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Original article

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SUMMARY

Background & aim: Diagnosing (disease-related) malnutrition in patients with obesity is challenging due to the complex interplay between excess body weight and physiological changes associated with illness and inadequate dietary intake, factors often overlooked in clinical assessments. Current global definitions of malnutrition do not adequately account for the distinctive characteristics of patients with obesity. This study aimed to develop a working definition of malnutrition in this population.
Methods: A modified three-round Delphi method was conducted between March and July 2024, involving 25 experts to achieve consensus on diagnosing malnutrition in obesity. In Round 1, participants evaluated 45 statements using a 5-point Likert scale. Feedback from this round guided revisions for Round 2, which focused on the Global Leadership Initiative on Malnutrition (GLIM) criteria and introduced nine revised statements. Round 3 further refined these statements, with the final consensus assessed using a binary agree/disagree scale. A threshold of ≥70 % agreement was set to define consensus in all rounds, with statements not meeting this threshold left undecided.
Results: Participation rates were 88 % (n = 22) in Round 1, 77 % (n = 17) in Round 2, and 50 % (n = 11) in Round 3. Of the 45 statements assessed in Round 1, 11 were accepted, 32 were undecided, and two were rejected. Round 2 introduced nine revised statements, of which seven were accepted and two remained undecided. In Round 3, nine statements were assessed, of which six were accepted, and three remained undecided. Consensus supported adopting the GLIM criteria as the foundation for the working definition. However, thresholds for weight loss and muscle mass and the relevance of functional parameters remained unresolved. C-reactive protein thresholds were agreed upon, but their relevance was debated due to the challenges in interpreting chronic low-grade inflammation in obesity. Participants emphasised the importance of assessing dietary quality and quantity, recommending dietitian involvement for improved accuracy.
Conclusion: Although a working definition for diagnosing malnutrition in patients with obesity was not achieved, this study lays a crucial foundation for further research. Key areas for future investigation

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include refining and validating parameters related to involuntary weight loss, muscle mass, inflammatory markers and dietary intake.

1. Introduction

Malnutrition greatly affects the health of hospitalised and institutionalised patients [1,2], as well as that of community-dwelling older individuals and those with chronic diseases [3,4]. It contributes to prolonged hospital stays, increased care burden, slower recovery, and reduced quality of life (QoL) [5,6]. Both malnutrition and overweight/obesity (hereinafter referred to as 'obesity') are categorised as nutrition disorders [7]. Furthermore, malnutrition can be classified into two categories: disease-related malnutrition (DRM), which can occur with or without inflammation, and malnutrition without disease [7].

Protein-energy malnutrition (PEM) is the most common form of DRM in hospitalised and chronically ill patients [8,9]. In some cases, PEM can co-exist with obesity within patients, presenting a particularly challenging clinical scenario [10]. This combination has been shown to worsen clinical outcomes more than in patients with malnutrition or obesity alone, contributing to inflammation, immune dysfunction, and inadequate dietary intake [11,12]. The COVID-19 pandemic in 2020–2021 further highlighted the increased health risks for patients with obesity, revealing a heightened risk of clinical complications, disease progression, and mortality [11–13].

Identifying malnutrition in patients with obesity is particularly challenging because the excess weight associated with obesity can mask conventional indicators of malnutrition [14]. Current tools rely heavily on anthropometric parameters such as involuntary weight loss, low body mass index (BMI), and low muscle mass, which are less representative in patients with obesity [15–18]. Additionally, these tools typically use cut-offs based on populations with a BMI <25 kg/m^2, increasing the risk of undiagnosed malnutrition in patients with obesity. While the Global Leadership Initiative on Malnutrition (GLIM) criteria are widely used for diagnosing malnutrition, their cut-offs for BMI, weight loss, and muscle mass do not adequately account for the complexities of diagnosing malnutrition in obesity [17].

With 43 % of the world's adult population (aged ≥18 years) classified as overweight and 16 % living with obesity [18], it is concerning that current screening tools cannot identify malnutrition in patients with obesity accurately. Effectively managing these coexisting nutrition disorders requires standardised, evidence-based terminology that is widely accepted within the professional community [7]. However, since current global consensus definitions of malnutrition do not apply to patients with obesity, this study aimed to establish a working definition of malnutrition specifically for this population. To achieve this, we conducted a modified Delphi study to propose a set of criteria for inclusion in this definition. The main aim of our Delphi study was to achieve consensus within our research context, with results intended to inform further research rather than seeking global agreement.

2. Methods

2.1. Study design

This study applied a three-round modified Delphi method conducted between March and July 2024. The Delphi method is a systematic, iterative process widely used in healthcare research to gather expert opinions and build consensus on clinical issues, particularly when definitive evidence is lacking and expert judgment is essential [19]. The method progresses through repeated rounds of structured feedback, voting, and refinement of statements to achieve consensus.

Our Delphi study involved three rounds with online questionnaires administered via Qualtrics (Qualtrics International Inc.) [20]. Invitations outlining the study's objectives and participation instructions were emailed, with follow-up reminders sent 1–2 weeks after the initial invitation to encourage participation. Questionnaires remained open for several weeks to accommodate participants' schedules.

The iterative feedback process was used to refine the structure and readability of the statements in each subsequent round, ensuring clarity and relevance. Additional statements were included as needed, based on expert input. An online meeting was held between Rounds 2 and 3 to facilitate interaction among participants and address areas of disagreement/indecision, enhancing the robustness of the study. During this meeting, experts clarified their viewpoints, justified arguments, and proposed refinements of statements. A non-anonymous voting system was adopted after the meeting to facilitate open decision-making. Despite this, participants' identities were anonymised in the report of the study.

