UNIVERSITEIT
AMSTERDAM

VU Research Portal

Frailty, Sarcopenia, and Malnutrition Frequently (Co-)occur in Hospitalized Older Adults

Ligthart-Melis, Gerdien C.; Luiking, Yvette C.; Kakourou, Alexia; Cederholm, Tommy; Maier, Andrea B.; de van der Schueren, Marian A.E.

Link to publication in VU Research Portal

JAMDA

Review Article

Frailty, Sarcopenia, and Malnutrition Frequently (Co-)occur in Hospitalized Older Adults: A Systematic Review and Meta-analysis

Gerdien C. Ligthart-Melis PhD [a], Yvette C. Luiking PhD [b,*], Alexia Kakourou PhD [b], Tommy Cederholm MD, PhD [c], Andrea B. Maier MD, PhD [d,e], Marian A.E. de van der Schueren PhD [f]

[a] Department of Health and Kinesiology, Center for Translational Research in Aging and Longevity, Texas A&M University, College Station, TX, USA
[b] Department of Specialized Nutrition, Danone Nutricia Research, Utrecht, the Netherlands
[c] Department of Public Health and Caring Sciences, Clinical Nutrition and Metabolism, Uppsala University, Uppsala, Theme Ageing, Karolinska University Hospital, Stockholm, Sweden
[d] Department of Human Movement Sciences, @AgeAmsterdam, Faculty of Behavioural and Movement Sciences, Amsterdam Movement Sciences, Vrije Universiteit, Amsterdam, the Netherlands
[e] Department of Medicine and Aged Care, @AgeMelbourne, Royal Melbourne Hospital, University of Melbourne, Melbourne, Victoria, Australia
[f] Department of Nutrition and Health, Faculty of Health and Social Studies, HAN University of Applied Sciences, Nijmegen, the Netherlands

A B S T R A C T

Objectives: The purpose of this systematic review and meta-analysis was to summarize the prevalence of, and association between, physical frailty or sarcopenia and malnutrition in older hospitalized adults.
Design: A systematic literature search was performed in 10 databases.
Setting and Participants: Articles were selected that evaluated physical frailty or sarcopenia and malnutrition according to predefined criteria and cutoffs in older hospitalized patients.
Measures: Data were pooled in a meta-analysis to evaluate the prevalence of prefrailty and frailty [together (pre-)frailty], sarcopenia, and risk of malnutrition and malnutrition [together (risk of) malnutrition], and the association between either (pre-)frailty or sarcopenia and (risk of) malnutrition.
Results: Forty-seven articles with 18,039 patients (55% female) were included in the systematic review, and 39 articles (8868 patients, 62% female) were eligible for the meta-analysis. Pooling 11 studies (2725 patients) revealed that 84% [95% confidence interval (CI): 77%, 91%, $I^2 = 98.4\%$] of patients were physically (pre-)frail. Pooling 15 studies (4014 patients) revealed that 37% (95% CI: 26%, 48%, $I^2 = 98.6\%$) of patients had sarcopenia. Pooling 28 studies (7256 patients) revealed a prevalence of 66% (95% CI: 58%, 73%, $I^2 = 98.6\%$) (risk of) malnutrition. Pooling 10 studies (2427 patients) revealed a high association [odds ratio (OR): 5.77 (95% CI: 3.88, 8.58), $P < .0001$, $I^2 = 42.3\%$] and considerable overlap (49.7%) between physical (pre-)frailty and (risk of) malnutrition. Pooling 7 studies (2506 patients) revealed a high association [OR: 4.06 (95% CI: 2.43, 6.80), $P < .0001$, $I^2 = 71.4\%$] and considerable overlap (41.6%) between sarcopenia and (risk of) malnutrition.
Conclusions and Implications: The association between and prevalence of (pre-)frailty or sarcopenia and (risk of) malnutrition in older hospitalized adults is substantial. About half of the hospitalized older adults suffer from 2 and perhaps 3 of these debilitating conditions. Therefore, standardized screening for these conditions at hospital admission is highly warranted to guide targeted nutritional and physical interventions.

© 2020 AMDA – The Society for Post-Acute and Long-Term Care Medicine.

* Address correspondence to Yvette C. Luiking, PhD, Department of Specialized Nutrition, Danone Nutricia Research, PO Box 80141, 3508 TC Utrecht, the Netherlands.
E-mail address: Yvette.luiking@nutricia.com (Y.C. Luiking).

Older adults are large users of hospital care.[1–3] Hospitalization in older adults is a risk factor for losing independence and consequent nursing home admittance.[4–6] Older age is accompanied by multi-morbidity and physically debilitating conditions that are predictive of adverse clinical outcomes. These conditions are partly reversible and include frailty, sarcopenia, and/or malnutrition.[2–4,7–15]

Frailty is a state of vulnerability and nonresilience with limited reserve capacity in major organ systems. It leads to reduced capability to withstand physical stress such as trauma or disease and is, therefore, accompanied by adverse clinical outcomes and increased risk of dependence and disability.[2,3,9,16,17] Frailty was observed to increase length of hospital stay and risk of mortality in older patients at medical wards.[18,19] and predicted postoperative complications, length of stay, and discharge to a skilled or assisted-living facility of older surgical patients who previously lived at home.[3]

Sarcopenia is characterized by progressive and generalized loss of skeletal muscle mass and strength,[12,20] with a risk of adverse outcomes such as physical disability, poor quality of life, and death.[12,13,21] Muscle mass and strength were associated with developing geriatric conditions and poorer cognition at hospital admission,[22,23] and predictive for difficulties in performing activities of daily living,[24] falls,[25,26] and mortality[26] 3 months after discharge. Sarcopenia is now recognized by the WHO as a muscle disease with an International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) diagnosis code M62.84.[27–29]

Malnutrition or undernutrition is the result of inadequate nutritional intake, often associated with inflammatory catabolism, leading to altered body composition, for example, decreased fat-free mass and body cell mass.[11] Under the general diagnosis of malnutrition are the etiology-based types of malnutrition, whereby cachexia represents chronic disease–related malnutrition with inflammation.[17,30] Malnutrition in older hospitalized patients is associated with increased medical resource use, increased in-hospital length of stay and mortality, impairments in functional ability, low muscle mass, reduced quality of life, and a higher rate of discharge to nursing homes.[8,31–38] After hip surgery, malnourished patients suffered from loss in activities of daily living more often and regained their prefracture mobility level less often, compared with well-nourished patients.[34] Malnutrition is also an important modifiable factor in both sarcopenia and frailty.[39]

Criteria to determine frailty, sarcopenia, and malnutrition, especially weight loss and loss of muscle mass and muscle strength, overlap.[40] Therefore, older people may suffer from more of these conditions at the same time. Previously, we observed a strong association between physical prefrailty or frailty and risk of malnutrition or malnutrition in community-dwelling older adults, with an overlapping prevalence of 19%.[41] The association between prevalence of prefrailty or frailty [together (pre-)frailty] and risk of malnutrition or malnutrition [together (risk of) malnutrition] is likely to be higher in the hospital, because community-dwelling older people who are frail and malnourished are likely more prone to hospitalization.

The purpose of this systematic review and meta-analysis was to gain insight into the prevalence and the magnitude of the association between physical (pre-)frailty or sarcopenia and (risk of) malnutrition in older hospitalized adults, because this knowledge can guide the need for standardized screening and targeted interventions, which have a positive impact on the recovery of older hospitalized patients during and after hospitalization and improve their level of independence after discharge from hospital.

Methods

Data Sources and Searches

The systematic review was conducted in line with the PRISMA standards.[42] A systematic literature search was performed by a librarian (S.E.) in PubMed and the ProQuest Databases Medline, Embase, SciSearch, EMCare, Current Contents, Gale Group Health Periodicals, Biosis Previews, CAB Abstracts, and FSTA, using the following search terms in title and/or abstract: (frail OR frailty OR prefrail OR prefrailty OR pre-frail OR pre-frailty OR "pre frail" OR "pre frailty" OR sarcopenia OR sarcopenic) AND (cachexia OR cachectic OR wasting OR malnutrition OR malnourish* OR undernutrition OR undernourish* OR nutrition*) AND (hospital* OR clinic OR clinics OR "medical centre" OR "medical center*") AND (prevalence OR prevalent OR incidence OR incident OR epidemiolog* OR frequency OR frequent OR risk). There were no restrictions regarding language or publication date. The last search was run on May 23, 2018. Duplicate records were removed by the Endnote reference manager program (before screening) and manually before and during screening.

Study Selection

Records were assessed for eligibility independently by 2 researchers (G.C.L-M. and S.E.) by screening of titles and abstracts and subsequent screening of full texts when abstracts were considered relevant. Abstracts were considered relevant when both physical (ie, NOT cognitive) frailty and nutritional status, or sarcopenia and nutritional status, were addressed in hospitalized participants with a mean age of 60 years or older. Full texts were selected when physical (pre-)frailty, sarcopenia, or (risk of) malnutrition were measured according to predefined criteria and cutoffs, prior to or during hospitalization, with no restrictions regarding study design or assessment/screening methods applied. Full texts were excluded when study participants were preselected for any of these 3 conditions. Furthermore, articles were included only when prevalence data were present in the full text or when these were provided by the authors on request. Authors who did not respond to such a request were reminded once. Conference abstracts, reviews, letters to the editor, case reports, and protocol articles without data were also excluded. Disagreements between reviewers were resolved by consulting a third reviewer (Y.C.L.).

Articles presenting results from the same study population were described individually in the qualitative part of the review, but the study population was only used once for the meta-analysis.

Data Extraction

One investigator (G.C.L-M.) extracted data regarding study design, country, study population, sample size, gender, age, tools or methods used to assess physical (pre-)frailty, sarcopenia, and (risk of) malnutrition and the applied cutoffs and prevalence of these conditions. In case of an intervention study, only baseline data were used. This data extraction was checked by a second researcher (J.H.). The quality of the reported prevalence of (pre-)frailty, sarcopenia, and (risk of) malnutrition was not tested for individual studies. However, we tried to ensure the inclusion of high-quality information in the meta-analysis by excluding articles that described study populations that were preselected for frailty, sarcopenia, or nutritional status by including studies in the meta-analysis that applied valid screening/assessment tools and clearly defined (pre-)frailty or sarcopenia and (risk of) malnutrition according to described/referred cutoffs, and by pooling data from studies that applied similar tools.

Data Synthesis and Statistical Analysis

Prevalence data on physical (pre-)frailty or sarcopenia and (risk of) malnutrition were included in the meta-analysis when valid and similar tools were used to assess these conditions. Tools were considered valid when their validity was described in prior studies. Tools were considered similar when they applied comparable definitions to determine (pre-)frailty, sarcopenia, and (risk of) malnutrition. For the

purpose of the meta-analysis, data were dichotomized into "robust" vs "(pre-)frail," "non-sarcopenic" vs "sarcopenic," and "normal nutritional status" vs "(risk of) malnutrition." Studies were also stratified into subgroups titled "medical," referring to patients admitted for any reason except surgical treatment; "surgical," referring to patients admitted for acute or elective surgery; and "mixed medical & surgical," referring to patients hospitalized for medical and surgical purposes.

To assess the association between physical (pre-)frailty and (risk of) malnutrition, and the association between sarcopenia and (risk of) malnutrition, data on the overlap of both conditions were required. When these were not reported in the article, authors were asked to complete cross tables with absolute data on the overlap of (pre-)frailty

and (risk of) malnutrition or sarcopenia and (risk of) malnutrition, according to the predefined cutoffs used in their studies.

A random-effects (RE) model was applied to account for possible heterogeneity between pooled studies. Heterogeneity between pooled studies was assessed using the I^2 statistic; I^2 values closer to 100% indicate high heterogeneity, whereas values near 0% indicate low heterogeneity. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to evaluate the association between (pre-)frailty and (risk of) malnutrition and the association between sarcopenia and (risk of) malnutrition when data on the overlap of both conditions were available.

