Nutrition 131 (2025) 112627

Contents lists available at ScienceDirect

Nutrition

journal homepage: www.nutritionjrnl.com

Applied nutritional investigation

Controlling nutritional status score and geriatric nutritional risk index as a predictor of mortality and hospitalization risk in hospitalized older adults

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ARTICLE INFO

Article History:
Received 8 August 2024
Received in revised form 18 October 2024
Accepted 30 October 2024

Keywords:
Malnutrition
Sarcopenia
CONUT score
GNRI
Hospitalization risk
Mortality risk

ABSTRACT

Background: The COntrolling NUTritional Status (CONUT) score and the Global Nutrition Risk Index (GNRI) are screening tools for assessing the risk of malnutrition based on widely available biochemical parameters. The primary objective of this study was to investigate the predictive value of CONUT and GNRI score on 36 months mortality and hospitalization risk in hospitalized older patients.
Methods: Data of 382 patients (196 women, mean age 80.9±6.8 years) were retrieved from the multicenter Italian Study conducted by the Gruppo Lavoro Italiano Sarcopenia–Trattamento e Nutrizione (GLISTEN) in 12 Acute Care Wards. Sarcopenia was defined as presence of low handgrip strength plus low skeletal mass index (EWGSOP2 criteria). CONUT score was calculated based on serum albumin, total cholesterol and total lymphocyte count, whilst the GNRI was calculated using serum albumin and present body weight/ideal body weight ratio.
Results: During the 36-month follow-up, 120 out of 382 participants died (31.4%). From the results of the survival analysis, and after adjustment for potential confounders, participants with CONUT-derived moderate to high risk of malnutrition had shorter survival (HR = 2.67, 95%CI 1.34–5.33 and HR = 3.98, 95% CI: 1.77–8.97, respectively), as well as shorter survival free of urgent hospitalization (HR = 1.91; 95% CI: 1.03–3.55 and HR = 1.98; 95% CI: 1.14–3.42, respectively). Conversely, only GNRI indicative of high risk of malnutrition was an independent predictor of mortality 1.96 (95% CI: 1.06–3.62), but not of hospitalization.
Conclusion: The CONUT score seems a valid tool to predict long-term mortality and hospitalization risk. Conversely, the GNRI is associated with long-term mortality, but not with hospital readmissions.

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https://doi.org/10.1016/j.nut.2024.112627
0899-9007/

Introduction

Malnutrition (undernutrition) in older adults is associated with major adverse outcomes such as high hospitalization rates, prolonged hospital stays, and increased mortality risk [1,2]. In recent years, the COntrolling NUTritional Status (CONUT) score and the Global Nutrition Risk Index (GNRI) have emerged as widely used screening tools for assessing the risk of malnutrition as a first step in a more comprehensive nutrition care process; they are simple, quick, easy to use, standardized and based on the use of commonly available biochemical parameters [3–9]. The CONUT score takes into account serum albumin, total lymphocyte count and total cholesterol level [3], while the GNRI includes serum albumin and the present body weight/ideal body weight ratio.

In the last few years, both CONUT and GNRI have been widely used in various clinical settings, including hospitals and long-term care facilities. Several papers have proposed CONUT and GNRI as promising prognostic markers, for instance, in patients with cancer [10], coronary artery disease [11], acute heart failure [12] and stroke [13].

Previous studies showed that CONUT and GNRI were associated with in-hospital mortality in frail older subjects [12,14–18], while studies investigating long-term mortality risk included patients suffering from specific diseases [19–21]. For instance, Yuan [19] found that both CONUT and GNRI values indicative of nutritional risk were associated with long-term mortality risk in Chinese subjects with ischemic stroke. In a recent metanalysis, Kheirouri investigated the prognostic role of preoperative CONUT score on post-treatment long-term outcomes including overall survival, recurrence-free survival, and cancer-specific survival in patients with cancer [20]. Furthermore, Arero investigated the importance of CONUT score for prediction of all-cause mortality and major adverse cardiovascular events in adult patients with coronary artery disease [21].

However, to our knowledge, the prognostic value of CONUT score and GNRI for all-cause mortality and hospitalization risk has not yet been investigated in a general population of hospitalized older adults living in a Western country. Therefore, in this study we aimed to investigate whether CONUT and GNRI are predictive of 36-month risk of death and hospitalization.

Material and methods

Study design and data collection

The Gruppo di Lavoro Italiano Sarcopenia–Trattamento e Nutrizione (GLISTEN) project is an observational study performed in Geriatric and Internal Medicine acute care wards of 12 Italian hospitals. The study population and methodology used in the GLISTEN project has been described elsewhere in detail [22] Exclusion criteria were age younger than 65 years and patient's unwillingness to take part in the study. Survival status and time to first hospitalization was recorded up to 36-months after hospital discharge.

For this study, we excluded 219 participants of the original 655 participants enrolled, because complete CONUT and GNRI data were not available, along with another 54 participants because sarcopenia criteria and/or data of hospitalization or death were missing: the final sample was 382 persons (196 females and 186 males, age 80.9 years). A comparison of subjects excluded (n = 273) from the present analysis with those who were included shows that those excluded were not different in sex distribution, age, weight, height, ADL and IADL.

Assessment of nutritional risk

CONUT score derives from the sum of 3 components: serum albumin score (0,≥3.5 g/dL; 2, 3.0–3.49 g/dL; 4, 2.50–2.99 g/dL; 6,<2.50 g/dL), total cholesterol score (0,≥180 mg/dL; 1, 140–179 mg/dL; 2, 100–139 mg/dL; 3,<100 mg/dL), and total lymphocyte count score (0,≥1600/mm^3; 1, 1200–1599/ mm^3; 2, 800–1199/ mm^3; 3,<800/mm^3) [3]. As originally proposed by Ignacio de Ulíbarri, the study population was divided in subjects with normal (score 0–1), low (2–4), moderate (5–8) or severe nutritional risk (9–12) [3]. Furthermore, the study population was divided in 2 groups according to CONUT score, CONUT ≥ 5, indicative of malnutrition and CONUT<5, indicative of normal nutritional state.

