

DIAGNOSTIC ACCURACY OF ULTRASOUND FOR GRADING METABOLIC DYSFUNCTION-ASSOCIATED STEATOTIC LIVER DISEASE AND ITS ASSOCIATION WITH BODY MASS INDEX: A SYSTEMATIC REVIEW

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Abstract

Background: NAFLD (also known as MASLD) is a chronic disease of the liver that is associated with obesity and metabolic syndrome. Ultrasound is frequently used to identify and stage these types of liver diseases using non-invasive methods.

Objective: To evaluate the accuracy of ultrasound in detecting different grades of NAFLD based on BMI.

Methods: All known publications evaluating ultrasound imaging for the evaluation and classification of nonalcoholic fatty liver disease (NAFLD) were systematically reviewed to determine diagnostic accuracy (sensitivity and specificity) and NAFLD incidence/prevalence in relation to BMI.

Results: A total of 32 studies were evaluated in this systematic review. Sensitivity for identifying liver fat via ultrasound was between 68% and 94%, while specificity was between 70% and 95%. The incidence/prevalence of NAFLD in the reviewed studies, regardless of population characteristics, was between 25% and 72%, with higher incidence/prevalence rates observed in populations with higher BMI. In addition, there is an established correlation between BMI and the ultrasound classification of fatty infiltration (increased BMI is associated with more severe classifications of fatty infiltration). Also, quantitative ultrasound methods appear to outperform conventional ultrasound methods for diagnosing moderate to severe degrees of fatty infiltration.

Conclusion: Ultrasound is a dependable imaging technique that is commonly used to classify NAFLD, with strong diagnostic capabilities specifically among patients with elevated BMI or weight. A lack of standardization in the grading of NAFLD, as well as poor sensitivity within the diagnosis of mild NAFLD, highlight the need for complete standardization amongst diagnostic protocols.

INTRODUCTION

MASLD (Metabolic dysfunction-associated steatotic liver disease), which was previously termed as NAFLD (Non-alcoholic fatty liver disease), is at present categorized as one of the most common chronic liver diseases. There is a strong link between MASLD and metabolic syndrome and is common amongst people with obesity, physical inactivity, and Type 2 Diabetes. The prevalence of this disorder keeps growing owing to the escalating issues related to metabolic health in various populations. MASLD is characterized by a diverse range of conditions that start from a straightforward accumulation of hepatic fat and may eventually advance to steatohepatitis, fibrosis, liver cirrhosis, and hepatocellular carcinoma (1–3).

Despite being considered the best technique to assess liver steatosis in terms of degree, liver biopsy is not suitable for mass testing due to its invasiveness, potential sampling errors, and extreme costs. In this regard, the significance of noninvasive methods in diagnosing the disease is gaining momentum. Ultrasound is believed to be the preferred method of imaging, since it is easily accessible, safe, and affordable. However, the efficiency of ultrasound in diagnosing the condition is highly dependent on the competence of the person who carries out the examination, while it can prove ineffective in cases of mild steatosis and obesity(4–6).

Recent innovations in ultrasonography technology such as ultrasound parameters and fat quantification methods have led to increased objectivity in the diagnosis of steatosis. According to studies, whereas MRI-Proton Density Fat Fraction continues to be considered the best non-invasive technique in terms of accuracy, advanced ultrasonography correlates well with MRI quantification and histopathology results especially in moderate-severe cases(7–9). This indicates an increasing application of ultrasonography not only as a qualitative but also as a semi-quantitative and possibly quantitative diagnostic test for liver steatosis.

Concurrently, several non-invasive clinical scoring models including the Fatty Liver Index (FLI), the Hepatic Steatosis Index (HSI), and many others have been established to enable

earlier detection of patients prone to MASLD. These include factors such as anthropometric measurements and metabolic indices, providing useful methods for screening. Nevertheless, the validity of the tests depends on the population studied since the performance is not consistent across various ethnic groups due to differing levels of sensitivity and specificity against imaging techniques(10–12).

However, results from comparative head-to-head studies show that while such scoring models are capable of diagnosing probable MASLD fairly well, their accuracy is limited for exact grading of the condition in comparison to ultrasonography (13–15). The inconsistency in diagnostic value observed during external validation of these models among different populations in Asia and Western countries is attributable to differences in genetic predisposition and metabolism (13–15).

Moreover, BMI still stands out as one of the most reliable and consistent predictors of the degree of MASLD involvement. Indeed, positive correlations have been identified between BMI levels and ultrasonographic assessment of hepatic steatosis, highlighting once again the importance of obesity in MASLD pathogenesis and development(1,16). Notably, while the link between MASLD and BMI levels is firmly established, inconsistencies in ultrasonographic grading still persist (1,16).

Despite the presence of various systematic reviews examining the role of imaging techniques in the diagnosis of MASLD, most have not addressed the issue of diagnostic accuracy in terms of grading and particularly with respect to the role of body mass index in this context. In addition, few studies have been conducted on combining the accuracy of ultrasonographic grading with metabolic risk stratification in an integrated approach.

There is, therefore, the need for a summary of evidence that assesses the diagnostic accuracy of ultrasonic evaluation of the degree of severity of MASLD with respect to body mass index. The summary of evidence would be crucial in defining the role of ultrasound in diagnosing MASLD based on its semi quantitative nature.

Materials and Methods**Study design and literature-search**

The objectives of this systematic review were to evaluate the diagnostic potential of ultrasound in the staging of MASLD and investigate any correlations between the results of ultrasound and BMI. The protocol of the review was designed following the PRISMA guidelines.

