SSR Institute of International Journal of Life Sciences
ISSN (O): 2581-8740 | ISSN (P): 2581-8732
Kumar *et al*., 2025
doi: 10.21276/SSR-IIJLS.2025.11.6.9

Original Article

open access

Hand Grip Strength and Psoas Muscle Index for Detection of Sarcopenia in Cirrhosis: A Cross-Sectional Study from India

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Received: 29 Jun 2025/ Revised: 21 Aug 2025/ Accepted: 11 Oct 2025

ABSTRACT

Background: This study aimed to establish specific thresholds for sarcopenia indicators, such as the psoas muscle index (PMI) and handgrip strength (HGS), to predict mortality in patients with end-stage liver disease (ESLD) and to examine the relationship between muscle parameters and survival outcomes.

Methods: This was a cross-sectional study of 100 patients aged 18–75 with ESLD (Child-Pugh Class B or C), excluding those with severe cardiac, pulmonary, renal diseases, or aggressive malignancies. For each participant, we assessed the relationship between sarcopenia markers—such as PMI and HGS—and their mortality rates. Our data collection covered demographics, nutritional status, and standard liver disease parameters (MELD, CTP scores). We also conducted comprehensive muscle and physical assessments, including body measurements, functional tests, and CT scans for imaging.

Results: Among the 100 ESLD patients, we identified mortality cut-off values for the PMI indicated high mortality risk<5.22 cm^2/m^2 for males and <3.83 cm^2/m^2 for females with excellent predictive accuracy (AUC 0.86, 95% CI of 0.78–0.92 In addition, cut-off values for HGS of ≤29.7 kg-force were also associated with higher mortality risk (AUC 0.89, 95% CI 0.81–0.94). Further analysis validated that reduced HGS values significantly correlated with a higher probability of mortality.

Conclusions: This study provides a practical, accessible method to identify sarcopenia-related risks in ESLD patients using simple, reliable measures. The strong association of sarcopenia with mortality, together with the exploration of mortality associated with sarcopenia in ESLD patients, identified the necessity for recognition and earlier intervention.

Key-words: Sarcopenia, End-Stage Liver Disease, Psoas Muscle Index, Handgrip Strength, Mortality Prediction, Muscle mass, Muscle function, Cross-sectional study

INTRODUCTION

Cirrhosis is one of the leading causes of death globally and significantly reduces patients' quality of life. A critical and often overlooked aspect of cirrhosis is sarcopenia, a condition characterised by significant loss of muscle mass and function.

How to cite this article
Kumar A, Singh C, Mazumder S, Premashish K. Hand Grip Strength and Psoas Muscle Index for Detection of Sarcopenia in Cirrhosis: A Cross-Sectional Study from India. SSR Inst Int J Life Sci., 2025; 11(6): 8661-8669.

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Losing muscle makes the disease more severe and raises the risk of death. It's estimated that sarcopenia affects a striking 40–70% of cirrhotic patients, a prevalence notably higher than in other gastrointestinal conditions, largely due to the metabolic imbalances caused by liver dysfunction. However, specific data on sarcopenia within the Indian population has been limited [1].

Common mortality indicators for cirrhotics include the CTP and MELD scores, though they do not always provide a complete picture. Frequently, these parameters do not take much consideration the important nutritional and functional states of the patient. Another confounding assessment is retention of fluids, which is perhaps the most common complication due to decreased protein synthesis, really emphasising

doi: 10.21276/SSR-IIJLS.2025.11.6.9

the dire need for more accurate means of patient evaluation.

Sarcopenia appears when the body disintegrates more protein than it can generate, this being often due to increased ammonia levels and hence metabolic disturbances caused by liver disease [2]. It also directly indicates protein-energy malnutrition, becomes a key marker for prognosis. The treatment of sarcopenia requires a vast multidisciplinary approach by way of nutrition, physical exercise, and looking in cases, pharmacological treatment. In a nutshell, current guidelines recommend moderate activity and adequate protein intake with branched-chain amino acids as well as aluminium reduction therapies. However, future studies intend to fine-tune these approaches for the perfect fit to different patient populations [3].

Since sarcopenia showed huge variation in definition among different studies and populations, this research was set forth to bridge the gap between various definitions. We intend to study sarcopenia in Indian patients having cirrhosis, using advanced CT to ascertain muscle mass, and correlate these imaging findings with important clinical and functional parameters [4-8].