The GNRI calculates nutrition related risk using serum albumin, present body weight (PBW), and ideal body weight (IBW), which was calculated from Lorentz equations as follows:

IBW = height−100−[(height-150)/4] for men and IBW = height−100−[(height−150)/2.5] for women.

The GNRI formula is:

GNRI = 1.487×Serum albumin (g/L)+41.7×PBW/IBW (kg) [7,22].

In line with Bouillanne, the study population was divided according to the GNRI score in subjects at major risk (GNRI < 82), moderate risk (GNRI 82 to <92), low risk (GNRI 92 to ≤98) and no risk (GNRI > 98). The study population was further divided in 2 groups according to GNRI, GNRI < 92, indicative of malnutrition and GNRI ≥ 92, indicative of normal nutritional state [7].

Assessment of sarcopenia

Sarcopenia was defined as presence of low muscle strength plus low muscle mass according to the EWGSOP2 criteria [24,25].

Muscle strength was assessed by handgrip strength (HGS) and measured using a hand-held dynamometer (JAMAR hand dynamometer Model BK-7498, Brookfield, IL) as described elsewhere [23]. Using the cut-off points from the EWGSOP2 consensus, low HGS referred to <27 kg for men and <16 kg for women as reported elsewhere [26].

Muscle mass was measured by bioimpendance analysis (BIA) using a Quantum/S Bioelectrical Body Composition Analyzer (Akern Srl, Florence, Italy) as previously reported [24]. Appendicular skeletal muscle mass (ASM) was calculated using the following equation of Sergi [28]: *ASM = −3.964 + (0.227xStature^2/ Resistance) + (0.095xWeight) + (1.384xSex) + (0.064xReactance)* where ASM is measured in kg, stature in cm, resistance and reactance in ohm, weight in kg; for sex, men = 1 and women = 0. ASM was standardizing by stature squared (ASM/ height^2). Low muscle quantity was classified as ASM/stature^2<7.0 kg/m^2 in men and <6.0 kg/m^2 in women in line with EWGSOP2 cutoff points [29].

Covariates

Sociodemographic variables (age, gender, smoking habits, education) were obtained through clinical interviews at hospital admission. Functional status in basic activities of daily living (ADL) and instrumental activities of daily living (IADL) and physical activity level as assessed with Physical Activity Scale for the Elderly (PASE) were assessed as reported elsewhere [22]. Diagnoses of specific medical conditions were gathered from the patient, attending physicians and through a careful review of medical charts [23].

Study outcomes

Mortality data were collected using data from the Mortality General Registry maintained by each Region. Time from the day of study enrollment to last follow up was considered as temporal function in our study. No information on the cause of death was collected. Information regarding hospital admissions was obtained for each subject through their general practitioners' records. Hospitalization was defined as a stay of at least 48h in an acute-care hospital.

Statistical analysis

A comparison of subjects excluded and included in the final analysis was performed with a repeated-measures analysis of variance (ANOVA).

Baseline characteristics were compared according to CONUT and GNRI score groups, using ≥5 and <92 cutoffs, respectively. Preliminarily, the Kolmogorov–Smirnov test was performed on all the anthropometric variables to assess evidence of nonnormality in the data. None of the results of the tests were significant, so continuous data with approximately normal distribution were described as mean±standard deviation and compared by t-test and 1-way ANOVA. Categorical variables were summarized in terms of counts and percentages and were compared by using Pearson's chi-squared test or the Fisher's exact test, as appropriate.

Crude hospitalization and mortality rates were estimated, and Kaplan-Meier curves were fitted to explore survival probabilities. The log-rank test was used to compare groups and the Cox regression analysis was done to determine the CONUT group and the GNRI group effect on 36-months mortality and survival without hospitalization. For both classifications, 5 nested models were fitted: unadjusted model, age and gender adjusted, sarcopenia adjusted, ADL adjusted and lastly, the model was further adjusted for all medical conditions.

Table 1
Characteristics of participants according to CONUT score and GNRI groups at baseline

	CONUT score <5, n = 229		CONUT score ≥5, n = 153			GNRI ≥92, n = 271		GNRI <92, n = 111		
	Mean	Std. Deviation	Mean	Std. Deviation	*P*	Mean	Std. Deviation	Mean	Std. Deviation	*P* value
Age (years)	79.8	6.2	82.6	7.3	<0.001	80.2	6.6	82.9	7.0	0.001
Gender (male %)	106 (46.3)		80 (52.3)		0.253	136 (50.2)		50 (45.0)		0.366
Sarcopenia (%)	51 (22.8)		53 (34.6)		0.010	48 (17.7)		56 (50.4)		<0.001
Weight (kg)	71.9	15.4	70.2	14.9	0.183	74.7	14.4	62.0	11.3	<0.001
Height (cm)	163.8	9.7	163.4	8.1	0.395	163.4	9.4	163.4	8.4	0.943
ADL total	4.7	1.8	4.3	1.9	0.076	4.5	1.9	4.5	1.9	0.786
PASE total	58.4	54.4	35.3	46.6	<0.001	53.1	53.4	40.6	49.5	0.030
IADL total	4.6	2.5	4.2	2.6	0.107	4.4	2.4	4.4	2.7	0.912
ASM/h2 (kg/m2)	6.8	1.2	6.6	1.2	0.117	7	1.1	6.2	1.1	<0.001
Handgrip (kg)	22.1	14.7	18.5	10.0	0.008	22.2	14.1	16.8	9.4	<0.001
Albumin (g/dL)	3.8	0.5	2.7	0.6	<0.001	3.7	0.6	2.5	0.5	<0.001
Total cholesterol (mg/dL)	172.7	43.3	138.3	39.9	<0.001	163.4	45.2	147.7	43.5	0.002
Limphocytes (cells count/mm3)	1826.7	1227.7	1834.8	3758.9	0.976	1623.4	970.8	2341.9	4488.8	0.013
ALT (IU/L)	19.4	19.6	31.1	44.7	0.001	21.1	24.8	31.5	46.1	0.005
Triglicerides (mg/dL)	113.6	52.1	104.5	51.2	0.105	110.1	53.8	109.9	51.9	0.910
HDL Cholesterol (mg/dL)	50.3	19.7	41.4	14.4	<0.001	48.2	19.5	43.2	15.1	0.030
CRP (mg/L)	3.4	6.0	5.2	6.9	0.027	4.5	6.9	4.1	5.8	0.639
Fibrinogen (mg/dL)	449.5	123.3	482.4	158.3	0.051	457.2	131.9	470.5	152.6	0.483
CONUT score	2.2	1.3	7.1	1.7	<0.001	3.0	2.2	6.9	2.2	<0.001
GNRI	107.9	12.8	88.8	13.1	<0.001	107.8	11.5	81.7	8.6	<0.001