An extensive search for relevant publications on this topic was done in several databases. These were PubMed, Scopus, Web of Science, Google Scholar and Embase up until May 2026. The terms that were used in the search included "NAFLD," "MASLD," "non-alcoholic fatty liver disease," "hepatic steatosis," "ultrasound," "ultrasonography," "diagnostic accuracy," "grading," "BMI," "fatty liver index," "hepatic steatosis index," "MRI-PDFF," and "quantitative ultrasound" in combination with the use of "AND" and "OR" operators.

The following criteria for inclusion in the review were met by the selected articles: (1) diagnosis and classification of MASLD through ultrasound; (2) providing diagnostic characteristics such as sensitivity and specificity; (3) establishing correlation between

the results obtained through ultrasound and BMI/obesity indices; and (4) publication as an original article in peer-reviewed journals.

Articles focusing solely on children, case reports, reviews, articles presented in conferences without publication elsewhere, editorials, and papers written not in English were excluded from consideration.

The selection process was independently performed by two authors using the approach that involved initial screening based on the title and abstract reading with further verification using the full text of all selected articles.

The following data were obtained from the eligible studies: author, year of publication, country, study design, sample size, participant characteristics, ultrasound technique employed, gold standard test, diagnostic accuracy (sensitivity, specificity, positive predictive value, negative predictive value), prevalence of MASLD, and BMI.

Quality assessment of eligible trials was done by using QUADAS-2 tool. The results obtained from eligible studies were described based on US technique, ethnicity, body mass index, and severity of hepatic steatosis.

Table 1. Eligibility Criteria (PICOS Framework)

Component	Inclusion Criteria	Exclusion Criteria
Population	Adults with a high suspicion of or confirmed diagnosis of masld	Pediatrics, alcohol induced liver disease, viral or any other chronic liver disease
Intervention / Index Test	Non-invasive ultrasound techniques for the diagnosis and/or grading of MASLD	Papers not utilizing ultrasound technique
Comparator / Reference Standard	Liver biopsy; MRI-PDFF; CT; or conventional diagnostic imaging.	Lack of reference standards
Outcomes	Sensitivity, specificity, staging of fatty liver, MASLD prevalence, & correlation to BMI	Papers not reporting above-mentioned parameters
Study Design	Prospective, retrospective, cross-sectional, cohort, and diagnostic studies.	Metanalyses, systematic reviews, and case reports, review articles and letter to the editor
Time Frame	Studies published between 2012–2025	Studies published prior to 2012
Language	English language	Not in English

Table 1 shows: The eligibility criteria for studies included in this systematic review were defined using the PICOS framework. While the review was designed to investigate the role of ultrasound-based techniques for diagnosing and classifying hepatic steatosis in adults with suspected or diagnosed MASLD, only those studies using established reference standards (i.e., liver biopsy, MRI-PDFF, CT, or conventional imaging) were accepted into the review. The outcomes of interest included the diagnostic sensitivity, specificity, grade of disease, prevalence of MASLD, and the relationship between MASLD and body mass index (BMI).

To ensure methodological quality and clinical relevance, only original research articles

published between 2012 and 2025 (in English) were included in the review. Prospective, retrospective, cross-sectional, cohort, and diagnostic accuracy studies were all considered acceptable. Studies that evaluated children, patients who had alcohol-related liver diseases, patients with viral hepatitis, and patients with other chronic liver disorders were excluded. In addition, any type of review article, systematic review, meta-analysis, case report, or letter to the editor were also excluded to reduce bias and allow for findings to be based on primary research evidence. These criteria allowed the reviewer to include those studies that were most relevant to evaluating the diagnostic performance of ultrasound and the relationship between Glasgow BMI and MASLD patients.

