ORIGINAL ARTICLE

ASSOCIATION BETWEEN PROTEINURIA AND SARCOPENIA

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Abstract

Introduction: Sarcopenia is an age-related condition characterized by progressive loss of muscle mass, strength, and function, leading to increased risk of disability and mortality. Although chronic kidney disease is a recognized contributor to sarcopenia, the role of proteinuria as a potential marker remains unclear.

We aim to investigate the association between dipstick-detected proteinuria and sarcopenia-related parameters in adults aged 40 years and older.

Materials and Method: This cross-sectional study included 1,513 participants aged 40–95 years. Sarcopenia was assessed according to EWGSOP2 criteria. Proteinuria was assessed using urine dipstick testing. Group comparisons were performed using nonparametric and categorical tests, and multivariable logistic regression analyses were conducted to evaluate independent associations after adjustment for age, sex, BMI, and serum creatinine.

Results: Significant differences across serum creatinine groups were observed in frailty status, nutritional status, and muscle quality (all $p < 0.001$). In univariate analyses, proteinuria was associated with lower grip strength, reduced STAR values, and poorer nutritional status; however, these associations were not maintained after adjustment. The multivariable model assessing proteinuria was not statistically significant. In contrast, confirmed sarcopenia was independently associated with older age, male sex, hypertension, and BMI, whereas diabetes mellitus was not. Grip strength was independently associated with age, serum creatinine, and nutritional status.

Conclusions: Proteinuria was not independently associated with sarcopenia in this cohort. These findings suggest that sarcopenia is primarily driven by systemic and cardiometabolic factors rather than renal markers such as proteinuria. Further longitudinal studies using standardized assessment methods are needed to clarify these relationships.

Keywords: Sarcopenia; Proteinuria; Muscle Strength; Nutritional Status; Aging.

INTRODUCTION

Sarcopenia is an age-related muscle disease characterized by the loss of muscle mass, muscle strength, and physical performance. This decline increases the risk of falls, disability, hospitalization, and mortality. Several working groups, including the European Working Group on Sarcopenia in Older People (EWGSOP, EWGSOP2), the Asian Working Group for Sarcopenia (AWGS), the International Working Group on Sarcopenia (IWGS), and the Foundation for the National Institutes of Health (FNIH), have proposed diagnostic definitions; however, no universal consensus has been reached. According to EWGSOP2, low muscle strength is the most reliable indicator of impaired muscle function. Reduced muscle strength is often accompanied by decreased muscle mass and reduced physical performance, ultimately leading to loss of independence in affected individuals (1,2).

In clinical practice, sarcopenia is often suspected when patients report difficulty rising from a chair or demonstrate slow walking speed. The worldwide prevalence of sarcopenia varies substantially depending on diagnostic criteria and study populations. Although global prevalence has been reported to be approximately 10% according to EWGSOP2 criteria, estimates range widely from 0.2% to 86.5% (3). Sarcopenia is strongly associated with aging; however, chronic conditions such as chronic kidney disease (CKD) may accelerate its progression through mechanisms such as uremia-induced catabolism.

Common assessment tools include handgrip strength and chair stand tests, which evaluate forearm and quadriceps strength, respectively, as well as the sonographic thigh adjustment ratio (STAR) (4–8). Frailty, neuromuscular dysfunction, and nutritional deficiencies, particularly inadequate protein intake, are also closely linked to sarcopenia (8,9). Because of the malnutrition is closely associated with sarcopenia and functional decline, nutritional status can be assessed using the Mini Nutritional Assessment–Short Form (MNA-SF), with scores categorized as >11 (normal), 8–11 (at risk), and <8 (malnourished) (10,11).

Proteinuria is another common, often asymptomatic finding that may indicate underlying kidney disease. Normal total urinary protein excretion is less than 150 mg/day, while normal urinary albumin excretion is less than 30 mg/day, corresponding to an albumin-to-creatinine ratio below 30 mg/g. Proteinuria is widely used in CKD staging and cardiovascular risk assessment and is commonly detected using semiquantitative methods such as urine dipstick analysis or the sulfosalicylic acid (SSA) test (12).

