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Research Article

Ultrasound Muscle Thickness-Defined Sarcopenia and Functional Outcome in Critically Ill Elderly: A Prospective Study

Dr Greeshma Vijayan[1], Dr Shilpa Avarebeel[2], Dr Deepak Benny[3], Dr Vikram Patil[4], Dr Prathibha Pereira[5]

[1]Postgraduate, Department of Geriatrics, JSS Medical College, JSS Academy of Higher Education and Research, Sri Shivarathreeshwara Nagara, Mysuru- 570015, Karnataka, India.
[2]Associate Professor, Department of Geriatrics, JSS Medical College, JSS Academy of Higher Education and Research, Sri Shivarathreeshwara Nagara, Mysuru- 570015, Karnataka, India.
[3]Postgraduate, Department of Radiology, JSS Medical College, JSS Academy of Higher Education and Research, Sri Shivarathreeshwara Nagara, Mysuru- 570015, Karnataka, India.
[4]Professor, Department of Radiology, JSS Medical College, JSS Academy of Higher Education and Research, Sri Shivarathreeshwara Nagara, Mysuru- 570015, Karnataka, India.
[5]Professor and Head, Department of Geriatrics, JSS Medical College, JSS Academy of Higher Education and Research, Sri Shivarathreeshwara Nagara, Mysuru- 570015, Karnataka, India.

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Corresponding Author:

Dr Greeshma Vijayan
Postgraduate, Department of Geriatrics, JSS Medical College, JSS Academy of Higher Education and Research, Sri Shivarathreeshwara Nagara, Mysuru- 570015, Karnataka, India.

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ABSTRACT

Introduction: Sarcopenia, a progressive loss of skeletal muscle mass and function, is increasingly recognised as a significant determinant of outcomes in critically ill elderly patients. In the ICU setting, the combination of age-related muscle loss and acute catabolic stress can lead to rapid functional decline, prolonged recovery, and increased healthcare utilisation. Early, accurate detection is essential for timely intervention, yet conventional diagnostic methods are often impractical in critically ill patients.
Methodology: This prospective observational study was conducted in the ICU of a tertiary care hospital in South India from June 2023 to July 2024. Elderly patients aged ≥60 years were evaluated for sarcopenia using bedside ultrasound to measure biceps brachii and rectus femoris muscle thickness. A functionally derived cutoff of ≤1.30 cm in either muscle indicated sarcopenia. Demographic, clinical, and laboratory data were recorded, and outcomes assessed included ICU stay, hospital stay, functional recovery (Barthel Index), and mortality.
Results: Of the 82 patients enrolled, 23.2% were sarcopenic. Sarcopenic patients had significantly lower mean muscle thickness, longer ICU stay (6.68 ± 6.56 vs 4.14 ± 2.01 days, $p<0.01$), and longer hospital stay (14.42 ± 12.90 vs 8.78 ± 3.28 days, $p<0.01$). Functional recovery was markedly poorer in the sarcopenic group ($p<0.05$). Mortality did not differ significantly between groups.
Conclusion: Sarcopenia is common among critically ill elderly patients and is strongly associated with prolonged hospitalisation and impaired functional recovery. Ultrasound offers a practical, non-invasive method for early sarcopenia detection, enabling targeted nutritional and rehabilitative interventions to improve outcomes in this high-risk population.

Keywords*: Sarcopenia, Critical illness, Elderly patients, Ultrasound, Muscle thickness, Functional recovery.*

INTRODUCTION

The global population is undergoing a profound demographic shift, with the proportion of individuals aged ≥65 years projected to nearly double from 12% in 2015 to 22% by 2050 (1). This unprecedented aging trend has far-reaching implications for healthcare systems, particularly in the management of age-associated conditions such as sarcopenia (2). Sarcopenia is defined as a progressive and generalized loss of skeletal muscle mass, strength, and function, and is

increasingly recognized as a major geriatric syndrome linked to disability, poor quality of life, and mortality (3). The worldwide prevalence is estimated at around 10% among adults over 60 years, increasing to over 50% in those above 80 years (4).

In critically ill elderly patients, sarcopenia represents a major clinical concern, compounding the metabolic, inflammatory, and immobilization-related muscle wasting induced by acute illness (5). Muscle loss in the ICU setting can progress rapidly, at rates of 2–3% per day, resulting in profound functional decline (6). The condition is associated with longer ICU and hospital stays, prolonged mechanical ventilation, increased healthcare costs, and higher mortality (7,8). Evidence suggests that sarcopenia in the critically ill is linked to a 70% higher mortality risk and extended ventilator dependency by an average of four days (9,10).

