Validated screening tools for the assessment of cachexia, sarcopenia, and malnutrition: a systematic review

Validated screening tools for the assessment of cachexia, sarcopenia, and malnutrition: a systematic review

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Abstract

Background: There is great overlap between the presentation of cachexia, sarcopenia, and malnutrition. Distinguishing between these conditions would allow for better targeted treatment for patients.

Objectives: The aim was to systematically review validated screening tools for cachexia, sarcopenia, and malnutrition in adults and, if a combined tool is absent, make suggestions for the generation of a novel screening tool.

Design: A systematic search was performed in Ovid Medline, EMBASE, CINAHL, and Web of Science. Two reviewers performed data extraction independently. Each tool was judged for validity against a reference method. Psychometric evaluation was performed as was appraisal of the tools' ability to assess the patient against consensus definitions.

Results: Thirty-eight studies described 22 validated screening tools. The Cachexia score was the only validated screening tool for cachexia and performed well against the consensus definition. Two tools assessed sarcopenia [the Short Portable Sarcopenia Measure (SPSM) and the SARC-F] and scored well against the 1998 Baumgartner definition. The SPSM required large amounts of equipment, and the SARC-F had a low sensitivity. Nineteen tools screened for malnutrition. The 3-Minute Nutrition Score performed best, meeting consensus definition criteria (European Society for Clinical Nutrition and Metabolism) and having a sensitivity and specificity of >80%. No tool contained all of the currently accepted components to screen for all 3 conditions. Only 3 tools were measured against cross-sectional imaging, a clinical tool that is gaining wider interest in body-composition analysis.

Conclusions: No single validated screening tool can be implemented for the simultaneous assessment of cachexia, sarcopenia, and malnutrition. The development of a tool that encompasses consensus definition criteria and directs clinicians toward the underlying diagnosis would be optimal to target treatment and improve outcomes. We propose that tool should incorporate a stepwise assessment of nutritional status–oral intake, disease status, age, muscle mass and function, and metabolic derangement. *Am J Clin Nutr* 2018;108:1–13.

Keywords: cachexia, sarcopenia, malnutrition, screening, assessment

INTRODUCTION

Unintentional weight loss (UWL) as a form of nutritional depletion is commonly seen in aging, cancer, and many chronic diseases. The main subtypes can be categorized into 3 primary syndromes: cachexia, age-related sarcopenia, and malnutrition. However, it is not clear whether existing screening tools are able to distinguish between these 3 conditions. This is due in part to the complex overlap between them. Loss of muscle mass is a key feature in both cachexia and sarcopenia, but patients with sarcopenia are not necessarily cachectic. Sarcopenia can occur simply with aging and leads to functional decline (1, 2). Cachexia involves complex metabolic pathways leading to systemic inflammation and muscle and fat wasting and must be present in association with a chronic disease (3). Cachexia differs from malnutrition in that it cannot be reversed by simple nutritional support (4). There are many definitions for each condition, with nutritional depletion playing a part in each, therefore making it difficult to separate them out (1–4). These conditions are also often not noticed in their earlier phases but

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Abbreviations used: CASCO, Cachexia Score; CT, computed tomography; DXA, dual-energy X-ray absorptiometry; MNA, Mini Nutritional Assessment; SGA, Subjective Global Assessment; SPSM, Short Portable Sarcopenia Measure; 3-MinNS, 3-Minute Nutrition Score; UWL, unintentional weight loss.

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do become apparent after a critical event or development of disability (5).

More than 70 nutritional screening tools for use in hospitals have been developed to facilitate easy screening or assessment of a patient's nutritional status or to predict poor clinical outcome related to UWL. Despite increasing research, there appears to be a lack of a practical and implementable clinical screening tool to support diagnosis (6). In the general community, the European Society for Clinical Nutrition and Metabolism endorses the use of the Malnutrition Screening Tool (MUST) (6, 7) and the Nutritional Risk Screening (NRS-2002) (8) and the Mini Nutritional Assessment (MNA)–Short Form for the elderly (9, 10). Some tools claim to have been developed to screen specific target groups; however, there are currently no disease-specific recommendations. There is no international consensus on a single "best tool" to identify all 3 syndromes across populations. The use of different tools in different studies makes drawing any conclusions about their comparison and meta-analyses difficult.

Current diagnostic methods for sarcopenia and cachexia include the assessment of body anthropometric measures using either BMI or estimated weight loss, or by direct assessment of muscle and fat mass using dual-energy X-ray absorptiometry (DXA), bioelectrical impedance analysis, computed tomography (CT), or MRI scanning. Although the latter 2 radiographic modalities are accurate, they are impractical and expensive and some expose the patient to radiation. This diagnostic approach to detect the presence of sarcopenia is time consuming, expensive, and requires highly specialized equipment (11). Therefore, a screening tool that is implementable in a larger population that allows for early detection is important. This approach would highlight the potential for further assessment with early biomarkers, thus allowing prophylactic intervention in malnutrition and driving further research in sarcopenia and cachexia.

We aimed to systematically review validated screening tools for the general adult population to enable clinicians to distinguish between the 3 syndromes. The specific strengths and limitations of each tool were assessed, as was the appropriateness of the validation population. Through psychometric evaluation and assessment of the tools against the agreed-upon consensus definitions, we also investigated if any one single tool could be used for the simultaneous assessment of all 3 syndrome.

METHODS

Methods for conducting systematic reviews of the effectiveness of interventions have been well described. In accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (12), we applied the principles to systematically reviewing validated screening tools used in the assessment of cachexia, sarcopenia, and malnutrition.

Literature review

A systematic search was performed on 7 August 2018 in Ovid Medline (1946–2017), EMBASE (1974–2017), CINAHL (Cumulative index to Nursing and Allied Health Literature), and Web of Science. Relevant articles were identified by title and abstract. Reference lists of review articles were also handsearched. Double data extraction was performed by 2 reviewers independently to ensure consistency. Any disagreements were settled by a third reviewer.

The basic search strategy was "Sarcopenia" OR "Cachexia" OR "Malnutrition" AND "screening" AND "validation study" using MeSH (Medical Subject Heading) terms and keywords appropriate to each database. No language restriction was imposed. The search was designed to be broad to ensure all validated tools were identified. A full copy of the search used for Medline can be found in the **Supplemental Material**. There were no disease-specific or language limits.

Inclusion and exclusion criteria

Studies were included if they had developed a screening tool that had been validated for the screening of either cachexia, sarcopenia, or malnutrition in adults (**Table 1**). Disease-specific tools were included. Studies were excluded if the tools had not been validated or if they assessed malnutrition in children or obesity in adults. Studies that described modified versions of pre-existing tools were also excluded because this was out of the scope of this review. It was intended that studies that included <25 patients should be excluded because they were unlikely to yield robust, generalizable psychometric results; however, no studies with numbers smaller than this were found.

