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Association between body mass index and severity of primary knee osteoarthritis: A hospital-based cross-sectional study.

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Abstract
Background:
Obesity is an important modifiable factor in primary knee osteoarthritis, although its relationship with radiographic severity, pain, and functional limitation varies across clinical populations.

Objectives:
To determine the association between body mass index and the radiographic and clinical severity of primary knee osteoarthritis.

Methods:
This hospital-based cross-sectional study included 100 adults with symptomatic primary knee osteoarthritis at Government Medical College/Government General Hospital, Nizamabad, Telangana, from October 2024 to September 2025. Body mass index was classified as normal, overweight or obese. Radiographic severity was graded using the Kellgren–Lawrence system. Pain, functional impairment and knee movement were assessed using a visual analogue scale, the Western Ontario and McMaster Universities Osteoarthritis Index and goniometric knee flexion. Associations were examined using analysis of variance, chi-square tests, correlation analysis and multivariable logistic regression.

Results:
The mean age was 58.6 ± 9.0 years, and 63.0% were women. Normal weight, overweight, and obesity were present in 26.0%, 42.0%, and 32.0%, respectively. Severe osteoarthritis was identified in 19.2% of normal-weight, 47.6% of overweight, and 78.1% of obese participants. Body mass index correlated positively with Kellgren–Lawrence grade, pain and total WOMAC score, and inversely with knee flexion. After adjustment for age, sex, and symptom duration, obesity remained independently associated with severe osteoarthritis (adjusted odds ratio, 8.21; 95% confidence interval, 2.05–32.89).

Conclusion:
Higher body mass index was associated with advanced radiographic disease, greater pain, poorer function and restricted knee movement. Obesity was an independent predictor of severe primary knee osteoarthritis.

Recommendations:
Routine weight assessment and structured weight-management counselling should be incorporated into knee osteoarthritis care, with longitudinal studies undertaken to clarify temporal and causal relationships.

Keywords: *Body mass index; obesity; primary knee osteoarthritis; Kellgren–Lawrence grade; Western Ontario and McMaster Universities Osteoarthritis Index; pain; functional limitation.*
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Introduction
Osteoarthritis is a chronic whole-joint disorder characterised by progressive cartilage degradation, subchondral bone remodelling, osteophyte formation, synovial inflammation and variable involvement of periarticular tissues. It is a major source of persistent pain, impaired mobility and loss

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of independence in middle-aged and older adults. The knee is among the most frequently affected weight-bearing joints because it is exposed to repetitive mechanical loading during standing, walking and stair climbing. With ageing populations and increasing obesity, the clinical and socioeconomic burden of knee osteoarthritis continues to rise.[1] Global burden estimates have ranked hip and knee osteoarthritis among the leading contributors to disability, demonstrating its importance as a public health problem rather than an unavoidable consequence of ageing.[2]

Primary knee osteoarthritis develops through interactions among age, sex, genetic susceptibility, joint anatomy, muscle weakness, previous occupational loading and metabolic factors. Excess body weight is one of the most important modifiable determinants. Longitudinal evidence from the Framingham Study indicated that obesity preceded radiographic knee osteoarthritis and that the association was particularly strong in women and in severe disease.[3] Case-control evidence has also shown a steep increase in knee osteoarthritis risk with obesity, especially when combined with previous knee injury or generalised osteoarthritic features.[4] Systematic reviews subsequently confirmed that overweight and obesity are consistently associated with the onset of knee osteoarthritis in older adults.[5] Prospective evidence further suggests a dose-response relationship, with the risk increasing as body mass index rises.[6]

The relationship between obesity and knee osteoarthritis extends beyond increased axial loading. Greater body mass increases compressive forces across the tibiofemoral and patellofemoral compartments, accelerates structural stress, and can alter gait mechanics. Adipose tissue also functions as an active endocrine organ that produces adipokines and inflammatory mediators, providing a plausible metabolic pathway linking obesity with pain and joint degeneration. Nevertheless, radiographic change and symptoms do not always progress in parallel. Some patients with advanced radiographic changes report limited pain, whereas others with less marked structural disease experience substantial functional restriction. Assessing radiographic grade together with pain, disability and range of motion therefore provides a broader representation of disease severity.