2.2. Questionnaire development

The development of the Delphi questionnaires was guided by the study team's expertise, a review of relevant literature and analyses of existing database research. A list of eight topics (Table 1) related to malnutrition screening and diagnosis was identified for inclusion in the first Delphi round questionnaire. These topics were considered critical for evaluating malnutrition in patients with obesity. The initial questionnaire included 45 statements addressing key challenges, opportunities, and areas of improvement across these topics.

The statements were developed to achieve consensus on effective approaches and were refined iteratively based on expert input. Each Delphi round allowed participants to provide free-text responses, enabling them to suggest additional statements, propose revisions for each topic, identify redundancies, and clarify comprehension issues.

2.3. Expert panel selection

A total of 25 experts were invited to participate in the Delphi study. Participants were selected based on their specialised knowledge, practical experience, and academic contributions in the fields of malnutrition, obesity, or both. A broad range of expertise was intentionally sought through purposive sampling to ensure comprehensive perspectives. This included medical doctors specialising in endocrinology and obesity management, dietitians, nutrition scientists, and researchers with specialised knowledge and experience in nutrition and dietetics, mainly focusing on malnutrition and obesity. Experts were identified through professional networks, relevant research contributions,

Table 1
Malnutrition assessment parameters evaluated in the development of the delphi study.

	Topic	Rationale
1	GLIM	The GLIM criteria define malnutrition using at least one phenotypic criterion (involuntary weight loss, low BMI, or reduced muscle mass) and one etiologic criterion (reduced energy intake or disease burden/inflammation) [24]. However, these criteria may not fully capture the complexities of diagnosing malnutrition in patients with obesity due to their unique body composition and characteristics [25,26]. Standard cut-off values for GLIM criteria may not be appropriately tailored for this population, requiring further research and modifications [27].
2	Screening Tools	Diagnosis of malnutrition follows screening with a validated screening tools for the presence of malnutrition [28]. Current screening methods used in patient populations with obesity include blood markers, malnutrition and physical/etiological assessments (Mwala et al., 2024, unpublished). These methods closely resemble those used for populations with a normal BMI (18.5–24.9 kg/m^2) [29], prompting concerns about their applicability and effectiveness in the distinctive context of obesity.
3	Operational Definitions	Operationalising malnutrition is crucial for accurate diagnosis [30], especially in complex patient populations like those with both malnutrition and obesity. While the GLIM criteria provide a structured framework [28], modifications tailored to this population are needed for effective application.
4	Weight and Weight Loss	Weight loss can be measured and reported using different measures, including percentage weight loss, changes in weight in kilograms and changes in BMI (kg/m2) [31]. According to the GLIM criteria, weight loss is expressed as a percentage of an individual's usual weight [28]. However, this measure can lead to varied interpretations, especially in patients with obesity, where the impact of weight loss may differ greatly. Evidence suggests that involuntary weight loss has a less detrimental impact on patients with obesity compared to those with normal weight. For instance, meta-analyses and studies, such as those from NHANES, indicate that while significant weight loss (>15 %) in patients with obesity does increase mortality risk, smaller weight loss (5–15 %) does not have the same impact [32]. The nutritionDay data on hospitalised patients suggest that the risk of mortality from weight loss is lower in higher BMI categories, with significant risks emerging only after substantial weight loss (e.g., >12.6 % in BMI >30 kg/m^2) [33].
5	Muscle Mass	Assessing muscle mass in patients with obesity is crucial yet challenging. While a higher BMI often corresponds to greater muscle mass, excess fat can distort measurements, leading to inaccuracies [35–37] Standard tools such as Bioelectric Impedance Analysis (BIA), Dual-energy X-ray Absorptiometry (DEXA), Computed tomography (CT) and anthropometry require population-specific cut-offs due to account for these challenges in patients with obesity. Age- and BMI-specific cut-offs such as those proposed for calf circumference [36], are emerging; however, further validation is needed. Although some studies [38–41] offer some guidance, further validation is needed to confirm the reliability of the tools used in this population.
5a	Muscle Mass (BIA)	BIA, though practical, tends to overestimate fat-free mass (FFM) in patients with obesity due to increased hydration levels in adipose tissue limitation that traditional BIA equations do not adequately address [34]. Our literature review and database analyses [38–41] indicate that standard cut-off points for low muscle mass established for normal-weight individuals may not be suitable for those with obesity.
5b	Muscle Mass (DEXA/CT)	DEXA and CT are valuable tools for muscle mass assessment, but they face challenges in obesity due to weight limitations [39]. Obesity is associated with higher muscle mass, as indicated by higher appendicular skeletal mass index (ASMI) values in this group. Clinically, CT-derived skeletal muscle cut-offs for low muscle mass are often used for obesity, particularly in populations with specific health conditions like cancer.
5c	Muscle Mass (Anthropometry)	Anthropometry, including calf circumference may serve as a practical marker when advanced body composition measures are unavailable. However, using standard cut-off points for normal-weight individuals is ineffective for identifying low calf circumference in those with a BMI over 25. New age- and BMI-specific thresholds (e.g., Gonzalez et al., 2021) improve accuracy, but further validation remains necessary [36].
6	Functional parameters	Although not part of GLIM, physical function assessments, such as hand grip strength (HGS) and the chair stand test are important for evaluating muscle strength and overall health. In patients with obesity, increased body mass may influence test results. Careful interpretation is required to distinguish between age-related declines, sarcopenia, and obesity-related functional limitations, while also recognising the major overlap and shared etiologies between these conditions, particularly in the context of malnutrition and sarcopenic obesity [36,37].
7	Inflammation	Inflammation triggers increased protein turnover, which leads to the loss of muscle mass, strength, and function [41]. For this reason, inflammation is a key component of malnutrition diagnosis in GLIM criteria [28]. Obesity often involves chronic low-grade inflammation driven by adipose tissue, which increases levels of pro-inflammatory cytokines like C-reactive protein (CRP) [42,43]. Establishing appropriate inflammation thresholds for patients with obesity remains challenging due to elevated baseline CRP levels.
8	Reduced Dietary intake	Determining appropriate cut-off values for reduced food intake in patients with obesity,who might be accustomed to overeating, is challenging due to their unique eating patterns and higher nutritional requirements compared to those with healthy weights [44]. The GLIM criterion of reduced dietary intake may not accurately reflect inadequate nutrient intake in obesity where daily energy intake can exceed requirements based on their higher body weight can exceed 4000 kcal/day (16,736 kJ/day), for weight maintenance [45,46]. Assessing dietary intake must take into consideration the impact of bariatric surgeries, such as gastric sleeve procedures, which reduce nutrient absorption and increase the risk of malnutrition due to dietary restrictions and intolerance to protein-rich foods [47–50].