Assessment of validity

Studies had to have evaluation of ≥ 2 of the following psychometric characteristics: content validity, construct validity (e.g., including convergent validity, discriminant validity), test-retest reliability, internal consistency, responsiveness, factor analysis, or criterion validity. Primary criteria used to evaluate the tools were construct validity and responsiveness.

Criterion and construct validity, reference method

Studying the validity of a tool usually involves comparison to a gold standard. Although many research groups are now using cross-sectional imaging to investigate UWL, there is currently no perfect gold standard. Studies used different reference methods to validate their tools (e.g., DXA and assessment by a health professional). The tools Subjective Global Assessment (SGA) and the MNA are the tools currently recognized as the industry standard and were therefore considered valid references. The term "criterion validity" was used for these comparisons.

Less-valid reference methods, including the use of other screening tools and blood tests (e.g., albumin) which can be influenced by other factors including inflammation and acute disease, were included because many research groups vary in their opinion on the optimal reference method (13). These comparisons were termed "construct validity."

Predictive validity

Predictive validity was assessed as the ability of the tool to predict the probability of a better or worse clinical outcome due to nutritional risk.

TABLE 1
Inclusion criteria

	Description
Types of participants: adults (aged >18 y) undergoing routine screening for cachexia, sarcopenia, or malnutrition	Includes patients with advanced cancer and end-stage cardiac, renal, and liver disease
Types of tools: validated, quantitative measurements of cachexia, sarcopenia or malnutrition	Tools developed for clinical or research purposes; completed by health care professionals
Psychometric evaluation (demonstration of ≥2 criteria)	
Content validity	Breadth of scope of tool: to what extent does it appear to capture the relevant aspects of unintentional weight loss; are there gaps?
Construct validity, including convergent validity, discriminant validity	How well the tool relates to other measures of the same construct; lack of correlation with dissimilar or unrelated constructs or variables
Test-retest reliability	How consistent an individual's scores are over a defined time period presuming weight stays constant
Internal consistency	How closely related are the different items in the tool?
Responsiveness	Ability to detect clinically meaningful change for individuals
Factor analysis	For a tool comprising several items, a way of grouping them into factors which may tap into a particular construct
Criterion validity	A shortened version of a scale, concurrent validity with the longer version that has been validated

Diagnostic criteria

Tools were also assessed for their ability to identify the risk of cachexia, sarcopenia, or malnutrition by comparison of their components against the components of each set of chosen diagnostic criteria (**Table 2**).

Assessment of bias

Assessment of bias was made with the use of a form of the Newcastle-Ottawa scale adapted for cross-sectional studies (14). Each study was scored out of 10 possible points, and a study with a score of <5 was considered to be at high risk of bias. Full details of the scoring used can be found in the **Supplemental Material**.

Secondary criteria

Secondary criteria included face validity, development and content validity, factor analysis, test-retest reliability, internal consistency, and respondent and administrative burden (the time and effort required to complete the tool). These are also summarized in Table 1. Data were extracted on the study participants, the tool used, and psychometric evaluations (inclusion criteria, Table 1). An assessment of sensitivity and specificity was made. A value >80% was considered good, 60–80% fair, and <60% poor. Agreement was also assessed as follows: 0.9–1.0 = excellent, 0.80–0.90 = good, 0.60–0.80 = fair, and <0.60 = poor.

RESULTS

Principal findings

Thirty-eight studies were included that described the validation of 22 screening tools. The majority of studies were excluded because they described nonvalidated tools. This is summarized in **Figure 1**.

The Cachexia score (CASCO) was the only screening tool for cachexia that had been validated. It performed well against diagnostic criteria (3), but sensitivities and specificities were not recorded. Only 2 tools assessed sarcopenia [the Short Portable Sarcopenia Measure (SPSM) and the SARC-F] and scored well against the agreed definition (1). However, the SPSM required a large amount of equipment and the SARC-F had very low sensitivity. Both were validated for use in the outpatient setting.

TABLE 2
Summary of proposed diagnostic criteria for identification of cachexia, sarcopenia, and malnutrition[1]

Syndrome	Diagnostic criteria
Cachexia	Weight loss >5% or weight loss >2% in individuals already showing depletion according to current body weight and height [BMI (in kg/m^2) <20] or skeletal muscle mass (sarcopenia)[2]
Sarcopenia	Loss of function: 6-min walk <400 m or gait speed <1.0 m/s Muscle mass: low appendicular lean mass or height[3] (2 SDs below the mean diagnostic on DXA[4])
Malnutrition	Protein-energy deficiency: risk indicated by low BMI <18.5 or weight loss >10% (indefinite time)/5% over last 3 mo and BMI <20 (if aged <70 y)/<22 (if aged >70 y) or FFMI <15 and 17 kg/m^2 in men and women, respectively[5]

[1]DXA, dual-energy X-ray absorptiometry; FFMI, fat-free mass index.
[2]Data from reference 3.
[3]Data from reference 2.
[4]Data from references 1 and 2.
[5]Data from reference 4.