Although CKD is a recognized risk factor for sarcopenia, the reverse relationship has been less extensively studied. Some evidence suggests that sarcopenia may contribute to protein-energy wasting and CKD progression, particularly in geriatric, diabetic, or transplant populations. However, the causal relationship remains unclear. Therefore, the present study aimed to investigate the potential association between sarcopenia and proteinuria (13).

MATERIALS AND METHOD

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. A total of 1,513 patients aged 40–95 years were included, and informed consent was obtained from all participants.

Definition and Assessment of Sarcopenia

Sarcopenia was defined according to EWGSOP2 criteria, which emphasize muscle strength and muscle quality. In this study, sarcopenia-related parameters included frailty score, handgrip strength, chair stand test, six-meter gait speed, STAR, and nutritional status.

Muscle strength was evaluated using handgrip strength and chair stand tests. Handgrip strength



was measured twice per hand with 30-second rest intervals. The chair stand test consisted of five sit-to-stand repetitions performed as quickly as possible.

Muscle quality was assessed using STAR, calculated as anterior thigh muscle thickness divided by BMI. Muscle performance was evaluated using a six-meter walking speed test.

Nutritional status was assessed using the MNA-SF.

Diagnostic Criteria

Sarcopenia was categorized according to EWGSOP2 as follows:

- Muscle strength: handgrip strength <27 kg (men), <16 kg (women)
- Muscle mass: STAR <1.4 (men), <1.0 (women)
- Physical performance: gait speed ≤0.8 m/s
- Physical function: 5xSTS ≥12 seconds
- Frailty and nutritional status were used for descriptive purposes only.

Sarcopenia Severity

- Probable sarcopenia: low muscle strength
- Confirmed sarcopenia: low strength + low muscle mass
- Severe sarcopenia: low strength + low muscle mass + low physical performance

Assessment of Proteinuria

Proteinuria was assessed using urine dipstick testing and categorized as negative, +1, +2, or +3.

Statistical Analysis

Analyses were performed using SPSS version 27. Continuous variables were analyzed using the Kruskal–Wallis test, and categorical variables were analyzed using chi-square or Fisher–Freeman–Halton tests. A p-value <0.05 was considered statistically significant.

Multivariable logistic regression was performed to evaluate associations between proteinuria and sarcopenia-related parameters after adjustment for age, sex, BMI, and serum creatinine.

RESULTS

The study included 1,513 participants (32.5% male, 67.5% female) with a mean age of 65.27 ± 8.51 years. The mean BMI was 31.69 ± 5.66 kg/m² (Table 1).

Table 1. Baseline Demographic and Clinical Characteristics of the Study Population

Variable	Category	Value
Sex, n (%)	Male	491 (32.5)
	Female	1022 (67.5)
Age (years)	Mean ± SD	65.27 ± 8.51
	Median (min–max)	65 (40–95)
Weight (kg)	Mean ± SD	80.06 ± 14.32
	Median (min–max)	79 (41–137)
Height (cm)	Mean ± SD	158.83 ± 9.24
	Median (min–max)	158 (105–187)
BMI (kg/m²)	Mean ± SD	31.69 ± 5.66
	Median (min–max)	30.97 (15.45–75.28)
Systolic BP (mmHg)	Mean ± SD	129.37 ± 17.45
	Median (min–max)	130 (80–200)
Diastolic BP (mmHg)	Mean ± SD	78.44 ± 11.82
	Median (min–max)	80 (50–120)
Smoking duration (years)	Mean ± SD	11.57 ± 19.38
	Median (min–max)	0 (1–140)
Alcohol use, n (%)	Regular drinker	5 (0.3)
	Social drinker	111 (7.3)
	Ex-drinker	1396 (92.3)
Atherosclerotic heart disease duration (years)	Mean ± SD	8.96 ± 6.60
	Median (min–max)	7 (0–40)
Diabetes duration (years)	Mean ± SD	11.05 ± 8.34
	Median (min–max)	10 (0–40)

BMI, body mass index; BP, blood pressure; SD, standard deviation.