MATERIALS AND METHODS

Inclusion Criteria- Our prospective observational cross-sectional study specifically focused on patients diagnosed with liver cirrhosis. This choice was crucial because cirrhosis is frequently linked to profound metabolic and physiological changes that directly affect muscle mass and strength, both of which are central to accurately assessing sarcopenia.

Exclusion Criteria

- ✓ We excluded patients with chronic kidney disease, diabetes, hypertension, malignancy, chronic obstructive pulmonary disease, inflammatory polyarthritis, cardiac failure, autoimmune disease, myopathy, and recent fever, as these conditions affect muscle mass and strength, confounding sarcopenia assessment.
- ✓ Patients who had acute infections (except spontaneous bacterial peritonitis) or infection within two weeks before evaluation were also excluded, as infection-induced metabolic and inflammatory changes could alter muscle metabolism and distort sarcopenia results.
- ✓ Patients with malignancy were excluded because cancer-related metabolic alterations and muscle wasting could interfere with the accurate assessment of sarcopenia specifically associated with liver disease.

Data Collection- Extensive data collection was conducted using structured questionnaires and clinical interviews across multiple domains. We documented demographic information such as age, gender, and socioeconomic status. We employed extensive nutritional assessments that evaluated dietary intakes/ patterns, eating behaviors, daily caloric intake (calories), protein, and dietary supplements. The severity of liver disease was determined through the Model for End-Stage Liver Disease (MELD) score, and the Child-Turcotte-Pugh (CTP) score was calculated based on clinical and laboratory data. Anthropometry included calculating Body Mass Index (BMI), waist-to-hip ratios, and body composition. Functional capacity was assessed through validated handgrip strength measurements using a dynamometer, and six-minute walk tests (6MWT) were conducted to assess physical performance. Computed tomography (CT) scans were used to measure muscle mass using several measures, such as psoas muscle index (PMI) and lumbar muscle index (L3-SMI). For the clinical interviews, we gathered complete medical histories as well as documentation of current pharmaceutical prescriptions and any changes in health status.

Statistical Analysis- Data were analyzed using SPSS version 26. Descriptive statistics were expressed as mean, median, and range for quantitative variables, and as frequencies and percentages for categorical data. Pearson correlation and binary logistic regression were used to assess associations, while ROC curves evaluated diagnostic accuracy. A p-value<0.05 was considered statistically significant. Patient outcomes were followed for six months, and only deaths due to liver disease were included in the analysis.

Ethical Considerations- The study was approved by the Institutional Ethical and Scientific Research Committee of Max Hospital. All participants provided consent. The study adhered to all ethical principles, which included the safety and confidentiality of all participants at all times.

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RESULTS

The study included 100 participants with a mean age of 47.74±10.22 years, ranging from 19 to 73 years. The majority of subjects (67%) were between 40 and 60 years, while 17% were aged 30–40 years. Males predominated, constituting 86% of the sample, resulting in a male-to-female ratio of 6.14:1. The mean body weight was 62.70±8.88 kg, and the mean height was 164.27±7.01 cm. The average BMI was 23.31±3.61 kg/m², indicating a generally normal weight profile, while the mean waist and hip circumferences were 92.23±5.35 cm and 104.25±6.51 cm, respectively (Table 1).

Table 1: Baseline Demographic and Anthropometric Characteristics of Study Participants (N=100)

Parameters	Values
Age	
Mean age (years)	47.74±10.22
Age range (years)	19-73
Age group 30-40 years, n (%)	17 (17%)
Age group 40-60 years, n (%)	67 (67%)
Gender	
Male, n (%)	86 (86%)
Female, n (%)	14 (14%)
Male: Female ratio	6.14:1
Anthropometric Parameters	
Weight (kg)	62.70±8.88
Height (cm)	164.27±7.01
BMI (kg/m²)	23.31±3.61
Waist circumference (cm)	92.23±5.35
Hip circumference (cm)	104.25±6.51

The study population was primarily middle-aged (86% males, mean age 47.74 years). Men's predominance (6.14:1) reflects traditional trends seen in alcoholic liver disease. The mean BMI was a normal value (23.31 kg/m²); however, the cohort is at high risk for sarcopenia, which illustrates that anthropometry may not reflect muscle wasting in cirrhotic patients, and this population needs specific diagnostic strategies to determine muscle wasting accurately.