Indian hospital populations frequently include patients who seek care only after symptoms interfere with daily activity. Local data describing how body mass index relates simultaneously to radiographic grade, pain, functional limitation and knee movement remain limited. Identifying this relationship can support early counselling, risk stratification and non-pharmacological management. The objective of the present study was to determine the association between body mass index and the severity of primary knee osteoarthritis among adults attending a tertiary-care hospital. The study also evaluated correlations between body mass index and Kellgren–Lawrence grade, pain intensity, WOMAC score, and knee flexion, and examined whether overweight or obesity independently predicted severe radiographic osteoarthritis.

Materials and methods

Study design and setting

A hospital-based cross-sectional analytical study was conducted from October 2024 to September 2025 in the Orthopaedics outpatient department of Government Medical College and Government General Hospital, Nizamabad, Telangana, India. The institution is a government medical college attached to a general hospital that provides outpatient, inpatient, and 24-hour emergency services and includes major clinical specialties, including Orthopaedics. The Orthopaedics outpatient service evaluates and manages patients with musculoskeletal disorders, including symptomatic degenerative knee disease, with radiographic assessment available through the hospital diagnostic services. Participants were recruited during routine outpatient attendance.

Study population

Adults aged 40 years or older who presented with knee pain and fulfilled the American College of Rheumatology clinical and radiographic criteria for primary knee osteoarthritis were eligible.[7] Patients with secondary osteoarthritis, inflammatory arthritis, major previous knee trauma, congenital or acquired deformity, metabolic bone disease, prior knee surgery, active infection, or incomplete clinical information were excluded. For bilateral disease, the knee with the higher Kellgren–Lawrence grade was designated the index knee; when grades were equal, the more symptomatic knee was evaluated.

Sample size and sampling

The required sample size was estimated using the single-proportion formula $n = Z^2p(1-p)/d^2$, where Z is the standard normal deviate for the desired confidence level, p is the anticipated proportion, and d is the absolute precision. Because a reliable local estimate was not available, p was set at 0.50 to provide the maximum variance. Using $Z = 1.96$ for a 95% confidence level and $d = 0.10$, $n = (1.96^2 \times 0.50 \times 0.50)/(0.10^2) = 96.04$. The target sample was therefore rounded upward to 100 participants. Consecutive eligible patients were enrolled after written informed consent until the target sample was achieved.

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Bias

Consecutive recruitment of all eligible patients during the study period was used to reduce selection bias. Eligibility criteria, the index-knee rule, and the structured case-record form were applied uniformly to all participants. Anthropometric measurements, pain assessment, WOMAC scoring, goniometric knee-flexion measurement, and radiographic grading were performed using predefined procedures to limit measurement and information bias. Potential confounding was addressed in the multivariable logistic-regression model by adjusting for age, sex, and symptom duration. Residual confounding and referral bias related to the single-hospital setting could not be eliminated and were considered when interpreting the findings.

Clinical and anthropometric assessment

Age, sex, symptom duration, laterality, and comorbid hypertension and diabetes mellitus were recorded using a structured case-record form. Weight was measured to the nearest 0.1 kg with light clothing, and height was measured to the nearest 0.1 cm without footwear. Body mass index was calculated as weight in kilograms divided by height in metres squared. Participants were categorised as normal weight (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²) or obese (≥30.0 kg/m²).

Assessment of osteoarthritis severity

Standing anteroposterior and lateral radiographs of the index knee were evaluated using the Kellgren–Lawrence grading system: grade I, doubtful narrowing with possible osteophytes; grade II, definite osteophytes with possible narrowing; grade III, multiple osteophytes, definite narrowing and possible bony deformity; and grade IV, marked narrowing with severe sclerosis and definite deformity.[8] Grades III and IV were classified as severe osteoarthritis. Pain during usual activity was measured on a 0–10 visual analogue scale. Functional impairment was assessed with the Western Ontario and McMaster Universities Osteoarthritis Index, scored from 0 to 96, with higher scores indicating worse symptoms and function.[9] Active knee flexion was measured in degrees using a standard goniometer.

