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Review Article

Role of musculoskeletal ultrasound in diagnosing and managing chronic inflammatory arthritis in overweight and obese patients: a narrative review

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ABSTRACT

Obesity and metabolic syndrome play a significant role in the complexity of chronic inflammatory arthritis. By promoting systemic inflammation and altering immune responses, these conditions can amplify joint-related symptoms, such as pain, synovitis, and enthesitis. This inflammatory and mechanical burden complicates clinical evaluation, as traditional disease activity scores may be skewed by excess weight, leading to inaccurate assessments. Imaging techniques like musculoskeletal ultrasound (MSUS) offer a promising tool to detect subclinical inflammation and improve diagnostic accuracy. This review examines the role of MSUS in the management of obese patients with inflammatory arthritis. We explore how MSUS can be leveraged to detect subclinical inflammation, improve diagnostic accuracy, and guide more effective management strategies. We also discuss the limitations of MSUS in this patient population, including the impact of excessive adipose tissue on image quality and the need for standardized protocols.

Graphical Abstract

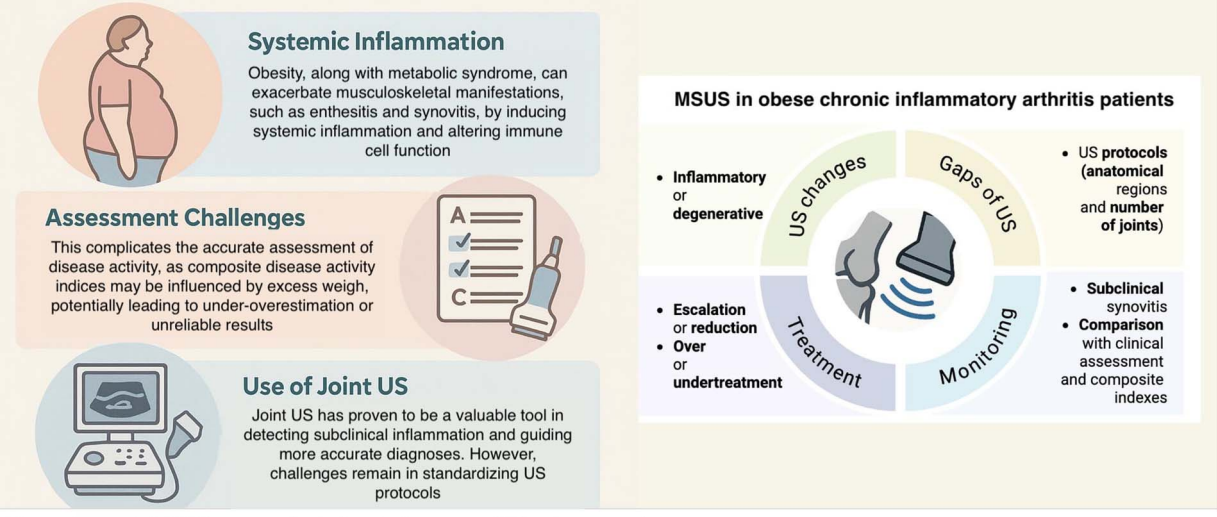

Figure legend: MSUS: musculoskeletal ultrasound US: ultrasound.

KEYWORDS Difficult-to-treat; obesity; body mass index; rheumatoid arthritis; psoriatic arthritis; spondyloarthritis; inflammation

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Introduction

Obesity and inflammatory arthritis are closely associated, with obesity being both a risk factor for and a consequence of inflammatory arthritis conditions, such as rheumatoid arthritis (RA), psoriatic arthritis (PsA), and spondyloarthritis (SpA) [1–4].

The interplay between these conditions involves both mechanical and immunometabolic mechanisms. In obese individuals, adipose tissue undergoes immune remodelling, with macrophage polarization towards a pro-inflammatory M1 phenotype and increased secretion of cytokines, such as TNF-α and IL-6, together with elevated leptin and reduced adiponectin levels [5, 6]. These changes contribute to a state of chronic low-grade inflammation that can amplify articular inflammation and pain perception [7, 8]. However, the exact processes underlying the selective activation of nociceptive, neuropathic-like, or nociplastic pain are still mostly poorly understood [9].

Due to all these aspects, obesity may influence composite clinimetric indices employed to assess disease activity in inflammatory arthritis [10].