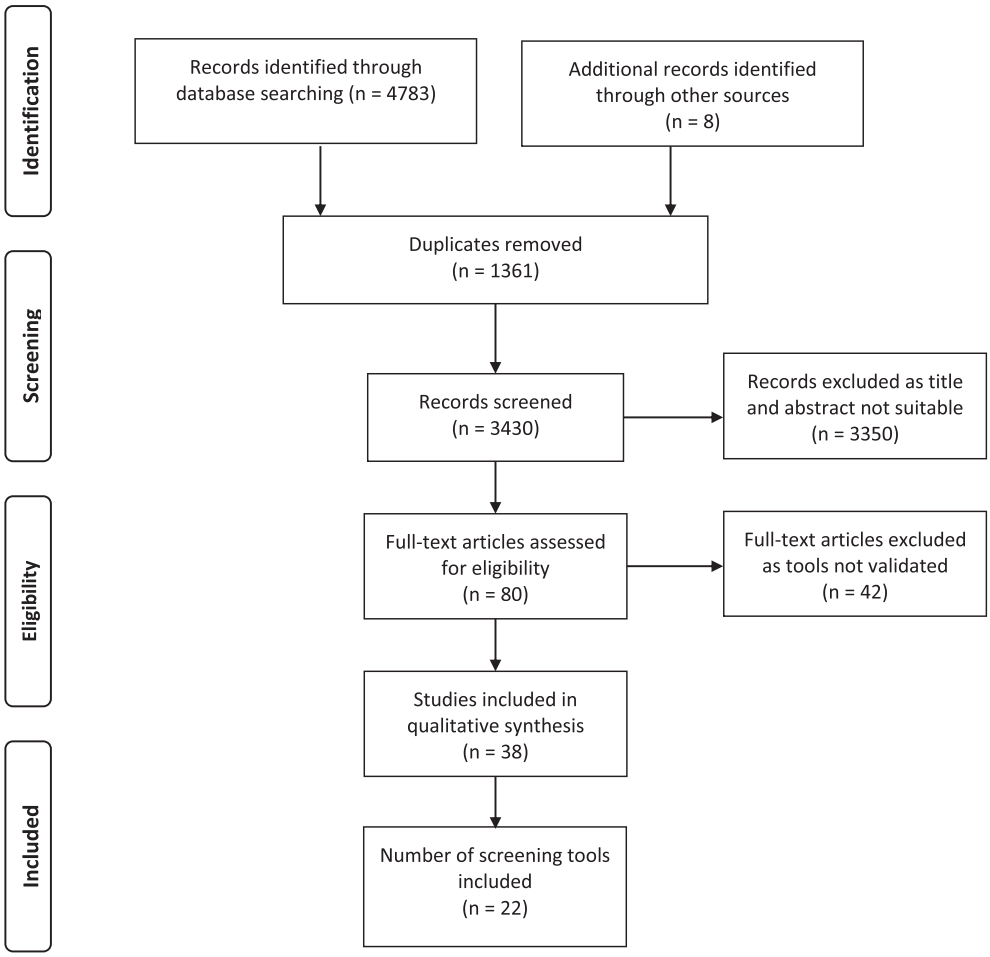

FIGURE 1 PRISMA flow diagram (12). PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Nineteen tools screened for malnutrition. The 3-Minute Nutrition Score (3-MinNS) proved to be the best, scoring well against the consensus definition (European Society for Clinical Nutrition and Metabolism) as well as having sensitivities and specificities >80%. There was no single validated tool that adequately screened for all 3 conditions. A critical appraisal of all tools can be found in **Table 3**.

Tools with evidence of validity, reliability, and acceptability

The available validity, reliability, and acceptability data are summarized in **Tables 4** and **5**. **Table 6** assesses how well each tool encompasses the criteria in the chosen definitions. Assessment of bias is shown in **Table 7**.

Sarcopenia

In total, 2 tools were found that were validated for the assessment of sarcopenia (SPSM and SARC-F). Three other tools assessed muscle function, but no other tools made an assessment of muscle strength, mass, or wasting. Both tools that were validated for the assessment of sarcopenia were done so in the community setting. They agreed with the SCWD diagnostic criteria, but the SARC-F showed variation in agreement against the 3 consensus definitions it was validated against (EWGSOP, IWGS criteria, and the Asian working group for sarcopenia). The SARC-F had good specificity (94.2–99.1%) but poor sensitivity (3.8–9.9%, dependent on sex) and also showed good agreement (0.78–0.90). Values for the SPSM were not assessed.

Cachexia

Only 1 tool had been validated for the screening of cachexia—the CASCO. Overall, 6 tools quantified weight loss within a specified time frame, with a further 3 quantifying it within an unspecified time frame. Sixteen tools characterized weight loss as unintentional. Only 7 tools asked about the presence of underlying disease, and only the CASCO took into account the presence of elevated inflammatory markers and quality of life. Sensitivities and specificities were not recorded for the CASCO, but it scored well in the assessment of its validity, with it being able to quantitatively classify stages of cachexia. Its ability to predict patient outcome was not assessed.

Malnutrition

Nineteen screening tools were found to be validated for the assessment of malnutrition. However, only 12 of these

TABLE 3
Critical appraisal of tools to measure unintentional weight loss[1]

Study, year (ref)	Tool	Description	Validation population	Validation reference	Strengths	Limitations
Sarcopenia						
Woo et al., 2014 (15)	SARC-F	A questionnaire regarding ability to carry a heavy load, walking, rising from a chair, climbing stairs, and frequency of falls	Community-dwelling Chinese ($n = 4000$)	3 consensus definitions of sarcopenia	Not dependent on cutoff values	No assessment of muscle mass, not validated in hospital populations
Miller et al., 2009 (16)	SPSM	Portable measure that combines estimates of muscle quantity and function into a single scale	Community-dwelling African Americans ($n = 998$)	DXA	Portable	Time-consuming, equipment-dependent, muscle mass not measured
Cachexia						
Argiles et al., 2017 (17)	CASCO	Score to classify cachectic patients into 3 different groups; includes 5 components: body weight loss and composition, inflammation/metabolic disturbances/immunosuppression, physical performance, anorexia, and quality of life	Cancer patients ($n = 186$)	Assessment by oncologist	Encompasses all diagnostic criteria	Involves many questions and measurements, does not include questions on disease state
Malnutrition						
Weekes et al., 2004 (18)	BAPEN	Tool based on 4 nutritional parameters (weight, height, recent UWL, and appetite)	Acute medical and elderly care wards ($n = 100$)	Dietitian	Quick and easy	Percentage of weight loss not quantified
Mimiran et al., 2011 (19)	BNST	Score based on UWL, unintentional eating loss, and being unable to eat for >5 d	Medical and surgical ($n = 446$)	Dietitian	Easily completed by nursing staff	Low importance given to amount of weight loss
Laporte et al., 2015 (20)	CNST	Tool containing 2 items: weight loss and decreased food intake	Medical and surgical ($n = 150$)	SGA	Very brief, can be completed by nontrained rater	Assessed on admission only; validity of rescreening unknown
Ignacio et al., 2005 (21)	CONUT	Evaluates nutrition using albumin, cholesterol, and lymphocyte count; automated system	Medical and surgical inpatients ($n = 53$)	SGA	Simple, automated	Markers vary depending on disease state, only done in patients who have blood samples taken
Guerra et al., 2017 (22)	EDC	Screening tool based on ESPEN criteria for diagnosis malnutrition	Medical and surgical inpatients ($n = 632$)	PG-SGA	Includes FFM assessment	Very low sensitivity
Abd-El-Gawad et al., 2014 (23)	GNRI	Modified nutritional risk index for geriatric patients (based on albumin, current and previous weight)	Acute geriatrics ward ($n = 131$)	MNA	Good prognosticator, does not require capacity	Diseases associated with high mortality or hypoalbuminemia excluded
Tammam et al., 2009 (24)	INSYST	Two-tiered tool: first is a simple prescreen aiming to establish if malnourished; second provides a more detailed evaluation	Medical, surgical and oncological inpatients ($n = 61$)	MUST and MNA	Does not require height and BMI, quick and easy	Ease of completing dependent on patient's cognitive state
Ferguson et al., 1999 (25)	MST	Two questions regarding appetite and UWL	Medical and surgical inpatients ($n = 408$)	SGA	Very quick, does not require calculations	Nonspecific
Isenring et al., 2006 (26)			Oncology outpatients ($n = 51$)	PG-SGA		
Neelemaat et al., 2011 (27)			Acute hospitalized ($n = 193$)	Malnutrition definition		
Nursal et al., 2005 (28)			Medical and surgical inpatients ($n = 2211$)	CT		
Young et al., 2013 (29)			Elderly medical inpatients ($n = 134$)	—		
Wu et al., 2012 (30)			Elderly inpatients ($n = 157$)	—		
Bhuachalla et al., 2018 (31)			Oncology patients ($n = 725$)	—		
Leiopold et al., 2018 (32)			Rehabilitation patients ($n = 160$)	—		
Kim et al., 2011 (33)	MSTC	Tool based on intake change, weight loss, ECOG performance status, and BMI	Oncology inpatients ($n = 1057$)	PG-SGA	Cancer-specific	Designed to be performed by dietitians, not nurses
Boleo-Tome et al., 2012 (34)	MUST	Five-step tool including BMI, unplanned weight loss, and presence of acute disease	Oncology inpatients ($n = 450$)	PG-SGA	Quick, easy	Does not pick up patients with normal BMI who are malnourished, UWL reported by patients is subjective
Leistra et al., 2013 (35)			Medical and surgical outpatients ($n = 2236$)	Malnutrition definition		
Sharma et al., 2017 (36)			Acute medical inpatients ($n = 132$)	CT		
Neelemaat et al., 2011 (27)			Elderly inpatients ($n = 198$)	—		
Kyle et al., 2006 (37)			Medical and surgical ($n = 995$)	—		