and involvement in guideline development to guarantee a diverse and knowledgeable panel.

Experts were primarily drawn from the Netherlands—reflecting the national focus of the Screening for Malnutrition and Obesity in Patients with COVID-19 and Other Diseases (SCOOP) consortium—but the panel also included participants from Italy, Spain, Brazil, Canada, and the USA to ensure a broader, more global perspective.

Before the first round, all participants received a background document summarising relevant literature, findings from database research, and detailed information on the topics under discussion.

2.4. Delphi rounds

2.4.1. Round 1

The first round introduced 45 statements. Participants evaluated each statement using a 5-point Likert scale ('strongly disagree', 'disagree', 'neither agree nor disagree', 'agree' and 'strongly agree') to express their level of agreement. Some statements used an extended 7-point Likert scale that included 'not applicable' and 'I don't know.' This round was exploratory, allowing participants to provide feedback on the statements and identify any areas that needed further clarification or revision. Anonymity was maintained throughout to reduce bias and promote honest feedback. Consensus was defined as ≥70 % agreement or disagreement with a statement.

2.4.2. Round 2

Based on the free-text responses and comments from Round 1, major revisions were made to the initial statements, focusing on establishing a working definition aligned with the GLIM criteria. As a result, nine new statements were introduced, incorporating feedback from eight previously undecided statements and one accepted statement. This round aimed to evaluate the suitability of the GLIM criteria for patients with obesity and identify potential refinements for malnutrition parameters in this population. Participants evaluated these updated statements on the same 5-point Likert scale used in Round 1. Additionally, this round allowed participants to refine their previous responses based on additional clarifications and changes to the statements. Consensus was defined as ≥70 % agreement or disagreement with a statement.

2.4.3. Round 3

In the final round, participants assessed nine revised statements based on the feedback provided in Round 2. Seven of these statements were refined from previously accepted statements, while two were derived from undecided statements. A simplified binary scale of 'agree' or 'disagree' was used to determine the final consensus. Consensus was defined as ≥70 % agreement or disagreement with a statement.

The flow of the study is depicted in Fig. 1.

2.5. Data analysis and presentation

Responses from each round of the Delphi study were exported from Qualtrics to Microsoft Excel for data storage and analysed using SPSS (version 29.0.2) [21]. Descriptive statistics were used to summarise participants' demographic characteristics and statement responses, expressed as percentages of agreement or disagreement. For analysis, responses of *'strongly agree'* and *'agree'* were combined to indicate overall agreement, while *'strongly disagree'* and *'disagree'* were combined to indicate overall disagreement. Neutral responses (*'I don't know'* and *'neither agree nor disagree'*) were grouped, and *'not applicable'* responses were excluded.

