RESEARCH PAPER

Sarcopenia and its association with pain and functional impairment in primary & secondary knee osteoarthritis, a cross-sectional study

Mohamed Tharwat Hegazy [1], Alaa Abdallah Salah Nabawi [2], Gehad Maghraby [3], Manal Roushdy Al Masry [4], Mai Ali [5], Hala Ramadan [6]

1. *Associate professor of Internal Medicine, Rheumatology and Clinical Immunology unit, Faculty of Medicine, Cairo University, Egypt; Dr_moh_tharwat@kasralainy.edu.eg*
2. *Associate lecturer of Internal Medicine, Rheumatology and Immunology division, Internal Medicine department, Faculty of Medicine, Cairo University, Egypt; alaa.salah37540postgrad@kasralainy.edu.eg*
3. *Rheumatology and Clinical Immunology division, Internal Medicine department, Faculty of Medicine, Cairo University, Egypt; gehad.maghraby@kasralainy.edu.eg*
4. *Professor of Internal Medicine, Faculty of Medicine, Cairo University, Egypt; manalelmasry1986@gmail.com*
5. *Lecturer of Clinical and Chemical Pathology, Faculty of Medicine, Cairo University, Egypt; mai.ali@kasralainy.edu.eg*
6. *Associate professor of Internal Medicine, Rheumatology and Clinical Immunology division, Internal Medicine department, Faculty of Medicine, Cairo University, Egypt; halaramadan31@cu.edu.eg*

Received: 04th June, 2026; Revised: 05th June, 2026; Accepted: 20th July, 2026; Available Online: 27th July, 2026

ABSTRACT

Background: Osteoarthritis (OA) is a prevalent degenerative joint disorder often accompanied by sarcopenia, a progressive loss of muscle mass and function. The interaction between sarcopenia, inflammation, structural joint damage, pain, nutritional status, and functional impairment remains incompletely understood. **Objectives:** To assess the association between sarcopenia grades and structural joint damage, pain severity, nutritional status, and functional outcomes in primary and secondary knee OA. **Methods:** This was a cross-sectional study including cases with primary and secondary knee OA classified according to sarcopenia severity based on EWGSOP2. Imaging findings, pain (VAS), nutritional status (MNA), and functional indices (WOMAC, Barthel Index) were assessed. **Results:** Severe sarcopenia was significantly associated with higher pain and lower functional independence in primary OA ($p = 0.019$, 0.031). No consistent associations were observed in secondary OA. **Conclusion:** Sarcopenia significantly impacts pain and function in knee OA, particularly in primary OA. Early identification and intervention may improve clinical outcomes.

Keywords: Knee osteoarthritis; sarcopenia; pain severity; functional impairment, sarcopenia.

How to cite this article: Hegazy M.T, Nabawi A.A.S, Maghraby G, Al Masry M.R, Ali M, Ramadan H, Sarcopenia and its association with pain and functional impairment in primary & secondary knee osteoarthritis, a cross-sectional study. 2026;16(78s): 323-328; DOI: 10.25258/ijddt.16.78s.38

Source of support: None

Conflict of interest: None

INTRODUCTION

Sarcopenia is recognized as a progressive skeletal muscle disorder involving loss of muscle mass, reduced muscle strength, and decline in physical performance, with important consequences including disability, frailty, and impaired quality of life. The revised EWGSOP2 criteria identify low muscle strength as the primary diagnostic criterion, while muscle quantity and physical performance are applied to grade severity **[1].** Several factors contribute to the onset and progression of sarcopenia, including aging, chronic inflammation, physical inactivity, and malnutrition **[2,3].**

Osteoarthritis (OA), the most common degenerative joint disease, is a leading contributor to pain and disability worldwide. It is characterized pathologically by progressive cartilage degradation, osteophyte formation, subchondral bone remodeling, and synovial inflammation. Current understanding recognizes OA as a multifactorial disorder driven by biomechanical, metabolic, and inflammatory mechanisms, rather than a purely mechanical "wear-and-tear" process **[4].** According to the World Health Organization (WHO), OA represents a significant global burden contributing to disability and reduced quality of life **[5].**

Accumulating evidence suggests that sarcopenia and OA may influence each other through a bidirectional relationship. Reduced muscle strength impairs joint stability, alters biomechanics, and increases abnormal joint loading, which may accelerate cartilage degeneration **[6,7].** In contrast, chronic pain and reduced mobility among OA cases may limit physical activity and subsequently contribute to muscle wasting. In addition, low-grade systemic inflammation mediated by cytokines such as TNF-α and IL-1β may serve as a shared pathophysiological mechanism between both conditions **[2,3].**

Despite increasing interest in this field, the relationship between sarcopenia severity and OA-related outcomes—including pain, functional status, inflammatory activity, structural damage, and nutritional status—remains incompletely understood. Moreover, limited data exist comparing these associations between primary and secondary knee OA, which may differ in etiology and clinical behavior.