(*Continued*)

TABLE 3
(*Continued*)

Study, year (ref)	Tool	Description	Validation population	Validation reference	Strengths	Limitations
Young et al., 2013 (29)			Medical inpatients ($n = 134$)	—		
Almeida et al., 2012 (38)			Surgical inpatients ($n = 300$)	—		
Velasco et al., 2011 (39)			Medical and surgical ($n = 400$)	—		
Bhuachalla et al., 2018 (31)			Oncology patients ($n = 725$)	—		
Prasad et al., 2012 (40)	NRI	Derived from serum albumin concentration and ratio of usual to present weight	Peritoneal dialysis patients ($n = 283$)	SGA	Assesses dialysis patients at risk	Relies on previous weight; limited use with changes in fluid status
Faramarzi et al., 2013 (41)			Colorectal cancer ($n = 52$)	CT		
Bhuachalla et al., 2018 (31)			Oncology patients ($n = 725$)	—		
Neelemaat et al., 2011 (27)	NRS-2002	Tool containing nutritional components of the MUST along with disease severity	Elderly inpatients ($n = 198$)	Definition of malnutrition	Includes disease severity; therefore. applicable in ITU	Ease of completing dependent on patient's cognitive state
Kyle et al., 2006 (37)			Medical and surgical ($n = 995$)	—		
Young et al., 2013 (29)			Elderly medical patients ($n = 134$)	SGA		
Almeida et al., 2012 (38)			Surgical inpatients ($n = 300$)	—		
Bauer et al., 2005 (42)			Acute geriatrics ward ($n = 121$)	—		
Velasco et al., 2011 (39)			Medical and surgical ($n = 400$)	—		
Soderhamn et al., 2002 (43)	NUFFE	Three-point ordinal scale with 15 items assessing weight loss, dietary history, appetite, and general activity	Elderly care rehab ward ($n = 114$)	MNA	Simple because lacks anthropometric measurements	Many confounding factors in questionnaire
Duerksen et al., 2000 (44)	SGA	Assessment of nutritional status based on history and examination	Acute elderly care and elderly rehab ($n = 95$)	Geriatric and internal medicine resident, total body nitrogen, anthropometric and biochemical data	Current gold standard	Reproducibility less than in nonelderly, unable to predict severe malnutrition in ESRD, requires experienced operator to carry out
Cooper et al., 2002 (45)			ESRD ($n = 76$)	—		
Moriana et al., 2014 (46)			Medical and surgical inpatients ($n = 197$)	—		
Kruizenga et al., 2005 (47)	SNAQ	26 questions related to eating and drinking difficulties, defecation, condition, and pain	Medical, surgical and oncological inpatients ($n = 291$)	Malnutrition criteria, CONUT	Corresponds to ESPEN criteria	High NPV, no outcome data
Leistra et al., 2013 (35)			Medical and surgical outpatients ($n = 2236$)	—		
Harada et al., 2017 (48)			Oncology outpatients undergoing chemotherapy ($n = 300$)	—		
Neelemaat et al., 2011 (27)			Medical and surgical inpatients ($n = 2211$)	—		
Young et al., 2013 (29)			Elderly medical inpatients ($n = 134$)	—		
Susetyowati et al., 2014 (49)	SNST	Six questions including weight loss, appetite, and health status	Medical and surgical inpatients ($n = 495$)	SGA	Can be done by nontrained staff	No anthropometric assessment, all subjective
Wong et al., 2011 (50)	Spinal NST	Tool that assesses 8 criteria including appetite, weight loss, and level of spinal cord injury	Spinal cord injury patients ($n = 150$)	Dietetic assessment	Disease specific	Requires specialized scales to measure paralyzed patients
Xia et al., 2016 (51)	R-NST	Nine questions assessing malnutrition risk/symptoms combined with albumin, CRP, and urea	Renal inpatients ($n = 122$)	SGA	Renal specific	Patients picked up for conditions other than malnutrition (e.g., hyperkalemia)
Lim et al., 2009 (52)	3-MinNS	Questionnaire based on diagnostic criteria for malnutrition and muscle wastage	Medical and surgical inpatients ($n = 818$)	SGA	Quick and easy	Dependent on cognitive state

[1]BAPEN, British Association for Parenteral and Enteral Nutrition; BNST, British Nutrition Screening Tool; CASCO, Cachexia Score; CNST, Canadian Nutrition Screening Tool; CONUT, Controlling Nutritional Status; CRP, C-reactive protein; CT, computed tomography; DXA, dual-energy X-ray absorptiometry; ECOG, ; EDC, ESPEN Diagnostic Criteria for Malnutrition; ESPEN, European Society for Clinical Nutrition and Metabolism; ESRD, end-stage renal disease; FFM, fat-free mass; GNRI, Geriatric Nutrition Risk Index; INSYST, Imperial Nutritional Screening System; ITU, ; MNA, Mini Nutritional Assessment; MST, Malnutrition Screening Tool; MSTC, Malnutrition Screening Tool for Cancer; MUST, Malnutrition Screening Tool; NPV, negative predictive value; NRI, Nutritional Risk Index; NRS-2002, Nutritional Risk Screening; NUFFE, Nutritional Form for the Elderly; PG-SGA, ; ref, reference; R-NST, Renal Nutritional Screening Tool; SARC-F, ; SGA, Subjective Global Assessment; SNAQ, Short Nutritional Assessment Questionnaire; Spinal NST, Spinal Nutritional Screening Tool; SPSM, Short Portable Sarcopenia Measure; UWL, unintentional weight loss; 3-MinNS, 3-Minute Nutrition Screening.