Composite indices, in fact, such as the Disease Activity Score (DAS28) and the Clinical Disease Activity Index (CDAI) in RA, the Disease Activity Score for Psoriatic Arthritis in PsA, the Ankylosing Spondylitis Disease Activity Score, and the Bath Ankylosing Spondylitis Disease Activity Index in SpA, combine multiple clinical variables to measure the severity of the disease, including joint swelling, tenderness, and markers of inflammation, e.g. C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) [10]. Previous research showed that obese inflammatory arthritis patients have higher tender joint count and visual analogue scale General Health due to higher pain perception [2, 11–15]. On the other hand, increased adipose tissue has been observed to affect the accuracy of swollen joint count (SJC) and entheseal assessment, lowering the correlations with disease activity/severity [16], but results in literature are controversial [13, 17, 18]. In the first assumption, clinical examination may overestimate articular, entheseal, and dactylitis involvement due to interposed confounding fatty tissue, with consequent potential overtreatment; in the latter situation, otherwise, clinical examination may prove unremarkable even if subclinical synovitis can be detectable [19–23].

Joint musculoskeletal ultrasound (MSUS) has thus emerged as a helpful tool to confirm joint inflammation in established inflammatory arthritis in obese individuals [20, 21, 23–25]. In addition, since the presence of subclinical inflammation on MSUS has been associated with subsequent development of inflammatory arthritis [26], it can be postulated that early ultrasound (US) screening among obese patients claiming inflammatory arthralgia could be scheduled in the future, in the same way as MSUS or magnetic resonance imaging (MRI) is nowadays provided in people affected by psoriasis (PsO) as a helpful tool to identify those at the risk of PsA, in particular to detect synovial-entheseal abnormalities [27, 28].

In this narrative review, we investigated how MSUS may help evaluating joint inflammation and damage in obese patients. We have summarized the main publications concerning MSUS application in obese patients, to investigate which could be the role of MSUS both in early and established inflammatory arthritis.

Methods

A comprehensive literature search was conducted following recommendations for narrative reviews [29] and using the major databases: PubMed/MEDLINE, Scopus, Web of Science T, and Cochrane Library. The search was limited to articles published between January 2000 and March 2025 to capture recent and relevant advances in the field of the value of MSUS in obese patients with inflammatory arthritis or inflammatory arthralgia.

Search strategy and selection process are reported in Supplementary Materials.

The selection of articles followed predefined inclusion and exclusion criteria.

The screening process commenced with an independent evaluation of titles and abstracts by two reviewers, followed by a full-text assessment to determine study eligibility. Any discrepancies between reviewers were resolved through consensus discussion or, if necessary, by consulting a third reviewer.

Inclusion criteria:

(1) Studies covering human studies that evaluated the use of MSUS in obese patients with inflammatory arthritis or with suspicious inflammatory arthralgia, or studies that commented results of MSUS among different BMI categories (overweight, as BMI between 25 and 29.9, and obese as BMI of 30 or higher, compared to normal weight, as BMI between 18.5 and 24.9).
(2) Articles reporting on diagnostic or therapeutic outcomes derived from MSUS in this patient group.
(3) Clinical trials, cohort studies, observational studies, systematic reviews, and case reports.
(4) English publications.

Exclusion criteria:

(1) Studies focusing on non-obese patients with inflammatory arthritis or those without a specific focus on MSUS or not concerned on different MSUS results among BMI categories.
(2) Articles published in other than English language, case reports, editorials, letters to the editor, conference abstracts, non-peer-reviewed sources, and studies unrelated to MSUS in obese patients with inflammatory arthritis.

Relevant data were extracted from the selected studies. Collected information included study design, study population, and type of inflammatory arthritis, explored joints or enthesis if known and key outcomes of the studies. The primary outcomes considered were diagnostic accuracy, clinical utility, and the impact of MSUS on treatment decisions and disease monitoring. Table 1 summarizes the main findings from literature search.

Discussion

Challenges of early inflammation detection in obese patients

Early detection of inflammatory arthritis signs is crucial, since early intervention can prevent long-term damage

Table 1. Key features of the selected studies.