In the Indian context, sarcopenia presents unique epidemiological challenges. Limited data indicate a prevalence of approximately 17.5% among community-dwelling elderly and up to 32.8% among hospitalized older adults (11). Contributing factors include nutritional deficiencies, low physical activity, chronic diseases, and socio-economic disparities (12). Rapid urbanization and changing family structures further exacerbate vulnerability among India's growing elderly population (13).

Despite its clinical relevance, sarcopenia often remains underdiagnosed in ICU settings due to limitations of conventional assessment methods such as computed tomography (CT), dual-energy X-ray absorptiometry (DEXA), or bioelectrical impedance analysis, which may be impractical for critically ill patients (14). Ultrasound has emerged as a promising bedside tool for assessing muscle thickness, offering advantages of portability, safety, and repeatability without radiation exposure (15). Measurements of biceps brachii and rectus femoris muscle thickness have shown good correlation with muscle mass and functional outcomes (16).

Several pathophysiological mechanisms contribute to the development of sarcopenia in critical illness, including systemic inflammation, hormonal changes, mitochondrial dysfunction, and nutritional deficits (17). Pro-inflammatory cytokines such as TNF-α, IL-1β, and IL-6 accelerate proteolysis, while immobilization reduces muscle protein synthesis (18). Age-related anabolic resistance further compounds these effects, making elderly ICU patients particularly susceptible (19).

Early identification of sarcopenia in critical illness is crucial for prognostication and guiding interventions. Studies have shown that sarcopenia predicts prolonged ICU and hospital stays, poor functional recovery, and higher rates of institutionalization post-discharge (20,21). However, there is limited research from low- and middle-income countries, including India, focusing on both prevalence and outcome prediction using feasible, bedside diagnostic approaches.

The current study addresses these gaps by evaluating the magnitude of sarcopenia among critically ill elderly patients in a tertiary care setting in India using ultrasound-based muscle thickness measurements. Furthermore, it examines associations between sarcopenia and key clinical outcomes, including ICU stay, hospital stay, and functional recovery, while proposing and validating practical cutoff values for muscle thickness. Establishing such cutoffs, derived from functional outcome data, can aid in risk stratification and targeted management strategies in the ICU.The findings of this study aim to inform clinical practice and contribute to the global evidence base on sarcopenia in the critically ill elderly, with particular relevance to resource-limited healthcare environments.

METHODOLOGY

A prospective observational study was conducted in the Intensive Care Unit (ICU) complex of a tertiary care hospital in South India over an 18-month period from June 2023 to July 2024. The primary objective was to assess the prevalence of sarcopenia in critically ill elderly patients using ultrasound-based muscle thickness measurement, and to evaluate its association with clinical outcomes including ICU stay, hospital stay, and functional recovery. The Institutional Ethical Committee approved the study, and informed consent was obtained from the participants.

Elderly patients aged ≥60 years of either gender, admitted to the ICU of the Department of Geriatrics and meeting the inclusion criteria, were recruited by convenient sampling. Patients with cerebrovascular accidents, chronic kidney disease, or neurodegenerative disorders were excluded to avoid confounding muscle mass and function assessment.

Sample size calculation was based on reported prevalence rates of sarcopenia in ICU elderly patients ranging from 5% to 13% in the study by Kizilarslanoglu MCet al, (22) in Ankara, Turkey, 2016.Using a single proportion formula with an expected prevalence of 13%, absolute precision of 10%, and a 95% confidence level, the required sample size was calculated to be 75. Allowing for a 10% non-response rate, the final sample size was set at 82 patients.

Demographic data, primary diagnoses, laboratory parameters (including serum albumin and creatinine), and nutritional status were obtained from patient case records and caregiver interviews. Functional status was assessed using the Barthel

Index, which measures independence in activities of daily living, at admission and prior to hospital discharge. The Barthel Index forms were translated into Kannada for local applicability.

Ultrasound Assessment of Muscle Thickness

Muscle mass was assessed via B-mode ultrasonography using a high-frequency linear transducer. Two muscle groups were measured:

- Biceps brachii (upper limb): With the patient supine, elbow extended, and forearm supinated, the measurement site was identified between the tip of the greater tuberosity and the tip of the olecranon.
- Rectus femoris (lower limb): With the patient supine, leg extended and relaxed, the measurement site was midway between the anterior superior iliac spine and the superior border of the patella.