TABLE 4
Psychometric evaluation of tools to measure unintentional weight loss[1]

Scale	Environment	Context (outpatients or inpatients)	Face validity	Content validity	Factor analysis	Construct validity	Discriminant validity	Predictive validity	Test-retest	Internal consistency	Responsiveness	Acceptability	Time to complete
Sarcopenia													
SARC-F	Community dwelling	Outpatients	♦	–	–	♦	–	♦	–	♦	–	♦	–
SPSM	Community dwelling	Outpatients	–	–	♦	X	♦	♦	♦	♦	♦	–	♦
Cachexia													
CASCO	Oncology	Outpatients	♦	♦	♦	♦	♦	–	–	♦	♦	–	–
Malnutrition													
BAPEN	Acute medical and elderly care	Inpatients	♦	–	–	♦	–	–	♦	–	♦	♦	♦
BNST	Spinal cord injuries	Inpatients	♦	–	♦	–	–	–	♦	–	–	–	–
CNST	Medical and surgical	Inpatients	♦	–	–	♦	–	♦	♦	–	–	–	–
CONUT	Medical and surgical	Inpatients	♦	–	X	♦	–	–	–	–	♦	♦	–
EDC	Medical and surgical	Inpatients	♦	–	–	–	–	♦	–	♦	–	–	–
GNRI	Acute geriatrics	Outpatients	♦	–	♦	–	–	♦	–	–	–	♦	–
INSYST	Medical, surgical, and oncology	Inpatients	♦	♦	–	♦	–	–	♦	–	♦	♦	♦
MST	Medical, surgical, and oncology	Inpatients, outpatients	♦	♦	♦	♦	–	♦	♦	♦	–	♦	–
MSTC	Oncology	Inpatients	♦	X	♦	♦	–	–	–	–	–	X	♦
MUST	Medical, surgical, and oncology	Inpatients, outpatients	♦	♦	X	♦	–	♦	–	–	♦	♦	♦
NRI	Peritoneal dialysis and colorectal cancer	Inpatients	–	–	♦	–	–	♦	–	–	–	♦	–
NRS-2002	Elderly, medical, and surgical	Inpatients	♦	♦	–	♦	–	♦	♦	–	♦	♦	♦
NUFFE	Elderly care rehab	Inpatients, outpatients	♦	♦	♦	♦	–	♦	♦	♦	–	–	–
R-NST	Renal	Inpatients	♦	♦	♦	♦	–	–	–	–	–	X	♦
SGA	Elderly, renal, medical, and surgical	Inpatients	♦	♦	♦	♦	–	♦	♦	♦	–	–	–
SNAQ	Medical, surgical, and oncology	Inpatients, outpatients	♦	♦	–	♦	♦	♦	♦	–	♦	♦	♦
SNST	Medical and surgical	Inpatients	♦	–	♦	–	♦	♦	♦	♦	♦	♦	♦
Spinal NST	Spinal cord injuries	Inpatients	♦	–	♦	–	–	–	♦	–	–	♦	♦
3-MinNS	Medical and surgical	Inpatients	♦	♦	–	♦	♦	♦	♦	–	♦	♦	♦

[1]BAPEN, British Association for Parenteral and Enteral Nutrition; BNST, British Nutrition Screening Tool; CASCO, Cachexia Score; CNST, Canadian Nutrition Screening Tool; CONUT, Controlling Nutritional Status; EDC, European Society for Clinical Nutrition and Metabolism Diagnostic Criteria for Malnutrition; GNRI, Geriatric Nutrition Risk Index; INSYST, Imperial Nutritional Screening System; MST, Malnutrition Screening Tool; MSTC, Malnutrition Screening Tool for Cancer; MUST, Malnutrition Screening Tool; NRI, Nutritional Risk Index; NRS-2002, Nutritional Risk Screening; NUFFE, Nutritional Form for the Elderly; R-NST, Renal Nutritional Screening Tool; SARC-F, ; SGA, Subjective Global Assessment; SNAQ, Short Nutritional Assessment Questionnaire; Spinal NST, Spinal Nutritional Screening Tool; SPSM, Short Portable Sarcopenia Measure; 3-MinNS, 3-Minute Nutrition Screening; ♦, tool assessed for and found to be valid; X, tool assessed for and found not to be valid; –, tool not assessed for/not enough information provided.

incorporated a question about dietary intake or decline. Six measured percentage weight loss over time, and 13 assessed BMI. In particular, those tools that had high sensitivities and specificities (Malnutrition Screening Tool for Cancer and Spinal Nutrition Screening Tool) did not encompass all parts of the agreed-upon definition. The Spinal Nutrition Screening Tool did not assess BMI and the Malnutrition Screening Tool for Cancer made no assessment of quantifying weight loss within a specified time frame. The 3-MinNS was the tool that incorporated the consensus definition criteria and also had high sensitivities and specificities (>80%).

DISCUSSION

Overview

Although current systematic reviews have described the results of studies examining malnutrition screening tools, to our knowledge this is the first review to examine tools that have been validated against another to assess cachexia, sarcopenia, and malnutrition. There has only been one previous review on tools for cachexia, sarcopenia, and malnutrition (53). This review did not include psychometric evaluation, did not comment on the validity of the tools, or compare them to the agreed-upon consensus definitions. Existing systematic reviews of malnutrition screening tools have been limited to describing tools that are non–disease-specific and "quick and easy" or that have been narrative in nature.

Thirty-eight studies describing 22 tools were identified and judged for validity against a reference method. In the absence of a generally recognized gold standard for screening, assessment by a professional, DXA, CT, MRI, anthropometric measures, or the screening tools SGA and MNA were considered "valid" reference methods by our research group (13, 44–46). Although cross-sectional imaging is now used routinely for body-composition analysis, only 3 tools identified were validated against CT. The heterogeneity in populations, age groups, tools, and reference methods was large, and therefore pooling of results was impossible. Most tools had only been tested in one population, making the drawing of any definitive conclusions difficult. There were too few disease-specific tools to conclude which would be superior for different disease processes.