ADL, activity of daily living; ALT, alanine aminotransferase; ASM, appendicular skeletal muscle; CRP, C-reactive protein; CONUT, controlling nutritional status; GNRI, geriatric nutritional risk index; HDL, high-density lipoprotein; IADL, instrumental activity of daily living; PASE, physical activity scale for the elderly.

All analyses were done using SPSS (IBM, version 25) and statistical significance was set at 0.05.

Results

General characteristics of participants according to CONUT score and GNRI at baseline are presented in Table 1. Participants with CONUT score≥5 were significantly older, and had greater prevalence of sarcopenia, as well as lower PASE, handgrip strength, albumin, total cholesterol and HDL. Moreover, they showed higher prevalence of sarcopenia, chronic heart and renal failure (data not shown). Subjects with GNRI<92 were significantly older, showed greater prevalence of sarcopenia and had lower weight, PASE, handgrip strength, albumin, total cholesterol, ALT and HDL. A higher prevalence of neoplasia and renal failure was observed in this group.

During 36-month follow-up, 120 out of 382 participants died and 162 were hospitalized, corresponding to 31.4% and 42.4% of the whole cohort, respectively.

As for CONUT scores, 78 subjects showed normal (score 0–1), 151 low (2–4), 119 moderate (5–8) and 34 severe risk of malnutrition (9–12). Figures 1A and B show Kaplan-Meier survival curves according to CONUT score groups for all-cause mortality and hospitalization, respectively. Participants with severe or moderate risk of malnutrition according with the CONUT score had a shorter survival as compared with those with low CONUT scores. Estimates derived from the Cox proportional hazard models are shown in Table 2. After full adjustment for potential confounders, CONUT-derived moderate to high nutritional risk was independently associated with shorter survival with HR of 2.67 (95% CI: 1.34–5.33) and 3.98 (95% CI: 1.77–8.97), respectively. Age and sarcopenia were also independent predictors of mortality with HR = 1.05; 95% CI: 1.01–1.08 and HR = 2.48; 95% CI: 1.63–3.79, respectively. Furthermore, pulmonary embolism (HR = 7.48; 95% CI: 2.39–23.41), deep vein thrombosis (HR = 2.81; 95% CI: 1.07–7.35), COPD (HR = 1.58; 95% CI: 1.01–2.41), acute renal failure (HR = 3.29; 95% CI: 1.10–9.81) and cancer (HR = 2.19; 95% CI: 1.14–4.23) were all independently associated with 36-month mortality.

In Figure 1B, the Kaplan–Meier curves show that participants with high CONUT score had the shorter survival free of urgent hospitalization. These findings were confirmed in multivariable Cox proportional hazard models (Table 3, Model 5): after adjusting for potential confounders, CONUT-derived moderate or high nutritional risk was still significantly associated with hospitalization risk (HR = 1.91; 95% CI: 1.03–3.55 and HR = 1.98; 95% CI: 1.14–3.42, respectively), whilst sarcopenia and ADL showed no association.

According to GNRI, 48 subjects were at major risk of malnutrition, 62 at moderate risk, 66 at low risk and 208 had no risk. Figure 2A shows that participants with GNRI scores indicative of high nutritional risk had a shorter survival as compared with subjects with a GNRI score indicative of no risk. Table 2 shows the association between GNRI groups and mortality according to Cox regression analysis: in the fully adjusted model (Model 5), the results of the survival analysis were confirmed with high risk of malnutrition according to GNRI was associated with mortality with an HR of 1.96 (95% CI: 1.06–3.62). Age and sarcopenia were independent predictors with HR of 1.06 (95% CI: 1.02–1.09) and 2.35 (95% CI: 1.50–3.70), respectively. Furthermore, pulmonary embolism (HR = 7.50; 95% CI: 2.33–24.07), deep vein thrombosis (HR = 2.89; 95% CI: 1.12–7.44), Parkinson disease (HR = 5.80; 95% CI: 1.87–18.00) and COPD (HR = 1.61; 95% CI: 1.04–2.49) were all independently related to 36 months mortality. Conversely, no differences were observed in survival free of hospitalization in different GNRI score groups (Fig. 2B and Table 3).