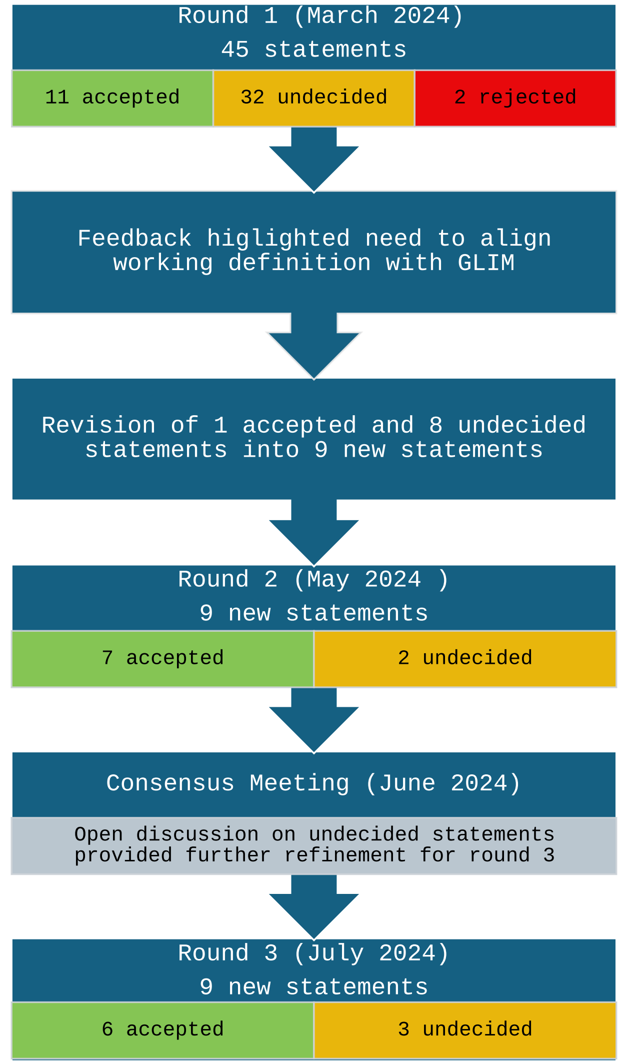

Fig. 1. Flow diagram of the three-round delphi study process.

A consensus threshold of ≥70 % agreement or disagreement was set to define whether a statement had achieved consensus. This threshold is consistent with previous Delphi studies [22–24]. Statements that did not meet the ≥70 % agreement or disagreement threshold were categorised as undecided.

3. Results

The responses to key statements from each round are presented in the results section of the paper (Tables 2–6), while additional statements are included in the supplementary material.

Table 2
Demographic characteristics of the expert panel involved in the three-round delphi study.

Characteristic	Sub-category	(n = 22)
Professional Background	Medical doctor	5
	Nutritionist/Dietitian	14
	Nutrition Scientist	1
	Researcher	2
Country of Residence	Brazil	1
	Canada	1
	Italy	1
	Spain	1
	The Netherlands	17
	USA	1

Table 3
Overview of key responses from round 1 of the delphi study.

Topic	Statement	Agree%[a]	Neutral%	Disagree%
GLIM	The GLIM diagnostic criteria should be used as a basis to diagnose malnutrition in patients with obesity.	**81.8**	9.1	9.1
	The current criteria within the GLIM diagnostic criteria for malnutrition are applicable to malnourished patients with obesity.	45.5	13.6	40.9
	The criteria within GLIM are sufficient to diagnose malnutrition in patients with obesity, but different cut-off points should be considered.	66.7	9.5	23.8
Screening Tools	Currently available screening tools for malnutrition are applicable for patients with obesity.	19.0	–	**81.0**
Weight and Weight Loss	We have good relevant cut-off points to define a patient with obesity as malnourished for weight loss.	65.0	15.0	20.0
Muscle Mass (BIA)	We do have good relevant cut-off points to define a patient with obesity as malnourished for low muscle mass by BIA.	25.0	10.0	65.0
	For application in clinical practice, BIA-derived and predicted cut-off points (across all age ranges and all BMI categories) can be applied as a proxy for muscle mass in patients with concurrent obesity and malnutrition [36].	55.0	20.0	25.0
	BIA-derived cut-off points for muscle mass can be used in a population with obesity, although literature indicates that BIA overestimates fat free mass in patients with obesity (possibly explained by a higher hydration of fat free mass) [34].	**70.0**	10.0	20.0
Muscle Mass (DEXA/CT)	We have good relevant cut-off points to define a patient with obesity as malnourished for low muscle mass by DEXA or CT.	55.0	10.0	35.0
Muscle Mass (Anthropometry)	We do have good relevant cut-off points to define a patient with obesity as malnourished for low muscle mass by waist circumference.	25.0	15.0	60.0
	We do have good relevant cut-off points to define a patient with obesity as malnourished for low muscle mass by hip circumference.	10.0	25.0	65.0
	We do have good relevant cut-off points to define a patient with obesity as malnourished for low muscle mass by calf circumference.	15.0	20.0	65.0
	We do have good relevant cut-off points to define a patient with obesity as malnourished for low muscle mass by arm circumference.	0.0	15.0	**85.0**
Functional parameters	We do have good relevant cut-off points to define a patient with obesity as malnourished for grip strength.	30.0	15.0	55.0
	We do have good relevant cut-off points to define a patient with obesity as malnourished for chair stand test.	20.0	25.0	55.0
	Grip strength is a relevant parameter to determine malnutrition in patients with obesity.	30.0	20.0	50.0
Inflammation	We do have good relevant cut-off points to define a patient with obesity as malnourished for inflammation.	55.0	20.0	25.0
Reduced Dietary intake	We do have good relevant cut-off points to define a patient with obesity as malnourished for dietary intake	65.0	15.0	20.0

[a] **Bold %** denotes that ≥70 % consensus was achieved.

3.1. Expert panel responses

Of the 25 experts invited to participate in the Delphi study, 22 accepted and participated in Round 1, resulting in a response rate of 88 %. Table 2 presents the demographic and professional characteristics of the expert panel. In Round 2, 17 experts participated, yielding a response rate of 77 %. Although 16 experts accepted the invitation to Round 3, only 11 (50 %) fully participated.

3.2. Questionnaire responses

3.2.1. Round 1

3.2.1.1. Summary of participants' comments from round 1. Participants in this exploratory round agreed to adopt the GLIM structure for malnutrition diagnosis in patients with obesity. However, they emphasised the need for adjustments due to the unique characteristics of this population. Participants called for refined cut-off points and definitions to ensure the criteria's

Table 4
Overview of key responses from round 2 of the delphi study.