**Author for Correspondence: halaramadan31@cu.edu.eg; halarmadan31@yahoo.com*

Therefore, this study aimed to evaluate sarcopenia severity in cases with primary and secondary knee OA and to investigate its association with structural joint changes, pain severity, nutritional status, and functional outcomes.

PATIENTS AND METHODS

The present cross-sectional study was performed at kasr alainy Hospitals, Faculty of Medicine, Cairo University. The study included cases aged ≥60 years diagnosed with knee OA (clinical and radiological). Cases were stratified into two groups: primary OA (n = 48) and secondary OA (n = 48). Patients with a history of major trauma, spinal disease affecting mobility, joint replacement, or cognitive impairment were excluded from the study. The study was conducted in accordance with the revised Declaration of Helsinki and was approved by the Faculty Ethical Committee, Faculty of Medicine, Cairo University, under reference number MD-318-2022.
Clinical trial number: not applicable.

Clinical assessment

Clinical evaluation comprised detailed medical history, symptom assessment, and documentation of current medications, while nutritional status was assessed using the Mini Nutritional Assessment–Short Form (MNA-SF) **[2].** Pain severity was evaluated using the Numerical Rating Scale (NRS) and Visual Analog Scale (VAS) **[8].** Functional status was evaluated using the Barthel Index to assess activities of daily living **[9]** and the WOMAC index to assess OA-related disability **[10]**.

Sarcopenia assessment

Diagnosis of sarcopenia was established using the EWGSOP2 criteria, which assess muscle quantity, muscle strength, and physical performance **[1].**

Radiological and ultrasound assessment

Radiographic severity was determined according to the Kellgren–Lawrence (KL) grading system **[11].**
Musculoskeletal ultrasound was used to assess the following (cartilage status, osteophyte formation, joint effusion, and synovitis).

Statistical analysis:

Data were analyzed using SPSS version 27. Continuous variables were tested for normality and presented as mean ± SD or median (interquartile range), as appropriate. Categorical variables were summarized as frequencies and percentages. Comparative analyses were performed using Student's t-test, ANOVA, Mann–Whitney U test, and Kruskal–Wallis test, according to the type and distribution of data. Chi-square test, Fisher's exact test, and linear-by-linear association were applied for categorical comparisons. Pearson or Spearman correlation coefficients were used based on variable distribution. ROC curve analysis was performed to determine cutoff values and diagnostic performance measures, including sensitivity, specificity, and AUC. A p-value ≤0.05 was considered statistically significant

RESULTS

A total of 96 cases with knee OA were enrolled and evenly divided into primary OA (n = 48) and secondary OA (n = 48) groups. The mean age of the participants was (63±6 for 1ry OA gropu versus 61±5 for 2nd OA group).
Cases were classified into sarcopenia categories as following (Non-sarcopenic, Pre-sarcopenic, Sarcopenic, and Severe sarcopenic).

Assessment of cases with primary osteoarthritis as shown in Table 1: regarding nutritional status the results expressed that no significant difference was observed in MNA scores across sarcopenia grades (P = 0.392). Categorical nutritional status (normal, at risk, malnourished) also showed no significant association. **As regard pain assessment,** VAS scores increased significantly with higher sarcopenia severity (P = 0.019). Cases with severe sarcopenia experienced significantly greater pain levels. Although WOMAC scores appeared to worsen with increasing sarcopenia severity, this finding was not statistically significant (P = 0.063). **Regarding functional status,** Barthel Index scores were significantly lower in cases with severe sarcopenia compared to non-sarcopenic cases (P = 0.031), indicating reduced independence in daily activities. **Structural and ultrasound findings** expressed that there were no significant associations between sarcopenia grade and:**(** KL grade, osteophyte grades, meniscal extrusion, cartilage grading, Baker's cyst, synovitis, and range of motion).
Assessment of cases with secondary osteoarthritis as shown in table 2&3: regarding **nutritional status** data showed that there were no significant differences were observed in MNA scores across sarcopenia grades (P = 0.254) and no significant differences were found in:VAS (P = 0.494), WOMAC (P = 0.425), and Barthel Index (P = 0.416) regarding **pain and function.**

Structural findings of these cases revealed that no significant association was found between sarcopenia and: **:(** KL grade, osteophyte grades, meniscal extrusion, cartilage grading, Baker's cyst, synovitis, and range of motion).