Discussion

This study supports the idea that CONUT-derived moderate/high nutritional risk is associated in older patients admitted to acute geriatric or internal medicine wards with an increased risk of mortality and hospitalization, even after adjustment for potential confounders. On the other hand, a GNRI-derived high nutritional risk was associated with an increased risk of mortality but not hospitalization. These associations were still significant in a sample of

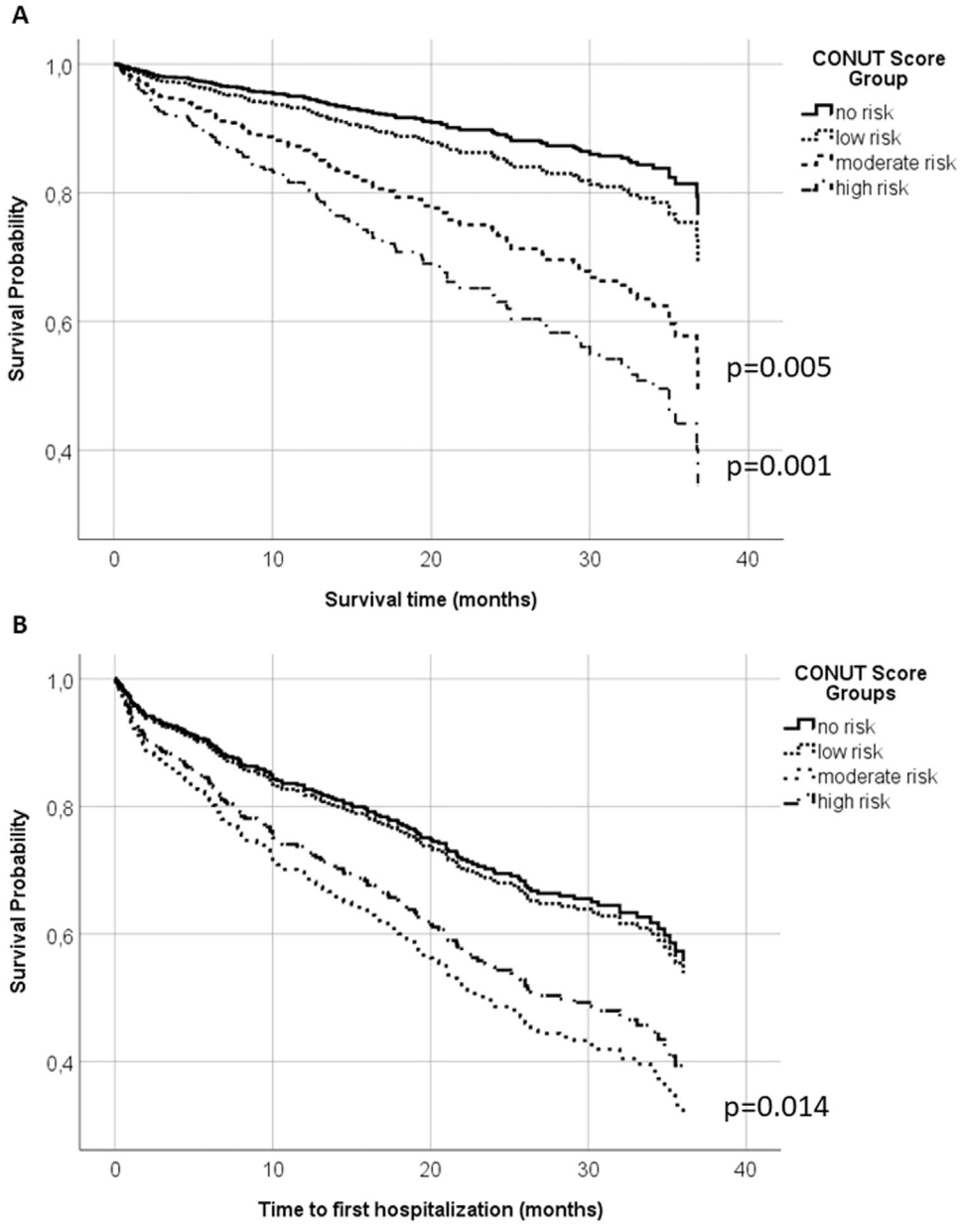

Fig. 1. Kaplan–Meier survival curves for all-cause mortality (A) and hospitalization (B) according to CONUT score groups, no risk (score 0–1), low (2–4), moderate (5–8) and severe risk of malnutrition (9–12).

older polymorbid patients with high prevalence of diseases associated with adverse outcomes.

CONUT score and GNRI are used in the first step (screening) of the nutritional care process [9]. Although both tools have been widely used [10–13], only limited evidence is available for hospitalized older patients, and even less in those admitted to acute wards. In the present study, a consistent proportion of the older patients exhibited moderate or severe/major nutritional risk; a high nutritional risk was associated with a greater prevalence of sarcopenia.

As major findings of the study, the CONUT score is predictive of mortality in hospitalized older adults suffering from various diseases; an increased mortality was observed in either moderate or, to a larger extent, severe risk but not for low risk. A cut-off value for mortality of 5 points was identified, which is the one usually indicated in the literature; other studies in specific diseases used lower cut-off values [10–13].

Overall, these results are in line with the few previous studies on hospitalized patients [14–16,25]: the CONUT score was associated with length of stay and in-hospital mortality [15], and also with hospital stay, but not mortality, in frail older patients [26].

This study provides new findings showing that the CONUT score is predictive of mortality in hospitalized older adults affected by various acute disease, which aligns with previous reports [14–16,25]. In a recent study the CONUT score was associated with hospital outcomes, and in particular length of stay and in-hospital mortality [15], whilst in another one the CONUT score came out as an independent predictor of longer hospital stay, but not of mortality, in old frail patients [26].