Topic	Statement	Agree%[a]	Neutral%	Disagree%
GLIM	The GLIM diagnostic criteria for malnutrition should be used as a basis to diagnose malnutrition in patients with obesity, however some criteria or cut-off points may need re-consideration.	**100.0**	–	-
Weight and Weight Loss	Weight loss as percentage of usual weight is preferred above weight loss in absolute values or kilograms for the diagnosis of malnutrition in patients with obesity.	**94.1**	5.9	–
	Weight loss (%), >5 % within past six months or >10 % indefinite of time, can be used in the definition of malnutrition in patients with obesity.	58.8	17.7	23.5
Muscle Mass	Malnutrition in patients with obesity and sarcopenic obesity are two different conditions.	**70.5**	11.8	17.7
Muscle Mass (BIA)	BIA may be a useful option for measuring low muscle mass in patients with obesity; however, further study is needed to assess the validity of this method in patients with obesity, as well as to determine the appropriate reference methods and cut-off points.	**82.3**	–	17.7
Muscle Mass (Anthropometry)	Calf circumference may be a practical marker for assessment of muscle mass in patients with obesity; however, further research is necessary to establish its value.	**76.5**	5.9	17.6
Functional parameters	Functional parameters (grip strength, chair stand test) are not valuable markers in the diagnosis of malnutrition in patients with obesity.	58.8	23.5	17.7
Inflammation	Inflammation can be used in the definition of malnutrition in patients with obesity. Cut-off points should follow the recent GLIM guidance paper.	**94.1**	–	5.9
Reduced Dietary intake	A poor dietary intake is important in the diagnosis of malnutrition in patients with obesity. This could include either 'eating less than requirements' (and aligning with the GLIM criteria) or 'eating an unhealthy diet' (determined by for example FFQ or dietary screener).	**88.2**	5.9	5.9

[a] **Bold %** denotes that ≥70 % consensus was achieved.

accuracy. Concerns were raised regarding the applicability of certain GLIM criteria, especially in measuring muscle mass. Participants noted the difficulty in distinguishing between limitations caused by obesity and those caused by malnutrition, particularly as body composition assessments like BIA are often unreliable for patients with obesity. They suggested rephrasing diagnostic questions to clarify which parameters apply better to diagnosing malnutrition in this group. They recommended considering additional factors, such as bariatric surgery, acute disease, and diet quality, for a more comprehensive evaluation.

Participants expressed reservations about using absolute weight loss measures (kg) to diagnose malnutrition in obesity. Instead, they advocated for expressing weight loss as a percentage of baseline weight. Some participants suggested that higher cut-off points or shorter timeframes might be necessary to reflect the characteristics of patients with obesity better.

There was strong support for including muscle mass as a key diagnostic criterion, although concerns were raised about the overlap with sarcopenic obesity, where muscle loss occurs alongside obesity. Participants called for more research and validation of methods like BIA, with a preference for multifrequency BIA to differentiate muscle mass from fluid retention, though concerns about its reliability in patients with obesity remained undecided.

Regarding anthropometric measures, participants were sceptical about using waist circumference to diagnose malnutrition in obesity, as it primarily reflects abdominal adiposity rather than muscle loss. They noted difficulties in standardising waist circumference measurements and questioned the relevance of this measure for identifying malnutrition. Similar reservations were expressed about using hip circumference, which was seen as another indicator of fatness rather than a marker for malnutrition. Calf circumference, on the other hand, was seen as a practical measure but remained unclear in terms of relevant cut-off points for identifying malnutrition in patients with obesity.

Participants also questioned the use of grip strength as a functional parameter for diagnosing malnutrition in obesity. They noted that factors like inflammation could influence grip strength and might not accurately reflect muscle loss related to malnutrition, with some suggesting it is more relevant for assessing sarcopenia.

On inflammation, participants had mixed opinions about using CRP levels for diagnosis. While some supported requiring consecutive elevated CRP measurements, others found it less relevant due to the chronic low-grade inflammation common in obesity. A 10 mg/L CRP cut-off was mostly suggested, but participants called for clarification on how CRP should be used in conjunction with other criteria.

Table 5
Overview of key responses from round 3 of the delphi study.

Topic	Statement	Agree%[a]	Disagree%
Weight and Weight Loss	Which percentage of weight loss over which period of time should be considered? Involuntary weight loss >5 % within past month, or >10 % beyond 1 month Involuntary weight loss >5 % within past 6 months, or >10 % beyond 6 months (GLIM)	54.5 45.5	–
Muscle Mass (BIA)	We ask you whether you agree with applying BIA measurements in practice, acknowledging its limitations.	**100.0**	–
	We suggest to apply the methods from the literature and data base analyses [38–41] in practice to study how they relate to each other and learn from this.	**91.0**	9.0
	We suggest using data-driven cut-off points for low muscle mass from data collected in practice.	**91.0**	0.0
	We suggest using the reference values for calf circumference that were derived from the nHanes database [41]. These reference values are adjusted for age, sex and BMI.	**81.8**	18.2
Functional parameters	Functional parameters should NOT be included in the reference method to define malnutrition in patients with obesity.	54.5	45.5
Inflammation	Do you agree to follow the GLIM guidance as described above?	**91.0**	9.0
Reduced Dietary intake	Please indicate whether you agree with the suggestion to leave the judgement of poor/ unhealthy dietary intake to a dietitian.	**81.8**	18.2

[a] **Bold %** denotes that ≥70 % consensus was achieved.