For each site, muscle thickness was measured perpendicular to the skin surface, avoiding compression artefacts. All measurements were taken by a trained examiner to minimize inter-observer variability.

Sarcopenia was defined using a functionally derived cutoff value for muscle thickness. Receiver-operating characteristics and distributional analysis linked to Barthel Index outcomes determined the optimal threshold. A cutoff of ≤1.30 cm in either biceps brachii or rectus femoris was selected, as it corresponded to patients with severe dependency at discharge and showed significant association with poor recovery.

Primary outcomes were ICU length of stay, total hospital stay, and functional improvement (change in Barthel Index). Secondary outcomes included mortality and nutritional modality during ICU admission.

Statistical Analysis

Data were analyzed using SPSS software. Continuous variables were expressed as mean ± standard deviation (SD) and compared using independent t-tests or ANOVA, as appropriate. Categorical variables were expressed as frequencies and percentages, and compared using Chi-square or Fisher's exact tests. Odds ratios (OR) with 95% confidence intervals (CI) were calculated for associations between sarcopenia and adverse outcomes. A p-value <0.05 was considered statistically significant. (Figure 1)

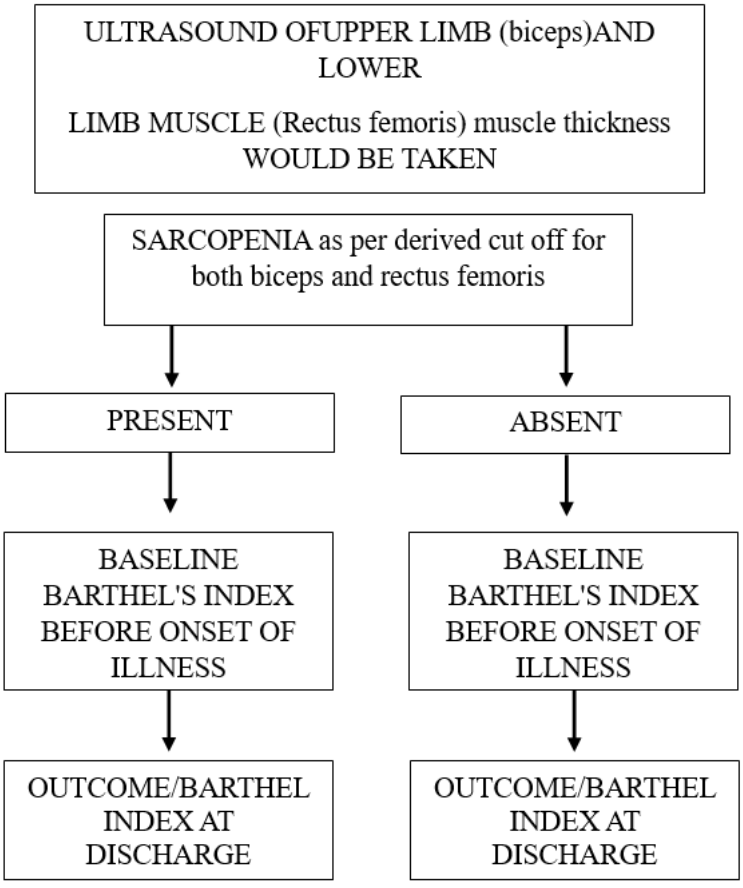

Figure 1: Flow diagram of the study conduct

RESULTS

The mean age of the study participants was 73.00±6.98years. Biceps muscle thickness averages 1.44 ± 0.34 cm with a range of 0.80-2.20 cm, showing relatively normal distribution around the mean. Rectus femoris musclethicknessshows greater variabilityat1.35±0.59cm withanextensive range of 0.60-5.80 cm. The median values (1.40 cm for both parameters) closely approximate the means, suggesting relatively normal distributions.