Forest plots were used to visualize the results of the prevalence of (pre-)frailty, sarcopenia, and (risk of) malnutrition, and the OR of (pre-)frailty in the presence of (risk of) malnutrition relative to

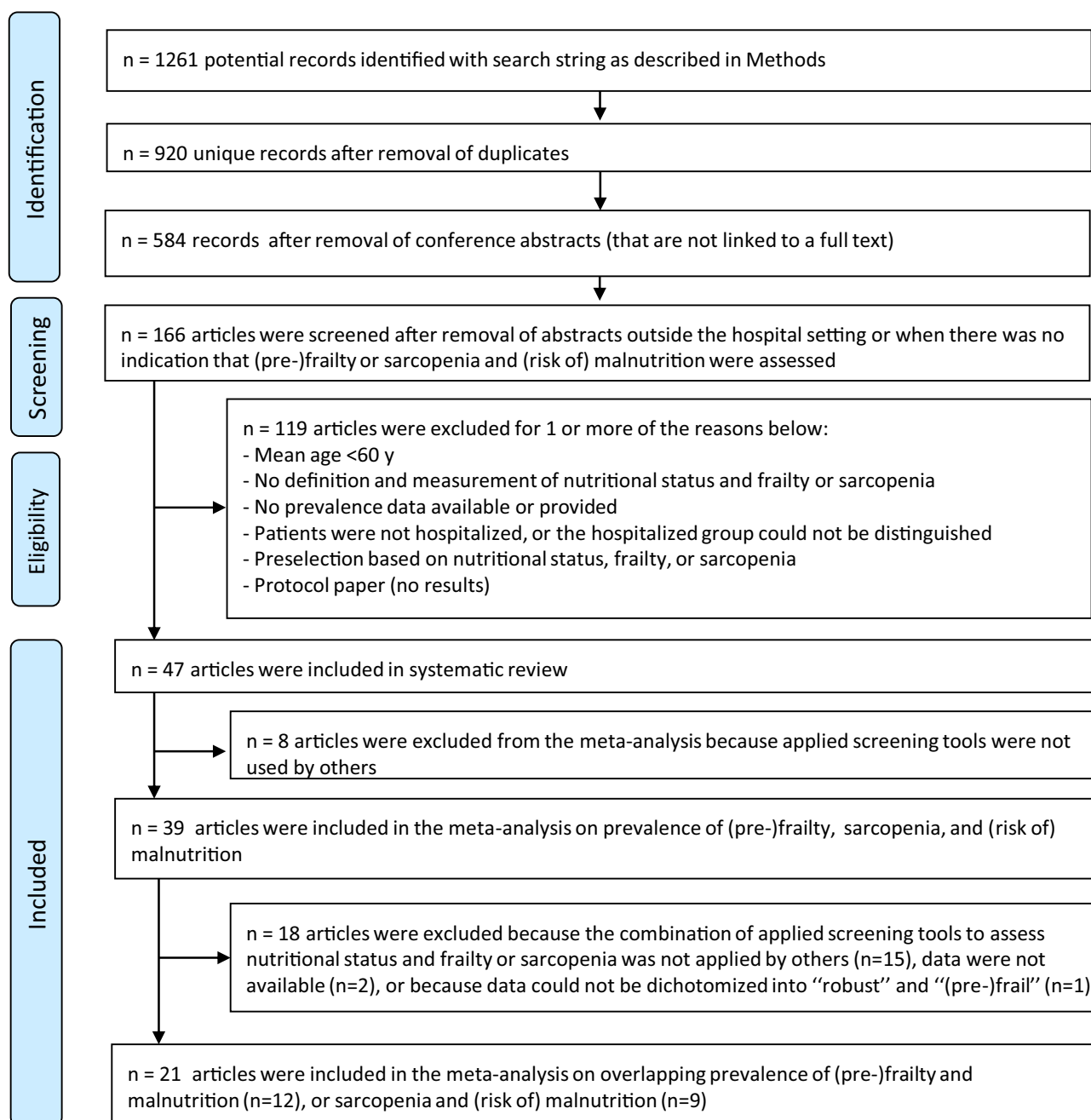**Fig. 1.** PRISMA flowchart of study selection for systematic review and meta-analysis of articles on studies that provide information about the prevalence of (pre-)frailty or sarcopenia and (risk of) malnutrition among hospitalized older adults.

absence of (risk of) malnutrition, as well as the OR of sarcopenia in the presence of (risk of) malnutrition relative to absence of (risk of) malnutrition. Funnel plots of either proportion or log OR estimates against their standard errors were plotted to visualize the heterogeneity between studies, whereas the Egger regression test[43] and Begg rank correlation test[44] were used to test funnel plots asymmetry, which may suggest a biased outcome. Bubble plots were used to visualize the overlapping prevalence of (pre-)frailty and (risk of) malnutrition and of sarcopenia and (risk of) malnutrition.

All analyses were performed in the statistical software environment R. The "metafor" R-package was used to produce the pooled estimates and create the forest plots. A P value < .05 was considered to indicate significance.

Results

Study Characteristics

From 920 unique records retrieved with the search, 166 articles were screened for eligibility (Figure 1). We contacted 44 authors for prevalence data and received additional data for 33 articles.[18,33,37,38,45–73] Forty-seven articles were included in the systematic review (Figure 1). Characteristics of these articles concerning 18,039 older hospitalized adults are summarized in Table 1, and provided as online Supplementary Material 1 (Tables S1 and S2).

Table 1 also shows the diversity in applied tools for screening and diagnosis of (pre-)frailty, sarcopenia, and (risk of) malnutrition. We

Table 1
Summary of Characteristics of the 47 Articles Included in the Systematic Review and Meta-analysis

	(Pre-)frailty and (Risk of) Malnutrition (n = 29* Articles)[†]	Sarcopenia and (Risk of) Malnutrition (n = 20* Articles)[‡]
Total patients with data, n	14,372	4604
Mean age range, y	73-85	62-86
% female range	25-76	30-79
Design	Prospective cohort (n = 18)[§,‖,**]	Prospective cohort (n = 8)[**]
	Cross-sectional (n = 5)	Cross-sectional (n = 8)[††]
	Retrospective (n = 4)	Retrospective (n = 4)
	Survey (n = 2)	
Study population	Medical (n = 16)[§,**]	Medical (n = 12)[**,††]
	Surgery (n = 9)	Surgery (n = 3)
	Mixed Medical & Surgery (n = 4)[‖]	Mixed Medical & Surgery (n = 5)[‡‡]
Largest subpopulation	Geriatrics (n = 10)[§,**]	Geriatrics (n = 10)[**,††]
Screening tool frailty or sarcopenia (>1 in some studies)	Fried (n = 7)[§]	EWGSOP no. 1 (n = 11)[**]
	Share-Fi (n = 4)[‖]	AWGS (n = 7)[††,‡‡]
	Trabucci (n = 3)	CT, SMI, MAMA, and HGS (with SNS muscle component ≥ 3 points) (n = 1)
	Adapted Fried (n = 2)	
	VMS (n = 2)	
	EFS (n = 2)[**]	
	CDM, CGA, Frail Scale, G8, GFI, GFI Stortecky, ISAR, MFI, CFS, DFI, AFN (n = 1)[‡‡]	
Screening Tool Malnutrition Status (>1 in some studies)	MNA-LF/FF (n = 13)[§,**]	MNA-LF (n = 7)[**,§§]
	MNA-SF (n = 8)[‖]	MNA-SF (n = 7)[††,‖‖]
	MUST (n = 3)	PG-SGA (n = 2)
	NGE, GNRI, CONUT, PNI, MST, SNAQ, SNS (n = 1)[§§]	BMI (n = 2)
		CONUT (n = 2)[‡‡]
		MUST, NRS, BMI (with albumin), ESPEN diagnostic criteria malnutrition together with MNA-SF, SNS (n = 1)[‖‖]
Supplemental data provided	n = 23[§,‖,**]	n = 12[**,††,‡‡]
Included in meta-analysis on prevalence of (pre-)frailty, sarcopenia, and (risk of) malnutrition	n = 22[§,‖,**]	n = 19[**,††,‡‡]
Included in meta-analysis on association between either (pre-)frailty or sarcopenia and (risk of) malnutrition	n = 11[§]	n = 9[**,††]

Frailty tools: Fried, phenotype according to Fried; Share-Fi, Survey of Health, Ageing and Retirement in Europe Frailty Instrument; VMS, Veiligheids Management Systeem; EFS, Edmonton Frail Scale; CDM, Cumulative Deficit Model; CGA items, items of Comprehensive Geriatric Assessment; G8, geriatric screening scale for frailty; GFI, Groningen Frailty Indicator; GFI Stortecky, Global Frailty Index Stortecky; ISAR, Identification of Seniors At Risk; MFI, Modified Frailty Index according to Robinson; CFS, Clinical Frailty Scale; DFI, Derby Frailty Index; AFN, Acute Frailty Network criteria. *Sarcopenia tools:* EWGSOP no. 1, 2010 definition European Working Group on Sarcopenia in Older People; AWGS, diagnostic algorithm of the Asian Working Group for Sarcopenia; CT, computed tomography; SMI, Skeletal Muscle Index; MAMA, midarm muscle area; HGS, handgrip strength. *Nutritional status tools:* MNA-LF/FF, Mini Nutritional Assessment—Long/Full Form; MNA-SF, MNA—Short Form; MUST, Malnutrition Universal Screening Tool; PG-SGA, Patient-Generated Subjective Global Assessment; BMI, body mass index; NGE, Nutritional Global Evaluation; GNRI, Geriatric Nutritional Risk Index; CONUT, Controlling Nutritional Status score; PNI, Prognostic Nutritional Index; MST, Malnutrition Screening Tool according to Ferguson; SNAQ, Short Nutritional Assessment Questionnaire; SNS, Subjective Nutritional Score; NRS, Nutritional Risk Screening; ESPEN, European Society for Clinical Nutrition and Metabolism. (See Supplementary Material 1 for references with these screening/assessment tools.)

*Articles by Perna et al[60,73] and Hernández-Luis et al[18] include data on frailty and sarcopenia and are therefore included in both the frailty and the sarcopenia population.

[†]Supplementary Material 1, Table S1.

[‡]Supplementary Material 1, Table S2.

[§]In 2 articles by Dent et al,[49,50] the study populations overlap.

[‖]Two articles by O'Shea et al. and Timmons et al[37,71] describe the same study population.

[**]Two articles by Perna et al. describe the same study population.[60,73]

[††]Two articles by Maeda et al[66,67] describe the same study population.

[‡‡]Two articles by Harada et al[63,64] describe the same study population.

[§§]One article by Sze et al[38] applied GNRI, CONUT, and PNI to assess nutritional status and CFS, DFI, and AFN to determine frailty.

[‖‖]One article by Yürüyen et al[70] applied MNA-LF, MNA-SF, MUST, as well as NRS, to asses nutritional status.

decided to pool data from studies that applied similar and valid screening or assessment tools, as explained in Methods.

For frailty, results obtained with the (adapted) Fried frailty pheno-type criteria, Share-Fi, or FRAIL scale were pooled in the meta-analysis. Eleven studies, described in 13 articles,[18,36,37,45–47,49–51,59,71,74,75] applied these tools, which all distinguish 3 categories: "robust," "pre-frail," and "frail." The validated Fried phenotype is perhaps the most established and most frequently applied phenotypic definition of physical frailty,[76] which is approximated by the validated Share-FI definition of frailty[77] and validated FRAIL Scale.[78,79]

For sarcopenia, results obtained with the 2010 definition according to the European Working Group on Sarcopenia in Older People (EWGSOP no. 1)[12] or the diagnostic algorithm of the Asian Working Group for Sarcopenia (AWGS)[80] were pooled in the meta-analysis. Fifteen studies, described in 18 articles,[35,60,62–70,72,73,81–85] applied these definitions, which both distinguish "sarcopenic" from "non-sarcopenic." The AWGS definition is in agreement with the EWGSOP no. 1 definition but applies different cutoffs in line with differences between muscle mass and strength between Asians and Europeans.