Table 2
Association between CONUT and GNRI score groups and mortality according to cox regression models adjusted for potential confounders

	Events (%)	Model 1 (unadjusted)	Model 2 (adjusted for age and gender)	Model 3 (adjusted for age, gender and sarcopenia)	Model 4 (adjusted for age, gender, sarcopenia, and ADL)	Model 5 (adjusted for age, gender, sarcopenia, ADL and other potential confounders*)
		HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
CONUT score						
0–1 (no risk, n = 78)	14 (17.9%)	1	1	1	1	1
		-	-	-	-	-
2–4 (low risk, n = 151)	36 (23.8%)	1.57 (0.85–2.94)	1.54 (0.82–2.86)	1.45 (0.78–2.70)	1.36 (0.73–2.55)	1.37 (0.71–2.65)
5–8 (moderate risk, n = 119)	50 (42.0%)	3.29 (1.80–6.01)	2.76 (1.50–5.09)	2.44 (1.32–4.52)	2.25 (1.21–4.19)	2.67 (1.34–5.33)
9–12 (high risk, n = 34)	20 (58.8%)	5.89 (2.95–11.76)	5.27 (2.63–10.58)	4.82 (2.40–9.69)	4.63 (2.30–9.34)	3.98 (1.77–8.97)
GNRI score						
>98 (no risk, n = 206)	52 (25.2%)	1	1	1	1	1
		-	-	-	-	-
92–98 (low risk, n = 66)	17 (25.7%)	1.17 (0.68–2.04)	1.03 (0.59–1.79)	0.99 (0.57–1.73)	0.95 (0.54–1.65)	0.86 (0.46–1.58)
82–91 (moderate risk, n = 62)	26 (41.9%)	1.89 (1.16–307)	1.60 (0.97–2.63)	1.37 (0.81–2.29)	1.36 (0.81–2.28)	1.25 (0.67–2.30)
<82 (high risk, n = 48)	25 (52.0%)	2.95 (1.82–4.78)	2.51 (1.54–4.09)	1.99 (1.17–3.38)	2.14 (1.25–3.67)	1.96 (1.06–3.62)

ADL, activity of daily living; CONUT, controlling nutritional status; GNRI, geriatric nutritional risk index; HR, hazard ratio.
*Heart failure, chronic renal failure, hypertension, atrial fibrillation, ischemic cardiopathy, deep vein and pulmonary embolism, peripheral artery disease, diabetes, hyper- or hypothyroidism, arthrosis, arthritis, chronic obstructive pulmonary disease, femoral fracture, major or minor stroke, dementia, Parkinson disease, acute renal failure, cancer and metastatic cancer.

The association between CONUT score and mortality is not surprising. The CONUT score is based on 2 biochemical parameters (serum albumin and cholesterol level) and 1 immune parameter (total lymphocyte count). Hypoalbuminemia is a well-known predictor for short-term prognosis in patients with cardiovascular disease [27], while low cholesterol levels predict short- and long-term mortality in older patients [28]. Low lymphocyte counts similarly predict unfavorable outcomes in older patients [29]. All the 3 parameters were affected not only by nutritional status but also by the exacerbation of disease.

GNRI is another well-known indicator of nutritional risk based on albumin and the ratio be-tween present weight and ideal

Table 3
Association between CONUT and GNRI score groups and hospitalization according to cox regression models adjusted for potential confounders

	Events (%)	Model 1 (unadjusted)	Model 2 (adjusted for age and gender)	Model 3 (adjusted for age, gender and sarcopenia)	Model 4 (adjusted for age, gender, sarcopenia, and ADL)	Model 5 (adjusted for age, gender, sarcopenia, ADL and other potential confounders*)
		HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
CONUT score						
0–1 (no risk, n = 78)	28 (35.9%)	1	1	1	1	1
		-	-	-	-	-
2–4 (low risk, n = 151)	53 (35.1%)	1.17 (0.74–1.85)	1.15 (0.73–1.82)	1.15 (0.73–1.83)	1.11 (0.70–1.76)	1.06 (0.65–1.72)
5–8 (moderate risk, n = 119)	58 (48.7%)	1.96 (1.24–3.10)	1.80 (1.13–2.87)	1.81 (1.13–2.89)	1.75 (1.09–2.81)	1.91 (1.03–3.55)
9–12 (high risk, n = 34)	17 (50.0%)	2.10 (1.14–3.86)	1.99 (1.08–3.66)	1.99 (1.08–3.68)	1.97 (1.05–3.58)	1.98 (1.14–3.42)
GNRI score						
>98 (no risk, n = 206)	82 (39.8%)	1	1	1	1	1
		-	-	-	-	-
92–98 (low risk, n = 66)	28 (42.4%)	1.31 (0.85–2.02)	1.22 (0.79–1.89)	1.22 (0.79–1.89)	1.18 (0.76–1.83)	1.24 (0.77–2.01)
82–91 (moderate risk, n = 62)	27 (43.5%)	1.32 (0.85–2.04)	1.22 (0.78–1.89)	1.20 (0.76–1.90)	1.21 (0.76–1.91)	1.32 (0.78–2.23)
<82 (high risk, n = 48)	19 (39.6%)	1.25 (0.75–2.09)	1.15 (0.69–1.93)	1.13 (0.65–1.95)	1.19 (0.68–2.07)	0.86 (0.47–1.60)

ADL, activity of daily living; CONUT, controlling nutritional status; GNRI, geriatric nutritional risk index; HR, hazard ratio.
*Heart failure, chronic renal failure, hypertension, atrial fibrillation, ischemic cardiopathy, deep vein and pulmonary embolism, peripheral artery disease, diabetes, hyper- or hypothyroidism, arthrosis, arthritis, chronic obstructive pulmonary disease, femoral fracture, major or minor stroke, dementia, Parkinson disease, acute renal failure, cancer and metastatic cancer.

