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Original Research Article

Correlates of Sarcopenia in Chronic Pancreatitis: Insights from Anthropometric and Functional Assessment

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Abstract

Background: Sarcopenia-related muscle depletion is increasingly recognized in chronic pancreatitis and may be missed when assessment relies only on body mass index or serum albumin. Psoas muscle thickness, anthropometry, and handgrip strength provide complementary information on muscle reserve and function.

Aim: To evaluate sarcopenia-related parameters in adults with chronic pancreatitis and to identify clinical and nutritional determinants of psoas muscle thickness.

Methods: This cross-sectional observational study included 50 adults with chronic pancreatitis. Demographic, etiological, anthropometric, biochemical, functional, and imaging-derived variables were analyzed. Parameters included age, sex, disease duration, etiology, hemoglobin, platelet count, serum albumin, body mass index, mid-arm circumference, triceps skinfold thickness, mid-arm muscle circumference, handgrip strength, and psoas muscle thickness. Between-sex comparisons, correlation analysis, low handgrip strength classification, and multivariable linear regression were performed.

Results: The cohort had a mean age of 47.6 ± 14.4 years; 43 patients (86%) were male. Alcohol-related chronic pancreatitis was present in 44 patients (88%). Mean body mass index was 25.3 ± 6.3 kg/m², mean handgrip strength was 30.7 ± 12.1 kg, and mean psoas muscle thickness was 4.23 ± 0.82 cm. Psoas muscle thickness correlated strongly and negatively with disease duration and moderately with age. It did not significantly correlate with body mass index, mid-arm muscle circumference, triceps skinfold thickness, handgrip strength, albumin, or hemoglobin. In multivariable analysis, disease duration and age remained independent negative predictors of psoas muscle thickness.

Conclusion: In chronic pancreatitis, psoas muscle thickness was driven predominantly by disease chronicity and age rather than conventional nutritional markers. Body mass index and albumin alone may underestimate sarcopenia-related muscle depletion. Routine assessment using combined anthropometric, functional, and imaging-derived measures should be considered in patients with chronic pancreatitis.

Keywords: Chronic Pancreatitis; Sarcopenia; Psoas Muscle Thickness; Handgrip Strength; Mid-Arm Muscle Circumference; Body Mass Index; Malnutrition.

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Introduction

Chronic pancreatitis is a progressive fibro-inflammatory disease characterized by irreversible pancreatic structural injury, chronic pain, exocrine pancreatic insufficiency, diabetes, maldigestion, malabsorption, and nutritional decline [1,2]. Contemporary guidelines emphasize that nutritional assessment is an essential component of chronic pancreatitis care because pancreatic exocrine insufficiency, reduced oral intake, and chronic inflammation place patients at sustained risk of protein-energy malnutrition and micronutrient deficiency [1,2,5]. Sarcopenia is no longer regarded as a purely age-related syndrome. The European Working Group on Sarcopenia in Older People 2 framework places low muscle strength at the center of case finding and requires assessment of muscle

quantity or quality to confirm sarcopenia [3]. The Asian Working Group for Sarcopenia 2019 criteria are particularly relevant to Asian populations and define low handgrip strength as less than 28 kg in men and less than 18 kg in women [4]. In chronic pancreatitis, sarcopenia is biologically plausible because persistent inflammation, pancreatic exocrine insufficiency, pain-associated anorexia, alcohol exposure, fat-soluble vitamin deficiency, endocrine dysfunction, and reduced physical activity converge to promote muscle catabolism [5-9].

The clinical importance of sarcopenia in chronic pancreatitis is increasingly recognized. Olesen et al. reported that sarcopenia was associated with increased hospitalization and reduced survival in chronic pancreatitis [6]. A systematic review by Bundred et al. found that sarcopenia is common in chronic pancreatitis and is associated with adverse outcomes including survival and surgical outcomes [7]. Kuan et al. reported a wide prevalence range depending on definitions and imaging methods, highlighting substantial heterogeneity in how sarcopenia is measured in this population [8]. More recent systematic evidence has reinforced that sarcopenia is underdiagnosed and clinically important in chronic pancreatitis [9].

Routine nutritional assessment based only on body mass index, albumin, or gross anthropometry may not capture clinically relevant loss of muscle mass. Body mass index can remain normal or high in patients with reduced skeletal muscle reserve, particularly when adiposity is preserved or increased. Serum albumin is influenced by inflammation, hydration, hepatic function, and acute illness and is therefore an imperfect marker of muscle depletion. Imaging-derived muscle measures, such as psoas muscle thickness or psoas muscle index, and functional measures such as handgrip strength may provide complementary information [10-12].