Table 6
Overview of undecided statements after round 3 of the delphi study.

Topic	Undecided Statements
Weight and Weight Loss	Weight loss (%), >5 % within past six months or >10 % indefinite of time, can be used in the definition of malnutrition in patients with obesity
Muscle Mass	At which percentile of the research cohort would you call the population at risk of low muscle mass?
Functional parameters	Functional parameters should NOT be included in the reference method to define malnutrition in patients with obesity

Finally, participants emphasised the importance of assessing reduced dietary intake in diagnosing malnutrition in patients with obesity. They advocated for evaluating not only protein and energy intake but also diet quality, micronutrient adequacy, and chronic conditions that affect food absorption. They stressed the need for comprehensive dietary assessments to accurately identify malnutrition risks in this population.

In summary, participants highlighted the need for refined GLIM criteria tailored to obesity, particularly in areas like weight loss measurements, muscle mass assessment, and anthropometric parameters. They also underscored the need for further research to validate methods like BIA and CRP and to incorporate additional factors such as diet quality and comorbidities into the assessment process.

3.2.2. Round 2

3.2.2.1. Summary of participants' comments from Round 2. In Round 2 of the study, participants highlighted the challenges of measuring muscle mass in patients with obesity, particularly noting that standard indices adjusted by height squared may not effectively identify low muscle mass. They suggested using the Sarcopenic Obesity Global Leadership Initiative's (SOGLI) cut-offs, which adjust muscle parameters by weight or BMI [35]. Additionally, participants recommended applying higher muscle mass cut-offs specific to patients with obesity. They also noted the need for reference ranges tailored to this population. Also, both the Dutch guideline for overweight and obesity (2023) and the European Association for the Study of Obesity (EASO) consensus [40] were referenced as useful sources.

When discussing weight and weight loss, participants raised concerns about the cut-off values used for diagnosing weight loss in patients with obesity, suggesting that more research is needed to establish precise cut-offs and timeframes. They highlighted the issue of indefinite timeframes and recommended specifying a timeframe, such as the past two years. The distinction between voluntary and involuntary weight loss was emphasised, and it was agreed that percentage-based measures—such as 5 % loss within one month or 10 % loss within six months—might reflect acute and significant weight loss better. Participants also discussed the importance of distinguishing between muscle loss and fat loss, and the need to clarify whether the proposed cut-offs apply to acute or gradual weight loss.

Regarding muscle mass assessment, participants criticised the use of BIA as an assessment due to its unreliable accuracy in patients with obesity. While BIA might be useful for group assessments, it was considered unsuitable as a screening tool and more appropriate for controlled research settings. Instead of scaling muscle to height squared, participants recommended using the specific cut-points provided in existing guidelines. They also proposed calf circumference (with obesity-specific cut-offs) as a potential alternative measurement. Moreover, the distinction between malnutrition and sarcopenia was emphasised, as malnutrition can contribute to or increase the risk of sarcopenia, which is not limited to protein and energy deficiencies but also includes other nutritional imbalances. Developing a practical prediction equation for BIA in obesity was seen as challenging due to the complexity of incorporating numerous variables, and while BIA's potential usefulness was acknowledged, participants expressed scepticism about the need for further studies in practical settings.

In terms of anthropometry, participants saw calf circumference as a useful screening tool in clinical settings, particularly when other body composition techniques are unavailable. However, it was noted that the assessment of calf circumference should be complemented by an evaluation of leg oedema, and its application should be adapted to account for obesity, as recommended by GLIM. While it could be practical with proper training, participants called for more research to establish reference ranges and cut-off points for patients with obesity and to understand its relationship with nutrient depletion, mobility, and physical activity. Concerns about measurement variability and patient differences were also noted.

Functional parameters were considered crucial for a comprehensive assessment, although they are not included in the GLIM criteria for diagnosing malnutrition. Participants emphasised that while HGS is a useful tool, it may not accurately reflect low strength in patients with obesity. To improve its accuracy, adjusting for factors like BMI (e.g., HGS/BMI) was suggested. Although HGS provides valuable information, the chair stand test was regarded as potentially more valuable, though further research is needed to confirm this. Participants agreed that while functional parameters are primarily indicative of sarcopenia, they could still provide important insights into assessing malnutrition in obesity, given the overlap between malnutrition in obesity and sarcopenic obesity.

Regarding inflammation, participants underscored that inflammation alone is insufficient for diagnosing malnutrition according to GLIM and that a phenotypic criterion is essential. They raised concerns about the appropriate cut-off points for low-grade inflammation in patients with obesity, as chronic low-grade inflammation can lead to elevated CRP levels that do not necessarily indicate malnutrition. The need for further research to determine the exact CRP cut-offs was emphasised, and participants noted the challenges in determining the timing, frequency, and methods for measuring inflammation, as well as the reference values to be used.

Finally, participants discussed reduced dietary intake assessment, noting the lack of simple, practical, and valid methods for untrained practitioners to assess malnutrition effectively. They recommended using terms like 'inadequate' or 'poor diet quality' instead of 'unhealthy diet' and suggested that diet quality should not be included as an etiologic criterion for malnutrition in the GLIM criteria, as it does not directly lead to the phenotypic criteria of malnutrition. Participants emphasised that an unhealthy diet should be considered separately from malnutrition, especially in patients with obesity, where malnutrition might not only stem from undernutrition but also from dietary imbalances. They recommended focusing on meeting energy and protein requirements, rather than combining diet quality with malnutrition criteria, as these are distinct concepts: inadequate intake versus poor diet quality.