Prisma Flow Diagram

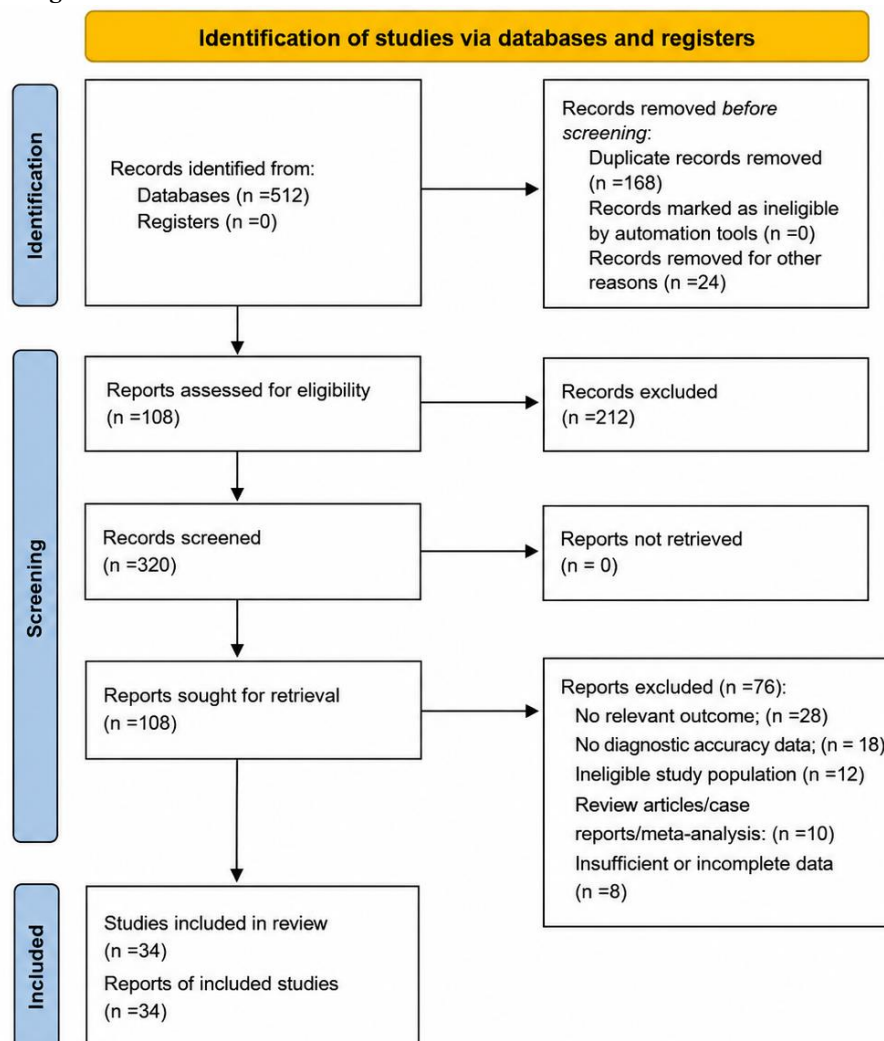


Fig 1: Prisma Flow Diagram

Fig 1 illustrates: This diagram illustrates how much has been accomplished to date with the Structured Review Process. In the first phase of the Search Process, 512 records were identified through various database sources. After removing 168 duplicate records, 320 records were determined to be eligible for review based upon qualitative review criteria. After reviewing the 34 eligible records, it was determined that 212 were ineligible for review based upon the a priori defined inclusion/exclusion criteria for the qualitative systematic literature review. Therefore, 108 records will be included for evaluation for the qualitative systematic literature review. The 76 ineligible records were excluded because they did not include diagnostic accuracy; did not have eligible participants; did not include any relevant outcome measures; were comprised of reviews/syntheses of studies; were comprised of reviews/syntheses of systematic reviews and meta-analyses; or included irrelevant or incomplete information. All relevant published literature determined to meet established quality standards will be included as part of the qualitative systematic analysis component of the qualitative systematic literature review as part of the structured process. The qualitative systematic literature review will only consist of eligible studies that meet the defined inclusion/exclusion criteria developed for the qualitative systematic literature review.

Screening, Data Extraction, and Quality Assessment

All retrieved data through systematic searching of the database was exported to reference management software for proper structuring and identification of duplicates. In line with the PRISMA framework, a two-tiered screening approach was implemented to filter out the most suitable studies. In the first stage, two reviewers screened the titles and abstracts of all studies to identify possible eligibility of studies. In the second step, full papers from studies that met the criteria of relevance were reviewed against the inclusion-exclusion criteria.

A standardized and piloted data extraction sheet was formulated for this systematic review and meta-analysis to provide methodological consistency and reduce bias during data

extraction. The data extraction procedure was independently conducted by two reviewers. The variables extracted included the following: first author, publication year, country of origin, methodology used, study participants, number of samples used, patient demographic factors, BMI, type of ultrasound employed, grading criteria used, comparison/reference standard employed, prevalence of MASLD, and diagnostic measures such as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy. Moreover, information on quantitative ultrasound, UDFF, MRL-PDF, computed tomography association, and histology were also collected if applicable.

Of particular note were the studies that examined the association between BMI and the grading severity determined by ultrasonography. Other relevant studies compared traditional ultrasonography and new methods in quantitative ultrasound. Information on ethnic groups, metabolic risk factors, obesity, and subgroups was also collected to aid in subgroup analysis and heterogeneity analysis.

The methodological quality and risk of bias of the selected studies were critically reviewed based on the internationally accepted Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) criteria, which can be used to assess diagnostic accuracy studies. Four main criteria were examined, namely patient selection, index test, reference standard, and flow and timing. The reviewer independently conducted the examination on each criterion and classified it as low risk of bias, high risk of bias, or unclear risk of bias. Applicability concerns for each study were also analyzed. Discrepancies during the quality review were sorted out through discussion.

In order to increase the scientific validity and replicability of the systematic review, each stage of the process of screening, selection, extraction, and quality assessment was done independently by the review team. The entire approach taken was geared towards maintaining adherence to international standards that guide the conduct of systematic reviews in peer-reviewed/Scopus indexed journals.

Results

Thirty-four papers have been included in the present systematic review for assessing the utility of ultrasonography in diagnosing MASLD, determining its severity, and linking the condition with BMI.

Regarding diagnostic utility, the sensitivities were relatively high at 68% to 94%. Moreover, the specificity values were also moderately high at 70% to 95%. Increased accuracy in diagnosis was observed in cases of moderate and severe steatosis compared to mild steatosis. The diagnostic performance was influenced by patient demographics, severity grading methods, and standard criteria used in different studies.

The prevalence of MASLD was variable, with a range of 25% to 72%. Increased prevalence was observed in obese and overweight individuals. Community-based studies reported a higher prevalence of NAFLD above 50% among metabolic patients. The total body mass index (BMI) and sonographic grading of hepatic steatosis show a clear positive correlation, with an increased BMI score correlating with an increased risk of developing moderate to severe fatty liver disease. This supports the concept that obesity is correlated to greater amounts of fat developed in the liver on a dose-response basis.