Reference	Study design	Study population (*n*)	Explored joints or enthesis	BMI distribution/ threshold	Study setting	Key outcomes
Alivernini *et al.* [30]	Prospective	RA ($n = 138$)	NA	BMI ≥ 25 kg/m^2 (overweight/obese)	Single-centre	In stable clinical and US remission under MTX + TNF-i, patients with BMI ≥ 25 kg/m^2, showed higher degree of residual synovitis in terms of synovial CD68+, CD20+, and CD3+ cells
Aydin *et al.* [21]	Prospective	AS ($n = 225$) and HC ($n = 95$)	Achilles tendons	BMI continuous variable	Multicentre	BMI correlated significantly with US enthesophyte scores in males only, not in females
Bakirci *et al.* [24]	Systematic review	SpA	NA	NA	Multicentre data (systematic review)	BMI is linked to both peripheral new bone formation and entheseal inflammation by imaging
Bauer *et al.* [25]	Prospective	RA ($n = 43$)	9 joints (wrist, 2–5 MCP, 2–3 PIP, and 2–5 MTP)	BMI categorized: <25, 25–30, and >30 kg/m^2	Single-centre	In obese RA patient, clinically assessed swollen joints are less likely to represent true synovitis (as measured by US). Disease activity in obese RA patients may be overestimated by CDAI/DAS28 calculation. Increased BMI category resulted in decreased likelihood of US positivity
Eder *et al.* [16]	Prospective	PsA ($n = 50$), PsO ($n = 66$), and HC ($n = 60$)	MASEI score: patella (at insertions of the quadriceps femoris and patellar tendons), Achilles tendon and plantar fascia insertions on the calcaneus, and triceps tendon insertion to the olecranon process	BMI categorized: <25, 25–30, >30 kg/m^2	Single-centre	MASEI is less specific in obese individuals (BMI > 30 kg/m^2) because no statistically significant difference was observed in both inflammatory and damage scores, as well as in the total MASEI score, across the three groups
Falsetti *et al.* [31]	Prospective	Low back pain and MetS ($n = 60$), and low back pain without MetS ($n = 60$)	Shoulders, elbows, hips, knees, and heels and LEI score	Mean BMI 29.8 kg/m^2 in MetS patients	Single-centre	Diffuse peripheral enthesitis is very common in MetS. Almost half of MetS patients can have a concurrent diagnosis of DISH; they are older, with higher inflammation, and higher PDUS enthesitis scores
Gisondi *et al.* [32]	Prospective	PsO ($n = 30$) and HC ($n = 30$)	GUESS score: Achilles, quadriceps, patellar entheses, and plantar aponeurosis	Mean BMI 28.5 kg/m^2; waist circumference measured	Single-centre	A small but significant correlation between GUESS score and BMI, waist circumference
Goossens *et al.* [23]	Prospective	RA ($n = 76$)	All 28 joints of DAS28	BMI categorized: < 25, 25–30, and > 30 kg/m^2	Single-centre	High BMI leads to an underestimation of both SJC and DAS28 in RA patients
Kaeley *et al.* [22]	Narrative review	Early inflammatory Arthritis	NA	NA	NA	Disease manifestations, such as enthesitis and dactylitis in obese patients can be clinically challenging to detect, and US can visualize them at subclinical level
Menegassi *et al.* [33]	Prospective	Severe obese patients (BMI $\geq$ 40 kg/m^2) without inflammatory arthritis ($n = 54$) and HC ($n = 49$)	Shoulder	BMI ≥ 40 kg/m^2	Single-centre	Obese group showed a greater incidence of shoulder pain and a greater incidence of pathological US (not inflammatory findings, but pathological changes of the rotator cuff, in terms of tendinosis and rupture) and CRP changes compared to control group

AS: ankylosing spondylitis; BMI: body mass index; CDAI: clinical disease activity index; CRP: C-reactive protein; DAS28: disease activity score in 28 joints; DISH: diffuse idiopathic skeletal hyperostosis; GUESS: Glasgow ultrasound enthesitis scoring system; HC: healthy controls; LEI: Leeds enthesitis index; MASEI: Madrid sonographic enthesitis index; MCP: metacarpalphalangeal joint; MTP: metatarsalphalangeal joint; MetS: metabolic syndrome; MTX: methotrexate; NA: not available; PDUS: power Doppler ultrasound; PIP: proximal interphalgeal joint; PsA: psoriatic arthritis; PsO: psoriasis; RA: rheumatoid arthritis; SJC: swollen joint count; SpA: spondyloarthritis; TNF-i: Tumour Necrosis Factor inhibitor; US: ultrasound.

[34–36]. However, in obese patients, the clinical detection of these early signs of disease can be less reliable, potentially leading to delays in diagnosis or treatment initiation [2].