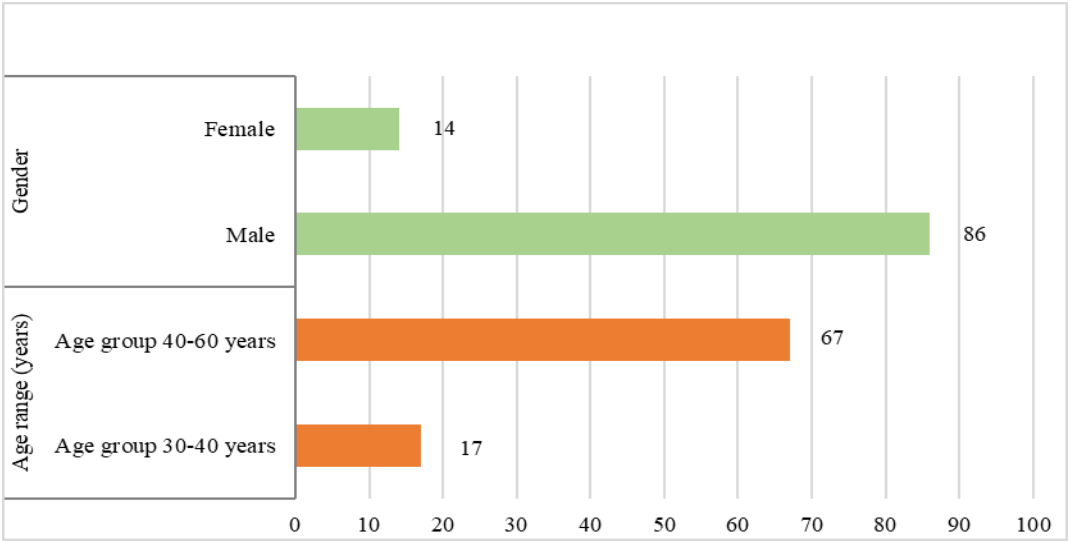

Fig. 1: Baseline Demographic and Anthropometric characteristics of study participants

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Table 2: Clinical Characteristics and Aetiology of Liver Cirrhosis

Parameter		n (%)
Aetiology of Cirrhosis	Alcoholic liver disease	67 (67%)
	Viral etiology	13 (13%)
	NASH	8 (8%)
	Cryptogenic cirrhosis	8 (8%)
	Other	4 (4%)
Clinical Manifestations	Abdominal distension	100 (100%)
	Splenomegaly	80 (80%)
	Upper GI bleeding	54 (54%)
BMI Categories	Normal (18.5-24.9 kg/m²)	54 (54%)
	Overweight (25-29.9 kg/m²)	30 (30%)
	Underweight (<18.5 kg/m²)	16 (16%)

Alcoholic liver disease predominated (67%), consistent with the male demographic profile. Universal abdominal distension (100%) and high splenomegaly prevalence (80%) indicate advanced portal hypertension with significant complications. The substantial upper GI bleeding rate (54%) reflects severe portal hypertensive disease, establishing this as a high-risk population despite relatively preserved BMI categories across the cohort.

