algorithms to automatically predict body composition and other nutritional metrics from ultrasound images. This approach, already explored for computed tomography (CT) scans,[36,37] could provide a user-friendly and deployable solution for assessing body composition and nutritional status. Recent studies have demonstrated promising results when segmenting muscle and fat for ultrasound musculoskeletal image as well as measuring the muscle morphological parameters. For example, Marzola et al.[38] adopted deep learning segmentation of transverse musculoskeletal ultrasound images to access the neuromuscular disease, and Saleh et al.[39] used deep learning-based localisation method to achieve automatic measurement of the abdominal muscle dimensions in ultrasound images. Despite these promising advancements, these studies focus on adult populations, and several challenges still impede their seamless integration into clinical practice. One major hurdle involves the demand for extensive and diverse datasets for training, ensuring that the models generalise effectively across different populations. The interpretability of deep learning models remains a significant concern due to their complex, multi-layered structures, necessitating efforts to enhance transparency in decision-making processes. Addressing data privacy and security issues is paramount when deploying these solutions in healthcare settings, requiring the development of robust methods for anonymising and safeguarding sensitive medical information.

To date, research on measuring body composition from ultrasound images has mainly relied on manual measurements (i.e., utilising built-in callipers to measure tissue thicknesses) rather than automated analysis. To the authors' knowledge, no studies have yet explored the use of deep learning for body composition assessment from ultrasound. To develop such a pipeline, ultrasound images and clinical data of each patient would need to be acquired following an experimental protocol, followed by a pre-processing stage prior to being input into the deep learning model. The preprocessed ultrasound images, together with human body composition and clinical data labels, may be used to train the deep learning model. Ultimately, a deep learning model for ultrasound image interpretation may provide an automated and end-to-end solution for nutritional and growth assessment.

Further, the ultrasound field has witnessed a surge in the commercialisation of portable probes, and their clinical efficacy in the musculoskeletal imaging space has been explored.[40] Such systems, which are relatively low-cost compared to other modalities, provide an accessible means to collect high-quality clinical data in a variety of healthcare settings, including resource-constrained environments.[41] Further, these systems offer a platform of applications for deep learning techniques, since mobile systems are now equipped to perform on-device inference and can offer an enhanced user experience. Therefore, deep learning models to predict relevant nutritional metrics such as body composition in combination with portable ultrasound systems may provide an ideal system for assessing nutrition and growth in the paediatric population.

### 4.1 | Limitations

This scoping review provides a comprehensive overview of the use of ultrasound in assessing body composition and nutritional status in paediatric populations. However, there are notable limitations. This review was restricted to articles written in English, which may have excluded relevant studies published in other languages. Additionally, the studies predominantly involved White populations from Western countries, potentially introducing demographic biases. The income level of the countries where studies were conducted could also influence the findings. Importantly, this scoping review was not designed to assess the quality of the included studies; instead, its primary focus was to map the existing literature and identify research gaps. As such, variations in study quality and methodological rigour are acknowledged as a limitation, and future research should include formal quality assessments to provide a more nuanced understanding of the evidence.

## 5 | CONCLUSION

This scoping review concludes that ultrasound imaging holds significant promise as a tool for assessing paediatric body composition and nutritional status, with potential benefits for growth and development monitoring. Several studies have successfully utilised ultrasound to assess muscle, fat, and body composition metrics. However, these studies were limited by issues such as reliance on manual measurements, lack of correlation with gold standard methods, limited geographic diversity, and challenges related to the deployability of ultrasound technology. To address these limitations and enhance the utility of ultrasound, we advocate for further research involving larger and more diverse cohorts to further evaluate this application. Additionally, leveraging advances in AI and portable devices could pave the way for automated assessment methods suitable for point-of-care applications. Such advancements have the potential to significantly improve the precision and accessibility of paediatric nutritional and growth assessment through ultrasound.

### DISCLAIMERS

The views expressed in the submitted article are our own and are not an official position of the institution or funder.

### AUTHOR CONTRIBUTIONS

**Bryan J. Ranger:** Conceptualization; investigation; funding acquisition; writing – original draft; methodology; writing – review and editing; formal analysis; project administration; supervision; resources; data curation; validation. **Allison Lombardi:** Writing – original draft; writing – review and editing; formal analysis; data curation. **Susie Kwon:** Writing – original draft; writing – review and editing; formal analysis; data curation. **Mary Loeb:** Writing – original draft; writing – review and editing; formal analysis; data curation. **Hayoung Cho:** Writing – original draft; writing – review and editing. **Keshi He:** Writing – original draft; writing – review and editing. **Donglai Wei:** Writing – original draft; writing – review and editing; funding acquisition; investigation. **Jinhee Park:** Conceptualization; investigation; funding acquisition; writing – original draft; methodology; writing – review and editing; validation; formal analysis; project administration; supervision; resources; data curation.

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The authors confirm that there are no relationships or activities related to the submitted manuscript that require disclosure.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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