Problems with current screening tools

For the generalized adult population, all of the tools showed inconsistent results with regard to their validity. The SGA,

TABLE 5
Sensitivity, specificity, predictive values, and reproducibility of the studies included[1]

Study, year (reference)	Screening tool	Sensitivity	Specificity	PPV	NPV	Agreement
Woo et al., 2014 (15)	SARC-F	3.8–9.9	94.2–99.1	8.4–54.8	78.4–94.9	0.78–0.90
Miller et al., 2009 (16)	SPSM	—	—	—	—	—
Argiles et al., 2017 (17)	CASCO	—	—	—	—	—
Weekes et al., 2004 (18)	BAPEN	—	—	—	—	0.77
Mirmiran et al., 2011 (19)	BNST	86.7	61.7	79.1	73.1	0.74
Laporte et al., 2015 (20)	CNST	72.6	85.1	81.2	77.0	0.88
Ignacio et al., 2005 (21)	CONUT	92.3	85	—	—	0.488
Guerra et al., 2017 (22)	EDC	17.1	98.3	89.1	58.9	0.803
Abd-El-Gawad et al., 2014 (23)	GNRI	83.1	51.2	78.95	58.33	0.713
Tammam et al., 2009 (24)	INSYST	95–100	65–83	—	—	0.73
Kim et al., 2011 (31)	MST	93	93	98.4	72.7	0.7
Ferguson et al., 1999 (25)		100	92	80	100	0.83
Isenring et al., 2006 (26)		67	86	—	—	0.53
Neelemaat et al., 2011 (27)		49	86	—	—	0.33
Nursal et al., 2005 (28)		73	55	—	—	0.28
Young et al., 2013 (29)		73	70	—	—	—
Wu et al., 2012 (30)		39	93	—	—	0.21
Bhuachalla et al., 2018 (31)		39.4–100	47–74.6	—	—	0.71
Leiopold et al., 2018 (32)		72.2	83.8	69.6	85.4	—
Kim et al., 2011 (33)	MSTC	94	84.2	67.8	97.6	0.70
Boleotome et al., 2012 (34)	MUST	80	89	100	100	—
Leistra et al., 2013 (35)		75	94	43	98	—
Sharma et al., 2017 (36)		69.7	75.8	75.4	70.1	0.49
Neelemaat et al., 2011 (27)		96	80	—	—	—
Kyle et al., 2006 (37)		61	79	—	—	—
Young et al., 2013 (29)		87	86	—	—	—
Almeida et al., 2012 (38)		85	93	—	—	—
Velasco et al, 2011 (39)		72	90	—	—	—
Bhuachalla et al., 2018 (31)		20.8–72.8	48–98.3	—	—	0.816
Prasad et al., 2012 (40)	NRI	92.9	32.39	80.41	60.53	0.63
Faramarzi et al., 2013 (41)		66	60	64	62	0.267
Bhuachalla et al., 2018 (31)		21.2–95	21.2–92.1	—	—	—
Neelemaat et al., 2011 (27)	NRS-2002	92	85	—	—	—
Kyle et al., 2006 (37)		62	93	—	—	—
Young et al., 2013 (29)		90	83	—	—	—
Almeida et al., 2012 (38)		80	89	—	—	—
Bauer et al., 2005 (42)		70	85	—	—	—
Velasco et al., 2011 (39)		74	87	—	—	—
Soderhamn et al., 2002 (43)	NUFFE	71	86	—	—	—
Xia et al., 2016 (51)	R-NST	97.3	74.4	88.0	93.6	0.95
Duerksen et al., 2000 (44)	SGA	—	—	—	—	—
Cooper et al., 2002 (45)		59–68	61–65	41–42	70–83	0.6
Moriana et al., 2014 (46)		—	—	—	—	—
Kruizenga et al., 2005 (47)	SNAQ	79	83	70	89	—
Leistra et al., 2013 (35)		43	99	78	96	—
Harada et al., 2017 (48)		43	99	—	—	—
Neelemaat et al., 2011 (27)		75	84	—	—	—
Young et al., 2013 (29)		79	90	—	—	—
Susetyowati et al., 2014 (49)	SNST	97	80	78	92	—
Wong et al., 2011 (50)	Spinal NST	85.7	76.1	62	92	0.57
Lim et al., 2009 (52)	3-MinNS	86	83	67	94	—

[1]BAPEN, British Association for Parenteral and Enteral Nutrition; BNST, British Nutrition Screening Tool; CASCO, Cachexia Score; CNST, Canadian Nutrition Screening Tool; CONUT, Controlling Nutritional Status; EDC, European Society for Clinical Nutrition and Metabolism Diagnostic Criteria for Malnutrition; GNRI, Geriatric Nutrition Risk Index; INSYST, Imperial Nutritional Screening System; MST, Malnutrition Screening Tool; MSTC, Malnutrition Screening Tool for Cancer; MUST, Malnutrition Screening Tool; NPV, negative predictive value; NRI, Nutritional Risk Index; NRS-2002, Nutritional Risk Screening; NUFFE, Nutritional Form for the Elderly; PPV, positive predictive value; R-NST, Renal Nutritional Screening Tool; SARC-F, ; SGA, Subjective Global Assessment; SNAQ, Short Nutritional Assessment Questionnaire; SNST, ; Spinal NST, Spinal Nutritional Screening Tool; SPSM, Short Portable Sarcopenia Measure; 3-MinNS, 3-Minute Nutrition Screening.

which is often considered to be the industry standard (54) and against which many tools are validated, has not itself been well validated. It performed well against the diagnostic criteria but sensitivities and specificities were either not recorded or poor. Arguably, the most well-known tools—MUST and NRS-2002—showed a variation in results from poor to good (27, 29, 34–39, 42), and consistency between groups in which the tools were studied was poor. The less well-known Nutritional Form for the Elderly (NUFFE) showed good validity, but it has been described in only a small portion of the literature and is not implemented widely (43). The "quick and easy" screening tools, including the Short Nutritional Assessment Questionnaire and Malnutrition Screening Tool, performed reasonably well (sensitivities of ~80%) in most studies in which they were used (25–30, 35, 47, 48). Of note because these tools are quick, they require a further detailed assessment by a qualified health

TABLE 6
Domains assessed by tools to measure relevant variables required to identify risks of malnutrition, sarcopenia, and cachexia[1]