Statistical analysis

Continuous variables were summarised as mean ± standard deviation and categorical variables as frequencies and percentages. Differences among body mass index categories were examined using one-way analysis of variance for continuous variables and Pearson's chi-square test for categorical variables. Pearson's correlation was applied to continuous measures, while Spearman's rank correlation was used for ordinal radiographic grade. Binary logistic regression estimated crude and adjusted odds ratios for severe osteoarthritis. The adjusted model included body mass index category, age, sex, and symptom duration. Statistical significance was set at $p<0.05$. Analyses were performed using IBM SPSS Statistics version 26.0. Reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology recommendations.[10]

Ethical considerations

Ethics committee approval was obtained from Government Medical College and Government General Hospital, Nizamabad, Telangana, India, before commencement of the study. Written informed consent was obtained from every participant before enrolment. Participant confidentiality was maintained through coded data collection and secure storage of study records.

Results

Participant characteristics

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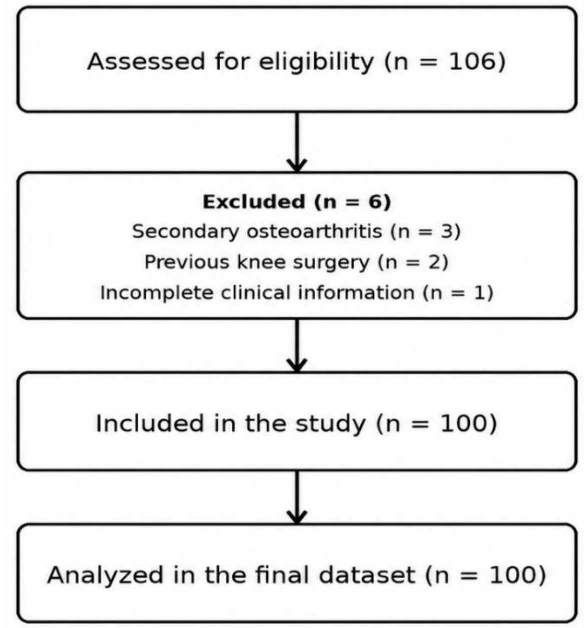
Figure 1: Flow of participants through the study



Note. The flow diagram reports the number assessed for eligibility, exclusions with reasons, the number included, and the number analyzed.

As shown in Figure 1, 106 patients with symptomatic primary knee osteoarthritis were assessed for eligibility. Six were excluded: three because of secondary osteoarthritis, two because of previous knee surgery, and one because of incomplete clinical information. Consequently, 100 participants were included, and all 100 were analyzed in the final dataset.

Table 1: Demographic and Clinical Characteristics of the Study Participants

Characteristic	Value
Age, years	58.6 ± 9.0
Age 40–49 years	16 (16.0)
Age 50–59 years	34 (34.0)
Age 60–69 years	37 (37.0)
Age ≥70 years	13 (13.0)
Female sex	63 (63.0)
Male sex	37 (37.0)
Duration of symptoms, years	5.8 ± 3.3
Bilateral knee involvement	61 (61.0)

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Characteristic	Value
Right-knee involvement	22 (22.0)
Left-knee involvement	17 (17.0)
Body mass index, kg/m²	27.7 ± 4.1
Normal BMI	26 (26.0)
Overweight	42 (42.0)
Obese	32 (32.0)
Hypertension	44 (44.0)
Diabetes mellitus	26 (26.0)
Kellgren–Lawrence grade I	15 (15.0)
Kellgren–Lawrence grade II	35 (35.0)
Kellgren–Lawrence grade III	32 (32.0)
Kellgren–Lawrence grade IV	18 (18.0)
Visual analogue scale pain score	5.4 ± 1.5
Total WOMAC score	53.9 ± 17.1
Knee flexion, degrees	113.0 ± 13.8

Note. Data are presented as mean ± standard deviation or n (%). BMI = body mass index; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

The analyzed cohort had a mean age of 58.6 ± 9.0 years (range, 40–78 years), and 63 participants (63.0%) were women. The mean symptom duration was 5.8 ± 3.3 years. Bilateral knee involvement was present in 61.0% of participants. The mean body mass index was 27.7 ± 4.1 kg/m²; 26.0% had normal weight, 42.0% were overweight, and 32.0% were obese. Hypertension and diabetes mellitus were present in 44.0% and 26.0%, respectively. Radiographically, 15.0% had Kellgren–Lawrence grade I disease, 35.0% grade II, 32.0% grade III, and 18.0% grade IV; thus, 50.0% had severe osteoarthritis (grade III or IV) (Table 1).