In summary, participants called for more research and clarity in areas such as muscle mass measurement, weight loss cut-offs, and inflammation. The need for clear guidelines on inadequate dietary intake and functional assessments in diagnosing malnutrition in patients with obesity was also emphasised.

3.2.3. Round 3

Following Round 2, the focus shifted towards operationalising the findings to ensure their practical consistency in diagnosing malnutrition in patients with obesity. This step was essential for refining the proposed criteria and ensuring their relevance for clinical settings. As a result, the statements in Round 3 were revised to assess how the proposed criteria could effectively be applied in practice, considering the unique challenges of this population.

3.2.3.1. Summary of participants' comments from round 3. In Round 3 of the study, participants expressed a preference for a higher weight loss threshold of 10 %, citing an increased risk of mortality associated with significant weight loss. While there was strong agreement on the use of BIA, participants acknowledged its limitations and preferred data-driven cut-off points, though the specific percentiles varied. The role of functional parameters in malnutrition assessment was debated, with many participants suggesting that these may be more reflective of sarcopenia rather than malnutrition specifically.

There was consensus on following the GLIM guidelines for inflammation, with participants agreeing that CRP measurements should be used when available. This was seen as an essential criterion for diagnosing malnutrition in patients with obesity.

Regarding reduced food intake or assimilation, participants emphasised the importance of a dietary assessment by a dietitian. However, concerns were raised about the practicality and completeness of collecting dietary data in routine clinical practice.

Several additional points were raised, including the need to clarify the distinction between 'poor dietary intake' and 'unhealthy diet' as the current definitions may not fully capture these concepts. Participants also suggested exploring alternative methods to measure energy intake to improve the reliability of dietary assessments. Finally, practical considerations related to the implementation of dietary and functional assessments in clinical studies were discussed, with a focus on ensuring these assessments can be incorporated into routine clinical practice without creating an undue burden on study experts or research teams.

4. Discussion

This modified Delphi study represents an important step towards developing a working definition of malnutrition in patients with obesity, addressing notable gaps in the clinical management of this complex condition. The expert panel highlighted the challenges in diagnosing malnutrition in obesity, emphasising the need for tailored methodologies that consider excess weight, the physiological changes associated with illness and inadequate dietary intake. While consensus was reached on using the GLIM criteria as the foundational framework for diagnosing malnutrition in obesity, the study did not yield a final working definition.

It was acknowledged, however, that the GLIM criteria require further adaptation for this population. A more detailed exploration of cut-off values for key indicators, such as weight loss and muscle mass, is needed to reflect the distinct phenotypical characteristics of obesity better. This would improve the accuracy and clinical applicability of the criteria.

The use of muscle mass as a diagnostic parameter remains uncertain, with concerns about the applicability of existing reference data across diverse populations (e.g., chronic vs. acute illnesses). BIA and anthropometry were criticised for their questionable accuracy in patients with obesity. While BIA is widely used for its convenience and non-invasiveness, its validity remains inconclusive, as it may be affected by factors such as excess fluid [34], which is more common in this population and can potentially lead to skewed results. Correction factors may be needed for more accurate measurements.

Alternative methods, such as DEXA and CT, may offer more reliable muscle mass assessments, but their accessibility, cost and weight restrictions present limitations [39]. No consensus was reached on the most appropriate assessment method for patients with obesity, highlighting the need for further research.

The role of inflammation in malnutrition diagnosis elicited debate, particularly regarding CRP as an inflammatory marker. While some consensus was reached on its cut-off values, concerns remained about CRP's validity as a standalone indicator due to its susceptibility to fluctuations influenced by chronic low-grade inflammation in obesity. Participants supported multi-point CRP assessments but acknowledged the need for further research to explore combinations of inflammatory markers and the importance of repeated measurements. This could improve the reliability and clinical applicability of inflammatory markers in patients with obesity.

Assessing reduced food intake or assimilation according to the GLIM criteria also emerged as another key challenge. Although most participants (65%) agreed on having relevant cut-off points to define a patient with obesity as malnourished based on dietary intake, they stressed the importance of evaluating both the quality and quantity of intake. High caloric consumption coupled with micronutrient deficiencies is frequently observed in patients with obesity, underscoring the need for comprehensive dietary assessments.

Participants also emphasised the need to use and differentiate between 'inadequate intake'—which refers to insufficient consumption relative to an individual's needs—and 'poor diet quality,' which involves unbalanced diets that may lead to nutrient deficiencies despite adequate caloric intake [49]. While this feedback reflected concerns around clarity, we further acknowledge that the commonly used term 'unhealthy diet' may be too vague and potentially misleading in the context of malnutrition assessment [50]. Adopting more precise, neutral terminology may improve clarity in assessing malnutrition and discussing related dietary factors, particularly in patients with obesity. The involvement of dietitians was also highlighted as essential for accurate data collection, alongside addressing the potential for underreporting within this population [51].

4.1. Strengths and limitations

The study's strengths include using the Delphi methodology, which facilitated structured expert input and iterative refinement of statements [23]. The modified Delphi approach also allowed for interactive discussions in the final round, enabling participants to clarify viewpoints and strengthen arguments [52]. By addressing multiple dimensions of malnutrition, such as inadequate dietary intake, low muscle mass, inflammation and functional parameters, the study provides a comprehensive framework for addressing this complex condition. Although not intended to establish clinical guidelines directly, the findings highlight key diagnostic challenges and unresolved areas. These insights may serve as a valuable foundation for future clinical application and guide the development of policies or standardised assessment strategies for malnutrition in patients with obesity.