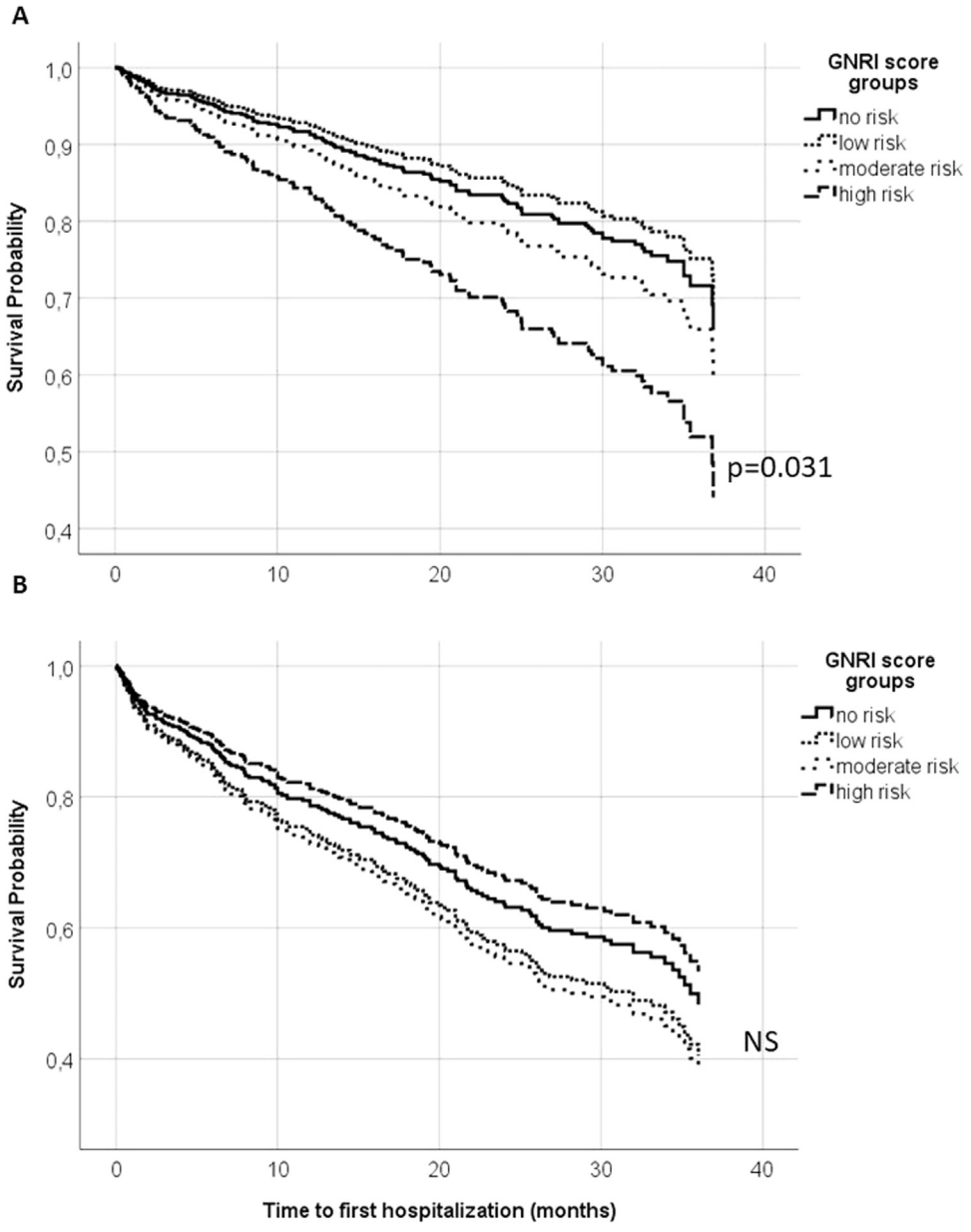

Fig. 2. Kaplan–Meier survival curves for all-cause mortality (A) and hospitalization (B) according to GNRI score groups, severe risk (GNRI <82), moderate risk (GNRI 82 to <92), low risk (GNRI 92 to ≤98) and no risk of malnutrition (GNRI >98).

weight [9]. In this study, similarly to CONUT, GNRI was able to discriminate the 3-year risk of all-cause mortality, in line with previous findings on morbidity and mortality in different diseases [30]. This was true for moderate or major risk, but not for low risk.

The other outcome considered was the rate of hospitalization, on which there is little evidence available in the literature. For instance, CONUT-derived nutritional risk was strongly associated with a greater long-term risk of hospitalization in patients with heart failure [31], and with hospitalization, but not mortality [26], in acutely ill older patients admitted for heart failure. This result is not surprising, considering that the lymphocyte count is thought to be an indicator of impaired immune defenses that could cause infections or other complications leading to short-term rehospitalizations [32].

Both, the CONUT and GNRI scores, are easy-to-use tools that stand out clearly from other malnutrition scores because they include opportunistic and widely available laboratory parameters, but CONUT was originally designed as a prognostic score for hospitalized patients, whilst GNRI was designed to predict risk of death, bedsores and infectious complications in a rehabilitation setting [7]. In fact, CONUT administered to hospitalized subjects proved to be promising screening indicator to identifying patients at higher risk of long-term major cardiovascular events and poor functional outcome at discharge [33].

When compared to each other, in a large Chinese cohort the CONUT had a better predictive power of in-hospital mortality compared to GNRI [16]. Similarly, the CONUT was slightly more discriminating for short-term prognosis than the GNRI in patients with chronic heart failure [25]. In this study, the AUC for mortality was greater for CONUT score than GNRI, while only the CONUT score emerged as an independent predictor of rehospitalization. This seems to suggest

that, at least in the patients studied, the CONUT score is more strictly associated with selected clinical outcomes, consistent with previous finding in a multicenter Chinese cohort and chronic heart failure.

This is the first study in hospitalized older adults testing the predictive potential of CONUT and GNRI as predictor of all-cause mortality and rehospitalization including also sarcopenia evaluation. We found that sarcopenia is independently related to mortality risk using both indexes. Sarcopenia can be considered a malnutrition consequence in the older adults, but our results seem to suggest that it has an independent effect on mortality. Conversely, no association was observed with rehospitalization risk.