This is due to the altered body composition in obese individuals, which may affect the accuracy of clinical assessments [23, 25]. Excess fat, particularly in the subcutaneous tissue, can mask the physical signs of inflammation, making it difficult for clinicians to palpate or identify tenderness and swelling [23, 25]. This can lead to an under-recognition of disease activity, particularly in the early stages of inflammatory arthritis when subtle changes are often the first signs of disease progression.

A review by Kaeley *et al.* [22] stated that disease manifestations, such as synovitis, tenosynovitis, enthesitis, and bone erosions in obese patients can be clinically challenging to detect, and MSUS can visualize them at subclinical level in early inflammatory arthritis.

The ability of MSUS to detect subclinical signs of such disease highlights its potential as a valuable tool in the early evaluation of patients complaining symptoms suspicious for arthropathies, especially in overweight/obese patients, where clinical examination is challenging.

Incorporating MSUS into routine clinical practice could also help to improve subsequent detection of joint inflammation during follow-up period, to guide more precise treatment choices [26].

Ultrasound gaps in monitoring subclinical synovitis in obese arthritis patients

While MSUS is a highly sensitive tool for detecting inflammation and can identify even subtle signs of disease activity, some studies reported that MSUS may fail to detect active arthritis in obese patients, particularly in joints with greater adipose tissue [30].

While MSUS is highly effective compared to clinical evaluation alone, it is important to recognize that increased adiposity can sometimes limit its effectiveness [37]. The quality of MSUS images can be reduced when there is excessive subcutaneous fat, particularly in obese patients. The deeper structures, like joints or tendons, may be more difficult to visualize, which could result in false negatives or incomplete assessments [38]. The effectiveness of MSUS also depends on the skill of the operator [39]: the accuracy in detecting subclinical synovitis or enthesitis relies on a trained practitioner to interpret the findings correctly [40].

Interestingly, the specific anatomical factors that affect MSUS diagnostic accuracy in obese patients are seldom addressed in literature. A significant gap in current research is the absence of a standardized protocol for MSUS assessment, particularly concerning which joints and the minimum number of joints that must be examined in obese individuals with inflammatory arthritis while searching for subclinical sings of disease. Further, it is possible that the higher frequencies commonly used for small joint imaging may exhibit reduced effectiveness in overweight/obese patients. This could be attributed to the increased subcutaneous fat and overall tissue mass, which may impair the transmission and penetration of the frequencies, potentially leading to less accurate or less efficient outcomes [41]. Further investigation may be needed to understand how adiposity influences the efficacy of such treatments in this patient population.

In Bauer *et al.*, a total of nine joints were scanned with MSUS in a RA population (wrist, metacarpalphalangeal 2–5, proximal interphalangeal 2/3, and metatarsophalangeal 2/5), and on the most active side along with authors' decision, typically the side with more pronounced symptoms, such as swelling or pain [25].

Kaeley *et al.* proposed an algorithm, developed by experience and not based on a clinical study, including:

(1) wrist, metacarpalphalangeal, metatarsalphalangeal, and proximal interphalangeal in RA;
(2) wrist, metacarpalphalangeal, metatarsalophalangeal, proximal and distal interphalangeal, and major enthesis in SpA;
(3) bilateral shoulders and hips, metacarpalphalangeal and proximal interphalangeal in polymyalgia rheumatica;
(4) wrist, metacarpalphalangeal and proximal interphalangeal, femoral cartilage, patellar ligament, medial collateral ligament, and metatarsalphalangeal in gout [22].

A more structured approach to MSUS, which includes clear criteria for both anatomical regions and the number of joints to be assessed, will be essential for enhancing diagnostic accuracy and ensuring reliable monitoring in obese patients with inflammatory arthritis.

Clinical remission in obese arthritis patients: clinical, ultrasound, or histopathological outcomes?

Clinical remission refers to a state where the visible or evident symptoms of the disease, such as joint pain, swelling, and joint stiffness, are significantly reduced, undetectable, or absent [42]. Clinical assessments might involve evaluating the number of swollen and tender joints, the patient's level of discomfort, or their functional ability [43]. Clinical remission implies that the patient is not experiencing overt symptoms of disease activity [44].

US remission refers to the absence of detectable features of inflammatory diseases, namely synovial thickening and power Doppler (PD) signals (indicating slow blood flow due to inflammation), or changes in soft tissue structure, such as tendons abnormalities [45].