The majority (62.2%) were aged 60–74 years, with smaller proportions in the 75–85 years (32.9%) and >85 years (4.9%) categories. Males formed two-thirds of the sample (68.3%), while females accounted for 31.7%. COPD and pneumonia were the most common primary diagnoses, but the "Others" category made up the largest share (42.7%), reflecting diverse medical conditions. (Table 1)

Table 1: Socio-demographic profile of the study subjects

Socio-demographic factors		Frequency (N=82)	Percentage (%)
Age (in years)	60-74	51	62.2
	75-85	27	32.9
	>85	4	4.9
Gender	Males	56	68.3
	Females	26	31.7
Primary Diagnosis	COPD	15	18.3
	Pneumonia	11	13.4
	UTI	5	6.1
	Sepsis	5	6.1
	LRTI	4	4.9
	CVA	4	4.9
	IHD	3	3.7
	Others	35	42.7

Out of the total sample, 23.2% (19 patients) were identified as sarcopenic based on ultrasound-derived muscle thickness cutoffs, while 76.8% (63 patients) were non-sarcopenic.Sarcopenia prevalence increased with age, and similar between sexes. Respiratory illnesses had the highest representation among diagnoses, while cardiovascular conditions showed no sarcopenia in this sample, possibly due to small subgroup size.(Figure 1)

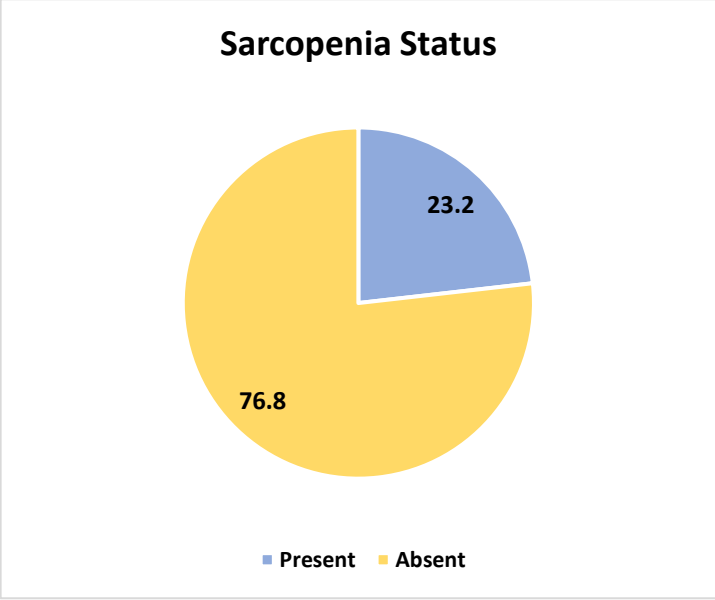

Figure 2: Magnitude of Sarcopenia

At admission, most patients (64.6%) had severe dependency, followed by moderate dependency (32.9%), with only 2 patients having mild dependency or independence. At discharge, functional recovery was evident: 13.4% were independent, 9.8% mildly dependent, 45.1% moderately dependent, and 31.7% still severely dependent. This shift indicates some improvement in functional status, although a substantial portion remained dependent.Normal diet was achieved by 44 patients (53.7%), representing the majority of the population at assessment. RT (tube) feeding was required in 21 patients (25.6%), while soft diet was prescribed for 17 patients (20.7%). The nutrition distribution reflects varying degrees

ofswallowing function and nutritional needs in the recovery population. The ability to tolerate normal diet in over half the patients suggests good overall recovery in nutritional function.

Of the two deaths recorded during hospitalization, one occurred in a sarcopenic patient and one in a non-sarcopenic patient, resulting in an equal mortality distribution (50% each). (Figure 2)