Our study has several strengths: this is a large multicenter prospective cohort study involving twelve acute geriatric and internal medicine hospital units with the aim of exploring the association between sarcopenia and a mortality, a clinical outcome that has not been investigated much in this setting. Second, this is the first study that investigated the predictive value of CONUT on mortality and hospitalizations, even after adjustment for sarcopenia and disability status.

Nevertheless, some limitations should be considered. First, we predicted appendicular muscle mass by BIA using Sergi equation, instead of dual-energy-X-ray absorptiometry (reference method).

Secondly, as previously described [23], the assessment of sarcopenia among acutely ill older patients could be affected by a transient impairment of muscle strength, unrelated to sarcopenia, but due to the systemic effect of the acute disease. Thirdly, we cannot exclude that the association between malnutrition, as evaluated with CONUT, and mortality is related to residual confounding since data on some potential other confounders (including admission diagnosis) were not available.

Conclusion

In this study of Italian hospitalized geriatric patients, the CONUT seemed to be a valid tool to predict long-term mortality and hospitalization, whilst GNRI was associated only with long-term mortality. Moreover, the CONUT and GNRI differed between sarcopenic and nonsarcopenic patients.

The CONUT and GNRI indexes are both feasible and easy to use. In fact, as compared to other tools, they did not require time for filling in questionnaires or performing bedside anthropometry or body composition measurements. Therefore, as these indexes can be useful methods for early identification of malnourished older subjects after hospital admission, their routine use could be pivotal in order to improve the nutritional care process, to correct and reverse malnutrition and prevent negative outcomes [34].

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Luca Scalfi: Conceptualization. **Pasquale Abete:** Writing – review & editing. **Giuseppe Bellelli:** Supervision. **Mario Bo:** Writing – review & editing. **Antonio Cherubini:** Writing – review & editing. **Francesco Corica:** Writing – review & editing. **Mauro Di Bari:** Writing – review & editing. **Marcello Maggio:** Writing – review & editing. **Maria Rosaria Rizzo:** Writing – review & editing. **Lara Bianchi:** Writing – review & editing. **Stefano Volpato:** Writing – review & editing, Data curation, Conceptualization. **Francesco Landi:** Writing – review & editing, Conceptualization.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

The data underlying this article cannot be shared publicly due to this option was not included in the informed consent signed by participants.

Acknowledgments

The manuscript was revised by Professor Mark Newman.

References

[1] Souza TT, Sturion CJ, Faintuch J. Is the skeleton still in the hospital closet? A review of hospital malnutrition emphasizing health economic aspects. Clin Nutr 2015;34(6):1088–92. https://doi.org/10.1016/j.clnu.2015.02.008.
[2] Jobim Milanez DS, Razzera EL, da Silveira Knobloch I, Lima J, Bernardes S, Silva FM. A scoping review on the GLIM criteria for malnutrition diagnosis: understanding how and for which purpose it has been applied in studies on hospital settings. Clin Nutr 2023;42(1):29–44. https://doi.org/10.1016/j.clnu.2022.10.022.
[3] Ignacio de Ulíbarri J, González-Madroño A, de Villar NGP, et al. CONUT: a tool for controlling nutritional status. First validation in a hospital population. Nutr Hosp 2005;20(1):38–45.
[4] Cabré M, Ferreiro C, Arus M, Roca M, Palomera E, Serra-Prat M. Evaluation of CONUT for clinical malnutrition detection and short-term prognostic assessment in hospitalized elderly people. J Nutr Health Aging 2015;19(7):729–33. https://doi.org/10.1007/s12603-015-0536-6.
[5] Sun X, Luo L, Zhao X, Ye P. Controlling nutritional status (CONUT) score as a predictor of all-cause mortality in elderly hypertensive patients: a prospective follow-up study. BMJ Open 2017;7(9):e015649. https://doi.org/10.1136/bmjopen-2016-015649.
[6] Li J, Feng D, Pang N, et al. Controlling nutritional status score as a new indicator of overt hepatic encephalopathy in cirrhotic patients following transjugular intrahepatic portosystemic shunt. Clin Nutr 2022;41(2):560–6. https://doi.org/10.1016/j.clnu.2021.12.036.
[7] Bouillanne O, Morineau G, Dupont C, et al. Geriatric Nutritional Risk Index: a new index for evaluating at-risk elderly medical patients. Am J Clin Nutr 2005;82(4):777–83. https://doi.org/10.1093/ajcn/82.4.777.
[8] Saka B, Kaya O, Ozturk GB, Erten N, Karan MA. Malnutrition in the elderly and its relationship with other geriatric syndromes. Clin Nutr Edinb Scotl 2010;29(6):745–8. https://doi.org/10.1016/j.clnu.2010.04.006.
[9] Serón-Arbeloa C, Labarta-Monzón L, Puzo-Foncillas J, et al. Malnutrition screening and assessment. Nutrients 2022;14(12):2392. https://doi.org/10.3390/nu14122392.
[10] Chen J, Song P, Peng Z, et al. The controlling nutritional status (CONUT) score and prognosis in malignant tumors: a systematic review and meta-analysis. Nutr Cancer 2022;74(9):3146–63. https://doi.org/10.1080/01635581.2022.2059091.
[11] Huang L, He R, Sun X, Lv J, Chen S. Association of controlling nutritional status score with adverse outcomes in patients with coronary artery disease: a systematic review and meta-analysis. Angiology 2023;74(2):149–58. https://doi.org/10.1177/00033197221094409.
[12] Kato T, Yaku H, Morimoto T, et al. Association with controlling nutritional status (CONUT) score and in-hospital mortality and infection in acute heart failure. Sci Rep 2020;10(1):3320. https://doi.org/10.1038/s41598-020-60404-9.
[13] Di Vincenzo O, Luisi MLE, Alicante P, et al. The assessment of the risk of malnutrition (Undernutrition) in stroke patients. Nutrients 2023;15(3):683. https://doi.org/10.3390/nu15030683.
[14] Rinninella E, Borriello R, D'Angelo M, et al. Controlling nutritional status (CONUT) as predictive score of hospital length of stay (LOS) and mortality: a prospective Cohort study in an internal medicine and gastroenterology unit in Italy. Nutrients 2023;15(6):1472. https://doi.org/10.3390/nu15061472.
[15] Miano N, Di Marco M, Alaimo S, et al. Controlling nutritional status (CONUT) score as a potential prognostic indicator of in-hospital mortality, sepsis and length of stay in an internal medicine department. Nutrients 2023;15(7):1554. https://doi.org/10.3390/nu15071554.
[16] Liu C, Zhu M. Controlling nutritional status (CONUT) score as a predictive marker of in-hospital mortality in elderly patients: a pooled analysis of cohort