However, some limitations should be noted. The small sample size may limit the generalisability of the findings. Additionally, the predominance of experts from the Netherlands could reduce the geographical diversity of perspectives. Although the panel included experts from other countries such as Brazil, Canada, Italy, Spain, and the USA, the concentration of Dutch-based experts may affect the broader development of the diagnostic criteria for malnutrition in obesity. Future studies would benefit from a more internationally diverse panel to improve the relevance of the findings across regions and disciplines.

The response rate declined across the Delphi rounds (88 % in Round 1, 77 % in Round 2, and 50 % in Round 3), which could affect the reliability and diversity of the final consensus. This increasing dropout rate, particularly in Round 3, may have resulted from participant fatigue or reduced engagement due to the demands of multiple rounds [53]. As participation reduced, the diversity of opinions represented in the panel's responses could have been compromised. Future studies could address this by implementing personalised invitations, frequent follow-ups, a shorter timeframe to sustain engagement, or incentives to encourage continued participation.

Furthermore, the generalisability of the findings could be improved by using a more representative sample. For instance, snowball sampling might be an effective way to broaden the pool of participants. While inviting experts ensured high levels of knowledge, the reliance on expert opinion also introduced subjectivity, which could affect the robustness of the findings.

Several strategies were applied within the Delphi method to minimize potential biases and encourage balanced participation. Anonymity during the Delphi rounds promoted honest responses and reduced the influence of dominant voices, allowing participants to express their views freely [53]. Multiple rounds allowed participants to refine their opinions based on anonymous feedback from the panel in each round, ensuring a more balanced and well-considered consensus. However, this flexibility may also have introduced biases, as participants could have adjusted their responses to align with the perceived majority opinion [53]. To mitigate this, the process was carefully managed to ensure a diverse group of experts was selected for their relevant expertise and alignment with the study's objectives [54]. Participants were also encouraged to retain their independence and provide authentic input based on their unique areas of knowledge.

Finally, the lack of consensus on certain statements on weight loss thresholds, muscle mass measurements and functional parameters highlights the need for future empirical validation. Despite these limitations, the study provides a valuable foundation for further international discussion on this complex topic.

5. Suggestions for future research

Impact of Involuntary Weight Loss in Obesity: Future research should examine the effects of involuntary weight loss on QoL, functionality, and other health outcomes beyond mortality. Establishing thresholds for critical weight loss in patients with obesity, including specific timeframes, is essential. Additionally, the overlap between involuntary weight loss and sarcopenic obesity [35] in this population requires further exploration.

Muscle Mass Parameters in Malnutrition Diagnosis: Further studies should investigate appropriate adjustments for height and body size in assessing muscle mass and identify thresholds that predict clinical outcomes in patients with obesity. Further studies are needed to understand how lean mass loss impacts functionality and QoL.

Functional Health Assessments: Future research may help evaluate functional parameters to distinguish malnutrition in patients with obesity from sarcopenic obesity, which often overlaps. Further studies should focus on assessing muscle functionality and QoL, particularly in patients with high-fat mass, low muscle mass, and inadequate dietary intake.

Inflammatory Markers: Further research is needed to determine the relevance of CRP and other inflammatory markers, such as IL-6, for diagnosing malnutrition in patients with obesity, Investigating the standardisation of these markers across diverse populations and conditions (e.g., acute vs. chronic disease) could lead to more consistent criteria.

Dietary Evaluations: Future studies should explore the integration of assessments for both dietary quality and quantity, supported by innovative technologies such as hyperspectral imaging, digital logs, and mobile apps. Investigating the effectiveness of these technologies could improve the accuracy of dietary evaluations and identify malnutrition risk more reliably, paving the way for their widespread adoption in clinical practice.

Clinical Imaging: Further research is needed to evaluate the use of routine CT imaging for assessing muscle loss in clinical settings. Studies should focus on leveraging existing CT data, typically collected for other diagnostic purposes, to monitor malnutrition-related muscle loss, and examine whether this approach can be standardised and integrated into clinical practice for early identification and ongoing.

Testing Consensus Guidelines in Clinical Practice: Further studies should assess the consensus guidelines in real-world clinical settings to evaluate their effectiveness and feasibility. This will help refine their application across diverse healthcare environments.

Generalisability Across Populations and Healthcare Systems: Future research should explore the applicability of the findings across different populations, considering demographics, comorbidities, and disease stages, and evaluate their use in various healthcare systems.

6. Conclusion

At the end of this modified Delphi study, no consensus was reached on a new working definition of malnutrition in patients with obesity. However, the study provides a critical foundation for understanding malnutrition in this population, emphasising the need for a comprehensive approach that integrates weight loss, functional parameters, reduced dietary intake, and inflammation.

Author contributions

JH and MdvdS: Conceptualisation, JH and MdvdS: Methodology, JH, NNM and MdvdS: Investigation, NNM and JH: Data Curation: NNM and JH: Formal Analysis: NNM and JH: Writing – Original Draft, All authors: Writing – Review & Editing and MdvdS: Supervision.

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Declaration of competing interest

The authors declare none.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnesp.2025.05.043.

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