Significant differences were observed across serum creatinine groups in frailty status, nutritional status (MNA-SF), and muscle quality (STAR) (all p < 0.001). The proportion of individuals with severe frailty (≥3) was substantially higher in the ≥1.4 mg/dL group compared with the lower creatinine groups. Similarly, MNA-SF distribution differed significantly, with a higher proportion of individuals classified as having normal nutritional status in the highest creatinine group. In addition, STAR values varied significantly, indicating differences in muscle quality across creatinine levels. (Table 2)

Patients without proteinuria had significantly higher STAR values and grip strength compared with those with higher proteinuria levels. MNA-SF scores also differed significantly among groups. However, no significant differences were observed in frailty scores, chair stand test, gait speed, or BMI. (Table 3)

Table 2. Comparison According to Serum Creatinine Levels

Variable	Category	<1.0	1.1–1.4	≥1.4	Total	p-value
Frailty	**0**	**440 (45.3)**	**73 (43.7)**	**14 (3.8)**	**527 (34.9)**	**0.001****
Frailty	1–2	459 (47.2)	77 (46.1)	17 (4.6)	553 (36.6)	
Frailty	≥3	73 (7.5)	17 (10.2)	342 (91.7)	432 (28.6)	
MNA-SF	**<8**	**23 (2.4)**	**5 (3.0)**	**1 (0.3)**	**29 (1.9)**	**0.001****
MNA-SF	8–11	276 (28.4)	45 (26.9)	14 (3.8)	335 (22.2)	
MNA-SF	>11	673 (69.2)	117 (70.1)	357 (96.0)	1147 (75.9)	
STAR	**Low**	**391 (40.2)**	**94 (56.3)**	**148 (39.7)**	**633 (41.8)**	**0.001****
STAR	High	582 (59.8)	73 (43.7)	225 (60.3)	880 (58.2)	

[b] Pearson's chi-square test; [d] Kruskal–Wallis test with Dunn–Bonferroni post hoc correction; * p < 0.05; ** p < 0.01
BMI, body mass index; STAR, sonographic thigh adjustment ratio; MNA-SF, Mini Nutritional Assessment–Short Form; F, female; M, male.

Table 3. Comparison of Groups According to Urine Dipstick Protein Levels

Variable	Category	Negative (n=1447)	+1 (n=44)	+2/+3 (n=22)	Total	p-value
Frailty	0	507 (35.1)	15 (34.1)	5 (22.7)	527 (34.9)	0.338
Frailty	1–2	532 (36.8)	14 (31.8)	7 (31.8)	553 (36.6)	
Frailty	≥3	407 (28.1)	15 (34.1)	10 (45.5)	432 (28.6)	
MNA-SF	**<8**	**26 (1.8)**	**3 (6.8)**	**0 (0.0)**	**29 (1.9)**	**0.019***
MNA-SF	8–11	327 (22.6)	3 (6.8)	5 (23.8)	335 (22.2)	
MNA-SF	>11	1093 (75.6)	38 (86.4)	16 (76.2)	1147 (75.9)	
STAR	**Low**	**593 (41.0)**	**24 (54.5)**	**16 (72.7)**	**633 (41.8)**	**0.003****
STAR	High	854 (59.0)	20 (45.5)	6 (27.3)	880 (58.2)	
Chair stand	<12	960 (66.9)	27 (61.4)	16 (76.2)	1003 (66.9)	0.489
Chair stand	≥12	474 (33.1)	17 (38.6)	5 (23.8)	496 (33.1)	
Grip strength (1st)	**Low**	**667 (46.2)**	**28 (65.1)**	**12 (54.5)**	**707 (46.9)**	**0.039***
Grip strength (1st)	High	776 (53.8)	15 (34.9)	10 (45.5)	801 (53.1)	
Grip strength (2nd)	Low	397 (27.5)	19 (43.2)	6 (27.3)	422 (27.9)	0.073
Grip strength (2nd)	High	1047 (72.5)	25 (56.8)	16 (72.7)	1088 (72.1)	
Grip strength (3rd)	Low	380 (26.4)	16 (36.4)	7 (31.8)	403 (26.7)	0.289
Grip strength (3rd)	High	1062 (73.6)	28 (63.6)	15 (68.2)	1105 (73.3)	
Gait time	Mean ± SD	8.43 ± 3.60	9.14 ± 3.43	8.91 ± 3.83	8.46 ± 3.60	0.295
Gait time	Median	7.6 (3.5–44.8)	8.4 (4.9–17.3)	7.8 (4.9–18.5)	7.6 (3.5–44.8)	
BMI	<24	129 (8.9)	4 (9.3)	1 (4.5)	134 (8.9)	0.790
BMI	25–30	484 (33.5)	12 (27.9)	6 (27.3)	502 (33.2)	
BMI	>30	833 (57.6)	27 (62.8)	15 (68.2)	875 (57.9)	