For (risk of) malnutrition, results obtained with the Mini Nutritional Assessment Long Form or Short Form (MNA LF/SF),[86–89] were pooled in the meta-analysis. Twenty-eight studies, described in 34 articles,[33,35–37,45–55,59,60,65–68,70,71,73–75,81–83,85,90,91] applied these tools, which are well-established tools for identification of nutritional status in older people. The MNA-SF is validated against the MNA-LF.[87,88] Both apply the categories "well nourished," "risk of malnutrition," and "malnutrition."

Meta-analysis Results

Prevalence of (Pre-)frailty, Sarcopenia and (Risk of) Malnutrition

Prefrailty and frailty

Eleven studies with data from 2725 patients were pooled for the prevalence of (pre-)frailty (Figure 2), which was 84% (95% CI: 77%, 91%) across all studies. The prevalence of prefrailty and frailty together and apart is described for all subgroups in Table 2. Asymmetry seemed present across the overall population (Supplementary Material 2, Figure S1; Egger test, $P = .03$). This asymmetry would be solved with removal of the study by Guerrero-Garcia,[75] which included only (pre-)frail patients without preselection; however, removal would not have changed the pooled estimates.

Sarcopenia

Fifteen studies with data from 4014 patients were pooled for the proportion of sarcopenia (Figure 3), which was 37% (95% CI: 26%, 48%) across all studies and is described for all subgroups in Table 2.

Risk of malnutrition and malnutrition

Twenty-eight studies with data from 7256 patients were pooled for the proportion of (risk of) malnutrition (Figure 4), which was 66% (95% CI: 58%, 73%) across all studies. The prevalence of risk of malnutrition and malnutrition together and apart is described for all subgroups in Table 2. We also investigated whether the pooled prevalence estimates were perhaps asymmetrical because of the selection of studies

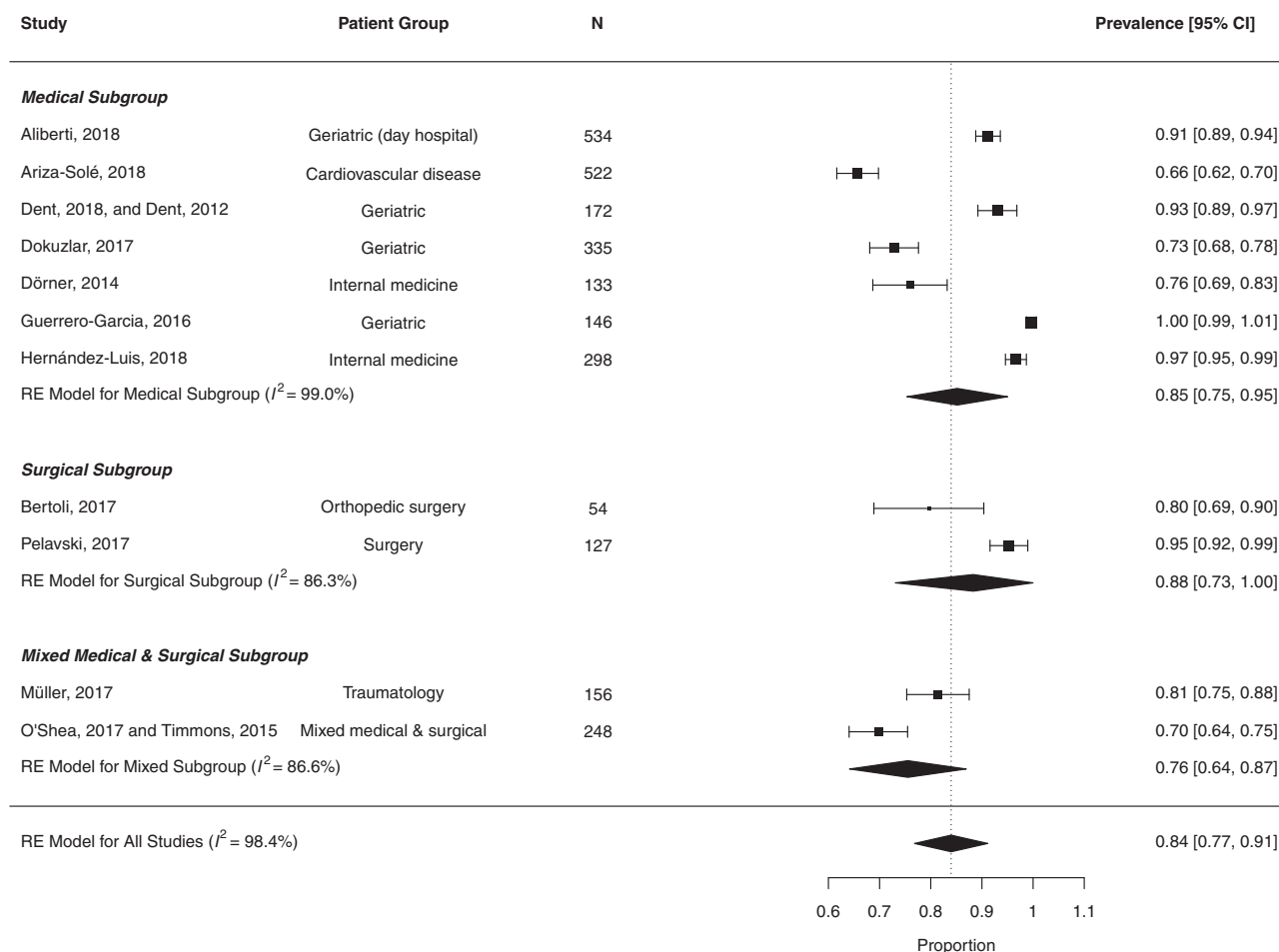| Study	Patient Group	N		Prevalence [95% CI]
Medical Subgroup				
Aliberti, 2018	Geriatric (day hospital)	534		0.91 [0.89, 0.94]
Ariza-Solé, 2018	Cardiovascular disease	522		0.66 [0.62, 0.70]
Dent, 2018, and Dent, 2012	Geriatric	172		0.93 [0.89, 0.97]
Dokuzlar, 2017	Geriatric	335		0.73 [0.68, 0.78]
Dörner, 2014	Internal medicine	133		0.76 [0.69, 0.83]
Guerrero-Garcia, 2016	Geriatric	146		1.00 [0.99, 1.01]
Hernández-Luis, 2018	Internal medicine	298		0.97 [0.95, 0.99]
RE Model for Medical Subgroup (I^2 = 99.0%)				0.85 [0.75, 0.95]
Surgical Subgroup				
Bertoli, 2017	Orthopedic surgery	54		0.80 [0.69, 0.90]
Pelavski, 2017	Surgery	127		0.95 [0.92, 0.99]
RE Model for Surgical Subgroup (I^2 = 86.3%)				0.88 [0.73, 1.00]
Mixed Medical & Surgical Subgroup				
Müller, 2017	Traumatology	156		0.81 [0.75, 0.88]
O'Shea, 2017 and Timmons, 2015	Mixed medical & surgical	248		0.70 [0.64, 0.75]
RE Model for Mixed Subgroup (I^2 = 86.6%)				0.76 [0.64, 0.87]
RE Model for All Studies (I^2 = 98.4%)				0.84 [0.77, 0.91]

0.6   0.7   0.8   0.9   1   1.1

Proportion

Fig. 2. Forest plot of the prevalence of (pre-)frailty among older hospitalized adults for the total population and for the medical, surgical, and mixed medical & surgical subgroups separately.

Table 2
Prevalence of Prefrailty and Frailty Together and Separately, Sarcopenia, and Risk of Malnutrition and Malnutrition Together and Separately

Condition	All Studies		Medical Subgroup		Surgical Subgroup		Mixed Medical & Surgical Subgroup	
	% (95% CI)	I^2 %	% (95% CI)	I^2 %	% (95% CI)	I^2 %	% (95% CI)	I^2 %
Pooled (pre-)frail	84 (77-91)	98.4	85 (75-95)	99.0	88 (73-100)	86.3	76 (64-87)	86.6
Prefrail	36 (29-44)	93.6	35 (29-41)	89.6	36 (9-63)	93.1	42 (8-76)	98.1
Frail	47 (37-57)	96.7	50 (37-64)	97.7	50 (39-62)	53.0	34 (11-56)	96.2
Sarcopenia	37 (26-48)	98.6	44 (29-58)	98.7	22 (19-25)	0.0	25 (9-40)	96.1
Pooled (Risk of) malnutrition	66 (58-73)	98.6	72 (63-81)	99.0	51 (40-62)	92.1	60 (55-65)	42.2
Risk of malnutrition	45 (41-49)	93.5	44 (38-51)	95.6	44 (36-52)	85.5	48 (41-55)	69.4
Malnutrition	20 (13-27)	99.8	26 (16-36)	99.4	6 (2-10)	88.7	11 (0-23)	96.8

I^2 represents heterogeneity. I^2 values closer to 100% indicate high heterogeneity, whereas values near 0% indicate low heterogeneity.

reporting frailty status or sarcopenia in combination with assessment of malnutrition (Supplementary Material 2, Figures S2 and S3). The pooled prevalence of (risk of) malnutrition for studies reporting sarcopenia (73%, 95% CI: 62%, 84%) was found to be marginally higher than for studies reporting (pre-)frailty (63%, 95% CI: 54%, 72%). This may imply that studies reporting on sarcopenia included an overall more malnourished (or at risk of malnutrition) population or that patients with (risk of) malnutrition are more prone to sarcopenia.