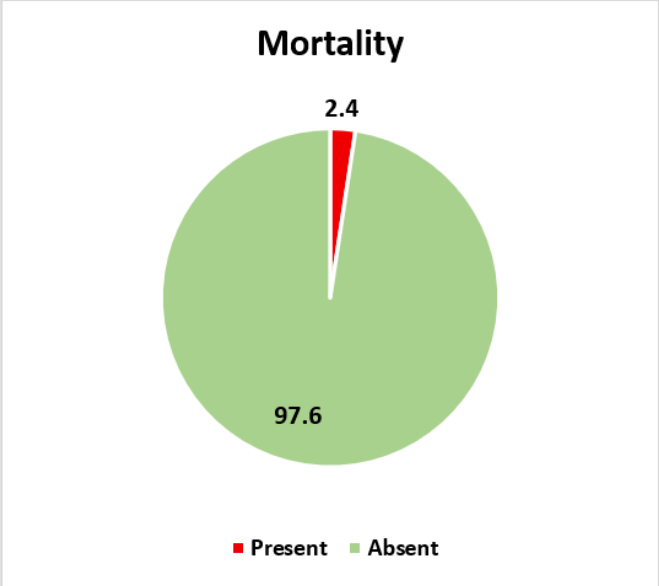

Figure 3: Mortality Distribution in the observed critically ill elderly

Sarcopenic patients show significantly lower biceps (1.28 ± 0.34 vs 1.48 ± 0.32 cm, $p<0.05$) and rectus femoris muscle thickness (1.11 ± 0.30 vs 1.43 ± 0.64 cm, $p<0.05$). ICU stay is significantly longer in sarcopenic patients (6.68 ± 6.56 vs 4.14 ± 2.01 days, $p<0.01$), as is hospital stay (14.42 ± 12.90 vs 8.78 ± 3.28 days, $p<0.01$). Age, albumin, and creatinine show no significant differences between groups, indicating sarcopenia's independence from these basic demographic and nutritional markers. These findings establish sarcopenia as a significant predictor of prolonged hospitalization and resource utilization. (Table 2)

Table2: Comparison of Continuous Variables by Sarcopenia Status

Variable	Sarcopenia Present(n=19) Mean ± SD	Sarcopenia Absent(n=63) Mean ± SD	t- value	p- value
Age (years)	73.79±7.37	72.76±6.84	0.564	>0.10
BicepsMuscleThickness (cm)	1.28 ±0.34	1.48 ±0.32	2.383	**<0.05**
RectusFemorisMuscle Thickness (cm)	1.11±0.30	1.43 ±0.64	2.140	**<0.05**
ICUDays	6.68 ±6.56	4.14 ±2.01	2.710	**<0.01**
HospitalDays	14.42±12.90	8.78 ±3.28	3.186	**<0.01**
Albumin(g/dL)	3.34 ±0.62	3.47 ±0.66	0.772	>0.10
Creatinine(mg/dL)	0.95 ±0.39	1.06 ±0.55	0.846	>0.10

Functional improvement, defined by a positive change in Barthel Index scores, was significantly lower in sarcopenic patients (13.0%) compared to non-sarcopenic patients (87.0%), with statistical significance ($p<0.05$). This indicates that sarcopenia is strongly linked to poor recovery in activities of daily living. Mortality was equal in both groups (one death each), showing no significant difference, possibly due to the small number of deaths. Prolonged ICU stay (>4 days) and extended hospital stay (>8 days) were more common in sarcopenic patients (29.7% and 30.6%, respectively) than in non-sarcopenic patients, although these differences were not statistically significant. (Table 3)

Table3: Factors associated with Sarcopenia

Variables		Sarcopenia Present (n=19)(%)	Sarcopenia Absent (n=63)(%)	χ^2 value	p- value
FunctionalStatus Improvement (Barthel Index)	Improved	6(13.0)	40(87.0)	6.037	**<0.05***
	Not Improved/ Deteriorated	13(36.1)	23(63.9)		
Mortality	Yes	1(50.0)	1(50.0)	0.829	>0.10
	No	18(22.5)	62(77.5)		
ICUStay Duration	>4days	11(29.7)	26(70.3)	1.831	>0.10
	≤4days	8(17.8)	37(82.2)		
HospitalStay Duration	>8days	11(30.6)	25(69.4)	1.635	>0.10
	≤8days	8(17.4)	38(82.6)		

Sarcopenia demonstrates moderate sensitivity (36.1%) but high specificity (87.0%) for predicting poor functional outcomes, with a positive predictive value of 68.4%. For prolonged ICU stay, sarcopenia shows 42.1% sensitivity and 80.9% specificity with 57.9% positive predictive value. Hospital stays prediction shows similar patterns with 47.4% sensitivity, 84.4% specificity, and 68.4% positive predictive value. The high specificity across outcomes indicates sarcopenia is a reliable marker when present, though its absence doesn't exclude poor outcomes.(Table 4)

Table 4: Predictive Value Analysis for Outcomes

OutcomeParameter	Sensitivity (%)	Specificity (%)	Positive Predictive Value(%)	Negative Predictive Value(%)	Accuracy (%)
Sarcopenia predicting Poor Functional Outcome	36.1	87.0	68.4	63.5	67.1
Sarcopenia predicting Prolonged ICU Stay (>4 days)	42.1	80.9	57.9	69.4	69.5
Sarcopenia predicting Prolonged HospitalStay (>8 days)	47.4	84.4	68.4	69.4	72.0