The inclusion of MSUS in treat-to-target (T2T) protocols aiming at achieving both clinical and US remission in RA has not demonstrated significant advantages over the pursuit of clinical remission alone [46, 47]. Moreover, the role of MSUS in the effective application of T2T strategies for moderate-to-severe arthropathies has yet to be clearly and unequivocally established, particularly in the context of RA [48]. Additionally, the presence of obesity exacerbates the complexity of this issue, potentially complicating both the diagnostic and therapeutic management in this patient population.

In a recent study of Alivernini *et al.*, overweight/obese RA in stable clinical and US remission still showed a higher degree of residual synovitis in terms of sublining CD68+, CD20+ cells, and lining and sublining CD3+ compared to normal weight RA [30]. These findings suggest that, indeed, overweight/obese RA show higher degree of synovitis at disease onset and after remission achievement based on MSUS (residual synovitis) that influences the remission rate and should be considered within the management of patients with RA [30].

Probably, in obese individuals, even if clinical symptoms are controlled with medications, the biochemical signals driving tissue-level inflammation may still be active [49].

This statement underscores the idea that patients who are considered in clinical and US remission may still be at risk for future flares and joint damage, contrary to what is typically observed in RA patients in general (non-obese patients), where clinical and PD activity on US are associated with an increased risk of flare, clinical remission, and PD remission are linked to a reduced risk of flare [50]. Thus, a more comprehensive, multi-faceted approach to disease monitoring and management is needed for obese patients with arthritis to prevent hidden inflammation and to improve overall outcomes.

Ultrasound in disease monitoring and treatment escalation in obese patients with inflammatory arthritis

Obesity has been associated with reduced effectiveness of standard of care treatments for inflammatory arthritis, including biologics and conventional DMARDs [51].

Not only increased BMI can affect the metabolism of medications, potentially requiring higher doses of drugs to achieve therapeutic effects, or leading to suboptimal drug levels in the body [52], but also obesity itself acts as a pro-inflammatory condition [30].

In the EULAR framework, inflammation not well controlled despite adequate treatment is one of the hallmarks of 'difficult-to-treat' (D2T) arthritis, and obesity can directly contribute to this by enhancing systemic inflammation [53, 54].

Identifying true synovitis in obese patients is critical for selecting the appropriate treatment regimen.

As abovementioned, joint evaluation in obese patients with arthritis can be challenging, as it may lead to both overestimation or underestimation of synovitis, which can ultimately impact diagnosis and treatment decisions [25, 55].

Research findings indicate that the effectiveness of MSUS in identifying synovitis may be influenced by BMI.

A study of Bauer *et al.* involving RA patients found that as BMI increased, the positive predictive value of clinically assessed swollen joints for true synovitis decreased, employing MSUS as the reference standard for synovitis detection [25]. This finding suggests that in obese RA patients, clinically assessed swollen joints are less likely to correspond with true synovitis compared with PDUS. As clinically-based disease, activity measures like CDAI and DAS28 might overestimate activity in this population, leading to unnecessary treatment escalation [25].

Other studies proved the opposite. A study by Goossens *et al.* [23] demonstrated that in RA patients with high BMI, both the SJC and DAS28 were lower when compared to US. This suggests that clinical assessments may underestimate disease activity in obese RA patients, as swollen joint could be missed on clinical examination [23].

The contrasting findings between the two studies regarding the relationship between BMI, clinical assessments, and disease activity in RA patients could indeed be attributed to differences in the specific joints examined in each study.

The first study, which found that as BMI increased, the positive predictive value of clinically assessed swollen joints for true synovitis decreased (using MSUS as the reference standard), only examined nine joints (wrist, metacarpalphalangeal 2–5, proximal interphalangeal 2/3, and metatarsalphalangeal 2/5). This limited joint count might have contributed to a less comprehensive assessment of disease activity, particularly in obese patients where deeper joints, often harder to assess clinically, could have been missed.

In contrast, the study by Goossens *et al.*, which showed that SJC and DAS28 were lower compared to MSUS examination in obese RA patients, took into account the evaluation of 28 joints through US. With a larger joint count, this study likely captured a more complete picture of the disease, making it more sensitive to subtle signs of inflammation that may have been overlooked in clinical assessments. As a result, clinical evaluations in this study may have underestimated disease activity, especially in joints where swelling could be masked due to obesity-related changes.

Thus, both studies emphasize a poor correspondence between clinical and US findings, but with different conclusions. The differences in results between the two studies may stem from the variation in the number of joints assessed, highlighting the importance of a comprehensive evaluation when assessing disease activity, as already stated in paragraph 2 of the current discussion.