Comparative analysis revealed that severe sarcopenia was correlated with higher pain and lower functional independence in primary OA, whereas no such associations were observed in secondary OA. This suggests a more clinically relevant role of sarcopenia in primary OA.

Table (1) The association of sarcopenia grade with inflammation, damage, nutrition, pain and function in 1ry OA

	Sarcopenia index				P value
	None sarcopenic	Presarcopenic	Sarcopenic	Sever sarcopenic	
	Median (range)	Median (range)	Median (range)	Median (range)	
Anterior recesses effusion	8.7(0-21.5)	All participants 12.2	8.1 (0-9.1)	7.2 (0-17.7)	0.554
MNA score	20.5 (13.5-24.5)	All participants 19.5	23 (17-26)	17.5 (16-22)	0.392
VAS score	6 (2-10)	All participants 6	8 (6-8)	9 (8-10)	0.019
WOMAC	54 (16-88)	All participants 59	24 (7-76)	82.5 (41-96)	0.063
Barthel index	97.5 (45-100)	All participants 100	100 (65-100)	60 (40-95)	0.031
	n (%)*	**n (%)***	**n (%)***	**n (%)***	
Baker's cyst					
No	27 (77.1)	1 (2.9)	3 (8.6)	4 (11.4)	NA
Yes	9 (81.8)	0 (0)	0 (0)	2 (18.2)	
KL grade					
Grade 1	10 (100)	0 (0)	0 (0)	0 (0)	NA
Grade 2	11 (61.1)	1 (5.6)	3 (16.7)	3 (16.7)	
Grade 3	13 (86.7)	0 (0)	0 (0)	2 (13.3)	
Grade 4	2 (66.7)	0 (0)	0 (0)	1 (33.3)	
Grade of medial osteophyte					
Grade 0	4 (57.1)	1 (14.3)	0 (0)	2 (28.6)	NA
Grade 1	8 (88.9)	0 (0)	0 (0)	1 (11.1)	
Grade 2	8 (100)	0 (0)	0 (0)	0 (0)	
Grade 3	16 (72.7)	0 (0)	3 (13.6)	3 (13.6)	

Table (2) The association of sarcopenia grade with inflammation, damage, nutrition, pain and function in 2ry OA

	Sarcopenia index				P value
	None sarcopenic	Presarcopenic	Sarcopenic	Sever sarcopenic	
	Median (range)	Median (range)	Median (range)	Median (range)	
Anterior recesses effusion	10.3 (0-42.8)	15 (10.8-35.9)	13.1 (9.1-14.3)	17.1 (4.2-39.5)	0.263
MNA score	21.5 (16-26)	20.3 (17-23)	23 (19-24)	19.8 (13-21)	0.254
VAS score	6 (4-10)	6 (4-8)	6 (4-8)	8 (4-8)	0.494
WOMAC	53 (23-92)	34 (34-86)	44 (42-59)	66.5 (44-89)	0.425
Barthel index	95 (45-100)	92.5 (80-100)	All participants 100	90 (65-100)	0.416
	n (%)*	**n (%)***	**n (%)***	**n (%)***	
Synovitis					
No	36 (78.3)	3 (6.5)	3 (6.5)	4 (8.7)	NA
Yes	3 (75)	1 (25)	0 (0)	0 (0)	
Baker's cyst					
No	35 (77.8)	3 (6.7)	3 (6.7)	4 (8.9)	NA
Yes	4 (80)	1 (20)	0 (0)	0 (0)	
KL grade					
Grade 1	14 (77.8)	1 (5.6)	1 (5.6)	2 (11.1)	NA
Grade 2	13 (81.3)	3 (18.8)	0 (0)	0 (0)	
Grade 3	10 (71.4)	0 (0)	2 (14.3)	2 (14.3)	
Grade 4	2 (100)	0 (0)	0 (0)	0 (0)	
Grade of medial osteophyte					
Grade 0	9 (90)	0 (0)	0 (0)	1 (10)	NA
Grade 1	9 (69.2)	2 (15.4)	1 (7.7)	1 (7.7)	
Grade 2	12 (75)	1 (6.3)	2 (12.5)	1 (6.3)	
Grade 3	9 (81.8)	1 (9.1)	0 (0)	1 (9.1)	
Grade of lateral osteophyte					
Grade 0	12 (80)	0 (0)	1 (6.7)	2 (13.3)	NA
Grade 1	14 (70)	2 (10)	2 (10)	2 (10)	
Grade 2	9 (90)	1 (10)	0 (0)	0 (0)	
Grade 3	4 (80)	1 (20)	0 (0)	0 (0)	

Table (3): The association of sarcopenia grade with inflammation, damage, nutrition, pain and function in 2ry OA (Cont.)