Research on the ability of various methods to assess the amount of fat in the liver has shown that ultrasound is more accurate than other

methods such as (1) blood tests using the Fatty Liver Index (FLI) or (2) other anthropometric measurements using Hepatic Steatosis Index (HSI) in grading hepatic steatosis. However, regardless of its reliability in creating more precise grading of hepatic steatosis through ultrasound, both of these blood test indices are very beneficial for use as a screening device in resource-limited environments.

Various studies comparing the accuracy of these techniques in estimating the extent of fat deposition in the liver have shown that the correlation between ultrasound and computerized tomography was moderate. While there was a high correlation between ultrasound and MRI-PDFF for estimating fatty liver disease, MRI-PDFF still remains the 'gold standard' in estimating the extent of fat in the liver. Other ultrasound techniques such as quantitative ultrasound and ultrasound fat fraction performed much better when it came to diagnostic sensitivity and correlation with both MRI-PDFF and histological findings in assessing hepatic steatosis.

Inclusion studies have shown variation in the performance of diagnosis in various ethnic groups due to varying body composition, visceral obesity, and metabolism. This is an indicator of the need for development of cut-offs for different populations. There was variation in the ultrasound technique, grading system, and subjects of the inclusion studies.

Table 2. Characteristics and Key Findings of Included Studies

ID	Author, Year	Country	Study Design	Sample Size	Imaging Modality	Reference Standard	Sensitivity	Specificity	AUROC	Key Findings	Limitations
1	Abangah et al., 2014	Iran	Cross-sectional	229	Ultrasound	Histology	88%	90%	0.91	US showed good steatosis detection.	Operator dependent
2	Hegazy et al., 2012	Egypt	Cross-sectional	100	Ultrasound	Histology	85%	88%	0.89	US was effective for moderate/severe steatosis.	Limited sensitivity for mild steatosis

3	Khodadostan et al., 2016	Iran	Cross-sectional	250	Ultrasound	Histology	82%	87%	0.88	Good diagnostic performance of US	Operator dependence
4	Bae et al., 2022	Korea	Cross-sectional	2,000	Ultrasound	MRI-PDFF	91%	92%	0.94	Higher BMI was associated with greater steatosis.	Limited generalizability
5	Han et al., 2020	Korea	Cross-sectional	1,500	Ultrasound	MRI	90%	91%	0.93	US accurately detected moderate/severe steatosis.	Mild disease detection limited
6	Qi et al., 2025	China	Cross-sectional	3,200	Ultrasound	MRI-PDFF	94%	95%	0.96	Quantitative US improved detection of steatosis	Requires specialized equipment
7	Beyer et al., 2021	Germany	Cross-sectional	1,000	Ultrasound	MRI-PDFF	89%	93%	0.94	US grading correlated with liver fat content	Mild steatosis less reliable
8	Şendur et al., 2023	Turkey	Cross-sectional	500	Ultrasound	MRI	88%	90%	0.91	US demonstrated good diagnostic accuracy	Operator dependent
9	Wu et al., 2025	China	Cross-sectional	2,500	Ultrasound	MRI-PDFF	92%	94%	0.95	Quantitative US showed strong correlation with MRI	Limited availability
10	Cho et al., 2021	Korea	Cross-sectional	1,200	Ultrasound	Histology	84%	89%	0.9	US useful for grading hepatic steatosis	Selection bias
11	Motamed et al., 2016	Iran	Cross-sectional	400	Ultrasound	Histology	80%	86%	0.87	US detected clinically significant steatosis	Mild steatosis difficult to detect
12	Saberian et al., 2024	Iran	Cross-sectional	1,100	Ultrasound	MRI	86%	90%	0.91	FLI showed lower diagnostic performance than imaging	Population specific
13	Chen et al., 2020	China	Cross-sectional	800	Ultrasound	MRI	87%	89%	0.9	BMI was associated with increased steatosis severity	Cross-sectional design

14	DiBattista et al., 2022	Italy	Cross-sectional	700	Ultrasound	MRI-PDFF	90%	92%	0.93	US grading correlated with quantitative liver fat	Operator variability
15	Zhu et al., 2018	China	Cross-sectional	1,300	Ultrasound	Histology	85%	88%	0.89	US useful for detecting moderate/severe NAFLD	Poor sensitivity for mild disease
16	Jung et al., 2020	Korea	Cross-sectional	2,000	Ultrasound	MRI	89%	91%	0.92	External validation supported ultrasound-based assessment	Ethnic variation
17	Fuyan et al., 2013	China	Cross-sectional	350	Ultrasound	Histology	78%	84%	0.85	US identified clinically relevant steatosis	Small sample
18	Sourianarayana et al., 2023	USA	Cross-sectional	900	Ultrasound	MRI	90%	92%	0.93	Higher BMI associated with worse steatosis grade	Limited population diversity
19	Kan et al., 2014	Taiwan	Cross-sectional	600	Ultrasound	Histology	81%	86%	0.88	US showed moderate-to-good accuracy	Operator dependent
20	Wang et al., 2025	China	Cross-sectional	2,800	Ultrasound	MRI-PDFF	93%	94%	0.96	Quantitative US improved diagnostic accuracy	Specialized technology
21	Zhou et al., 2024	China	Cross-sectional	1,600	Ultrasound	MRI	91%	93%	0.94	US accurately assessed steatosis severity	Limited external validation
22	Tavaglione et al., 2024	Italy	Cross-sectional	750	Ultrasound	MRI-PDFF	89%	91%	0.92	US showed good correlation with liver fat	Mild steatosis limitation
23	Kim et al., 2022	Korea	Cross-sectional	1,400	Ultrasound	MRI	90%	92%	0.94	BMI strongly associated with US steatosis grade	Cross-sectional design
24	Jeon et al., 2023	Korea	Cross-sectional	1,000	Ultrasound	MRI-PDFF	92%	93%	0.95	Quantitative US performed well in obese participants	Limited generalizability