Moving to SpA, a study by Aydin *et al.* [21] found that BMI significantly correlates with US enthesophyte scores in males but not in females affected by ankylosing spondylitis (AS). This observation aligns with other research indicating that the relationship between BMI and enthesophyte development may differ by sex and BMI, even in healthy people [56].

Additionally, a recent systematic literature review in SpA observed a moderately positive correlation between BMI and enthesitis scores assessed through different imaging techniques (both MSUS and MRI), indicating that higher BMI may contribute to peripheral inflammation at tendon and ligament insertion sites [24].

However, the study of Aydin *et al.* focused on Achilles tendon [21] and results could be debatable, because of the local mechanical stresses or other tendon-specific factors (such as repetitive strain or previous injury) could be more influential, compared to other tendons.

The MASEI index (MAdrid Sonographic Enthesitis Index) and GUEST score (Glasgow Ultrasound Enthesitis Scoring System) are tools used to assess enthesitis in patients with SpA [57]. The MASEI index involves US imaging to evaluate tenderness, swelling, and inflammation at key enthesis sites [58], as the GUEST score [59], to detect both clinical and subclinical inflammation, incorporating features like PD and B-mode imaging. Both methods provide more precise and objective assessments of enthesitis compared to physical examination alone, helping to monitor disease activity and guide treatment decisions.

A moderate positive correlation was observed even between MASEI scores for enthesitis (including the insertions of the quadriceps femoris upon patella, patellar tendons, Achilles tendon, plantar fascia insertions on the calcaneus and triceps tendon insertion to the olecranon process) and BMI in another study [20]. In this study, in PsA patients with a BMI between 25 and 30 (overweight), MASEI score was higher compared to those with psoriasis alone (PsO) [20]. In contrast to Aydin *et al.* study, no significant differences in MASEI scores were found among PsA/PsO patients and even healthy control (HC) with a BMI over 30, and multivariate analysis revealed no statistically significant differences in either inflammatory or damage scores, nor in the total MASEI score, across the three groups in obese individuals [20].

In a study by Gisondi *et al.* [32], a small but significant correlation between GUESS score (including Achilles tendon,

quadriceps, patellar entheses, and plantar aponeurosis), BMI and waist circumference was observed in asymptomatic PsO patients. Despite the lack of symptoms, the findings suggested that higher BMI and waist circumference were associated with increased US evidence of enthesitis in these patients. This suggests that even in the absence of overt symptoms, increased adiposity may contribute to subclinical inflammation at enthesis sites, potentially influencing the progression towards PsA in the future. The study highlights the role of obesity as an important factor in the early detection of enthesitis, underscoring the importance of monitoring for inflammation in asymptomatic PsO patients, particularly those with higher body mass [32].

Nevertheless, the fact that the correlation is described as weak suggests that while there is a relationship, it is not relevant, implying that not only anthropometric indexes, but other factors likely play a more significant role in driving disease activity at the entheses.

It is plausible that certain entheses may be more vulnerable to the effects of obesity, and this could explain why the MASEI score or GUESS score – assessing different enthesis sites – do not show a consistent correlation with higher BMI.

Since enthesitis in PsA is driven by both inflammation and mechanical stress [60], it is plausible that in obese individuals, the additional mechanical stress on certain anatomical areas may exacerbate tendon inflammation in those areas, while inflammation in other sites might not be as pronounced due to less mechanical strain.

This could lead to a situation where the MASEI score or the GUESS score do not show significant differences in obese patients if the entheses that are less impacted by mechanical stress do not show increased inflammation, even though certain other entheses might.

This insight would warrant further investigation to understand the role of specific entheses in obesity-related exacerbations of PsA and SpA, as it could have implications for clinical management. For example, focusing on weight-bearing joints or areas with greater mechanical strain (such as the knees, hips, or Achilles tendons), clinicians might consider targeting localized interventions (e.g. physical therapy, tailored exercise, or anti-inflammatory treatments) for these areas, while also addressing systemic inflammation through immunosuppressants.

To conclude, upon this context, a study by Falsetti *et al.* provided valuable insights, emphasizing that it is not solely obesity, but also metabolic syndrome (MetS), that plays a crucial role in exacerbating musculoskeletal issues such as enthesitis [31].

The study observed that 86% of patients with both low back pain and MetS exhibited peripheral enthesitis, a notable increase compared to just 13.3% in controls without MetS [31].