[b] Pearson's chi-square test; [c] Fisher–Freeman–Halton test; [d] Kruskal–Wallis test * p < 0.05; ** p < 0.01
BMI, body mass index; STAR, sonographic thigh adjustment ratio; MNA-SF, Mini Nutritional Assessment–Short Form; F, female; M, male.

Table 4. Summary of Associations Between Proteinuria, Sarcopenia, and Related Factors

Analysis	Variable	Effect Size	95% CI	p-value	Interpretation
Proteinuria (Univariate)	Grip strength	↓		0.039	Lower in proteinuria
	STAR	↓		<0.01	Lower in proteinuria
	MNA-SF	↓		0.019	Worse nutrition
	Frailty, gait, chair stand, BMI			>0.05	No difference
Proteinuria (Multivariable)	Grip strength	β = −0.043		0.428	Not significant
	BMI	β = −0.011		0.705	Not significant
	Creatinine	β = 0.079		0.486	Not significant
	MNA-SF	β = 0.39		0.091	Borderline
	Model			0.43	Not significant
Grip Strength Model	Age	β = −0.19		<0.001	Strong negative effect
	Creatinine	β = −0.12		0.002	Significant
	MNA-SF	β = −0.76		<0.001	Strongest determinant
	BMI, STAR			NS	Not significant
Sarcopenia Model	Age (per year)	OR 1.02	1.01–1.04	0.010	Independent predictor
	Male sex	OR 2.55	1.85–3.51	<0.001	Strongest predictor
	Hypertension	OR 2.24	1.53–3.27	<0.001	Significant
	BMI	OR 1.01	1.00–1.03	0.040	Weak effect
	Diabetes	OR 1.06	0.80–1.41	0.686	Not significant
Medication Model	Antihypertensive use	OR 1.82	1.27–2.61	0.001	Associated
	Diabetes medication			0.667	Not significant

[a] Kruskal–Wallis with Dunn's post hoc; [b] chi-square or Fisher–Freeman–Halton; [c] logistic/linear regression with ORs (95% CI) and β. $p < 0.05$ considered significant.

BMI, body mass index; STAR, sonographic thigh adjustment ratio; MNA-SF, Mini Nutritional Assessment–Short Form; OR, odds ratio; CI, confidence interval; β, regression coefficient; NS, not significant.