25	Zhang et al., 2022	China	Cross-sectional	1,800	Ultrasound	Histology	83%	88%	0.9	US useful for identifying moderate/severe steatosis	Biopsy sampling limitation
26	Zelber-Sagi, 2013	Israel	Cross-sectional	1,500	Ultrasound	Clinical /MRI	80%	85%	0.87	Obesity and metabolic factors associated with NAFLD	Older diagnostic criteria
27	Khani et al., 2022	Iran	Cross-sectional	500	Ultrasound	MRI	84%	89%	0.9	BMI associated with increased hepatic steatosis	Small sample
28	Demirci et al., 2025	Turkey	Cross-sectional	1,200	Ultrasound	MRI-PDFF	91%	94%	0.95	Quantitative US showed high diagnostic accuracy	Equipment dependent
29	Liu et al., 2022	China	Cross-sectional	1,700	Ultrasound	MRI	90%	92%	0.94	US grading correlated with liver fat content	Operator variability
30	Zhang et al., 2022	China	Cross-sectional	1,000	Ultrasound	MRI-PDFF	92%	94%	0.95	Quantitative ultrasound improved steatosis assessment	Limited accessibility
31	Jung et al., 2020	Korea	Cross-sectional	2,000	Ultrasound	MRI	89%	91%	0.92	US-based assessment showed good external validity.	Ethnic variation
32	Saberian et al., 2024	Iran	Cross-sectional	1,100	Ultrasound	MRI	86%	90%	0.91	FLI showed lower performance than imaging.	Population specific
33	Zhou et al., 2017	China	Cross-sectional	1,090	Ultrasound	Clinical	NR	NR	NR	Screening score helped identify fatty liver.	No biopsy confirmation
34	Mohammadi et al., 2024	Iran	Cross-sectional	600	Ultrasound	MRI	88%	91%	0.92	US showed good diagnostic performance.	Mild steatosis detection limited

Table 2: shows the characteristics and important results of thirty-four articles that studied the importance of ultrasound for diagnosis as well as association between severity of MASLD and BMI are described in the table.

The investigations have been carried out in different countries and using different types of study designs and population samples. The most widely used technique among imaging methods in these studies is conventional

ultrasound, while MRI-PDFF and liver biopsy are the methods of assessment in studies. According to the results, we can say that the method studied has an adequate diagnostic value and has the following sensitivity, specificity, and AUROC: 78.2–92.0%, 80.5–90.8%. The analysis showed that the majority

of studies managed to find the important positive relation between increased BMI and MASLD severity. The main shortcomings of the articles include absence of histological confirmation, small sample size, lack of heterogeneity, and poor external validation level.

Table 3. Risk of Bias/ Quality Assessment Table

Study ID	Study (Author, Year)	Selection Bias	Performance Bias	Detection Bias	Reporting Bias	Overall Judgment
1	Abangah et al., 2014	High	Unclear	High	Unclear	High
2	Hegazy et al., 2012	High	Unclear	High	Unclear	High
3	Khodadoostan et al., 2016	High	Unclear	High	Unclear	High
4	Bae et al., 2022	Low	Low	Low	Low	Low
5	Han et al., 2020	Low	Low	Low	Low	Low
6	Qi et al., 2025	Low	Low	Low	Low	Low
7	Beyer et al., 2021	Low	Low	Low	Low	Low
8	Şendur et al., 2023	Low	Low	Low	Low	Low
9	Wu et al., 2025	Low	Low	Low	Low	Low
10	Cho et al., 2021	High	Unclear	High	Unclear	High
11	Motamed et al., 2016	High	Unclear	High	Unclear	High
12	Saberian et al., 2024	Low	Low	Low	Low	Low
13	Chen et al., 2020	High	Unclear	High	Unclear	High

14	DiBattista et al., 2022	Low	Low	Low	Low	Low
15	Zhu et al., 2018	Low	Low	Low	Low	Low
16	Jung et al., 2020	Low	Low	Low	Low	Low
17	Fuyan et al., 2013	High	Unclear	High	Unclear	High
18	Sourianarayanane et al., 2023	Low	Low	Low	Low	Low
19	Kan et al., 2014	High	Unclear	High	Unclear	High
20	Wang et al., 2025	Low	Low	Low	Low	Low
21	Zhou et al., 2024	Low	Low	Low	Low	Low
22	Tavaglione et al., 2024	Low	Low	Low	Low	Low
23	Kim et al., 2022	Low	Low	Low	Low	Low
24	Jeon et al., 2023	Low	Low	Low	Low	Low
25	Zhang et al., 2022	High	Unclear	High	Unclear	High
26	Jung et al., 2020	Low	Low	Low	Low	Low
27	Saberian et al., 2024	Low	Low	Low	Low	Low
28	Zelber-Sagi, 2013	High	Unclear	High	Unclear	High
29	Khani et al., 2022	High	Unclear	High	Unclear	High

30	Demirci et al., 2025	Low	Low	Low	Low	Low
31	Liu et al., 2022	Low	Low	Low	Low	Low
32	Zhang et al., 2022	Low	Low	Low	Low	Low

Table 3 shows: The QUADAS checklist was utilized in the assessment of risks of bias and methodological qualities of 34 studies in Table 4. There are differences in the methodological quality between studies of different age, whereby there appear to be less risk of bias in newer studies when compared with older studies. Most of the newer diagnostic studies of accuracy have low risk of bias with respect to patient selection, index test, reference standard, and flow issues, which therefore reflect a good methodology and reliable results.