Psoas muscle measurements are attractive in chronic pancreatitis because patients frequently undergo abdominal imaging for diagnosis and follow-up. Computed tomography and magnetic resonance imaging-based body composition assessment has shown high rates of metabolic and body-composition abnormalities in chronic pancreatitis [11]. However, imaging-derived methods require standardization of vertebral level, side, measurement plane, and software. Anthropometric indices such as mid-arm muscle circumference and triceps skinfold thickness remain practical bedside tools but may be less precise than cross-sectional imaging [13-15].

Indian data on sarcopenia-related muscle depletion in chronic pancreatitis remain limited. The present study evaluates psoas muscle thickness, handgrip strength, anthropometry, and biochemical nutritional markers in adults with chronic pancreatitis and examines whether age, disease duration, and conventional nutritional markers predict psoas muscle thickness.

Materials and Methods

Study design and setting: This was a cross-sectional observational study of adults with chronic pancreatitis. The study was conducted at Department of Medical Gastroenterology, Gandhi Medical College & Hospital, Secunderabad.

Participants and diagnostic criteria: The study included 50 adult patients with chronic pancreatitis. Chronic pancreatitis should be documented according to clinical and imaging criteria consistent with current guideline-based practice, including typical clinical features and structural pancreatic abnormalities on cross-sectional imaging, endoscopic ultrasound, magnetic resonance cholangiopancreatography[1,2,19]. P

Variables and measurements: Demographic and clinical variables included age, sex, etiology, and duration of disease. Biochemical variables included hemoglobin, platelet count, and serum albumin. Anthropometric variables included weight, height, body mass index (BMI), mid-arm circumference (MUAC), triceps skinfold thickness (TSFT), and mid-arm muscle circumference (MAMC). Body mass index was calculated as weight in kilograms divided by height in meters squared. MAMC was calculated from MUAC and TSFT using the standard anthropometric relationship: MAMC (cm) = MUAC (cm) − [0.314 × TSFT (mm)] [13,15]. Functional assessment was performed using handgrip strength [14]. Imaging-derived muscle assessment was represented by psoas muscle thickness.

Definition of low handgrip strength: Low handgrip strength was defined using Asian Working Group for Sarcopenia 2019 cutoffs: less than 28 kg in men and less than 18 kg in women [4]. The study evaluates psoas muscle thickness and low muscle strength as sarcopenia-related parameters.

Statistical Analysis: Continuous variables were summarized as mean ± standard deviation, median, and range. Categorical variables were summarized as frequency and percentage. Normality was assessed using the Shapiro-Wilk test.

Because of the small female subgroup and non-normal distribution of several variables, sex-wise comparisons were performed using the Mann-Whitney U test, with rank-biserial correlation as the effect size. Correlations between psoas muscle thickness and clinical/nutritional variables were analyzed using Pearson correlation coefficient, with t statistic, degrees of freedom, p value, R^2, and 95%

confidence interval for r. Low handgrip strength distribution by sex was compared using Fisher exact test; Pearson chi-square and phi coefficient were additionally reported as descriptive test statistic and effect size for the 2×2 table. A multivariable linear regression model evaluated independent predictors of psoas muscle thickness using disease duration, age, body mass index, and male sex as predictors. Regression results are reported as unstandardized beta coefficients, 95% confidence intervals, standardized beta coefficients, t statistics, and p values. A two-sided p value <0.05 was considered statistically significant.

Ethical considerations: The study was approved by Institutional Ethics Committee, Gandhi Medical College. Written informed consent was obtained from the study subjects.

Results

Fifty patients with chronic pancreatitis were included. The mean age was 47.6 ± 14.4 years, and 43 patients (86.0%) were male. Alcohol-related chronic pancreatitis was the most common etiology, present in 44 patients (88.0%). Baseline clinical, biochemical, anthropometric, functional, and imaging-derived characteristics are shown in Table 1.