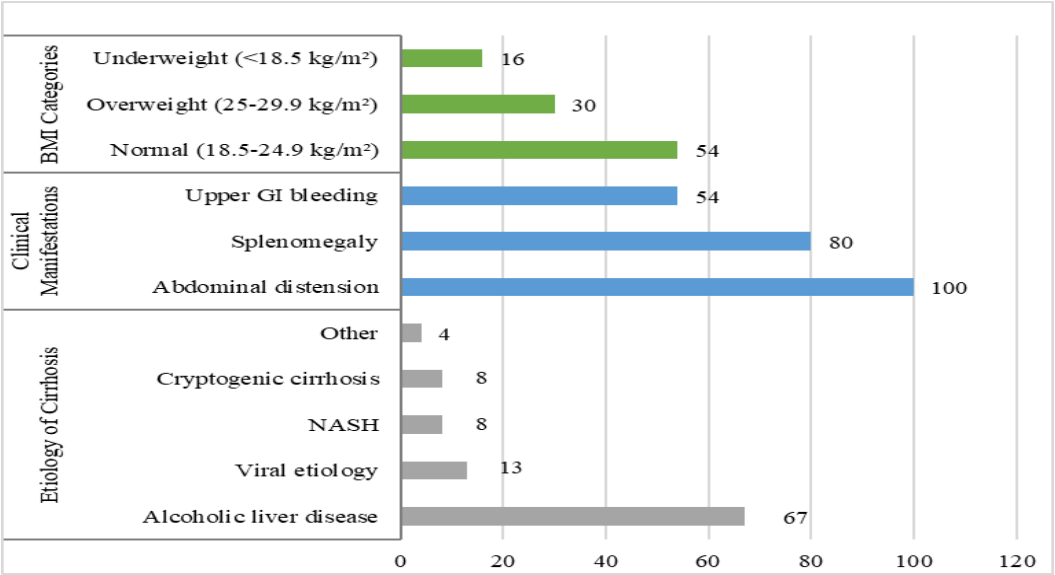

Fig. 2: Clinical Characteristics and Etiology of Liver Cirrhosis

Table 3: Laboratory Parameters and Functional Assessment

Parameter	Mean±SD	Normal Range
Liver Function Tests		
MELD Score	14.42±4.74	-
Serum bilirubin (mg/dl)	2.77±3.23	0.2-1.2
Serum albumin (g/dl)	2.75±0.40	3.5-5.0
Total serum protein (g/dl)	6.55±0.65	6.0-8.3
Prothrombin time (sec)	22.78±4.45	11-13
INR	1.63±0.32	0.8-1.2
Functional Parameters		

doi: 10.21276/SSR-IIJLS.2025.11.6.9

Hand grip strength (kg-force)	28.66±6.09	-
6-minute walk test (meters)	396.17±119.95	-
CT Scan Parameters		
PMI (cm^2/m^2)	5.10±0.60	-
TPA (cm^2/m^2)	4.52±0.57	-

Laboratory parameters revealed moderate hepatic dysfunction (MELD 14.42±4.74) with significant synthetic impairment, including hypoalbuminemia (2.75 g/dl) and coagulopathy (INR 1.63). Despite these abnormalities, patients maintained reasonable functional capacity (6MWT 396.17±119.95 meters), suggesting that sarcopenia assessment becomes crucial for identifying additional functional limitations beyond standard liver function markers in cirrhotic patients.

Table 4: Prevalence and Characteristics of Sarcopenia

Parameter	Overall Cohort (N=100)	Sarcopenic Patients (N=61)	Non-sarcopenic Patients (N=39)
Prevalence			
Sarcopenia, n (%)	61 (61%)	-	-
Demographics			
Age (years)	47.74±10.22	-	-
Weight (kg)	62.70±8.88	62.30±8.75	-
Height (cm)	164.27±7.01	163.52±7.09	-
BMI (kg/m^2)	23.31±3.61	23.43±3.94	-
Clinical Parameters			
MELD Score	14.42±4.74	14.47±5.19	-
Serum bilirubin (mg/dl)	2.77±3.23	3.00±3.62	-
Serum albumin (g/dl)	2.75±0.40	2.75±0.42	-
Serum protein (g/dl)	6.55±0.65	6.59±0.72	-
Prothrombin time (sec)	22.78±4.45	22.94±4.93	-
INR	1.63±0.32	1.64±0.35	-
Serum creatinine (mg/dl)	-	1.02±0.34	-
Functional Assessment			
Hand grip strength (kg-force)	28.66±6.09	25.24±3.10	-
PMI (cm^2/m^2)	5.10±0.60	4.92±0.49	-
TPA (cm^2/m^2)	4.52±0.57	4.26±0.43	-
6MWT (meters)	396.17±119.95	313.38±36.00	-
Anthropometric Measures			
Waist circumference (cm)	92.23±5.35	89.72±4.96	-
Hip circumference (cm)	104.25±6.51	105.13±7.76	-

Sarcopenia affected 61% of patients, representing a remarkably high prevalence in liver cirrhosis. Sarcopenic patients demonstrated significantly compromised functional parameters, including reduced hand grip strength (25.24±3.10 kg-force) and severely impaired exercise capacity (6MWT 313.38±36.00 meters vs. overall mean 396.17 meters), indicating substantial functional consequences of muscle wasting that extend beyond traditional liver assessment parameters.

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Table 5: Diagnostic Performance of Various Parameters for Sarcopenia Detection

Parameter	AUROC	95% CI	p-value	Cut-off Value	Sensitivity (%)	Specificity (%)
Clinical Scores						
CTP Score	0.57	0.47-0.67	0.18	>10	31.15	82.05
MELD Score	0.50	0.40-0.60	0.97	≤10.59	26.23	87.18
Functional Parameters						
Hand grip strength (kg-force)	0.89	0.81-0.94	<0.0001	≤29.7	98	83.62
CT Scan Parameters						
PMI (cm^2/m^2)	0.86	0.78-0.92	<0.0001	≤5.22	96	84.62
TPA (cm^2/m^2)	0.88	0.80-0.93	<0.0001	≤4.78	98	82.56

Hand grip strength demonstrated superior diagnostic performance for sarcopenia detection (AUROC 0.892, sensitivity 98%, cut-off ≤29.7 kg-force), establishing it as an excellent bedside screening tool. CT-based parameters (PMI, TPA) also showed excellent accuracy (AUROC >0.86), while traditional liver severity scores (CTP, MELD) performed poorly, emphasizing the need for sarcopenia-specific diagnostic tools rather than conventional liver assessments.