	Patient reported weight loss						BMI and FFM measurements		Nutritional intake				Assessment of muscle mass and function		Disease state		Measures of metabolic derangement				
	Weight loss																				
Screening tool	Quantified within specified time frame	Quantified without time-frame	Unquantified with time frame	Unquantified, without time frame	UWL specified	Muscle mass	BMI	FFMI	Loss of appetite	Poor dietary intake/intake decline	Supplemental feeding in use?	Symptoms that would prevent eating (e.g., vomiting, ulcers)	Physical performance	Muscle strength	Presence of illness	Fatigue	Increased inflammatory markers	Anaemia	Low serum albumin	Other blood tests (e.g., glucose/urea)	QOL
Sarcopenia																					
SARC-F	X	X	X	X	X	X	X	X	X	X	X	X	✓	✓	X	X	X	X	X	X	X
SPSM	X	X	X	X	X	X	✓	✓	X	X	X	X	✓	✓	X	X	X	X	X	X	X
Cachexia																					
CASCO	X	✓	X	X	✓	X	X	✓	✓	✓	X	X	✓	X	X	✓	✓	✓	✓	✓	✓
Malnutrition																					
BAPEN	X	X	X	✓	✓	X	✓	X	X	✓	X	X	X	X	X	X	X	X	X	X	X
BNST	X	X	X	✓	✓	X	✓	X	X	✓	X	X	X	X	X	X	X	X	X	X	X
CNST	X	X	✓	X	✓	X	X	X	X	✓	X	X	X	X	X	X	X	X	X	X	X
CONUT	X	X	X	X	X	X	✓	X	X	X	X	X	X	X	✓	X	X	X	✓	✓	X
EDC	X	X	✓	X	X	X	✓	✓	X	✓	X	X	X	X	X	X	X	X	X	X	X
GNRI	X	X	✓	X	✓	X	✓	X	X	X	X	X	X	X	X	X	X	X	✓	X	X
INSYST	✓	X	X	X	✓	X	X	X	X	✓	X	X	X	X	✓	X	X	X	X	X	X
MST	X	✓	X	X	✓	X	X	X	✓	X	X	X	X	X	X	X	X	X	X	X	X
MSTC	X	X	X	✓	✓	X	✓	X	X	✓	X	X	✓	X	X	✓	X	X	X	X	X
MUST	✓	X	X	X	✓	X	✓	X	X	X	X	X	X	X	✓	X	X	X	X	X	X
NRI	X	X	✓	X	✓	X	X	X	X	X	X	X	X	X	X	X	X	X	✓	X	X
NRS-2002	X	✓	X	X	X	X	✓	X	X	✓	X	X	X	X	✓	X	X	X	X	X	X
NUFFE	X	X	X	✓	✓	X	✓	X	X	✓	X	X	X	X	X	X	X	X	X	X	X
R-NST	✓	X	X	X	X	X	X	X	✓	✓	X	✓	X	X	✓	X	X	X	X	X	X
SGA	✓	X	X	X	✓	X	✓	✓	✓	✓	✓	X	✓	X	X	X	X	X	X	X	X
SNAQ	✓	X	X	X	✓	X	✓	X	✓	✓	X	X	X	X	X	X	X	X	X	X	X
SNST	X	X	✓	X	✓	X	X	X	X	✓	X	X	X	X	X	X	X	X	X	X	X
Spinal	X	X	X	✓	✓	X	✓	X	✓	✓	X	X	X	X	✓	X	X	X	X	X	X
NST																					
3-MinNS	✓	X	X	X	✓	X	✓	X	X	✓			X	X	✓	X	X	X	✓	X	X

[1] Data adapted from reference 51. BAPEN, British Association for Parenteral and Enteral Nutrition; BNST, British Nutrition Screening Tool; CASCO, Cachexia Score; CNST, Canadian Nutrition Screening Tool; CONUT, Controlling Nutritional Status; EDC, European Society for Clinical Nutrition and Metabolism Diagnostic Criteria for Malnutrition; FFM, fat-free mass; FFMI, fat-free mass index; GNRI, Geriatric Nutrition Risk Index; INSYST, Imperial Nutritional Screening System; MST, Malnutrition Screening Tool; MSTC, Malnutrition Screening Tool for Cancer; MUST, Malnutrition Screening Tool; NPV, negative predictive value; NRI, Nutritional Risk Index; NRS-2002, Nutritional Risk Screening; NUFFE, Nutritional Form for the Elderly; PPV, positive predictive value; QOL, quality of life; R-NST, Renal Nutritional Screening Tool; SARC-F, ; SGA, Subjective Global Assessment; SNAQ, Short Nutritional Assessment Questionnaire; SNST, ; Spinal NST, Spinal Nutritional Screening Tool; SPSM, Short Portable Sarcopenia Measure; UWL, unintentional weight loss; 3-MinNS, 3-Minute Nutrition Screening.

TABLE 7
Newcastle-Ottawa scale adapted for cross-sectional studies

	Woo et al., 2014	Miller et al., 2009	Argiles et al., 2017	Weekes et al., 2004	Mirmiran et al., 2011	Laporte et al., 2015	Ignacio et al., 2005	Guerra et al., 2017	Abd-El-Gawad et al., 2014	Tammam et al., 2009	Ferguson et al., 1999	Isenring et al., 2006	Neelemaat et al., 2011	Nursal et al., 2005	Young et al., 2013	Bhuachalla et al., 2018	Leiopold et al., 2018	Wu et al., 2012	Kim et al., 2011	Boleo-Tome et al., 2012	Leistra et al, 2013	Sharma et al, 2017	Kyle et al, 2006	Almeida et al, 2012	Velasco et al, 2011	Prasad et al 2012	Faramarzi et al, 2013	Bauer et al, 2005	Soderhamn et al, 2002	Duerksen et al, 2000	Cooper et al, 2002	Moriana et al, 2014	Kruizenga et al, 2005	Harada et al, 2017	Susetyowati et al, 2014	Wong et al, 2011	Xia et al, 2016	Lim et al, 2009
Selection (maximum: 5 stars)																																					
1. Representativeness of the sample	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2. Sample size justified			*									*													*							*		*	*	*		
3. Response rate satisfactory	*	*	*	*	*	*			*			*	*	*		*		*			*		*	*	*	*		*	*	*	*	*	*	*		*	*
4. Ascertainment of exposure (validated measurement tool used)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
							*	*		*	*	*		*				*	*	*		*	*	*	*	*	*	*	*		*	*		*		*	*
														*	*	*																						
Comparability (maximum: 2 stars)																																					
1. The study controls for disease severity	*	*	*					*	*																				*								
2. Study controls for other confounding factors	*	*							*										*				*											*			
Outcome (maximum: 3 stars)																																					
1. Assessment of outcome	*				*	*	*			*	*	*				*		*				*							*	*							
					*	*	*			*	*					*		*				*							*	*							
2. Appropriate statistical test described	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
																									*							*						
Total (out of 10)	7	6	5	5	6	6	6	5	6	6	6	6	4	5	4	7	4	7	5	4	4	6	6	5	6	5	4	5	5	7	7	6	4	6	6	4	5	5

[1] Scores <5 indicate high risk of bias. *Assessed in study and found to be present.

professional if screening is positive. They also miss ~20% of at-risk patients at initial screening and therefore may be more useful in screening high-risk patients.