This finding is important because MetS involves a cluster of metabolic abnormalities (e.g. insulin resistance, type 2 diabetes, dyslipidemia, and hypertension) that can contribute to systemic inflammation, which may, in turn, exacerbate local inflammatory processes in joints and entheses [61].

Unlocking the distinction: joint ultrasound to uncover inflammatory versus degenerative changes in arthralgia among obese patients

Obesity presents a diagnostic challenge *per se* in the evaluation of inflammatory arthralgia due to overlapping clinical features and the mechanical burden of excess weight [62].

The role of MSUS in this population is increasingly recognized as pivotal for early detection of pathological changes of joints and extra-articular structures, which may be either inflammatory or degenerative in nature, both of which can contribute to pain [22].

In a recent study by Menegassi *et al.*, obese patients showed a greater incidence of shoulder pain and a greater incidence of pathological MSUS examination (not inflammatory findings, but pathological changes of the rotator cuff, in terms of tendinosis and rupture) and CRP changes compared to control group [33]. The increased incidence of tendinosis and rupture in the obese group could be due to both the mechanical stress of excess weight and potential metabolic/inflammatory factors [30].

A similar finding was reported in the aforementioned study by Aydin *et al.*, which demonstrated that a higher BMI was a risk factor for the development of enthesophytes in both individuals with SpA and HC [21]. The fact that this was only observed in males suggests a gender-biased difference in how mechanical stress triggers a response, potentially related to skeletal and muscle mass [21]. This supports the idea of an intrinsic bone-forming phenotype in males, influenced by hormonal, mechanical, environmental, and other factors [21].

Similarly, in the study by Eder *et al.*, no statistically significant difference was observed in both inflammatory and damage scores, as well as in the total MASEI score, across PsA, PsO, and HC groups [20].

Further, degenerative or mechanical abnormalities in weight-bearing joints may be misinterpreted as inflammatory arthritis, particularly in obese patients, where excess weight increases mechanical stress on lower limb entheses [22].

Towards standardization and clinical implementation of MSUS in obese arthritis patients

Given the challenges of clinical joint examination in obese patients, a standardized, pragmatic approach to MSUS could enhance both diagnostic accuracy and therapeutic guidance.

When performing MSUS in overweight and obese patients, joint selection should prioritize:

(1) Superficial, accessible, and disease-relevant joints, including wrists, metacarpalphalangeal (MCP) 2–5, proximal interphalangeal (PIP) 2–3, and metatarsalphalangeal (MTP) 2–5 for RA;
(2) Peripheral entheses (Achilles tendon, quadriceps and patellar tendon insertions, plantar fascia, and lateral epicondyle) for PsA and SpA;
(3) Large weight-bearing joints (knees, shoulders, and hips) when clinical examination is limited by adiposity or pain localization.

Regarding technical parameters, high-frequency linear probes (12–18 MHz) are optimal for small and medium joints, while lower frequencies (6–10 MHz) may be required for deeper joints in obese individuals to ensure adequate tissue penetration. Proper gain adjustment and patient positioning can further mitigate image degradation due to adipose tissue.

In clinical practice, MSUS should be performed both in symptomatic and asymptomatic phases:

(1) At baseline, to document subclinical inflammation and establish a reference for disease monitoring;
(2) During follow-up, particularly when clinical and laboratory findings diverge, or when BMI-related limitations reduce the reliability of joint counts;