Association Between BMI and Radiographic Severity

Table 2: Distribution of Kellgren–Lawrence Grades by BMI Category

BMI category	Kellgren–Lawrence grade, n (%)				Total, n (%)
	Grade I	Grade II	Grade III	Grade IV	
Normal weight (n = 26)	9 (34.6)	12 (46.2)	4 (15.4)	1 (3.8)	26 (100.0)
Overweight (n = 42)	5 (11.9)	17 (40.5)	15 (35.7)	5 (11.9)	42 (100.0)
Obesity (n = 32)	1 (3.1)	6 (18.8)	13 (40.6)	12 (37.5)	32 (100.0)
Total	**15 (15.0)**	**35 (35.0)**	**32 (32.0)**	**18 (18.0)**	**100 (100.0)**

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Original Article

Note. Percentages are calculated within BMI category. Pearson's $\chi^2(6, N = 100) = 27.33$, $p < .001$. BMI = body mass index.

Radiographic severity increased progressively across body mass index categories. Severe osteoarthritis was present in 5 of 26 normal-weight participants (19.2%), 20 of 42 overweight participants (47.6%), and 25 of 32 participants with obesity (78.1%). Grade IV disease increased from 3.8% in the normal-weight group to 11.9% in the overweight group and 37.5% in the obesity group. Body mass index category was significantly associated with Kellgren–Lawrence grade, $\chi^2(6, N = 100) = 27.33$, $p < .001$ (Table 2). Mean body mass index also increased across radiographic grades, from 23.9 ± 2.7 kg/m² in grade I to 31.0 ± 3.7 kg/m² in grade IV, $F(3, 96) = 16.09$, $p < .001$.

Clinical severity across BMI categories

Table 3: Clinical characteristics by bmi category

Variable	Normal weight (n = 26)	Overweight (n = 42)	Obesity (n = 32)	Test statistic	p
Age, years	55.1 ± 8.7	58.2 ± 9.0	62.1 ± 8.1	$F(2, 97) = 4.80$	.010
Duration of symptoms, years	4.2 ± 2.5	5.7 ± 3.1	7.2 ± 3.6	$F(2, 97) = 6.61$	.002
Visual analogue scale score	4.1 ± 1.2	5.3 ± 1.3	6.5 ± 1.2	$F(2, 97) = 26.85$	< .001
Total WOMAC score	39.8 ± 12.7	52.6 ± 13.5	67.1 ± 14.8	$F(2, 97) = 28.67$	< .001
Knee flexion, degrees	122.6 ± 10.8	114.2 ± 11.5	103.7 ± 13.0	$F(2, 97) = 18.66$	< .001
Severe osteoarthritis, n (%)	5 (19.2)	20 (47.6)	25 (78.1)	$\chi^2(2) = 22.05$	< .001

Note. Continuous variables are presented as mean ± standard deviation and were compared using one-way analysis of variance. Severe osteoarthritis was defined as Kellgren–Lawrence grade III or IV and was compared using Pearson's chi-square test. BMI = body mass index; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

Clinical severity also showed a graded relationship with body mass index. Mean visual analogue scale pain scores increased from 4.1 ± 1.2 in the normal-weight group to 5.3 ± 1.3 in the overweight group and 6.5 ± 1.2 in the obesity group, $F(2, 97) = 26.85$, $p < .001$. Total WOMAC scores increased in parallel (39.8 ± 12.7, 52.6 ± 13.5, and 67.1 ± 14.8, respectively), $F(2, 97) = 28.67$, $p < .001$, whereas mean knee flexion decreased from 122.6 ± 10.8° to 114.2 ± 11.5° and 103.7 ± 13.0°, $F(2, 97) = 18.66$, $p < .001$. Participants with obesity were also older and had a longer duration of symptoms (Table 3).

Correlations Between BMI and Osteoarthritis Measures

Table 4: Correlations of BMI With Clinical and Radiographic Measures

Outcome measure	Correlation coefficient	p
Kellgren–Lawrence grade	.49	< .001
Visual analogue scale pain score	.51	< .001
Total WOMAC score	.57	< .001
Duration of symptoms	.32	.001
Knee flexion	−.47	< .001

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Original Article

Note. Pearson's correlation coefficient (r) was used for continuous variables; Spearman's rank-order coefficient (ρ) was used for Kellgren–Lawrence grade. BMI = body mass index; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

Body mass index correlated positively with Kellgren–Lawrence grade (Spearman's $\rho = .49$, $p < .001$), pain intensity ($r = .51$, $p < .001$), total WOMAC score ($r = .57$, $p < .001$), and symptom duration ($r = .32$, $p = .001$). It correlated inversely with knee flexion ($r = -.47$, $p < .001$), indicating greater restriction of movement at higher body mass index values (Table 4). The total WOMAC score was also strongly correlated with radiographic grade (Spearman's $\rho = .61$, $p < .001$), while symptom duration showed a weaker positive correlation with radiographic severity (Spearman's $\rho = .34$, $p = .001$).