Biceps and rectus femoris muscle thickness shows a weak positive correlation (r=0.280), indicating these measurements capture somewhat different aspects of muscle mass. The low correlation suggests upper and lower limb muscle measurements provide complementary rather than redundant information. (Table 5)

Table 5: Muscle Thickness Parameters Correlation Analysis

Parameter 1	Parameter 2	Correlation Coefficient(r)	Interpretation	Clinical Significance
Biceps Muscle Thickness	Rectus Femoris Muscle Thickness	0.280	Weak Positive Correlation	Both parameters reflect muscle mass loss

DISCUSSION

This study demonstrates that sarcopenia, defined by ultrasound-derived muscle thickness cutoffs, is prevalent in 23.2% of critically ill elderly patients in a tertiary care ICU. The finding is comparable to reports from previous studies, where prevalence among older ICU patients ranged from 14% to 32% depending on population and diagnostic method (4,11). Sarcopenia in critical illness is clinically significant, as it combines the effects of age-related muscle loss with the catabolic stress of acute disease, resulting in rapid muscle depletion and impaired recovery (2).

Our results reveal that sarcopenic patients had significantly lower biceps and rectus femoris muscle thickness and experienced prolonged ICU and hospital stays. This aligns with the work of Moisey et al., who found that reduced skeletal muscle area on admission predicted fewer ventilator-free days and extended ICU and hospital stay in elderly ICU patients (7). Puthucheary et al. further demonstrated that critically ill patients can lose up to 17% of rectus femoris cross-sectional area within 10 days, leading to functional decline (6).

A key finding in our study was the strong association between sarcopenia and poor functional recovery as measured by the Barthel Index. Only 13% of sarcopenic patients improved functionally compared to 87% of non-sarcopenic patients. Weijs et al. similarly reported that low skeletal muscle area independently predicted poor physical function at discharge (9). The mechanisms include systemic inflammation, immobilisation, and age-related anabolic resistance, all of which reduce muscle protein synthesis and increase proteolysis (17).

Interestingly, mortality rates did not differ significantly between sarcopenic and non-sarcopenic patients in our cohort. While some studies have linked sarcopenia to higher ICU mortality (22), our small sample size and low death count may have limited detection of such an association. Nonetheless, the prognostic value of sarcopenia for functional outcomes and hospital stay remains clinically relevant.

The use of ultrasound in our study proved feasible, safe, and reliable for muscle thickness measurement in the ICU setting. Similar to findings by Thomaes et al., ultrasound offers advantages over CT or DEXA, particularly in critically ill patients where bedside assessment is necessary (14). Our functionally derived cutoff of ≤1.30 cm for either biceps or rectus femoris thickness is a novel contribution, providing a clinically meaningful threshold for identifying high-risk patients in resource-limited settings.

From a clinical standpoint, early detection of sarcopenia can guide targeted interventions such as optimised protein-energy nutrition, early mobilisation, and resistance exercise. Evidence suggests that adequate protein intake combined with exercise can slow or reverse muscle loss in older adults (8). Implementing such measures in ICU protocols could potentially shorten recovery time and improve quality of life after discharge.

Strengths of our study include its prospective design, objective ultrasound-based measurements, and linkage of cutoffs to functional outcomes. Limitations include its single-centre scope, small sample size, and absence of post-discharge follow-up. Future research should validate our findings in larger, multi-centre studies and explore the impact of targeted sarcopenia interventions on long-term outcomes.

CONCLUSION

This study demonstrates that sarcopenia is a prevalent condition among critically ill elderly patients, affecting nearly one-fourth of the study population. Using ultrasound-derived muscle thickness measurements, sarcopenia was identified as a significant predictor of prolonged ICU and hospital stays, as well as poor functional recovery at discharge. The functionally derived muscle thickness cutoff of ≤1.30 cm for either biceps brachii or rectus femoris proved clinically relevant in identifying high-risk patients. While mortality differences were not statistically significant, the strong association with adverse recovery outcomes highlights the importance of early detection and intervention. Ultrasound offers a practical, non-invasive, and bedside-appropriate tool for sarcopenia assessment, especially in resource-limited settings. Incorporating routine sarcopenia screening into ICU practice, alongside targeted nutritional and mobilisation strategies, could improve functional outcomes and reduce healthcare burden. Larger multi-centre studies are warranted to validate these findings and explore the benefits of early, targeted interventions for sarcopenic critically ill elderly patients.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee (JSS/MC/PG/2046/69/2023-24)

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