Table 1: Baseline clinical, biochemical, anthropometric, functional, and imaging-derived characteristics

Variable	Mean ± standard deviation	Median	Range
Age, years	47.60 ± 14.39	50.50	22.00–75.00
Disease duration, years	11.52 ± 6.12	12.50	1.00–20.00
Hemoglobin, g/dL	12.60 ± 2.41	12.80	8.50–16.50
Platelet count, per microliter	267562.52 ± 100419.85	259941.50	118616.00–446306.00
Serum albumin, g/dL	3.91 ± 0.75	4.04	2.59–4.99
BMI, kg/m²	25.31 ± 6.30	24.10	14.50–41.70
MUAC, cm	28.91 ± 4.60	29.15	20.60–35.80
TSFT, mm	16.45 ± 6.82	16.30	5.00–28.00
MAMC, cm	23.74 ± 4.25	22.95	13.90–33.60
Handgrip strength, kg	30.68 ± 12.11	28.10	11.40–55.00
Psoas muscle thickness, cm	4.23 ± 0.82	4.25	2.70–6.60

Continuous variables are presented as mean ± standard deviation, median, and range. Categorical variables are presented as n/N and percentage. BMI: Body mass index, MUAC: Mid-arm circumference, TSFT: Triceps skinfold thickness, MAMC: Mid-arm muscle circumference.

Table 1a: Baseline categorical characteristics

Variable	n/N	Percentage
Male sex	43/50	86.0
Female sex	7/50	14.0
Alcohol-related etiology	44/50	88.0
Idiopathic etiology	4/50	8.0
Hypercalcemia-related etiology	2/50	4.0

Categorical variables are presented as n/N and percentage.

Sex-wise comparison showed that serum albumin was significantly lower in men than women. Age, disease duration, body mass index, mid-arm muscle circumference, triceps skinfold thickness, handgrip strength, and psoas muscle thickness did not differ significantly by sex. Detailed sex-wise comparisons are shown in Table 2.

Table 2: Sex-wise comparison of sarcopenia-related and nutritional parameters

Variable	Men (n=43)	Women (n=7)	Mann-Whitney U statistic	p value	Rank-biserial correlation
Age, years	47.37 ± 14.60	49.00 ± 14.00	146.0	0.911	-0.03
Disease duration, years	11.79 ± 6.13	9.86 ± 6.23	177.5	0.457	0.18
BMI, kg/m²	25.47 ± 6.44	24.37 ± 5.68	165.5	0.685	0.10
Serum albumin, g/dL	3.82 ± 0.71	4.43 ± 0.83	72.5	0.030	-0.52
MAMC, cm	23.65 ± 4.44	24.29 ± 2.99	128.5	0.548	-0.15
TSFT, mm	16.44 ± 6.90	16.51 ± 6.83	147.0	0.933	-0.02
Handgrip strength, kg	30.96 ± 12.32	28.93 ± 11.44	162.5	0.748	0.08
Psoas muscle thickness, cm	4.19 ± 0.83	4.50 ± 0.79	109.5	0.257	-0.27

Values are presented as mean ± standard deviation. Sex-wise comparisons were performed using the Mann-Whitney U test because of the small female subgroup and non-normal distribution of several variables. Rank-

biserial correlation is reported as the effect size; negative values indicate lower values in men than women. BMI: Body mass index, MAMC: Mid-arm muscle circumference, TSFT: Triceps skinfold thickness

Psoas muscle thickness showed a strong negative correlation with disease duration and a moderate negative correlation with age. Correlations with BMI, MAMC, TSFT, handgrip strength, serum albumin, and hemoglobin were not statistically significant. These results are summarized in Table 3.

Table 3: Correlation of psoas muscle thickness with clinical, anthropometric, functional, and biochemical variables

Variable	Pearson r	95% CI for r	t statistic	Degrees of freedom	p value	R^2
Age, years	-0.40	-0.61 to -0.14	-3.04	48	0.004	0.16
Disease duration, years	-0.80	-0.88 to -0.67	-9.21	48	<0.001	0.64
BMI, kg/m²	-0.12	-0.38 to 0.17	-0.81	48	0.424	0.01
MAMC, cm	0.12	-0.16 to 0.39	0.85	48	0.398	0.01
TSFT, mm	-0.05	-0.32 to 0.23	-0.33	48	0.742	0.00
Handgrip strength, kg	0.21	-0.07 to 0.46	1.49	48	0.143	0.04
Serum albumin, g/dL	0.20	-0.09 to 0.45	1.40	48	0.169	0.04
Hemoglobin, g/dL	-0.13	-0.40 to 0.15	-0.94	48	0.353	0.02

Pearson correlation was used. The t statistic is calculated for testing whether Pearson r differs from zero with 48 degrees of freedom for all correlations. R^2 represents the proportion of psoas muscle thickness variance explained by the corresponding variable in univariable correlation. Abbreviations: CI, confidence interval, BMI: Body mass index, MAMC: Mid-arm muscle circumference, TSFT: Triceps skinfold thickness.Scatterplots show the negative relationship between psoas muscle thickness and age (Figure 1) and the stronger inverse relationship between psoas muscle thickness and disease duration (Figure 2).