The tool that performed the best for malnutrition was the 3-MinNS (52). It showed high sensitivity and specificity (>80%) and accurately encompassed the correct diagnostic criteria (percentage of weight loss over a specified time and measurement of BMI) for malnutrition. It was validated in acute medical and surgical patients and proved quick and easy to complete. It has only been validated in one study, and therefore it cannot be assumed that it would perform as well in different patient populations. Both tools that assessed sarcopenia (SPSM, SARC-F) scored well against the agreed-upon definition (15, 16). However, the SPSM required transport of equipment and the SARC-F had a very low sensitivity (13, 15). The CASCO was the only validated screening tool for cachexia (17). It performed well against diagnostic criteria, but sensitivities and specificities were not recorded. It has also only been validated in the cancer setting; more work would be needed to validate the tool in other cachectic populations or the general adult population.

Most tools were validated in the adult hospital inpatient setting. Tools for sarcopenia have only been validated in healthy, community-dwelling elderly individuals (15, 16). Length of hospital stay is diminishing worldwide, and outpatient nutritional screening is advocated to detect patients at risk. In this review, we identified 8 studies in which outpatients were included. More studies focusing on the construct and predictive validity of tools for outpatient screening are warranted, especially because care is shifting to this setting.

The tool that appeared to have the broadest coverage was the CASCO (17). It is the only tool that screens for cachexia but also detects many of the variables required for a diagnosis of malnutrition. However, assessment of muscle mass or function (required for sarcopenia) is not included. One previous review showed that 20 screening tools appeared to be relevant for starvation, but none contained all of the currently accepted components needed to screen for sarcopenia and cachexia risk (53). Our study supports this finding.

Outlook and recommendations for future tools

A screening tool needs to be developed that encompasses the criteria to detect all 3 possible syndromes. This concept is supported by the notion that, in humans, there may be no "pure" phenotype of cachexia, because it is usually associated with reduced food intake (potential for malnutrition) and increasing age (increasing sarcopenia) (55). There is also currently a lack of agreement as to the diagnostic criteria for each syndrome and the relative importance of body-composition analysis and the nature of depleted tissue within each definition. We hypothesized that the overlap between syndromes could be shown, as in **Figure 2**, along with the identified best-performing tools for each aspect.

There are clearly many existing validated screening tools (at least for malnutrition). It is unlikely that any further novel tools will be devised without breakthroughs in biomarker development. We therefore suggest that the ideal composite tool should incorporate a stepwise assessment of nutritional status—oral intake, disease status, patient age, muscle mass and function, and metabolic derangement. The presence of underlying disease

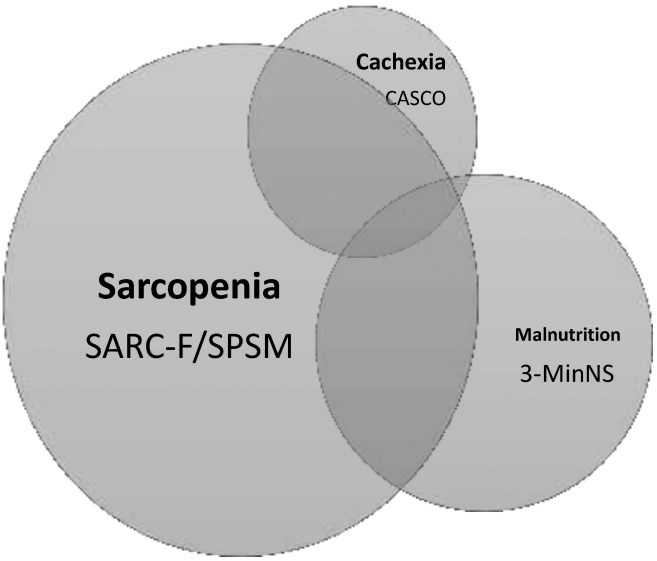

FIGURE 2 Diagram to show overlap between cachexia, sarcopenia, and malnutrition. The sizes of the circles represent the perceived sizes of each clinical problem. CASCO, Cachexia Score; SARC-F, ; SPSM, Short Portable Sarcopenia Measure; 3-MinNS, 3-Minute Nutrition Score.

is a key question in order to stratify the syndromes. Suggested components for use in creating a new tool are depicted in **Table 8**.

The use of screening for all 3 syndromes will allow for a more targeted intervention. Screening for cachexia, sarcopenia, or malnutrition is not warranted unless it is accompanied by an intervening care plan. It would be expected that an adequate intervention would prevent any further decline in health status and therefore lead to a positive effect on disease outcome. Most studies did not comment on intervention, which, depending on the balance of the 3 syndromes, may need to include varying attention to nutrition, exercise, and measures to combat inflammation.

Strengths, limitations, and assessment of bias

One of the strengths of this review is that it provides a complete overview of tools that have been validated for cachexia, sarcopenia, and malnutrition. We did not describe reliability, repeatability, or other clinical outcome measures in any great detail. The review used the consensus definitions of each syndrome. We are aware, however, that many other definitions exist. However, there were a number of study limitations. There was a risk of bias when assessing each tool for their predictive validity. Studies may have been biased if they did not adjust for factors such as cancer stage or disease severity. Because

TABLE 8
Suggested components for use in creating a new screening tool

1. Quantification of weight loss
2. Measurement of BMI
3. Assessment of appetite/dietary intake and decline
4. Underlying health state: Is there the presence of chronic disease?
5. Take into account patient's age (i.e., age >60 y more likely to be sarcopenic)
6. Assessment of muscle mass and function
7. Measurement of metabolic derangement/increased C-reactive protein

clinical outcome is affected by more than just nutritional status alone, adjusting for these variables is important. Nutritional intervention is likely to improve outcomes for malnutrition, but potentially not for age-related sarcopenia or established cachexia. Only one study discussed whether they did this. There is no agreed-upon "gold standard" tool, and therefore we chose cross-sectional imaging and the SGA and MNA on the basis of the results of previous studies (13). Tools that were compared with potentially less-valid standards were also included to allow a wider analysis. Full nutrition assessments were different in each study, ranging from anthropometric to biochemical measures and full assessment by a medical professional. Conclusions from this review were based on the original studies in which there may have been varying definitions with regard to the subject group, syndrome, or assessment undertaken. Another potential limitation is that we excluded modified versions of pre-existing tools. They were excluded because reliability and validity data would only relate to the modified tool and it was therefore difficult to assess improvements from the original. It is possible that these tools were being improved or evaluated more thoroughly.

Conclusions

We have highlighted that many practitioners who regularly come into contact with patients suffering from weight loss are not able to easily screen between the conditions of cachexia, sarcopenia, and malnutrition because there is no single validated tool that can be implemented for the assessment of all 3 conditions. The adaptation of existing screening tools incorporating all relevant criteria described in this review would be optimal for diagnosis and to direct the content of complex interventions.

The authors' responsibilities were as follows—MJJ and LW: designed the project; JM and UN: conducted the review; JM and LW: wrote the manuscript; RJES, DC, and MJJ: critically appraised the manuscript; MJJ and RJES: had overall responsibility for the final content; and all authors: read and approved the final manuscript. The authors declared no conflicts of interest.

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