Overlap and Association Between (Pre-)frailty and (Risk of) Malnutrition

Ten studies in 12 articles,[36,37,45–47,49–51,59,71,74,75] with data from 2427 patients were included in the meta-analysis evaluating the association between (pre-)frailty and (risk of) malnutrition. For the total population, the overlapping prevalence of (pre-)frail with (risk of) malnutrition was 49.7%; 14.6% had neither of the conditions (Figure 5). The OR of (pre-)frailty in the presence of (risk of) malnutrition relative
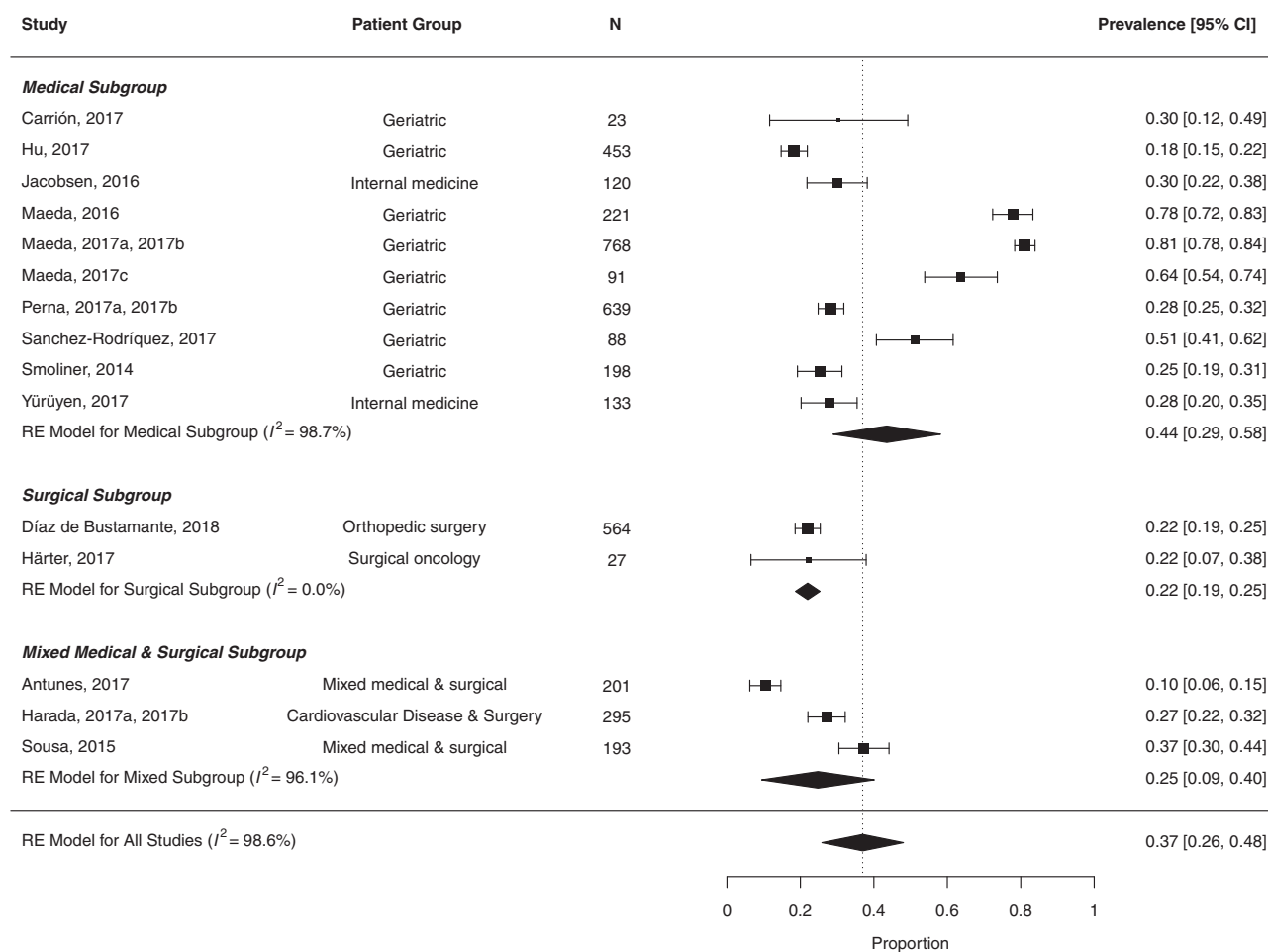

Fig. 3. Forest plot of the prevalence of sarcopenia among older hospitalized adults for the total population and for the medical, surgical, and mixed medical & surgical subgroups separately.

Study	Patient Group	N	Prevalence [95% CI]
Medical Subgroup			
Aliberti, 2018	Geriatric (day hospital)	534	0.54 [0.50, 0.58]
Ariza-Solé, 2018	Cardiovascular disease	522	0.53 [0.49, 0.57]
Bo, 2017	Cardiovascular disease	452	0.78 [0.74, 0.82]
Carrión, 2017	Geriatric	23	0.70 [0.51, 0.88]
Dent, 2018, and Dent, 2012	Geriatric	172	0.80 [0.74, 0.86]
Dokuzlar, 2017	Geriatric	335	0.16 [0.12, 0.20]
Donini, 2002	Geriatric	486	0.97 [0.95, 0.98]
Donini, 2003	Geriatric	167	0.98 [0.95, 1.00]
Dörner, 2014	Internal medicine	133	0.77 [0.70, 0.84]
Guerrero-Garcia, 2016	Geriatric	146	0.75 [0.68, 0.82]
Hu, 2017	Geriatric	453	0.52 [0.47, 0.56]
Jacobsen, 2016	Internal medicine	120	0.75 [0.67, 0.83]
Maeda, 2016	Geriatric	221	0.79 [0.73, 0.84]
Maeda, 2017a, 2017b	Geriatric	768	0.84 [0.81, 0.87]
Maeda, 2017c	Geriatric	91	0.84 [0.76, 0.91]
Perna, 2017a, 2017b	Geriatric	639	0.89 [0.86, 0.91]
Smoliner, 2014	Geriatric	198	0.74 [0.68, 0.80]
Yürüyen, 2017	Internal medicine	133	0.65 [0.57, 0.73]
RE Model for Medical Subgroup (I^2 = 99.0%)			0.72 [0.63, 0.81]
Surgical Subgroup			
Bertoli, 2017	Orthopedic surgery	54	0.56 [0.42, 0.69]
de Thézy, 2017	Cardiovascular surgery	49	0.53 [0.39, 0.67]
Eichler, 2018	Cardiovascular surgery	344	0.39 [0.34, 0.44]
Fiatarone Singh, 2009	Orthopedic surgery	193	0.58 [0.51, 0.65]
Kenig, 2016	GI surgery	126	0.27 [0.19, 0.35]
Kristjansson, 2012	Surgical oncology	165	0.55 [0.48, 0.63]
Pelavski, 2017	Surgery	127	0.70 [0.62, 0.78]
RE Model for Surgical Subgroup (I^2 = 92.1%)			0.51 [0.40, 0.62]
Mixed Medical & Surgical Subgroup			
Antunes, 2017	Mixed medical & surgical	201	0.59 [0.52, 0.66]
Müller, 2017	Traumatology	156	0.56 [0.48, 0.64]
O'Shea, 2017, and Timmons, 2015	Mixed medical & surgical	248	0.65 [0.59, 0.70]
RE Model for Mixed Subgroup (I^2 = 42.2%)			0.60 [0.55, 0.65]
RE Model for All Studies (I^2 = 98.6%)			0.66 [0.58, 0.73]

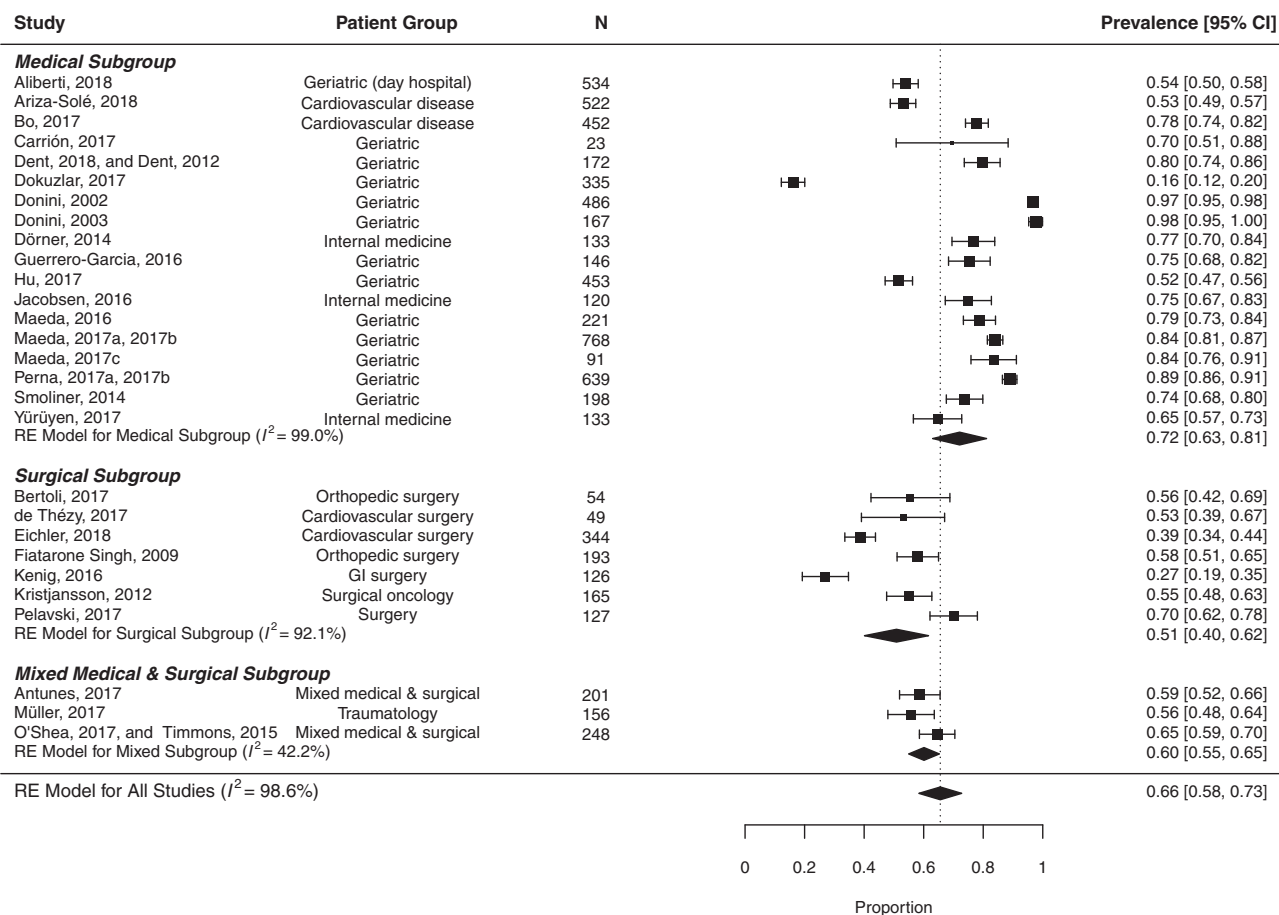Proportion: 0 0.2 0.4 0.6 0.8 1

Fig. 4. Forest plot of the prevalence of (risk of) malnutrition among older hospitalized adults for the total population and for the medical, surgical, and mixed medical & surgical subgroups separately.

to absence of (risk of) malnutrition was 5.77 (95% CI: 3.88, 8.58; $P < .001$, $I^2 = 42.3\%$) in the total population, 6.00 (95% CI: 3.50, 10.29; $P < .001$, $I^2 = 51.0\%$) in the medical subgroup, 16.67 (95% CI: 3.60, 77.23; $P < .001$, $I^2 = 0.0\%$) in the surgical subgroup, and 4.31 (95% CI: 2.38, 7.79; $P < .001$, $I^2 = 23.1\%$) in the mixed medical & surgical subgroup (Figure 6). Asymmetry was present across the overall population (Supplementary Material 2, Figure S4; Egger test, $P = .008$) but not in the biggest medical subgroup (Egger test, $P = .26$) that contributed most to the estimation of the overall pooled OR across studies. The asymmetry seemed mostly due to 2 surgical studies with small sample sizes and large standard errors of OR estimates.

Overlap and Association Between Sarcopenia and (Risk of) Malnutrition

Seven studies, described in 9 articles,[35,60,65–68,70,73,81] with data from 2506 patients were included in the meta-analysis evaluating the association between sarcopenia and (risk of) malnutrition. The overlapping prevalence of sarcopenia with (risk of) malnutrition was 41.6%; 18.9% of the patients had neither of the conditions (Figure 7). The OR of sarcopenia in the presence of (risk of) malnutrition relative to the absence of (risk of) malnutrition was 4.06 (95% CI: 2.43, 6.80; $P < .001$, $I^2 = 71.4\%$) in the total population, 3.99 (95% CI: 2.25, 7.06; $P < .0001$, $I^2 = 76.5\%$) in the medical subgroup, and 4.80 (95% CI: 1.37, 16.87) in the single mixed medical and surgical study (Figure 8).

Heterogeneity of Results

Large heterogeneity was observed for prevalence of (pre-)frailty, sarcopenia, and (risk of) malnutrition at the total population level (Figures 2-4). Because of stratification in medical, surgical, and mixed medical & surgical subgroups, heterogeneity decreased in the surgical and in the mixed medical & surgical subgroup. The heterogeneity of results on the OR between (pre-)frailty and (risk of) malnutrition was moderate for the total group and medical subgroup, low for the mixed medical & surgical subgroup, and absent for the surgical subgroup. Heterogeneity of results on the association between sarcopenia and (risk of) malnutrition were higher than the association between (pre-)frailty and (risk of) malnutrition.