Predictors of Severe Knee Osteoarthritis

Table 5: Logistic Regression Analysis of Factors Associated With Severe Knee Osteoarthritis

Predictor	Crude OR [95% CI]	p	Adjusted OR [95% CI]	p
Normal weight	Reference	—	Reference	—
Overweight	3.82 [1.15, 12.69]	.029	2.65 [0.73, 9.61]	.139
Obesity	15.00 [4.17, 53.93]	< .001	8.21 [2.05, 32.89]	.003
Age, per 1-year increase	1.07 [1.02, 1.12]	.006	1.06 [1.01, 1.12]	.021
Female sex	1.46 [0.64, 3.34]	.368	1.24 [0.49, 3.14]	.650
Symptom duration, per year	1.20 [1.07, 1.35]	.002	1.17 [1.02, 1.34]	.025

Note. Severe osteoarthritis was defined as Kellgren–Lawrence grade III or IV. The adjusted model included BMI category, age, sex, and symptom duration. OR = odds ratio; CI = confidence interval; BMI = body mass index.

In unadjusted analysis, overweight participants had 3.82-fold higher odds of severe osteoarthritis than normal-weight participants, while participants with obesity had 15.00-fold higher odds. After adjustment for age, sex, and symptom duration, obesity remained independently associated with severe osteoarthritis (adjusted OR = 8.21, 95% CI [2.05, 32.89], $p = .003$), whereas the association with overweight status was attenuated and was no longer statistically significant (adjusted OR = 2.65, 95% CI [0.73, 9.61], $p = .139$). Increasing age and longer symptom duration were also independently associated with severe disease, while sex was not (Table 5). Collectively, the results indicate that higher body mass index was associated with greater radiographic severity, more pain, poorer functional status, and reduced knee flexion.

Discussion

The study analyzed 100 adults with symptomatic primary knee osteoarthritis after 106 patients were assessed for eligibility; the mean age was 58.6 ± 9.0 years, 63.0% were women, and 74.0% were either overweight or obese (Figure 1 and Table 1). In relation to the primary objective, radiographic severity increased markedly across body mass index categories, with severe osteoarthritis rising from 19.2% in normal-weight participants to 78.1% among those with obesity (Table 2). The secondary clinical objectives showed the same direction: higher body mass index was associated with greater pain and functional impairment and with lower knee flexion (Table 3), while correlation analyses demonstrated significant relationships with radiographic grade, pain, WOMAC score, symptom duration, and knee flexion (Table 4). Finally, obesity remained independently associated with severe radiographic osteoarthritis after adjustment for age, sex, and symptom duration (Table 5).

The radiographic findings directly support the study objective of determining whether body mass index is associated with structural severity. The progressive shift toward Kellgren–Lawrence grades III and IV across increasing body mass index categories (Table 2) is consistent with established epidemiological evidence showing that excess body weight precedes or increases the risk of knee osteoarthritis. The Framingham cohort identified obesity as an important antecedent of knee

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Original Article

osteoarthritis, and Coggon and colleagues reported a pronounced increase in risk among adults with obesity.[3,4] Systematic reviews and prospective evidence have further demonstrated a consistent dose-response relationship between increasing body mass index and knee osteoarthritis risk.[5,6,11] Mechanistically, greater body mass increases repetitive tibiofemoral and patellofemoral loading, while adipose-derived inflammatory mediators may also contribute to cartilage degeneration and synovial inflammation.[1]

The clinical findings address the objective of examining pain, functional limitation, and knee movement in relation to body mass index. Participants with obesity had the highest pain and WOMAC scores and the lowest knee-flexion values (Table 3), and the correlation analysis showed a positive association of body mass index with pain and WOMAC score and an inverse association with knee flexion (Table 4). These results indicate that excess body weight is related not only to radiographic change but also to patient-experienced disability. Weiss reported greater knee pain at higher body mass index values even after accounting for radiographic severity, suggesting that load-independent mechanisms may contribute.[12] Cubukcu and colleagues also described relationships among pain, disability, and radiographic findings, although their strengths varied.[13] Pain-related reduction in physical activity may further promote weight gain, muscle weakness, and functional deterioration, producing a self-reinforcing cycle.