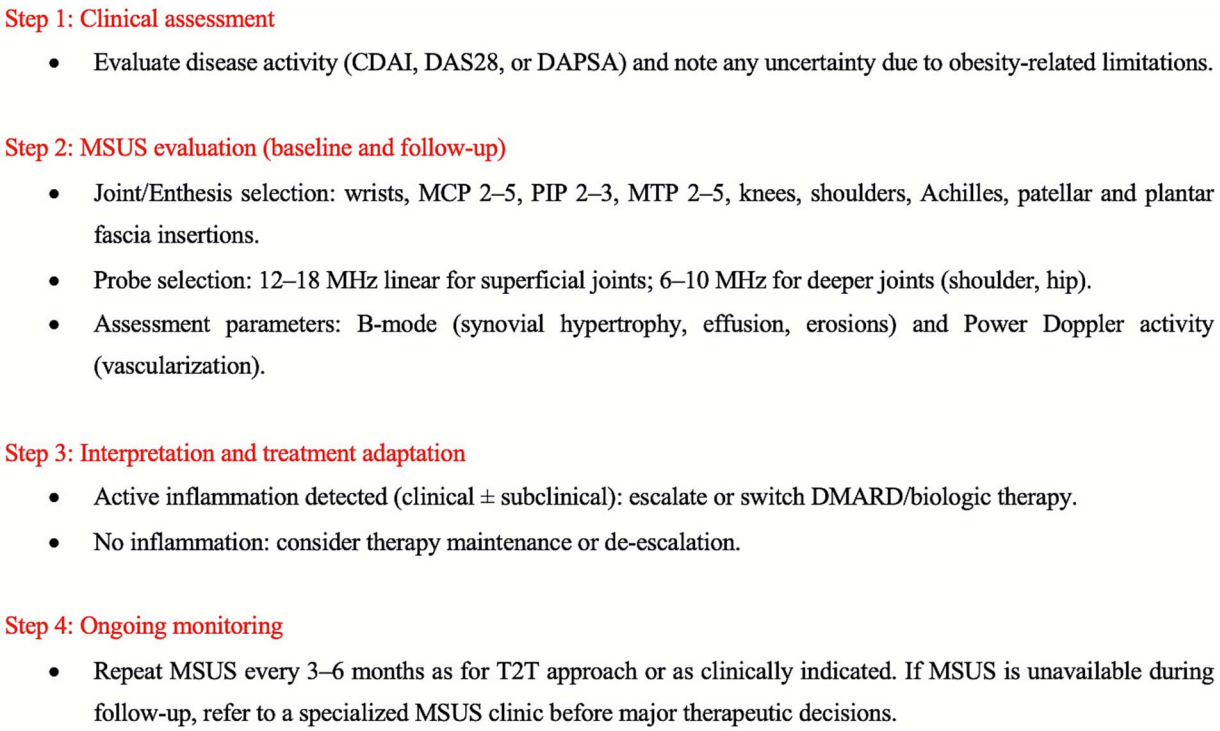

Figure 1. Proposed MSUS-guided workflow for the management of obese patients with inflammatory arthritis.

(3) At remission assessment, to detect residual synovitis or enthesitis before modifying therapy.

Where in-office MSUS is not available, referral to specialized US clinics should be encouraged for periodic evaluation – at least at diagnosis and during major treatment decisions – to ensure accurate disease monitoring and support T2T adjustments.

By integrating MSUS more systematically, clinicians can apply the same T2T strategy used for patients with normal BMI, but with greater precision in obese individuals, compensating for the diagnostic 'blind spots' of clinical joint examination (Figure 1).

Conclusions

The relationship between obesity, metabolic syndrome, and inflammatory arthritis is complex and multifaceted, significantly impacting disease detection and management.

Obesity, along with metabolic syndrome, can exacerbate musculoskeletal manifestations, including enthesitis and synovitis, by inducing a background systemic inflammation and altering immune cell function.

This complicates the accurate assessment of disease activity, as composite disease activity indices may be influenced by excess weight, potentially leading to under-/overestimation or unreliable results.

MSUS has proven to be a valuable tool in detecting subclinical synovial and entheseal inflammation and guiding more accurate diagnoses. However, challenges remain in standardizing US protocols and overcoming the limitations introduced by excessive adipose tissue around joint, which can reduce diagnostic accuracy.

Additionally, the impact of obesity on disease progression and treatment response highlights the need for tailored interventions.

Further research should focus on refining diagnostic and treatment protocols that consider both the mechanical and systemic inflammatory effects of obesity, ensuring more accurate disease management and preventing unnecessary delays or escalations in treatment.

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Author contributions

- Substantial contributions to the conception or design of the work or the acquisition, analysis, or interpretation of data for the work: G.C., B.M., A.B., E.S., and D.G.
- Drafting of the work or critical review of the work for important intellectual content: G. C., B.M., G.S., G.A., A.B., E.S., M.G., and D.G.
- Final approval of the version to be published: G.C., B.M., G.S., G.A., A.B., E.S., M.G., and D.G.

All the authors agree to be accountable for all the aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of interest

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Data availability

No new data were generated or analyzed in the preparation of this narrative review. All data referenced in this article are available from the

cited literature. Further inquiries can be directed to the corresponding author.

Ethics statement

This article is a narrative review of previously published literature and does not involve any new studies with human participants or animals performed by any of the authors. Therefore, ethical approval was not required.

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