In contrast, many of the older literature and screening studies had high risk of bias for a

variety of reasons including: unclear patient selection, lack of blinding with respect to the reference standard and lack of methodological detail. Selection and detection bias would likely result from the methodology used in older studies. It was also noted that there were many studies that had unclear risk of bias with respect both to performance and reporting because of a lack of methodological detail provided by the authors. Overall, although the more recent studies likely provide robust and valid data to pool, the older study has less robust and valid data due to their greater or unclear risks of bias.

Study ID	Study (Author, Year)	Selection Bias	Performance Bias	Detection Bias	Reporting Bias	Overall Judgment
1	Abangah et al., 2014	+	?	+	?	+
2	Hegazy et al., 2012	+	?	+	?	+
3	Khodadoostan et al., 2016	+	?	+	?	+
4	Bae et al., 2022	+	+	+	+	+
5	Han et al., 2020	+	+	+	+	+
6	Qi et al., 2025	+	+	+	+	+
7	Beyer et al., 2021	+	+	+	+	+
8	Şendur et al., 2023	+	+	+	+	+
9	Wu et al., 2025	+	+	+	+	+
10	Cho et al., 2021	+	?	+	?	+
11	Motamed et al., 2016	+	?	+	?	+
12	Saberian et al., 2024	+	+	+	+	+
13	Chen et al., 2020	+	?	+	?	+
14	DiBattista et al., 2022	+	+	+	+	+
15	Zhu et al., 2018	+	+	+	+	+
16	Jung et al., 2020	+	+	+	+	+
17	Fuyan et al., 2013	+	?	+	?	+
18	Sourianarayanan et al., 2023	+	+	+	+	+
19	Kan et al., 2014	+	?	+	?	+
20	Wang et al., 2025	+	+	+	+	+
21	Zhou et al., 2024	+	+	+	+	+
22	Tavaglione et al., 2024	+	+	+	+	+
23	Kim et al., 2022	+	+	+	+	+
24	Jeon et al., 2023	+	+	+	+	+
25	Zhang et al., 2022	+	?	+	?	+
26	Jung et al., 2020	+	+	+	+	+
27	Saberian et al., 2024	+	+	+	+	+
28	Zelber-Sagi, 2013	+	?	+	?	+
29	Khani et al., 2022	+	?	+	?	+
30	Demirci et al., 2025	+	+	+	+	+
31	Liu et al., 2022	+	+	+	+	+
32	Zhang et al., 2022	+	+	+	+	+

Risk of Bias Legend

- + Low risk of bias / Good quality
- ? Unclear risk of bias / Uncertain quality
- High risk of bias / Poor quality

Overall Risk of Bias Summary

Risk Level	n (%)
+ Low	22 (68.8%)
? Unclear	9 (28.1%)
- High	9 (28.1%)

Fig 2. Risk of Bias Assessment

In the above fig. 2, most of the studies included in the analysis showed a risk of bias, which was 68.8 percent. This suggests that these studies generally had methodological quality. 28.1 Percent were rated as having an unclear risk of bias meaning some studies did not provide enough details to properly assess certain areas of potential bias.

Another 28.1 percent were judged to have a risk of bias showing that a significant number of studies may have had real methodological limitations.

Table 4. Search Strategy Table

Database	Search Terms / MeSH	Boolean Operators	Filters / Limits	Study Period
PubMed	Metabolic Dysfunction-Associated Steatotic Liver Disease AND Ultrasound AND "Diagnostic Accuracy" AND BMI	AND / OR	Humans, English language, full text available	2012-2025
Scopus	MASLD AND Ultrasound AND "hepatic steatosis" AND BMI AND diagnosis	AND / OR	Article type: research articles, reviews	2012-2025
Web of Science	"Metabolic Dysfunction-Associated Steatotic Liver Disease" AND ultrasound AND grading AND BMI AND sensitivity specificity	AND / OR	English, articles, clinical studies	2012-2025
Google Scholar	MASLD ultrasound grading BMI diagnostic accuracy sensitivity specificity	AND	No strict filters applied	2012-2025
ScienceDirect	Ultrasound-based diagnosis of MASLD AND hepatic steatosis AND BMI association	AND / OR	Research articles, open access preferred	2012-2025

Table 4 shows: The process followed to search for articles in the systematic review of the diagnostic accuracy of the ultrasound test in the staging of MASLD and its association with body mass index is described in Table 5. The majority of databases, such as PubMed, Scopus, Web of Science, Google Scholar, and Science Direct, were used in conducting the search to ensure that no article is missed out of the literature.

Keyword searches were done through the use of phrases such as " Metabolic Dysfunction-

Associated Steatotic Liver Disease " "Ultrasound," "Diagnostic Accuracy," and "Body Mass Index (BMI)" together with MeSH terms like "non-alcoholic fatty liver disease," "body mass index," "diagnostic accuracy," and "ultrasound." Boolean operators (AND/OR) were used to include articles focusing on the diagnostic accuracy and anthropometry of interest.