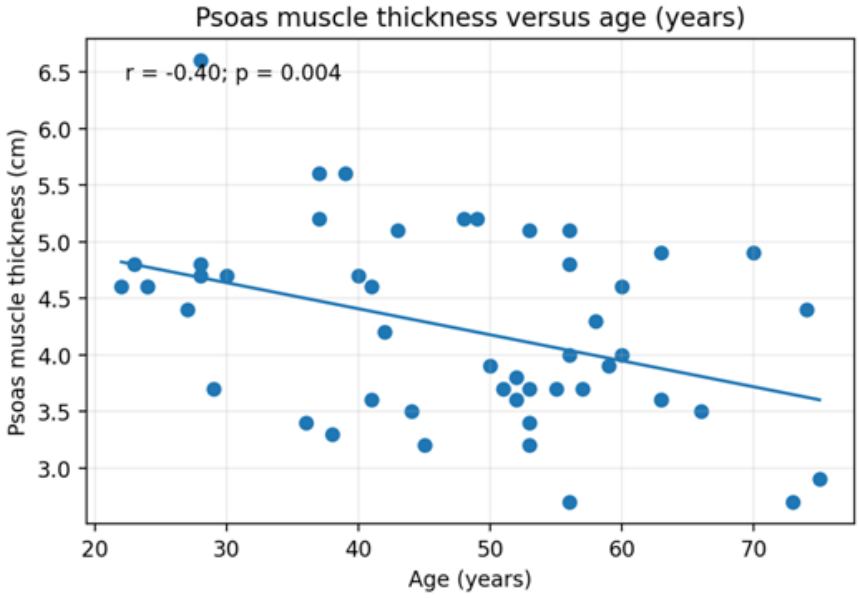

Figure 1: Scatterplot showing the relationship between psoas muscle thickness and age

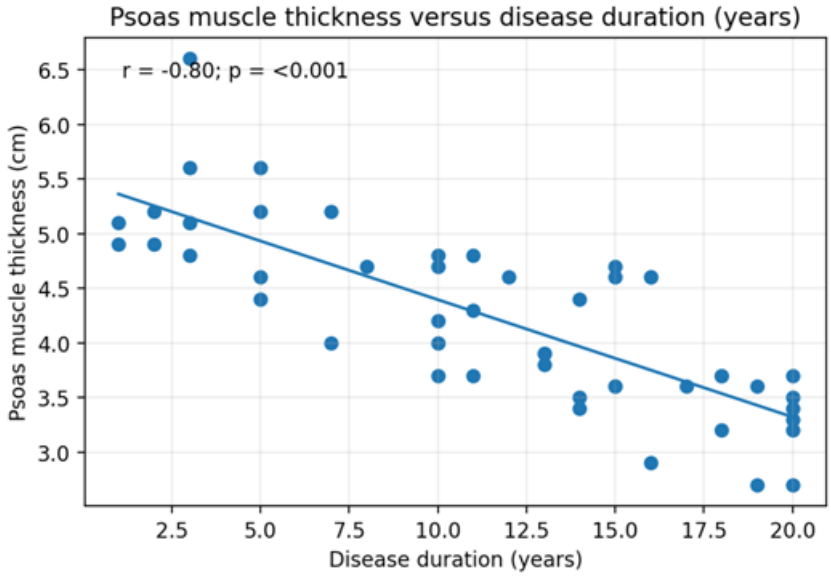

Figure 2: Scatterplot showing the relationship between psoas muscle thickness and disease duration

Using Asian Working Group for Sarcopenia 2019 handgrip cutoffs, low handgrip strength was present in 24 of 50 patients (48.0%). Low handgrip strength was not significantly associated with sex by Fisher exact test (p=0.420). The sex-wise distribution of low handgrip strength is shown in Table 4.