Discussion

In this systematic review and meta-analysis, we summarized the literature on the prevalence of (pre-)frailty or sarcopenia in combination with the prevalence of (risk of) malnutrition in older hospitalized adults. Eight of 10 of the older patients were (pre-)frail (36% prefrail and 47% frail), one-third had sarcopenia, and two-thirds had (risk of) malnutrition (45% risk of malnutrition and 20% malnutrition). The OR between and overlapping prevalence of (pre-)frailty and (risk of) malnutrition were 5.77 and 50%, respectively. The OR between and overlapping prevalence of sarcopenia and (risk of) malnutrition were 4.06 and 42%, respectively.
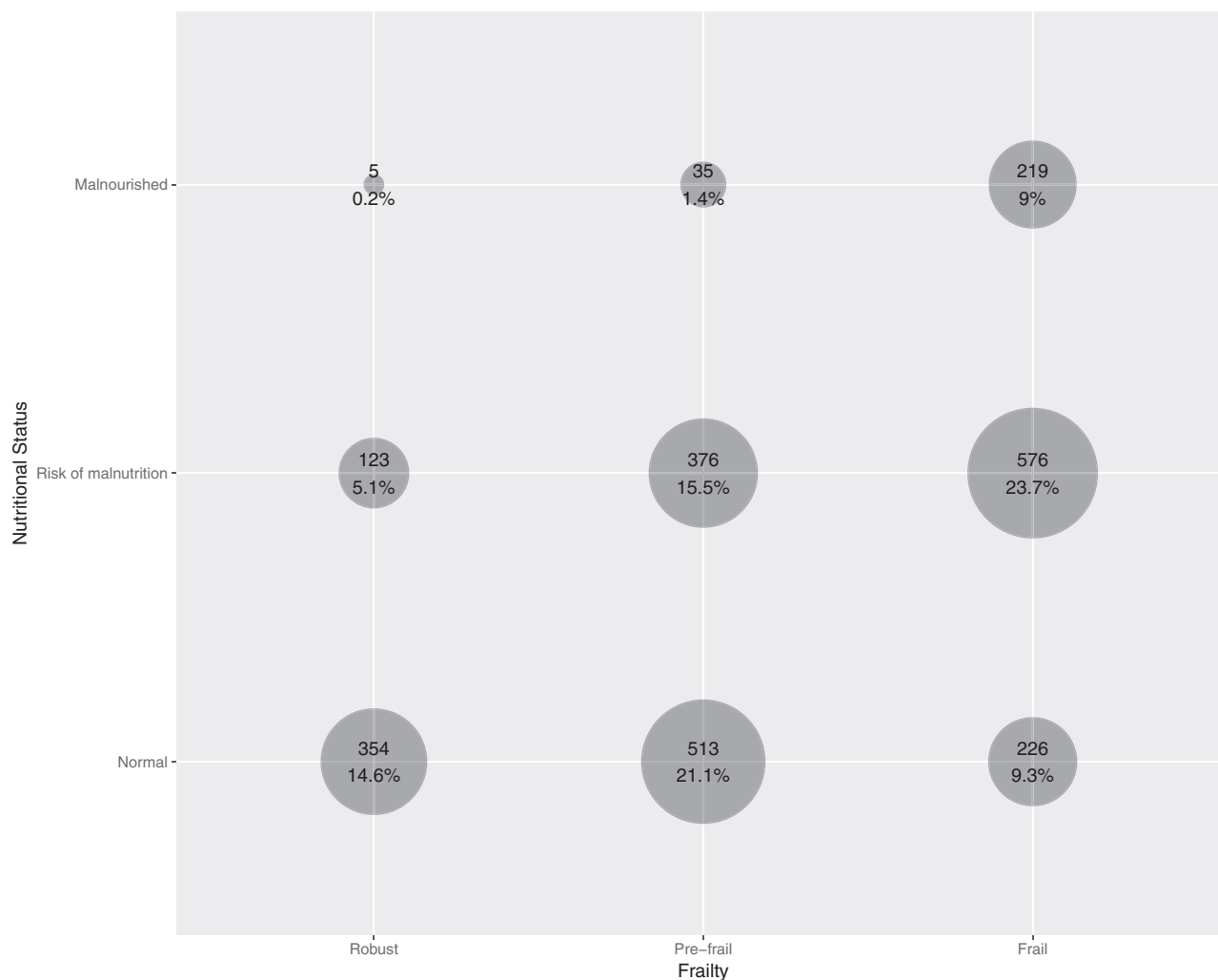
Fig. 5. Bubble plot of the overlapping prevalence of robust, prefrail, and frail and normal nutritional status, risk of malnutrition, or malnourished for the total population.

Prevalence of (Risk of) Malnutrition, (Pre-)frailty, and Sarcopenia

We are not aware of other meta-analyses with respect to the prevalence of frailty in hospitalized older adults, except for 1 in ICU patients.[92] In our study, the pooled prevalence of (pre-)frailty (84%) among older hospitalized adults was observed to be higher than in community-dwelling older adults (71%).[41] The prevalence of frailty (ie, excluding prefrailty) was twice as high compared with community results (47% vs 19%). The observed prevalence of 37% sarcopenia in our meta-analysis could also not be compared with results of other meta-analyses in hospitalized patients. The sarcopenia prevalence of hospitalized older adults was substantially higher than among community-dwelling as reported in the systematic review by Cruz-Jentoft et al,[93] who showed that prevalence of sarcopenia in community-dwelling older adults ranged from 1% to 29%. It is likely that the sarcopenia prevalence in inpatients depends considerably on the applied definition,[94] and that the prevalence is even higher when measured at hospital discharge, because of a rapid decline of strength and mass during hospitalization.[95] The observed pooled overall prevalence of 66% for (risk of) malnutrition, with 45% at risk of malnutrition and 20% malnourished, was very much in agreement with previous meta-analyses in hospitalized older patients based on MNA data. Cereda et al[96] reported a pooled prevalence of 46% at risk of malnutrition and 22% malnutrition, and a recently published meta-analysis by the MaNuEl Consortium[97] reported a pooled prevalence

of (risk of) malnutrition in European hospitalized older adults of 61% (95% CI: 55%, 67%) using MNA-SF. Our previous meta-analysis in community-dwelling older adults[41] revealed an MNA-assessed prevalence of 21% for (risk of) malnutrition, with 19% at risk of malnutrition and 2.3% malnourished. Altogether, the prevalence of (pre-)frailty, sarcopenia, and (risk of) malnutrition was shown to be substantial, and also much higher among older hospitalized than among community-dwelling older adults. The high prevalence of these conditions likely contributes to the large proportion of hospitalized older adults who are discharged from the hospital to post-acute care services that largely encompass physical and/or occupational therapy services; namely, skilled nursing facility for rehabilitation and home health services.

Association Between Either Frailty or Sarcopenia and (Risk of) Malnutrition

As anticipated beforehand, this meta-analysis revealed a high overlapping prevalence of (pre-)frailty and (risk of) malnutrition (50%) in hospitalized older adults, which was much larger than in the community, with 19% of older people having both (pre-)frailty and (risk of) malnutrition.[41] The current meta-analysis furthermore revealed a high overlapping prevalence of sarcopenia and (risk of) malnutrition (42%). In 1 of 5 patients, none of the conditions was observed. When only 1 condition was present, the highest prevalence
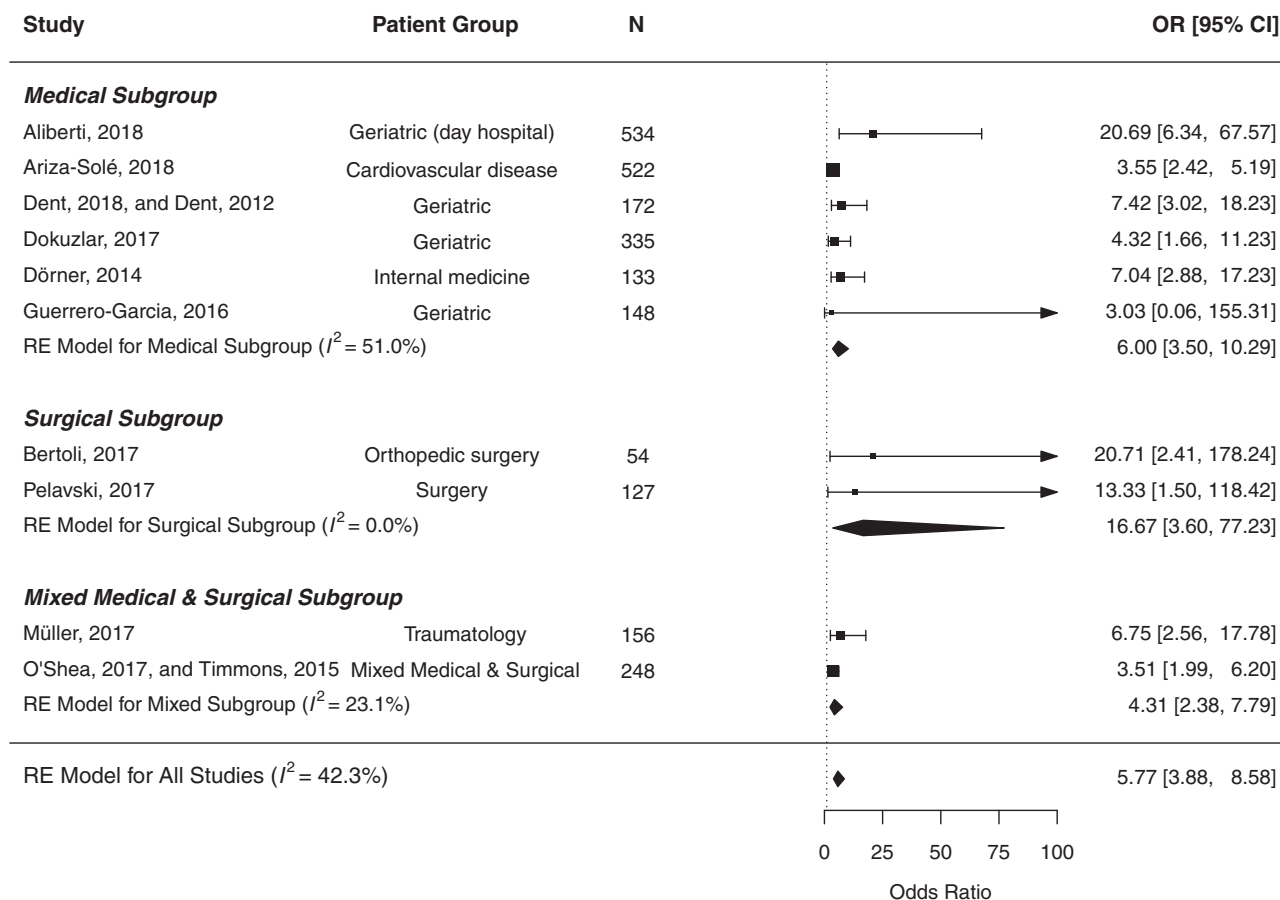
Study	Patient Group	N	OR [95% CI]
Medical Subgroup			
Aliberti, 2018	Geriatric (day hospital)	534	20.69 [6.34, 67.57]
Ariza-Solé, 2018	Cardiovascular disease	522	3.55 [2.42, 5.19]
Dent, 2018, and Dent, 2012	Geriatric	172	7.42 [3.02, 18.23]
Dokuzlar, 2017	Geriatric	335	4.32 [1.66, 11.23]
Dörner, 2014	Internal medicine	133	7.04 [2.88, 17.23]
Guerrero-Garcia, 2016	Geriatric	148	3.03 [0.06, 155.31]
RE Model for Medical Subgroup ($I^2 = 51.0\%$)			6.00 [3.50, 10.29]
Surgical Subgroup			
Bertoli, 2017	Orthopedic surgery	54	20.71 [2.41, 178.24]
Pelavski, 2017	Surgery	127	13.33 [1.50, 118.42]
RE Model for Surgical Subgroup ($I^2 = 0.0\%$)			16.67 [3.60, 77.23]
Mixed Medical & Surgical Subgroup			
Müller, 2017	Traumatology	156	6.75 [2.56, 17.78]
O'Shea, 2017, and Timmons, 2015	Mixed Medical & Surgical	248	3.51 [1.99, 6.20]
RE Model for Mixed Subgroup ($I^2 = 23.1\%$)			4.31 [2.38, 7.79]
RE Model for All Studies ($I^2 = 42.3\%$)			5.77 [3.88, 8.58]