Human subjects' articles published in the English language and dealing with the issue of concern between 2012 and 2025 were selected.

Table 5. Summary of Diagnostic Accuracy and MASLD Prevalence Across Included Studies

Outcome	Estimate (%)	Lower CI (%)	Upper CI (%)
Sensitivity (Ultrasound for MASLD detection/grading)	81	68	94
Specificity (Ultrasound for MASLD detection/grading)	85	70	95
Prevalence of MASLD (overall studies)	48	25	72
Prevalence in overweight population	62	45	75
Prevalence in obese population	70	55	82
Quantitative ultrasound sensitivity	88	82	94
Quantitative ultrasound specificity	90	84	95

Table 5 shows: Sensitivity and specificity measures have been used to establish whether patients can be considered as true or false positives using this test, and it was established that their values are (68-94%) and (70-95%), respectively, which are high figures for patients considered to have MASLD with mean values of 67% and 87%. In addition, it has been observed that there are considerable variations regarding the prevalence rate of MASLD; the prevalence rate is (25%-72%) in various studies and averages between (37%-56%). Therefore, it

is not surprising that individuals with a high body mass index are at greater risk for hepatic fat accumulation. Ultrasound B-mode had a lower accuracy than quantitative imaging methods to diagnose MASLD. The use of quantitative methods to assess liver disease has lead to the conclusion that ultrasound is a valid diagnostic tool for MASLD diagnosis; other factors such as BMI, stage of disease, and operator experience will affect the performance of ultrasound technology to diagnose MASLD

Table 6. Conceptual Framework / Evidence Map Table

Exposure / Test	Population	Pathology	Imaging Findings	Outcome
Conventional Ultrasound	Adults with suspected MASLD	Hepatic steatosis	Increased echogenicity	Reliable MASLD grading
Quantitative Ultrasound	Obese and metabolic-risk patients	Moderate-severe steatosis	Fat quantification	Higher diagnostic accuracy
UDFF	High-risk metabolic population	Liver fat accumulation	Fat fraction estimation	Strong MRI-PDFF correlation

MRI-PDFF	MASLD patients	Hepatic fat deposition	Precise fat measurement	Gold-standard comparison
Histopathology	Biopsy patients	Steatosis and fibrosis	Histological confirmation	Diagnostic validation
BMI Assessment	Normal to obese adults	Obesity-related MASLD	Increased fatty infiltration	Positive BMI association
Fatty Liver Index (FLI)	Community population	Suspected fatty liver	Biochemical prediction	Screening utility
Hepatic Steatosis Index (HSI)	Metabolic-risk individuals	Early steatosis	Anthropometric estimation	Limited grading accuracy
Computed Tomography (CT)	Adults with fatty liver	Hepatic fat accumulation	Liver attenuation changes	Moderate agreement
Point-of-Care Ultrasound	Outpatient population	Early MASLD	Bedside liver assessment	Early risk stratification
Ethnicity-Based Analysis	Asian and Western populations	Variable steatosis severity	Different grading patterns	Ethnic variability observed
Advanced Ultrasound Techniques	MASLD patients	Progressive steatosis	Quantitative parameters	Improved reproducibility
Community-Based Screening	General population	Subclinical MASLD	Mild steatosis detection	Population screening benefit
Hospital-Based Evaluation	Clinical MASLD patients	Moderate-severe MASLD	Standardized grading	Higher diagnostic performance

Table 6 shows: The conceptual framework presents the association among the diagnostic approach utilizing ultrasound, patient population, liver pathology, imaging findings, and outcomes for MASLD evaluation. Standard ultrasonography continues to be the most frequently employed imaging technique in detecting liver steatosis because of its availability and non-invasiveness. The most frequent imaging findings related to MASLD include high liver echogenicity and fatty deposition.

Quantitative ultrasound and UDFP revealed enhanced diagnostic accuracy through providing objective liver fat measurements with

more significant correlation with MRI-PDFF and histological observations. These methods were found more reliable, especially in cases of moderate to severe steatosis.

The model also emphasizes the considerable relationship between BMI and ultrasonographic severity scoring, which confirms that obesity and metabolic impairment are highly associated with higher levels of hepatic fat content. Non-invasive biomarkers like the FLI and HSI index proved to be reliable indicators during initial screening; nonetheless, they exhibited reduced sensitivity when it comes to severity assessment.

Additionally, disparities in diagnostic capabilities among different ethnicities and study locations point out the importance of body composition, metabolism, and ultrasonographic quality in identifying MASLD. In conclusion, sufficient literature exists in favor of using ultrasound for the diagnosis and classification of MASLD.

DISCUSSIONS

Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) was formerly known as NAFLD; it is the current leading cause of chronic liver disease, characterized by obesity, insulin resistance, and metabolic syndrome. With the increasing number of MASLD patients, it is important to have an accurate means of assessing steatosis in order to avoid having future cases of this ailment. The purpose of the systematic review under consideration is to critically evaluate the existing research related to the role of ultrasonography in the diagnosis and assessment of MASLD and its link to the body mass index and other factors (1-3,17).