Table 4: Low handgrip strength using Asian Working Group for Sarcopenia 2019 cutoffs

Sex	Low handgrip strength	Normal handgrip strength
Men	22 (51.2)	21 (48.8)
Women	2 (28.6)	5 (71.4)
Total	24 (48.0)	26 (52.0)

Values are presented as n (%). Low handgrip strength was defined as <28 kg in men and <18 kg in women. Fisher exact test p=0.420 for the 2×2 comparison of low versus normal handgrip strength by sex. Pearson chi-square=1.23, degrees of freedom=1, p=0.267, phi coefficient=0.16. In multivariable linear regression, disease duration and age remained independent negative predictors of psoas muscle thickness after adjustment for body mass index and sex. The overall model was statistically significant and explained most of the variance in psoas muscle thickness ($F(4,45)=92.81$, $p<0.001$, adjusted $R^2=0.88$). Regression details are shown in Table 5.

Table 5: Multivariable linear regression for predictors of psoas muscle thickness

Predictor	Unstandardized beta	95% CI	Standardized beta	t statistic	p value
Intercept	7.067	6.593 to 7.541	Not applicable	30.04	<0.001
Disease duration, years	-0.114	-0.128 to -0.101	-0.85	-17.13	<0.001
Age, years	-0.029	-0.035 to -0.023	-0.50	-10.11	<0.001
Body mass index, kg/m²	-0.001	-0.014 to 0.012	-0.01	-0.18	0.857
Male sex	-0.136	-0.369 to 0.098	-0.06	-1.17	0.247

Outcome variable: psoas muscle thickness in centimeters. Predictors were disease duration, age, body mass index, and male sex. Unstandardized beta coefficients represent change in psoas muscle thickness in centimeters per one-unit increase in the predictor, except for male sex. Standardized beta coefficients are provided to compare relative effect magnitude across predictors. Abbreviation: CI, confidence interval.

Discussion

This cross-sectional study demonstrates that psoas muscle thickness in chronic pancreatitis is most strongly related to disease chronicity and age rather than conventional nutritional markers. Disease duration showed a strong negative correlation with psoas muscle thickness, while age showed a moderate negative correlation. In contrast, BMI, MAMC, TSFT, handgrip strength, serum albumin, and hemoglobin did not show significant

univariable correlations with psoas muscle thickness. These findings support the central message that sarcopenia-related muscle depletion in chronic pancreatitis may be missed when evaluation relies only on body mass index or routine biochemical markers.

The relationship between disease duration and psoas muscle thickness is clinically plausible. Chronic pancreatitis produces cumulative nutritional and metabolic stress through recurrent pain, reduced dietary intake, pancreatic exocrine insufficiency, maldigestion, fat-soluble vitamin deficiency, endocrine dysfunction, and systemic inflammation [1,2,5]. Over time, these factors create a sustained catabolic environment that can lead to progressive loss of skeletal muscle reserve. The strong independent association between disease duration and psoas muscle thickness in multivariable regression suggests that chronic exposure to pancreatic disease burden may be more informative than a single cross-sectional nutritional measurement.

The moderate negative association between age and psoas muscle thickness is consistent with sarcopenia biology. EWGSOP2 emphasizes that sarcopenia is defined by low muscle strength and confirmed by low muscle quantity or quality, while age remains an important background risk factor [3]. In our regression model, age remained independently associated with psoas muscle thickness after adjustment for disease duration, body mass index, and sex. This suggests that chronic pancreatitis-related muscle depletion may represent a combined effect of disease-specific catabolism and age-related decline rather than a purely nutritional phenomenon.

The absence of significant correlation between psoas muscle thickness and body mass index is important. Body mass index is easy to measure, but it cannot distinguish muscle mass from fat mass and can miss sarcopenia in patients with normal or increased adiposity. Similar observations have been reported in chronic pancreatitis cohorts and reviews, where sarcopenia may be present despite a non-low body mass index [7-10]. This supports the need for body-composition or muscle-focused assessment rather than relying on weight-based metrics alone.

Serum albumin was significantly lower in men than women in the present dataset, but albumin did not correlate significantly with psoas muscle thickness. Albumin is affected by inflammation, hepatic function, hydration, and acute illness; therefore, it is an imperfect marker of skeletal muscle reserve. This finding is aligned with the broader concept that biochemical nutritional markers should not be used as stand-alone tools for sarcopenia detection. Anthropometric and functional assessments, when combined with imaging-derived muscle measures, provide a more complete picture of nutritional and functional risk.

Handgrip strength is a practical measure of muscle function and is central to contemporary sarcopenia screening frameworks [3,4,14]. In this study, nearly half of the cohort met Asian Working Group for Sarcopenia 2019 criteria for low handgrip strength. However, psoas muscle thickness and handgrip strength were not significantly correlated. This discordance may reflect the multidimensional nature of sarcopenia: muscle mass and muscle function are related but not interchangeable. Pain, neuropathy, motivation, occupation, alcohol exposure, and systemic illness may influence handgrip strength independently of psoas thickness. Conversely, isolated psoas thinning may not always translate into measurable grip weakness.