Odds Ratio: 0 25 50 75 100

Fig. 6. Forest plot of the OR of (pre-)frailty in the presence of (risk of) malnutrition relative to absence of (risk of) malnutrition for the total population and for the medical, surgical, and mixed medical & surgical subgroups separately.

was observed for (pre-)frailty without (risk of) malnutrition (30%), or (risk of) malnutrition without sarcopenia (34%). The high overlapping prevalence of frailty or sarcopenia with (risk of) malnutrition agrees with the outcome of strong associations between those conditions, as estimated by their ORs. This substantial overlap of conditions furthermore shows that approximately half of the hospitalized older adults suffer from at least 2 of these debilitating conditions. A combination of these conditions likely synergistically impairs outcome. For example, older adults admitted to an acute care unit, who were at risk of malnutrition or malnourished according to the MNA-SF, were significantly more likely to die within 3 months after admission than those without sarcopenia.[98] Furthermore, the high prevalence, and the overlap in criteria, of conditions makes it plausible that a number of older patients suffer from all 3 conditions.

Clinical Relevance of Findings and Future Research

The high prevalence and overlap between frailty or sarcopenia and malnutrition argues for standardized screening for these conditions at or before hospital admission. The question remains how our findings can guide interventions that will reduce the added risk of impaired clinical outcome because of these conditions. Because of the substantial overlap in the evaluated geriatric conditions, most older patients are likely to benefit from nutritional support with a protein-enriched diet that also provides an adequate amount of energy. This is supported by the observation in Dutch hospitalized undernourished older adults that only 1 in 4 had a protein and energy intake level that met their requirements on the fourth day of hospital admission.[99] The

effort to reach nutritional requirements is worthwhile, as shown by Schuetz et al[100] in the recent EFFORT trial. This trial showed that individualized nutritional support, including oral nutritional supplements, in older medical inpatients at nutritional risk (NRS 2002 ≥ 3 points) reduced adverse clinical outcome and mortality within 30 days after admission.[100] Besides nutrition, inclusion of physical exercise in some form is warranted, especially in case of, but also to prevent, sarcopenia and consequent loss of mobility and independence.[14,101–104] Recently, the quality and performance committee of the American Geriatrics Society advocated for greater focus on mobility as an outcome for hospitalized older adults, and provided recommendations to implement exercise in basic hospital care for older people, preferably by nursing staff, based on already existing successful exercise programs in some hospitals.[104] Also, the maintenance of muscle mass in disease is nowadays considered an important outcome of nutritional intervention.[7] Future research should focus on implementation of screening for frailty, sarcopenia, and malnutrition as part of comprehensive geriatric assessment, and evidence-based interventions such as nutritional support and an exercise program. This will preserve or restore nutritional status, muscle mass, strength, and function, and hence contribute to improved clinical outcome.

Strengths and Limitations

Strengths of this systematic review and meta-analysis are the systematic approach and the extensive quantitative analysis. Many authors were approached, and they were kind enough to provide requested data. Eight articles were not included in the systematic
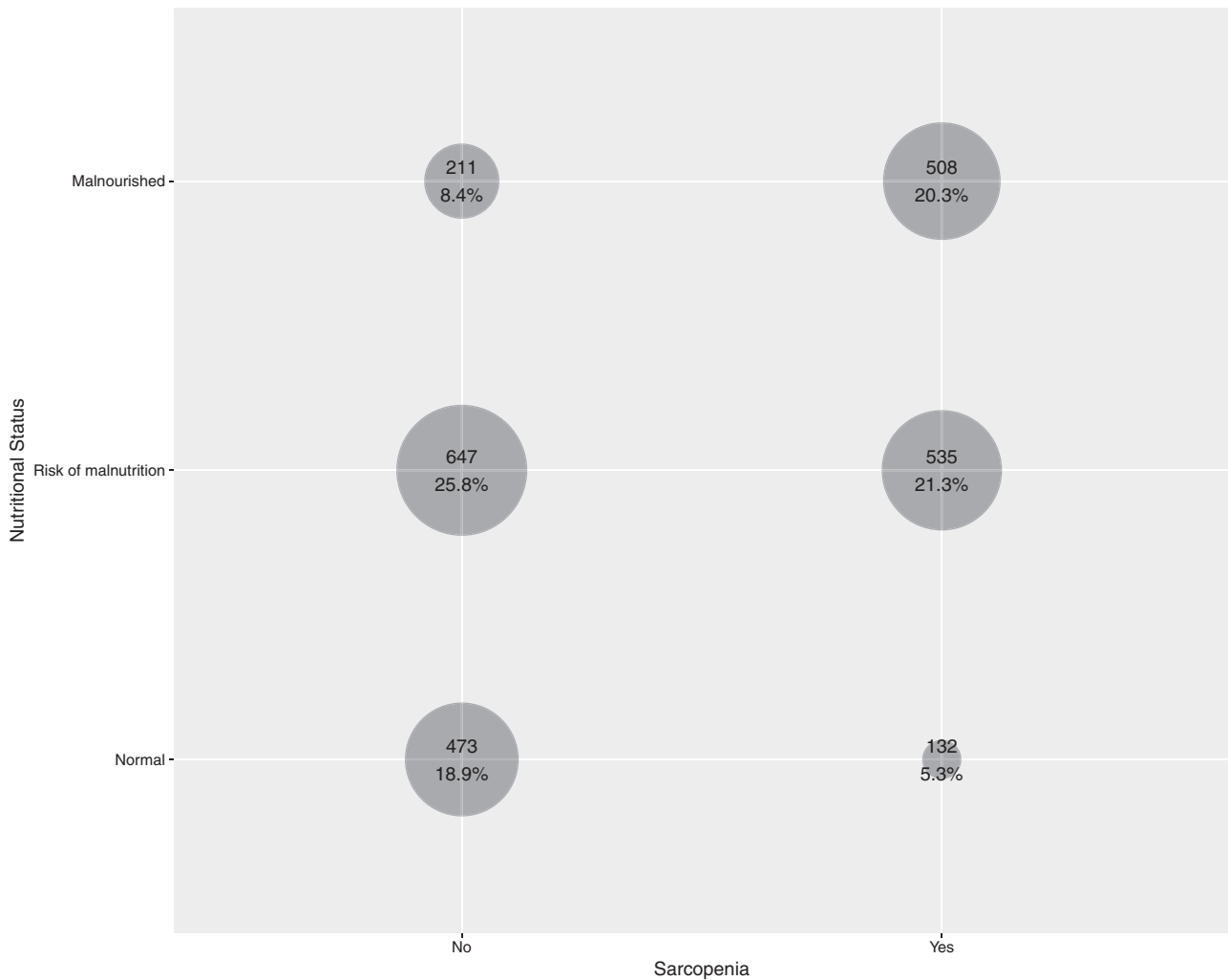
Fig. 7. Bubble plot of the overlapping prevalence of no sarcopenia or sarcopenia and normal nutritional status, risk of malnutrition, or malnourished for the total population.

review, because prevalence data were not provided, and 3 articles could not be included in the meta-analysis because no overlapping data were provided.

It may be considered a limitation that this systematic review and meta-analysis is partly based on the outcome of screening tools and not on assessment. Another limitation is that the MNA does not reveal the etiology of malnutrition. In the future, when studies use the GLIM criteria[30] to diagnose malnutrition, a meta-analysis may be able to distinguish the prevalence of cachexia in older hospitalized adults. Such a meta-analysis may also reveal a greater overlap between cachexia and sarcopenia, considering the characteristics of both conditions.[40] Furthermore, in spite of applied stratification, heterogeneity remained high, possibly because of the difference in type of patients inherent to the variety of reasons for admission. Heterogeneity may also have been enhanced by differences in the timing of assessment, which varied from at admission to 4 days after admission. However, the reduced heterogeneity with pooling of the ORs is encouraging, since this confirms a true overall effect in our meta-analysis and, hence, provides evidence of a strong relationship between (pre-) frailty and (risk of) malnutrition, and between sarcopenia and (risk of) malnutrition. Another limitation of the study is the observed asymmetry for the association between and prevalence of (pre-)frailty and (risk of) malnutrition, although pooled estimates remained valid. Specific inclusion of studies that report on both conditions may have

contributed to observed asymmetry. We did not look at the overlapping prevalence of (pre-)frailty and sarcopenia, but the 2 articles included in the systematic review that reported prevalence of both frailty and sarcopenia together with nutritional status[60,73] observed that sarcopenia was associated with higher frailty scores. Finally, we did not include a quality assessment of individual articles, but tried to improve the quality of our meta-analysis data by selecting studies that applied similar and valid tools to identify (pre-)frailty or sarcopenia (risk of) malnutrition, and by excluding studies that preselected for any of these conditions. However, information on how screening/ assessment was performed in the included studies in the meta-analysis was limited, and we cannot exclude that this may have led to a risk of bias.