Table 6: Summary of Key Findings and Clinical Implications

Finding	Values	Clinical Significance
Sarcopenia Prevalence	61%	High prevalence in cirrhotic patients
Best Diagnostic Parameter	Hand grip strength	AUROC 0.89, highest sensitivity (98%)
Optimal HGS Cut-off	≤29.7 kg-force	Practical bedside assessment tool
CT Parameters Performance	PMI: AUROC 0.86 TPA: AUROC 0.88	Excellent imaging-based diagnosis
Male Predominance	6.14:1 ratio	Reflects an alcoholic liver disease pattern
Functional Impairment	6MWT: 313.38±36 m in sarcopenic	Significant exercise limitation
Age Distribution	67% in 40-60 years	Peak productive age group affected

This study establishes sarcopenia as highly prevalent (61%) in liver cirrhosis, significantly affecting productive-age individuals with substantial functional implications. Hand grip strength provides a simple, cost-effective screening tool superior to traditional liver assessments. These findings support integrating routine sarcopenia screening into standard cirrhosis care, given the availability of practical diagnostic tools and the profound impact on patient functional capacity.

DISCUSSION

Sarcopenia stands out as a significant and frequent complication in patients battling liver cirrhosis, profoundly influencing their prognosis. The early identification of sarcopenia is absolutely crucial for enhancing the quality of life and markedly reducing the risk of life-threatening consequences for these patients. The primary strategies available involve restoring nutritional balance and counteracting the body's

doi: 10.21276/SSR-IIJLS.2025.11.6.9

catabolic state, necessitating prompt nutritional supplementation and preventing prolonged periods of deprivation. Therefore, having a rapid, easy, and reliable diagnostic method is of utmost importance [3,4].

We evaluated the presence of sarcopenia at Max Super Speciality Hospital, Vaishali (Ghaziabad), in 100 patients with decompensated liver disease over a period of 21 months. The average (±SD) age of the sample population was 47.74±10.22 years, with a majority of patients being male (86 males and 14 females), representative of the male predominance of alcoholic liver disease. These demographics are very similar to previous studies; for example, Tandon *et al.* [5] noted an average (±SD) age of 58±10 years in their prospective cohort study of 159 patients with cirrhosis, while Prado *et al.* [6] had an average age of 63.9±10.4 years. Similar to our study, Hanai *et al.* [7] also found increased prevalence of sarcopenia in males in their study among patients with liver disease.

In our study, we found the prevalence of sarcopenia was 61%, which is above the mean prevalence reported in some of the previous studies [5,8]. Such high prevalence robustly emphasises the burden that sarcopenia has on patients with liver cirrhosis and the critical need for recognition and intervention in this patient population. Lattanzi *et al.* [8] described a 32% prevalence of sarcopenia in patients with compensated cirrhosis and a 54% prevalence in patients with decompensated cirrhosis. Variation in sarcopenia prevalence can be attributed to differences in diagnostic modalities utilised and severity of underlying liver disease [9,10]. Sarcopenia, in our investigation, was not related to weight, height, or BMI. The explanation for this unexpected finding may be because of "sarcopenic obesity", where loss of muscle mass occurs and weight or fat mass is remaining or has increased. This finding is contrary to Hanai *et al*. [7], who noted that body mass index was a predictor of sarcopenia. Nevertheless, our observations are consistent with Tsien *et al.* [11] and Hara *et al.* [12], who identified obesity, as well as concurrent loss of skeletal muscle and accumulation of adipose tissue, as occurring in cirrhotic patients, a phenomenon that results in sarcopenic obesity. Montano-Loza *et al.* [13] also emphasise that sarcopenia is not limited to those below normal body weight, but that this condition can also be hidden in cirrhotic patients regardless of their BMI. Abdominal distension was the most predominant symptom among the study participants, followed by splenomegaly and upper gastrointestinal bleeding. The findings in our study corroborate Hsu *et al.* [14], who reported ascites as the most predominant symptom in cirrhotic patients and noted sarcopenia as a predictor for disease prognosis in cirrhosis.