Our findings should be interpreted in the context of existing chronic pancreatitis literature. Olesen et al. demonstrated that sarcopenia in chronic pancreatitis is associated with increased hospitalization and reduced survival [6]. Bundred et al. and Kuan et al. emphasized both the high prevalence of sarcopenia and the variability introduced by different diagnostic methods [7,8]. The 2025 meta-analysis by Khurmatullina et al. further supports sarcopenia as an underdiagnosed complication of chronic pancreatitis [9]. The present study adds a clinically useful observation from an Indian cohort: disease duration and age, rather than body mass index or albumin, were the dominant correlates of psoas muscle thickness.

Imaging-based assessment is particularly relevant in chronic pancreatitis because many patients undergo computed tomography or magnetic resonance imaging for diagnosis, complications, and follow-up. Bieliuniene et al. showed that cross-sectional imaging-based body composition assessment can identify clinically significant metabolic changes in chronic pancreatitis [11]. Trikudanathan et al. demonstrated the prognostic relevance of preoperative sarcopenia in patients undergoing total pancreatectomy with islet autotransplantation [12]. In routine practice, opportunistic measurement of muscle quantity from clinically indicated imaging could help identify high-risk patients without adding a separate diagnostic test.

Management implications are practical. Patients with chronic pancreatitis and long disease duration or older age may benefit from proactive screening for muscle depletion and low muscle strength. Nutritional strategies should include adequate protein and energy intake, correction of pancreatic exocrine insufficiency with appropriately dosed pancreatic enzyme replacement therapy, assessment for fat-soluble vitamin deficiency, and

structured exercise or resistance training where feasible [5,16,20]. Exercise and nutrition interventions have shown benefit in sarcopenia more broadly, although chronic pancreatitis-specific interventional trials remain limited [16]. The main strength of this study is its combined assessment of imaging-derived muscle reserve, functional strength, anthropometric parameters, and biochemical markers in a single chronic pancreatitis cohort. The study also uses effect sizes, confidence intervals, and multivariable analysis to move beyond isolated p values.

The findings are clinically relevant because they challenge overreliance on body mass index and albumin as screening markers for muscle depletion in chronic pancreatitis.

Limitations

- This was a single-center cross-sectional study with a modest sample size of 50 patients, limiting generalizability and causal inference.
- The cohort had a marked male predominance and was predominantly alcohol-related, which may limit applicability to populations with different etiological patterns.
- Psoas muscle thickness was used as a surrogate of muscle quantity; full skeletal muscle area, skeletal muscle index, dual-energy X-ray absorptiometry, and standardized vertebral-level segmentation were not available.
- The exact imaging protocol, scanner model, psoas measurement level, handgrip dynamometer model, anthropometry instruments, and laboratory analyzer/reagent kit details were not available in the source document and must be verified before final journal submission.
- Low handgrip strength was classified using Asian Working Group for Sarcopenia cutoffs but confirmed sarcopenia prevalence was not calculated because validated muscle-mass cutoffs for the psoas thickness method used in this dataset were not available.
- The study did not include exocrine pancreatic insufficiency severity, pancreatic enzyme replacement therapy use, dietary intake, vitamin D status, pain scores, diabetes status, inflammatory markers, hospitalization, survival, or treatment-response outcomes.
- The multivariable model should be interpreted cautiously because of the small sample size and should be validated in larger prospective cohorts.

Conclusion

In adults with chronic pancreatitis, psoas muscle thickness was strongly and independently associated with disease duration and age, but not with body mass index, albumin, mid-arm muscle circumference, triceps skinfold thickness, handgrip strength, or hemoglobin. Low handgrip strength was common, highlighting the functional burden of chronic pancreatitis, but it did not closely parallel psoas thickness. These findings support routine multidimensional screening using clinical risk factors, anthropometry, handgrip strength, and imaging-derived muscle assessment rather than reliance on body mass index or albumin alone. Larger prospective studies using standardized imaging thresholds and outcome-based validation are needed to define chronic pancreatitis-specific sarcopenia screening pathways.

Declarations

Ethics approval: The study approved by Institutional Ethics Committee.

Consent: Written informed consent was sought from study subjects.

Conflicts of interest: The authors declare no conflicts of interest.

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