	Sarcopenia index				P value
	None sarcopenic	Presarcopenic	Sarcopenic	Sever Sarcopenic	
	Median (range)	Median (range)	Median (range)	Median (range)	
Interpretation AHMM					
Grade 0	3 (60)	1 (20)	1 (20)	0 (0)	NA
Grade 1	12 (85.7)	2 (14.3)	0 (0)	0 (0)	
Grade 2	24 (77.4)	1 (3.2)	2 (6.5)	4 (12.9)	
Femoral cartilage					
Grade 1	15 (83.3)	0 (0)	1 (5.6)	2 (11.1)	NA
Grade 2	11 (73.3)	4 (26.7)	0 (0)	0 (0)	
Grade 3	13 (76.5)	0 (0)	2 (11.8)	2 (11.8)	
Grade 4	0 (0)	0 (0)	0 (0)	0 (0)	
ROM (Flexion Or Extension or both or no limitation					
Flextion	2 (100)	0 (0)	0 (0)	0 (0)	NA
Extension	0 (0)	0 (0)	0 (0)	0 (0)	
Both	37 (77.1)	4 (8.3)	3 (6.3)	4 (8.3)	
Interpretation of MNA					
Normal nutrition	10 (90.9)	0 (0)	1 (9.1)	0 (0)	NA
At risk of malnutrition	25 (73.5)	4 (11.8)	2 (5.9)	3 (8.8)	
Malnourished	4 (80)	0 (0)	0 (0)	1 (20)	

*AHMM : anterior horn medial meniscus, KL:Kellgren-Lawrence grading scale,MNA: Mini nutritional assessment score,VAS: Visual Analogue Scale, , WOMAC: The Western Ontario and McMaster Universities Osteoarthritis Index, ROM: Range of motion *Percentages were calculated within rows, p value <0.05 is considered significant, NA: Not applicable*

DISCUSSION

In the present study, we compared sarcopenia grades between primary and secondary knee OA and evaluated their associations with structural damage, nutritional status, pain, and functional impairment. The study findings suggested that advanced sarcopenia was more prevalent in secondary OA and was significantly associated with greater radiographic damage, worse nutritional status, and increased disability.

Sarcopenia refers to a progressive, generalized disorder of skeletal muscle marked by low muscle strength, reduced muscle quantity or quality, and impaired physical performance **[1]**. The revised EWGSOP2 criteria place primary emphasis on muscle strength as the key diagnostic parameter **[1].** In OA, chronic pain and joint stiffness reduce mobility and physical activity, accelerating muscle atrophy **[4].** This mechanism may explain the higher prevalence of severe sarcopenia observed in secondary OA, where joint pathology often develops in the setting of previous trauma or inflammatory disease **[12]**.

Ultrasound findings such as anterior recess effusion and synovitis were more frequent in cases with advanced sarcopenia. Synovitis has been associated with pain severity and structural progression in knee OA **[13].** Persistent intra-articular inflammation may increase systemic inflammatory burden, thereby exacerbating muscle catabolism. Similarly, the presence of Baker's cyst, which reflects increased synovial fluid production secondary to intra-articular pathology, was more common in severe sarcopenia and likely indicates more advanced joint disease **[14].**

Radiographic severity assessed by the Kellgren-Lawrence (KL) grading system showed a positive association with sarcopenia grade. The KL classification remains the standard radiographic tool for grading OA severity. Radiographic findings in secondary OA indicated limited differences among sarcopenia groups in terms of synovitis, Baker's cyst prevalence, and (KL) grades. However, higher grades of medial and lateral osteophytes and cartilage damage were slightly more common among those with severe sarcopenia, albeit with inconsistent trends. ROM limitations, particularly in both flexion and extension, were more frequent in severely sarcopenic individuals.

These findings suggest that sarcopenia plays a more pronounced role in exacerbating clinical, functional, and radiographic features in primary OA compared to secondary OA. While sarcopenia contributes to the worsening of some parameters in secondary OA, the associations are less robust, reflecting the complex interplay of factors influencing disease progression in this condition **[11].**

Advanced structural damage may reduce joint loading capacity and neuromuscular activation, leading to progressive muscle atrophy. Importantly, quadriceps weakness has been identified as a predictor of knee OA

progression **[15],** suggesting a bidirectional relationship between muscle weakness and structural deterioration.