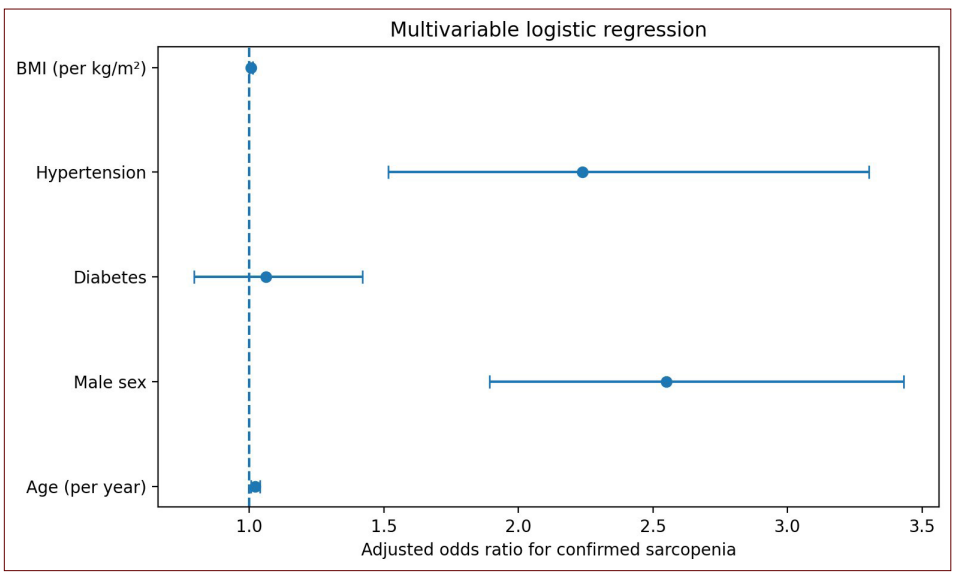


Figure 1. Adjusted odds ratios for confirmed sarcopenia from multivariable logistic regression analysis.

Error bars represent 95% confidence intervals. The vertical dashed line indicates an odds ratio of 1.0. Age, male sex, hypertension, and BMI were included in the model. Hypertension showed a significant association with sarcopenia, whereas diabetes was not significant after adjustment.

In the adjusted logistic regression model, no independent association was found between proteinuria and sarcopenia-related parameters. The model was not statistically significant and showed limited explanatory power. Grip strength analysis revealed independent associations with age, serum creatinine, and MNA-SF score, highlighting the importance of nutritional status. (Table 4)

A separate multivariable model evaluating sarcopenia showed that (Figure 1)

- Age, male sex, hypertension, and BMI were independently associated
- Diabetes was not independently associated
- Antihypertensive medication use was associated, while diabetes medication use was not

Because of the cross-sectional design, causal relationships can not be established.

DISCUSSION

Sarcopenia is a progressive condition characterized by the loss of muscle mass, muscle quality, and muscle function. It typically begins as early as the fourth decade of life and becomes more pronounced with advancing age. Sarcopenia increases the risk of weakness, falls, hospitalization, disability, and mortality (14,15). Malnutrition and protein-energy insufficiency are well-established predictors of sarcopenia, and CKD is closely linked to its development (16–18). Kidney function also declines with age, which may contribute to the increasing prevalence of sarcopenia in older adults. Previous studies have demonstrated that sarcopenia becomes more frequent as CKD progresses and may be present even in the early stages of renal disease (19–21). In our cohort, serum creatinine levels were positively correlated with grip strength, chair stand performance, and STAR values, but negatively correlated with MNA-SF scores. These findings suggest that serum creatinine alone may be insufficient for the simultaneous assessment of sarcopenia and kidney function (22-24).

The predominant form of sarcopenia is age-related (primary sarcopenia), whereas secondary sarcopenia arises in association with conditions such as malnutrition, chronic illness, and physical inactivity or immobilization (25). Age-associated hormonal alterations and increased oxidative stress have been recognized as major contributors to muscle deterioration. Beyond these mechanisms, chronic low-grade inflammation plays a pivotal role in the underlying pathophysiology of sarcopenia. This sustained inflammatory state inhibits muscle protein synthesis and accelerates muscle breakdown (26).

In the present study, nutritional status, evaluated using the MNA-SF, emerged as one of the most influential determinants of muscle strength, surpassing the effects of age and renal function. This finding highlights the fundamental importance of nutrition in both the development and progression of sarcopenia, extending beyond the assessment of muscle mass alone. Accordingly, ensuring adequate protein intake and optimizing nutritional status may represent key strategies for prevention and management.

Accumulating evidence has emphasized the significance of chronic inflammation—commonly termed "inflammaging"—in the pathogenesis of sarcopenia. In contrast to acute inflammation, which is a transient and protective response, chronic inflammation persists at low intensity over prolonged periods and is characterized by elevated levels of pro-inflammatory cytokines, including interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and C-reactive protein (CRP). This pro-inflammatory milieu contributes to muscle degradation through multiple biological pathways (27).