Alcoholic liver disease was the most common cause of cirrhosis in our study population. We meticulously collected detailed information on alcohol consumption to establish a causative correlation with the development of cirrhosis. Dasarathy *et al.* [15] Recognized malnutrition as the most frequent complication in alcoholic liver disease (ALD) and lamented the lack of effective therapies to reverse malnutrition in ALD. Malnutrition in ALD is a complex condition, with sarcopenia, or skeletal muscle loss, being a major component responsible for adverse clinical consequences.

The high prevalence of sarcopenia in our study highlights the rampant malnutrition affecting patients with liver cirrhosis, particularly within the Indian population. Early assessment of sarcopenia is absolutely vital for improving longevity in this chronic disorder. Our findings are consistent with the established understanding that decompensated patients exhibit a high prevalence of malnutrition due to the multifaceted catabolism associated with worsening liver function [8,13]. In our study, the CTP score and Model for End-Stage Liver Disease (MELD) score were not found to be significantly correlated with sarcopenia. This stands in contrast to findings from Tandon *et al.* [5] and Hsu *et al.* [14], who reported significant associations between sarcopenia and CTP/MELD scores. However, our results are consistent with those of Montano-Loza *et al.* [13], who also found no significant correlation between sarcopenia and these scores. Handgrip strength (HGS) was significantly correlated with sarcopenia in our study, aligning with findings from Abe *et al.* [16] and Leong *et al.* [17], who reported HGS as a predictive measure of clinical outcomes. Carey *et al.* [18] also underscored the importance of the 6-Minute Walk Test (6MWT) in identifying patients at increased risk for mortality before liver transplantation. The CT Scan Psoas Muscle Index (PMI) and Total Psoas Area (TPA) were both significantly correlated with sarcopenia in our study. These findings are consistent with those of Hamaguchi *et al.* [19] and Ebadi *et al.* [20], who reported significant associations

doi: 10.21276/SSR-IIJLS.2025.11.6.9

between CT-derived muscle indices and sarcopenia. Our low skeletal muscle mass cut-offs were similar to those reported by Hamaguchi *et al.* [19] from a large Japanese population.

While our study offers valuable insights, several limitations exist. Cirrhosis diagnosis relied on clinical, biochemical, and ultrasonographic parameters rather than liver biopsy, the gold standard. The relatively small sample size may limit the generalizability of findings. Female representation was minimal, inadequately reflecting the female cirrhotic population. Additionally, specific cut-off values for low handgrip strength and skeletal muscle mass tailored to the Indian population were not defined, which would enhance the clinical applicability of our results.

This study emphasizes integrating sarcopenia assessment into standard cirrhosis management protocols, particularly crucial in resource-constrained settings like India. Simple, reliable tools such as handgrip strength and CT scans enable early sarcopenia detection, facilitating prompt treatment and significantly improving patient outcomes and quality of life. Future research should prioritise longitudinal studies examining sarcopenia progression in cirrhotic patients and evaluating long-term nutritional intervention impacts. Intervention studies investigating targeted nutritional, physical, and pharmacological approaches are essential. Standardizing diagnostic criteria across diverse ethnic populations would enhance early identification and treatment effectiveness. Additionally, larger sample sizes with balanced gender distribution would provide more robust, generalizable findings for comprehensive sarcopenia management.

CONCLUSIONS

The study concluded that sarcopenia was highly prevalent (61%) among patients with liver cirrhosis, predominantly of alcoholic etiology and affecting mainly middle-aged males. Despite moderate hepatic dysfunction, patients with sarcopenia showed marked functional impairment, reflected by reduced hand grip strength and lower exercise capacity. Hand grip strength proved to be the most reliable bedside marker for sarcopenia, showing excellent sensitivity and diagnostic accuracy (AUROC 0.892, cut-off ≤29.7 kg-force), comparable to CT-based indices (PMI, TPA). These results emphasize the importance of incorporating muscle strength assessment into routine evaluation of cirrhotic patients for early detection and timely management. The study highlights the clinical relevance of sarcopenia screening as a simple, cost-effective addition to existing cirrhosis care, especially in resource-limited settings, and suggests future longitudinal research to improve patient outcomes and survival.

CONTRIBUTION OF AUTHORS

Research concept- Anant Kumar
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Materials- Kar Premashish
Data collection- Dr Chitragandha Singh
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Article editing- Anant Kumar
Final approval- Subhashish Mazumder

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