Conclusions and Implications

The association between either (pre-)frailty or sarcopenia and (risk of) malnutrition is substantial, indicating that most hospitalized older adults suffer from 2 or perhaps even 3 of these debilitating conditions during their hospital stay. This advocates the inclusion of screening tools to assess nutritional status, frailty, and sarcopenia in comprehensive geriatric assessment before or at hospital admission and during hospital stay. The high overlap in the studied geriatric conditions also justifies treatment with an appropriate combination of
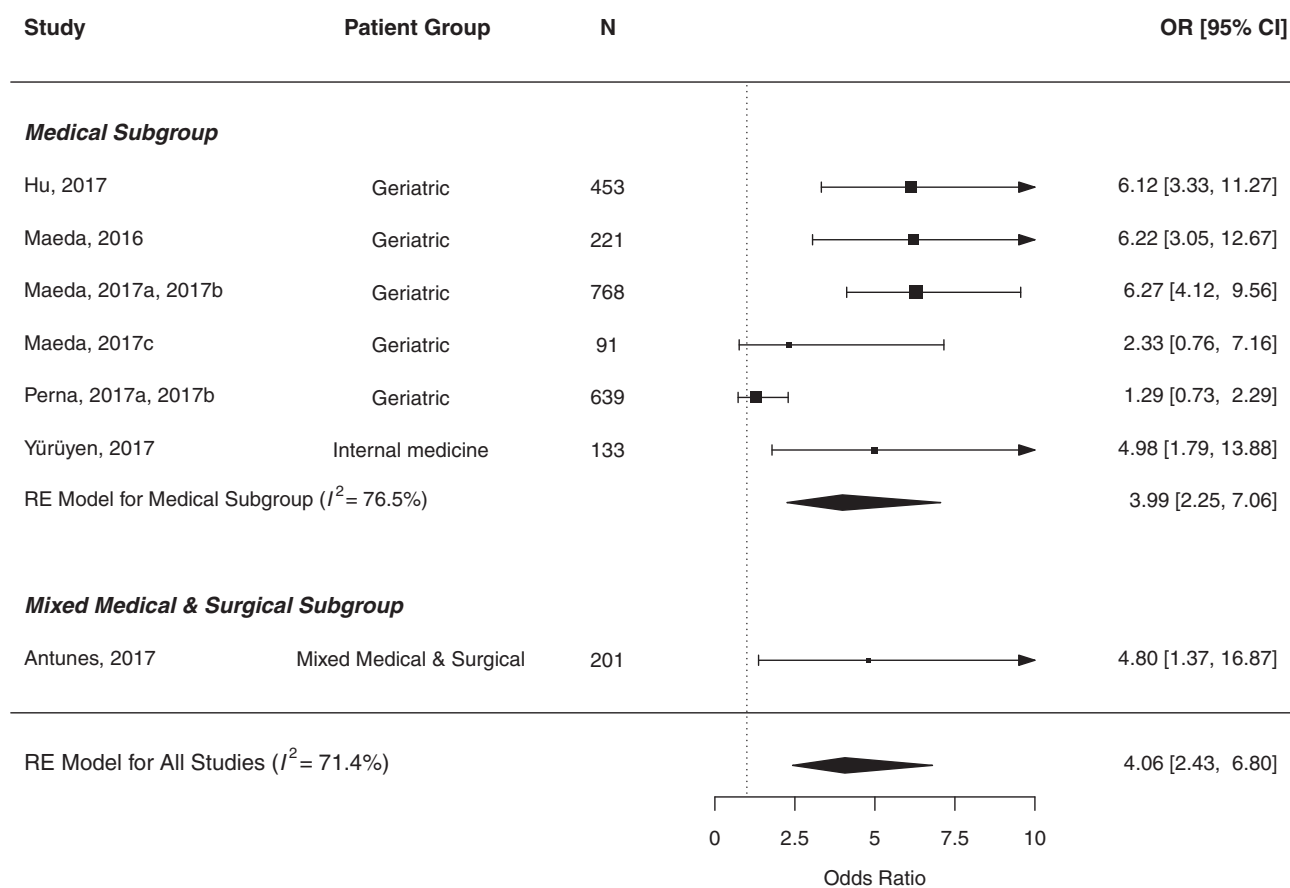
Study	Patient Group	N		OR [95% CI]

Fig. 8. Forest plot of the OR of sarcopenia in the presence of (risk of) malnutrition relative to absence of (risk of) malnutrition for the total population and for the medical, surgical and mixed medical & surgical subgroups separately.

nutritional support and exercise program in the majority of older hospitalized adults. Further research is needed to evaluate the effect of screening for (pre-)frailty, sarcopenia, and (risk of) malnutrition and subsequent nutritional and exercise intervention during and after hospital stay on clinical outcomes. Ideally, an assessment and treatment plan with regular follow-up is put in place for all hospitalized older patients.

Acknowledgments

Supplementary Data

Supplementary data related to this article can be found online at https://doi.org/10.1016/j.jamda.2020.03.006.

References

1. Ellis G, Gardner M, Tsiachristas A, et al. Comprehensive geriatric assessment for older adults admitted to hospital. Cochrane Database Syst Rev 2017;9: CD006211.
2. Amrock LG, Deiner S. The implication of frailty on preoperative risk assessment. Curr Opin Anaesthesiol 2014;27:330—335.
3. Makary MA, Segev DL, Pronovost PJ, et al. Frailty as a predictor of surgical outcomes in older patients. J Am Coll Surg 2010;210:901—908.
4. Anpalahan M, Gibson SJ. Geriatric syndromes as predictors of adverse outcomes of hospitalization. Intern Med J 2008;38:16—23.
5. De Saint-Hubert M, Schoevaerdts D, Cornette P, et al. Predicting functional adverse outcomes in hospitalized older patients: A systematic review of screening tools. J Nutr Health Aging 2010;14:394—399.
6. Gill TM, Allore HG, Holford TR, et al. Hospitalization, restricted activity, and the development of disability among older persons. JAMA 2004;292: 2115—2124.
7. Deutz NEP, Ashurst I, Ballesteros MD, et al. The underappreciated role of low muscle mass in the management of malnutrition. J Am Med Dir Assoc 2019; 20:22—27.
8. Felder S, Lechtenboehmer C, Bally M, et al. Association of nutritional risk and adverse medical outcomes across different medical inpatient populations. Nutrition 2015;31:1385—1393.
9. Ambler GK, Brooks DE, Al Zuhir N, et al. Effect of frailty on short- and mid-term outcomes in vascular surgical patients. Br J Surg 2015;102:638—645.
10. Barker LA, Gout BS, Crowe TC. Hospital malnutrition: prevalence, identification and impact on patients and the healthcare system. Int J Environ Res Public Health 2011;8:514—527.
11. Cederholm T, Bosaeus I, Barazzoni R, et al. Diagnostic criteria for malnutrition: An ESPEN Consensus Statement. Clin Nutr 2015;34:335—340.
12. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing 2010;39:412—423.
13. de Hoogt PA, Reisinger KW, Tegels JJW, et al. Functional Compromise Cohort Study (FCCS): Sarcopenia is a strong predictor of mortality in the intensive care unit. World J Surg 2018;42:1733—1741.

14. Deutz NE, Bauer JM, Barazzoni R, et al. Protein intake and exercise for optimal muscle function with aging: Recommendations from the ESPEN Expert Group. Clin Nutr 2014;33:929–936.
15. Campbell SE, Seymour DG, Primrose WR. A systematic literature review of factors affecting outcome in older medical patients admitted to hospital. Age Ageing 2004;33:110–115.
16. Clegg A, Young J, Iliffe S, et al. Frailty in elderly people. Lancet 2013;381:752–762.
17. Cederholm T, Barazzoni R, Austin P, et al. ESPEN guidelines on definitions and terminology of clinical nutrition. Clin Nutr 2017;36:49–64.
18. Hernández-Luis R, Martín-Ponce E, Monereo-Muñoz M, et al. Prognostic value of physical function tests and muscle mass in elderly hospitalized patients. A prospective observational study. Geriatr Gerontol Int 2018;18:57–64.
19. Khandelwal D, Goel A, Kumar U, et al. Frailty is associated with longer hospital stay and increased mortality in hospitalized older patients. J Nutr Health Aging 2012;16:732–735.
20. Cruz-Jentoft AJ, Bahat G, Bauer J, et al. Sarcopenia: Revised European consensus on definition and diagnosis. Age Ageing 2019;48:16–31.
21. Vetrano DL, Landi F, Volpato S, et al. Association of sarcopenia with short- and long-term mortality in older adults admitted to acute care wards: results from the CRIME study. J Gerontol A Biol Sci Med Sci 2014;69:1154–1161.
22. van Dam R, Van Ancum JM, Verlaan S, et al. Lower cognitive function in older patients with lower muscle strength and muscle mass. Dement Geriatr Cogn Disord 2018;45:243–250.
23. Van Ancum JM, Scheerman K, Pierik VD, et al. Muscle strength and muscle mass in older patients during hospitalization: The EMPOWER Study. Gerontology 2017;63:507–514.
24. Meskers CGM, Reijnierse EM, Numans ST, et al. Association of handgrip strength and muscle mass with dependency in (instrumental) activities of daily living in hospitalized older adults—The EMPOWER study. J Nutr Health Aging 2019;23:232–238.
25. Van Ancum JM, Pijnappels M, Jonkman NH, et al. Muscle mass and muscle strength are associated with pre- and post-hospitalization falls in older male inpatients: A longitudinal cohort study. BMC Geriatr 2018;18:116.
26. Reijnierse EM, Verlaan S, Pham VK, et al. Lower skeletal muscle mass at admission independently predicts falls and mortality 3 months post-discharge in hospitalized older patients. J Gerontol A Biol Sci Med Sci 2019;74:1650–1656.
27. Anker SD, Morley JE, von Haehling S. Welcome to the ICD-10 code for sarcopenia. J Cachexia Sarcopenia Muscle 2016;7:512–514.
28. Gonzalez-Granda A, Schollenberger A, Haap M, et al. Optimization of nutrition therapy with the use of calorimetry to determine and control energy needs in mechanically ventilated critically ill patients: The ONCA study, a randomized, prospective pilot study. J Parenter Enter Nutr 2019;43:481–489.
29. Vellas B, Fielding RA, Bens C, et al. Implications of ICD-10 for sarcopenia clinical practice and clinical trials: Report by the International Conference on Frailty and Sarcopenia Research Task Force. J Frailty Aging 2018;7:2–9.
30. Cederholm T, Jensen GL, Correia M, et al. GLIM criteria for the diagnosis of malnutrition—A consensus report from the global clinical nutrition community. Clin Nutr 2019;38:1–9.
31. Oliveira MR, Fogaca KC, Leandro-Merhi VA. Nutritional status and functional capacity of hospitalized elderly. Nutr J 2009;8:54.
32. Pierik VD, Meskers CGM, Van Ancum JM, et al. High risk of malnutrition is associated with low muscle mass in older hospitalized patients—A prospective cohort study. BMC Geriatr 2017;17:118.
33. Eichler S, Salzwedel A, Harnath A, et al. Nutrition and mobility predict all-cause mortality in patients 12 months after transcatheter aortic valve implantation. Clin Res Cardiol 2018;107:304–311.
34. Goisser S, Schrader E, Singler K, et al. Malnutrition according to mini nutritional assessment is associated with severe functional impairment in geriatric patients before and up to 6 months after hip fracture. J Am Med Dir Assoc 2015;16:661–667.
35. Hu X, Zhang L, Wang H, et al. Malnutrition-sarcopenia syndrome predicts mortality in hospitalized older patients. Sci Rep 2017;7:3171.
36. Müller FS, Meyer OW, Chocano-Bedoya P, et al. Impaired nutritional status in geriatric trauma patients. Eur J Clin Nutr 2017;71:602–606.
37. O'Shea E, Trawley S, Manning E, et al. Malnutrition in hospitalised older adults: A multicentre observational study of prevalence, associations and outcomes. J Nutr Health Aging 2017;21:830–836.
38. Sze S, Zhang J, Pellicori P, et al. Prognostic value of simple frailty and malnutrition screening tools in patients with acute heart failure due to left ventricular systolic dysfunction. Clin Res Cardiol 2017;106:533–541.
39. Martone AM, Onder G, Vetrano DL, et al. Anorexia of aging: A modifiable risk factor for frailty. Nutrients 2013;5:4126–4133.
40. Jeejeebhoy KN. Malnutrition, fatigue, frailty, vulnerability, sarcopenia and cachexia: Overlap of clinical features. Curr Opin Clin Nutr Metab Care 2012;15:213–219.
41. Verlaan S, Ligthart-Melis GC, Wijers SLJ, et al. High prevalence of physical frailty among community-dwelling malnourished older adults—A systematic review and meta-analysis. J Am Med Dir Assoc 2017;18:374–382.
42. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. Ann Intern Med 2009;151:264–269. W264.
43. Egger M, Davey Smith G, Schneider M, et al. Bias in meta-analysis detected by a simple, graphical test. BMJ 1997;315:629–634.
44. Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. Biometrics 1994;50:1088–1101.
45. Aliberti MJR, Apolinario D, Suemoto CK, et al. Targeted geriatric assessment for fast-paced healthcare settings: Development, validity, and reliability. J Am Geriatr Soc 2018;66:748–754.
46. Ariza-Solé A, Guerrero C, Formiga F, et al. Global Geriatric Assessment and In-Hospital Bleeding Risk in Elderly Patients with Acute Coronary Syndromes: Insights from the LONGEVO-SCA Registry. Thromb Haemost 2018;118:581–590.
47. Bertoli A, Valentini A, Cianfarani MA, et al. Low FT3: A possible marker of frailty in the elderly. Clin Interv Aging 2017;12:335–341.
48. de Thézy A, Lafargue A, d'Arailh L, et al. Relevance of G8 scale in referring elderly patients with aortic stenosis requiring a TAVI for a geriatric consultation. Geriatr Psychol Neuropsychiatr Vieil 2017;15:357–363.
49. Dent E, Visvanathan R, Piantadosi C, et al. Use of the mini nutritional assessment to detect frailty in hospitalised older people. J Nutr Health Aging 2012;16:764–767.
50. Dent E, Wright O, Hoogendijk EO, et al. Nutritional screening and dietitian consultation rates in a geriatric evaluation and management unit. Nutr Diet 2018;75:11–16.
51. Dokuzlar O, Soysal P, Isik AT. Association between serum vitamin B_{12} level and frailty in older adults. North Clin Istanb 2017;4:22–28.
52. Donini LM, de Felice MR, Tassi L, et al. A "proportional and objective score" for the Mini Nutritional Assessment in long-term geriatric care. J Nutr Health Aging 2002;6:141–146.
53. Donini LM, Savina C, Rosano A, et al. MNA predictive value in the follow-up of geriatric patients. J Nutr Health Aging 2003;7:282–293.
54. Kenig J, Wałęga P, Olszewska U, et al. Geriatric assessment as a qualification element for elective and emergency cholecystectomy in older patients. World J Emerg Surg 2016;11:36.
55. Kristjansson SR, Rønning B, Hurria A, et al. A comparison of two pre-operative frailty measures in older surgical cancer patients. J Geriatr Oncol 2012;3:1–7.
56. Mazzola M, Bertoglio C, Boniardi M, et al. Frailty in major oncologic surgery of upper gastrointestinal tract: How to improve postoperative outcomes. Eur J Surg Oncol 2017;43:1566–1571.
57. McRae PJ, Walker PJ, Peel NM, et al. Frailty and geriatric syndromes in vascular surgical ward patients. Ann Vasc Surg 2016;35:9–18.
58. Oud FMM, de Rooij SEJA, Schuurman T, et al. Predictive value of the VMS theme "frail elderly": Delirium, falling and mortality in elderly hospital patients. Ned Tijdschr Geneeskd 2015;159:A8491.
59. Pelavski AD, De Miguel M, Alcaraz Garcia-Tejedor G, et al. Mortality, geriatric, and nongeriatric surgical risk factors among the eldest old: A prospective observational study. Anesth Analg 2017;125:1329–1336.
60. Perna S, Francis MDA, Bologna C, et al. Performance of Edmonton Frail Scale on frailty assessment: Its association with multi-dimensional geriatric conditions assessed with specific screening tools. BMC Geriatr 2017;17:2.
61. van der Ven MJH, Schoon Y, Olde Rikkert MGM. Unplanned readmissions of frail elderly patients: A retrospective analysis of admissions in a teaching hospital. Ned Tijdschr Geneeskd 2015;159:A9211.
62. Díaz de Bustamante M, Alarcón T, Menéndez-Colino R, et al. Prevalence of malnutrition in a cohort of 509 patients with acute hip fracture: The importance of a comprehensive assessment. Eur J Clin Nutr 2018;72:77–81.
63. Harada H, Kai H, Niiyama H, et al. Effectiveness of cardiac rehabilitation for prevention and treatment of sarcopenia in patients with cardiovascular disease—A retrospective cross-sectional analysis. J Nutr Health Aging 2017;21:449–456.
64. Harada H, Kai H, Shibata R, et al. New diagnostic index for sarcopenia in patients with cardiovascular diseases. PLoS One 2017;12:e0178123.
65. Maeda K, Akagi J. Sarcopenia is an independent risk factor of dysphagia in hospitalized older people. Geriatr Gerontol Int 2016;16:515–521.
66. Maeda K, Akagi J. Cognitive impairment is independently associated with definitive and possible sarcopenia in hospitalized older adults: The prevalence and impact of comorbidities. Geriatr Gerontol Int 2017;17:1048–1056.
67. Maeda K, Shamoto H, Wakabayashi H, et al. Sarcopenia is highly prevalent in older medical patients with mobility limitation: Comparisons according to ambulatory status. Nutr Clin Pract 2017;32:110–115.
68. Maeda K, Takaki M, Akagi J. Decreased skeletal muscle mass and risk factors of sarcopenic dysphagia: A prospective observational cohort study. J Gerontol A Biol Sci Med Sci 2017;72:1290–1294.
69. Sousa AS, Guerra RS, Fonseca I, et al. Sarcopenia among hospitalized patients—A cross-sectional study. Clin Nutr 2015;34:1239–1244.
70. Yürüyen M, Yavuzer H, Yavuzer S, et al. Comparison of nutritional risk screening tools for predicting sarcopenia in hospitalized patients. Turk J Med Sci 2017;47:1362–1369.
71. Timmons S, Manning E, Barrett A, et al. Dementia in older people admitted to hospital: A regional multi-hospital observational study of prevalence, associations and case recognition. Age Ageing 2015;44:993–999.
72. Härter J, Orlandi SP, Gonzalez MC. Nutritional and functional factors as prognostic of surgical cancer patients. Support Care Cancer 2017;25:2525–2530.
73. Perna S, Peroni G, Faliva MA, et al. Sarcopenia and sarcopenic obesity in comparison: Prevalence, metabolic profile, and key differences. A cross-sectional study in Italian hospitalized elderly. Aging Clin Exp Res 2017;29:1249–1258.
74. Dorner TE, Luger E, Tschinderle J, et al. Association between nutritional status (MNA®-SF) and frailty (SHARE-FI) in acute hospitalised elderly patients. J Nutr Health Aging 2014;18:264–269.