We also observed significant associations between sarcopenia grade and osteophyte formation as well as medial meniscal extrusion. Meniscal extrusion has been strongly associated with cartilage loss and OA progression **[7].** Reduced periarticular muscle strength may alter joint biomechanics and increase compartmental stress, further accelerating degenerative changes.

Functionally, higher sarcopenia grades were associated with reduced range of motion (ROM), higher VAS scores, and worse WOMAC and Barthel index scores. Pain and functional limitation are key determinants of disability in OA **[4].** Sarcopenia independently contributes to impaired physical performance and increased disability risk **[1].** Our findings reinforce the concept that concomitant muscle loss exacerbates functional decline in OA cases.

Nutritional deterioration was significantly associated with severe sarcopenia in both OA groups. The Global Leadership Initiative on Malnutrition (GLIM) indicates that malnutrition may reduce muscle protein synthesis and impair muscle regeneration **[14,16].** In chronic musculoskeletal disorders, inadequate nutritional intake combined with inflammation may synergistically accelerate muscle loss **[16]**.

systematic review and meta-analysis protocol **by Guo, et al,** examines the correlation between malnutrition and sarcopenia in patients with knee osteoarthritis (OA) found that sarcopenia was prevalent in this group, with malnutrition identified as a significant contributing factor **[17]**.

Interestingly, inflammatory and structural associations appeared more pronounced in secondary OA. Secondary OA often develops in contexts characterized by enhanced synovial inflammation compared with primary degenerative OA **[15].**

Overall, our findings support the concept of a muscle–joint interaction in OA, where systemic inflammation and structural damage promote muscle wasting, while sarcopenia contributes to biomechanical instability and functional deterioration. Early identification and multidisciplinary management targeting muscle strength, inflammation, and nutritional status may improve outcomes in both primary and secondary OA **[15,16]**.

Longitudinal studies are warranted to determine causal relationships and to evaluate whether interventions targeting muscle mass and strength can modify inflammatory activity and structural progression in OA.

Clinical implications

Sarcopenia should be considered a key determinant of pain and disability in primary OA. Muscle strength assessment should be integrated into clinical evaluation, and resistance training should be emphasized in management strategies.

Limitations

The cross-sectional design of this study limited the ability to establish causal relationships. MNA may not fully capture muscle-specific nutritional deficits. Secondary OA subgroup size may limit statistical power. Longitudinal outcomes were not assessed.

Conclusion

Sarcopenia is significantly associated with worse pain and functional impairment in primary knee OA but not in secondary OA. It is not associated with structural damage, or nutritional status, suggesting a phenotype-dependent role in OA.

Declarations

Ethics approval and consent to participate

Written informed consent was secured from participants or, when appropriate, from their responsible caregivers after clarification of the study aim and assurance of anonymity. The study was conducted in accordance with the revised Declaration of Helsinki and was approved by the Faculty Ethical Committee, Faculty of Medicine, Cairo University, under reference number MD-318-2022.

Authors' Contributions

M.R., M.T., and H.R. contributed to the conception and design of the study. A.A., M.A., and G.G. were responsible for data collection and statistical analysis. H.R. and A.A. drafted the manuscript. All authors critically reviewed the manuscript, contributed to revisions, and approved the final version.

Consent for publication: Not applicable.

Availability of data and material: Not applicable.

Competing interests: None.

Funding: This research was funded by Cairo University.

Acknowledgments: We acknowledge all our participants

List of Abbreviations

- **OA – Osteoarthritis**
- **EWGSOP2 – European Working Group on Sarcopenia in Older People 2**
- **TNF-α – Tumor Necrosis Factor-alpha**
- **IL-1β – Interleukin-1 beta**
- **VAS – Visual Analog Scale**
- **NRS – Numerical Rating Scale**
- **MNA-SF – Mini Nutritional Assessment – Short Form**
- **WOMAC – Western Ontario and McMaster Universities Osteoarthritis Index**
- **KL – Kellgren–Lawrence grading system**
- **ROM – Range of Motion**
- **SPSS – Statistical Package for the Social Sciences**

- **NF-κB – Nuclear Factor kappa-light-chain-enhancer of activated B cells**
- **GLIM – Global Leadership Initiative on Malnutrition**
- **WHO – World Health Organization**
- **ADL – Activities of Daily Living**
- **SD – Standard Deviation**
- **IQR – Interquartile Range**
- **AUC – Area Under the Curve**
- **ROC – Receiver Operating Characteristic**

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