Alterations in gut microbiota composition may further intensify this process. Increased intestinal permeability facilitates the translocation of bacterial endotoxins into the systemic circulation, thereby enhancing inflammatory responses. Consequently, modulation of the gut microbiome has been



proposed as a potential therapeutic approach to attenuate chronic inflammation and slow the progression of sarcopenia (27).

These factors may contribute to the development and progression of sarcopenia both in early midlife (around the fourth decade) and more prominently after the age of 65.

In the present study, diabetes and hypertension were associated with modest reductions in muscle strength, with the lowest values observed in individuals with both conditions. However, age and sex demonstrated substantially stronger associations with muscle strength. These findings suggest that while cardiometabolic comorbidities contribute to sarcopenia, their effects may be secondary to aging and inherent biological differences. Furthermore, hypertension, but not diabetes, was independently associated with sarcopenia in multivariable analysis, suggesting a potentially greater role for vascular and hemodynamic factors in muscle deterioration.

The observed association between antihypertensive medication use and sarcopenia likely reflects underlying disease burden rather than a direct pharmacological effect. However, the absence of detailed adjustment for disease severity and medication characteristics limits the ability to draw definitive conclusions.

The apparent association between proteinuria and sarcopenia-related parameters disappears after adjustment, suggesting that the observed relationship is largely driven by systemic confounding factors.

The borderline association observed with MNA-SF should be interpreted cautiously, as it did not reach statistical significance.

Taken together, the findings of this study suggest that sarcopenia is driven more by systemic factors, particularly nutritional status and inflammation, than by muscle mass alone. The interplay between aging, metabolic health, and chronic disease appears to be central to its pathogenesis.

Limitations

This study has several limitations. The cross-sectional design precludes causal inference. Important confounders such as diabetes severity, inflammation, and physical activity were not fully adjusted. Proteinuria was assessed using a single dipstick measurement, and muscle mass was evaluated using STAR rather than DXA/BIA. The overweight study population may limit generalizability.

CONCLUSIONS

This study investigated the association between dipstick-detected proteinuria and sarcopenia-related parameters, including muscle strength, nutritional status, and functional performance, in adults aged 40 years and older.

Although univariate analyses suggested potential associations between proteinuria and selected sarcopenia markers, these findings were not confirmed in multivariable models after adjustment for age, sex, BMI, and renal function. Accordingly, proteinuria was not independently associated with sarcopenia-related parameters in this cohort, and most biochemical and clinical variables did not differ significantly across proteinuria groups.

In contrast, multivariable analysis of confirmed sarcopenia demonstrated that older age, male sex, hypertension, and BMI were independently associated with sarcopenia, whereas diabetes mellitus was not. These findings suggest that sarcopenia in this population is more strongly related to demographic and cardiometabolic factors than to proteinuria.

The interpretation of these findings is limited by several factors, including the cross-sectional design, which precludes causal inference, the use of semiquantitative dipstick testing for proteinuria assessment, the relatively low prevalence of proteinuria, and the use of a non-standard method (STAR) for muscle mass evaluation instead of established techniques such as DXA or BIA.

Therefore, routine proteinuria screening alone appears insufficient for sarcopenia risk stratification in clinical practice.

Future studies should employ longitudinal designs, include larger and more representative populations, and utilize standardized quantitative methods to better clarify these relationships and determine their clinical significance.

Ethics approval and consent to participate: The study was performed in accordance with the ethical standards provided in the *1964 Declaration of Helsinki* and its later amendments or comparable ethical standards. The study was approved by the Ethical Council in 2024 with the number "2024-02/05". Informed consent to participate was obtained from all of the participants in the study.

Authors' Contributions: Research idea and study design: SYI, ED; data acquisition: ED; data analysis/interpretation: SYI; statistical analysis: SYI; supervision and mentorship: ÖK.

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