75. Guerrero-García NB, Gómez-Lomelí ZM, Leal-Mora D, et al. Frailty in the elderly and nutritional status according to the Mini Nutritional Assessment. Rev Med Inst Mex Seguro Soc 2016;54:312—317.

76. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: Evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56:M146—M156.

77. Romero-Ortuno R, Walsh CD, Lawlor BA, et al. A frailty instrument for primary care: findings from the Survey of Health, Ageing and Retirement in Europe (SHARE). BMC Geriatr 2010;10:57.

78. Abellan van Kan G, Rolland YM, Morley JE, et al. Frailty: toward a clinical definition. J Am Med Dir Assoc 2008;9:71—72.

79. Morley JE, Malmstrom T, Miller D. A simple frailty questionnaire (FRAIL) predicts outcomes in middle aged African Americans. J Nutr Health Aging 2012;16:601—608.

80. Chen L-K, Liu L-K, Woo J, et al. Sarcopenia in Asia: Consensus report of the Asian Working Group for Sarcopenia. J Am Med Dir Assoc 2014;15: 95—101.

81. Antunes AC, Araújo DA, Veríssimo MT, et al. Sarcopenia and hospitalisation costs in older adults: A cross-sectional study. Nutr Diet 2017;74:46—50.

82. Carrion S, Roca M, Costa A, et al. Nutritional status of older patients with oropharyngeal dysphagia in a chronic versus an acute clinical situation. Clin Nutr 2017;36:1110—1116.

83. Jacobsen EL, Brovold T, Bergland A, et al. Prevalence of factors associated with malnutrition among acute geriatric patients in Norway: A cross-sectional study. BMJ Open 2016;6:e011512.

84. Sánchez-Rodríguez D, Marco E, Ronquillo-Moreno N, et al. Prevalence of malnutrition and sarcopenia in a post-acute care geriatric unit: Applying the new ESPEN definition and EWGSOP criteria. Clin Nutr 2017;36:1339—1344.

85. Smoliner C, Sieber CC, Wirth R. Prevalence of sarcopenia in geriatric hospitalized patients. J Am Med Dir Assoc 2014;15:267—272.

86. Guigoz Y, Vellas B, Garry PJ. Assessing the nutritional status of the elderly: The Mini Nutritional Assessment as part of the geriatric evaluation. Nutr Rev 1996;54(1, pt 2):S59—S65.

87. Rubenstein LZ, Harker JO, Salva A, et al. Screening for undernutrition in geriatric practice: Developing the Short-Form Mini-Nutritional Assessment (MNA-SF). J Gerontol A Biol Sci Med Sci 2001;56:M366—M372.

88. Kaiser MJ, Bauer JM, Ramsch C, et al. Validation of the Mini Nutritional Assessment Short-Form (MNA-SF): A practical tool for identification of nutritional status. J Nutr Health Aging 2009;13:782—788.

89. Isautier JMJ, Bosnic M, Yeung SSY, et al. Validity of nutritional screening tools for community-dwelling older adults: A systematic review and meta-analysis. J Am Med Dir Assoc 2019;20:1351.

90. Bo M, Li Puma F, Badinella Martini M, et al. Effects of oral anticoagulant therapy in older medical in-patients with atrial fibrillation: A prospective cohort observational study. Aging Clin Exp Res 2017;29:491—497.

91. Fiatarone Singh MA, Singh NA, Hansen RD, et al. Methodology and baseline characteristics for the Sarcopenia and Hip Fracture study: A 5-year prospective study. J Gerontol A Biol Sci Med Sci 2009;64:568—574.

92. Muscedere J, Waters B, Varambally A, et al. The impact of frailty on intensive care unit outcomes: A systematic review and meta-analysis. Intensive Care Med 2017;43:1105—1122.

93. Cruz-Jentoft AJ, Landi F, Schneider SM, et al. Prevalence of and interventions for sarcopenia in ageing adults: A systematic review. Report of the International Sarcopenia Initiative (EWGSOP and IWGS). Age Ageing 2014;43: 748—759.

94. Reijnierse EM, Buljan A, Tuttle CSL, et al. Prevalence of sarcopenia in in-patients 70 years and older using different diagnostic criteria. Nurs Open 2019;6:377—383.

95. Van Ancum JM, Scheerman K, Jonkman NH, et al. Change in muscle strength and muscle mass in older hospitalized patients: A systematic review and meta-analysis. Exp Gerontol 2017;92:34—41.

96. Cereda E, Pedrolli C, Klersy C, et al. Nutritional status in older persons according to healthcare setting: A systematic review and meta-analysis of prevalence data using MNA®. Clin Nutr 2016;35:1282—1290.

97. Leij-Halfwerk S, Verwijs MH, van Houdt S, et al. Prevalence of protein-energy malnutrition risk in European older adults in community, residential and hospital settings, according to 22 malnutrition screening tools validated for use in adults >/=65 years: A systematic review and meta-analysis. Maturitas 2019;126:80—89.

98. Cerri AP, Bellelli G, Mazzone A, et al. Sarcopenia and malnutrition in acutely ill hospitalized elderly: Prevalence and outcomes. Clin Nutr 2015;34: 745—751.

99. Leistra E, Willeboordse F, van Bokhorst-de van der Schueren MA, et al. Predictors for achieving protein and energy requirements in undernourished hospital patients. Clin Nutr 2011;30:484—489.

100. Schuetz P, Fehr R, Baechli V, et al. Individualised nutritional support in medical inpatients at nutritional risk: A randomised clinical trial. Lancet 2019; 393:2312—2321.

101. Morley JE, Abbatecola AM, Argiles JM, et al. Sarcopenia with limited mobility: An international consensus. J Am Med Dir Assoc 2011;12:403—409.

102. Morley JE, Argiles JM, Evans WJ, et al. Nutritional recommendations for the management of sarcopenia. J Am Med Dir Assoc 2010;11:391—396.

103. Aarden JJ, van der Schaaf M, van der Esch M, et al. Muscle strength is longitudinally associated with mobility among older adults after acute hospitalization: The Hospital-ADL study. PLoS One 2019;14: e0219041.

104. Wald HL, Ramaswamy R, Perskin MH, et al. The case for mobility assessment in hospitalized older adults: American Geriatrics Society White Paper Executive Summary. J Am Geriatr Soc 2019;67:11—16.