studies. Clin Nutr ESPEN 2021;46:S599–600. https://doi.org/10.1016/j.clnesp.2021.09.163.
[17] Yıldırım B, Karakaya Z, Acar E, et al. Controlling nutritional status score predicts in-hospital mortality in acute pulmonary embolism. Med Princ Pract 2022;31(5):439–44. https://doi.org/10.1159/000525240.
[18] Di Vincenzo O, D'Elia L, Ballarin G, Pasanisi F, Scalfi L. Controlling nutritional status (CONUT) score and the risk of mortality or impaired physical function in stroke patients: A systematic review and meta-analysis. Nutr Metab Cardiovasc Dis NMCD 2023;33(8):1501–10. https://doi.org/10.1016/j.numecd.2023.05.012.
[19] Yuan K, Zhu S, Wang H, et al. Association between malnutrition and long-term mortality in older adults with ischemic stroke. Clin Nutr 2021;40(5):2535–42. https://doi.org/10.1016/j.clnu.2021.04.018.
[20] Kheirouri S, Alizadeh M. Prognostic potential of the preoperative controlling nutritional status (CONUT) score in predicting survival of patients with cancer: a systematic review. Adv Nutr 2021;12(1):234–50. https://doi.org/10.1093/advances/nmaa102.
[21] Arero G, Arero AG, Mohammed SH, Vasheghani-Farahani A. Prognostic potential of the controlling nutritional status (CONUT) score in predicting all-cause mortality and major adverse cardiovascular events in patients with coronary artery disease: a meta-analysis. Front Nutr 2022;9:850641. https://doi.org/10.3389/fnut.2022.850641.
[22] Bray G. What is the ideal body weight? J Nutr Biochem 1998;9(9):489–92. https://doi.org/10.1016/S0955-2863(98)00007-2.
[23] Bianchi L, Abete P, Bellelli G, et al. Prevalence and clinical correlates of sarcopenia, identified according to the EWGSOP definition and diagnostic algorithm, in hospitalized older people: the GLISTEN study. J Gerontol A Biol Sci Med Sci 2017;72(11):1575–81. https://doi.org/10.1093/gerona/glw343.
[24] Bianchi L, Maietti E, Abete P, et al. Comparing EWGSOP2 and FNIH sarcopenia definitions: agreement and 3-year survival prognostic value in older hospitalized adults: the GLISTEN study. J Gerontol A Biol Sci Med Sci 2020;75(7):1331–7. https://doi.org/10.1093/gerona/glz249.
[25] Sze S, Pellicori P, Zhang J, Weston J, Clark AL. The impact of malnutrition on short-term morbidity and mortality in ambulatory patients with heart failure. Am J Clin Nutr 2021;113(3):695–705. https://doi.org/10.1093/ajcn/nqaa311.
[26] Bermejo RMA, Ferreiro RG, Román AV, et al. Nutritional status is related to heart failure severity and hospital readmissions in acute heart failure. Int J Cardiol 2017;230:108–14.
[27] Soeters PB, Wolfe RR, Shenkin A. Hypoalbuminemia: pathogenesis and clinical significance. JPEN J Parenter Enteral Nutr 2019;43(2):181–93. https://doi.org/10.1002/jpen.1451.
[28] Zhang Z, Pereira SL, Luo M, Matheson EM. Evaluation of blood biomarkers associated with risk of malnutrition in older adults: a systematic review and meta-analysis. Nutrients 2017;9(8):829. https://doi.org/10.3390/nu9080829.
[29] Majmundar M, Kansara T, Park H, et al. Absolute lymphocyte count as a predictor of mortality and readmission in heart failure hospitalization. Int J Cardiol Heart Vasc 2022;39:100981. https://doi.org/10.1016/j.ijcha.2022.100981.
[30] Hao X, Li D, Zhang N. Geriatric Nutritional Risk Index as a predictor for mortality: a meta-analysis of observational studies. Nutr Res N Y N 2019;71:8–20. https://doi.org/10.1016/j.nutres.2019.07.005.
[31] Agnoletti D, Arcaro G, Scaturro G, et al. Controlling nutritional status score predicts 2-year outcomes in elderly patients admitted for acute heart failure. Intern Emerg Med 2023;18(4):1031–9. https://doi.org/10.1007/s11739-023-03230-x.
[32] Han X, Cai J, Li Y, et al. Baseline objective malnutritional indices as immune-nutritional predictors of long-term recurrence in patients with acute ischemic stroke. Nutrients 2022;14(7):1337. https://doi.org/10.3390/nu14071337.
[33] Hirahara N, Matsubara T, Hayashi H, Takai K, Nakada S, Tajima Y. Prognostic importance of controlling nutritional status in patients undergoing curative thoracoscopic esophagectomy for esophageal cancer. Am J Ther 2018;25(5):e524–32. https://doi.org/10.1097/MJT.0000000000000414.
[34] Visser M, Mendonça N, Avgerinou C, et al. Towards developing a core outcome set for malnutrition intervention studies in older adults: a scoping review to identify frequently used research outcomes. Eur Geriatr Med 2022;13(4):867–79. https://doi.org/10.1007/s41999-022-00617-5.