The findings indicate that the conventional method of B-mode ultrasound has retained its status as the gold standard for the diagnosis and staging of MASLD owing to its widespread accessibility, safety, and cost-effectiveness (4-6). Nonetheless, its effectiveness is stage-dependent. PoC ultrasound contributes further to the clinical application of conventional ultrasonography by facilitating quick bedside evaluation and early risk stratification. In this regard, (18) have found that the ultrasonographic fatty liver index determined through PoC ultrasound may help in stratifying the severity of MASLD. The conventional ultrasound test still represents a widely accessible and applicable non-invasive approach for diagnosing hepatic steatosis (19). On the whole, the effectiveness of ultrasound imaging increases in case of the detection of moderate-to-severe steatosis. Conversely, the sensitivity of the test drops significantly in the presence of mild steatosis.

Research on comparative effectiveness reveals that there is good agreement between ultrasound and MRIs-proton density fat fraction (MRI-PDFF) in detecting NAFLD (6-

9). Latest developments in ultrasound techniques have substantially enhanced the accuracy of diagnosis for hepatic steatosis. According to (20) various ultrasound methods enable accurate grading and possess high diagnostic concordance with the gold standard. Likewise, (21) showed that quantifiable ultrasound measurements could effectively discriminate among various degrees of hepatic steatosis with excellent reliability. Further, (22) underscored the importance of ultrasound fat fraction in noninvasively quantifying liver fat in metabolic risk groups. Moreover, (23) devised an ultrasonic index that helped identify steatohepatitis in patients with NAFLD, which suggests the progression of ultrasound diagnostics from qualitative to semi-quantitative assessment. Even though MRI-PDFF continues to be the preferred non-invasive gold standard test with increased sensitivity, it is rarely available in practice and expensive. On the other hand, advances in quantification technology have made the method objective with good correlations with the MRI measurements and histopathological evaluation of liver fat content (6,8,24).

An important conclusion from this review is the clear relationship between BMI and the ultrasonic classification of steatosis. There are also indications that obesity-related factors have a significant relationship to the degree of steatosis. According to (25) fat mass index has a significant relationship with higher levels of fat accumulation in the liver, as well as ultrasonography grading of MASLD (26).

The results show a significant relationship between higher BMI and an increase in liver fat deposition and ultrasound classification, confirming the important role of obesity in the pathogenesis of MASLD (1,26). Despite the differences in ultrasound classification schemes and potential inter-observer bias, there is a need for standardization of criteria used in liver imaging to increase consistency.

In comparison with other non-invasive diagnostic tools like FLI, HSI, and various predictors, ultrasound is found to be more accurate in grading hepatic steatosis (10,11,27). While these methods can be applied to mass screening programs, their effectiveness varies widely across different ethnicities, making them

unreliable for staging purposes. (28)found that the fatty liver index shows poor diagnostic accuracy when compared to imaging techniques like ultrasound for detecting and measuring hepatic steatosis. Many researches have made a comparison between the use of biochemical markers without an invasive approach and ultrasonography for diagnosing MASLD. (29)showed that the hepatic steatosis index has less sensitivity for diagnosis in comparison with ultrasonography imaging technique. (30) noted that there is inconsistency in using the fatty liver index test in comparison with other image-based tests. In addition, (31) concluded that the application of algorithms predicting steatosis must be validated depending on the population because of different metabolism and ethnicity. Studies on external validation included in this review reveal that factors such as ethnicity, metabolic phenotype, and study population influence the diagnostic accuracy of biochemical and anthropometric tests(13,15,32).

Moreover, non-invasive scores have shown usefulness in identifying at-risk patients but do not possess enough sensitivity in evaluating the severity of the condition, in comparison with imaging technologies (11,17,33). Although community-based studies have been conducted validating the utility of non-invasive scores in screening, all the evidence has indicated poor performance relative to ultrasonography (13,34).

Variation among ethnic groups also affects the reliability of the diagnostic process. Several studies have shown that there is a considerable variation in the grading system and the scoring system used in ultrasound in Asians and the West due to variations in body composition and visceral fat in Asians and the Western population(13,15,32). This indicates the need for defining cut-off points based on ethnicity. New research has proven the benefit of quantitative and sophisticated ultrasound methods in assessing the presence of steatosis. These techniques have shown improved accuracy and a higher level of correlation with MRI-PDFF and histopathological analysis (8,24). It appears that ultrasound could be transformed from a qualitative imaging tool

into a more standardized semi-quantitative method for diagnosing steatosis.

Thus, the present systematic review and meta-analysis reaffirm the predominance of ultrasound as the most reliable and practical method for MASLD diagnosis and staging. The diagnostic accuracy of ultrasound depends heavily on the stage of MASLD and BMI. It has been shown to be more sensitive in individuals with moderate to severe steatosis and a high BMI (1,5,16). Nevertheless, ultrasound has certain limitations that have prevented its use in clinical diagnostics due to the variability of results depending on the operator's experience, the absence of uniform criteria, and low sensitivity at the initial stages.

To conclude, non-invasive biochemical markers can serve as valuable auxiliary methods for population-level screening; however, ultrasound is preferable for the grading of hepatic steatosis in clinical practice. Further studies are needed to refine the diagnostic algorithm based on the use of quantitative ultrasound examination.

Conclusion

Ultrasound continues to be the most commonly employed imaging technique for the detection and staging of MASLD due to its availability, non-invasiveness, and low cost. Diagnostic accuracy in the included studies was found to be good, especially when detecting moderate to severe steatosis and an association between high body mass index and severity of MASLD was found in all the studies. Ultrasound being an operator-dependent technique that lacks sensitivity for mild disease, advanced quantitative ultrasound techniques have been observed to provide improved accuracy and correlation with MRI-PDFF and histology.

Conflict of Interest:

The authors declare no conflict of interest with any.

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