The multivariable analysis addressed the objective of determining whether overweight or obesity independently predicted severe radiographic disease. Obesity retained a strong association after adjustment, whereas the estimate for overweight was attenuated and became non-significant (Table 5). This difference may reflect limited statistical precision, overlap between body mass index and age, or a possible threshold effect in which more substantial adiposity produces clearer structural consequences. The wide confidence interval around the obesity estimate indicates uncertainty in its exact magnitude, although the direction is consistent with prospective dose-response evidence.[6] Increasing age and longer symptom duration were also independently associated with severe osteoarthritis, reinforcing the multifactorial nature of the disease.

These findings have practical implications for the objectives of risk identification and clinical management. Body mass index should be documented routinely, and patients with overweight or obesity should receive individualized counselling on dietary modification, low-impact aerobic activity, muscle strengthening, and joint-protection strategies. The IDEA randomized clinical trial showed that intensive diet-induced weight loss combined with exercise improved pain and function and reduced inflammatory and mechanical outcomes in adults with overweight or obesity and knee osteoarthritis.[14] Weight management should therefore be integrated with analgesia, physiotherapy, and management of cardiometabolic comorbidity rather than treated as an optional adjunct.

Generalizability

The findings are most generalisable to middle-aged and older adults with symptomatic primary knee osteoarthritis attending tertiary-care outpatient services in Telangana and comparable Indian settings. Consecutive recruitment and inclusion of both sexes and all radiographic grades improve clinical applicability. Generalisation to community populations, asymptomatic individuals, underweight patients, other ethnic groups, and patients managed exclusively in primary care should remain cautious because referral patterns and disease severity may differ substantially.

Conclusion

In this hospital-based cross-sectional study, increasing body mass index was strongly associated with greater radiographic and clinical severity of primary knee osteoarthritis. Obese participants had substantially higher frequencies of Kellgren–Lawrence grade III or IV disease, greater pain, higher WOMAC scores and reduced knee flexion compared with normal-weight participants. Obesity remained an independent predictor of severe osteoarthritis after adjustment for age, sex and symptom duration. These findings strengthen the evidence that excess body weight is a clinically relevant and modifiable factor in knee osteoarthritis. Early identification of elevated body mass index and integration of weight reduction, exercise and functional rehabilitation into routine care could reduce symptom burden and preserve mobility.

Limitations

The cross-sectional design prevents determination of temporal sequence or causality. Recruitment from a single tertiary-care hospital may introduce referral and selection bias despite consecutive enrolment. Body mass index does not distinguish fat mass from lean mass or capture central adiposity. Radiographic grading was based on one index knee, and interobserver reliability was not assessed. Residual confounding from occupation, physical activity, diet, and previous minor injury remains possible.

Recommendations

Body mass index should be assessed at every clinical encounter for knee osteoarthritis and incorporated into risk

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Original Article

stratification. Patients with overweight or obesity should receive structured dietary counselling, progressive low-impact exercise, quadriceps strengthening and realistic weight-loss targets. Multidisciplinary pathways involving orthopaedic surgeons, physicians, physiotherapists and dietitians are advisable for patients with severe symptoms or cardiometabolic comorbidity. Future multicentre prospective studies should include larger community-based samples, repeated anthropometric measurements, waist circumference, body-composition assessment and serial radiographs. Intervention studies should determine whether sustained weight reduction slows radiographic progression and improves pain, function, mobility and quality of life across different osteoarthritis phenotypes.

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Abbreviations

BMI: body mass index;
CI: confidence interval;
OR: odds ratio;
WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.

Source of funding

The study had no funding.

Conflict of interest

The authors declare no conflict of interest.

Author contributions

RC - conception and study design, interpretation of results, literature review, preparation of the first draft, statistical interpretation, and manuscript revision. KVSR - interpretation of results, literature review, preparation of the first draft, and manuscript revision.

Data availability

Data are available from the corresponding author on reasonable request.

Author biography

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Original Article

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