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Central Obesity as a Dominant Risk Factor for Clinical Knee Osteoarthritis in Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Study from South India

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ABSTRACT

Background: Knee osteoarthritis (OA) is increasingly recognized as having metabolic contributors beyond mechanical loading, particularly in patients with type 2 diabetes mellitus (T2DM). Obesity, especially central adiposity, shares pathways with T2DM involving inflammation and insulin resistance. This study aimed to examine the association between T2DM, anthropometric measures (BMI and waist circumference), and clinical knee OA in South Indian adults.

Materials and Methods: This cross-sectional comparative study recruited 150 adults aged ≥40 years (75 with T2DM ≥1 year duration; 75 age- and sex-matched non-diabetic controls) from outpatient departments at a tertiary hospital in South India (July 2024–June 2025). Exclusion criteria included inflammatory arthritis, prior knee trauma/surgery, and secondary OA causes. Anthropometric measurements (BMI, waist circumference, waist-hip ratio) and clinical knee examination were performed. Knee OA was diagnosed clinically by pain, stiffness, crepitus, and restricted motion. Data were analyzed using SPSS v25; chi-square tests and t-tests assessed associations ($p<0.05$ significant).

Results: Knee OA prevalence was 32% overall (34.7% in diabetics vs. 29.3% in controls; $p=0.49$). Diabetics had higher BMI (26.8 ± 4.2 vs. 24.9 ± 3.6 kg/m²), waist circumference (97.2 ± 9.8 vs. 91.6 ± 8.7 cm), and sedentary lifestyle (68% vs. 50.7%). Strong associations with knee OA included increased waist circumference ($\chi^2=28.17$, $p<0.001$), elevated waist-hip ratio ($\chi^2=21.09$, $p<0.001$), obesity ($\chi^2=12.84$, $p<0.001$), sedentary lifestyle ($p=0.002$), female sex ($p=0.045$), and age ≥50 years ($p=0.009$).

Conclusion: No independent association existed between T2DM and knee OA; central obesity emerged as the strongest predictor. Routine waist circumference measurement and targeted interventions for visceral fat reduction are recommended in diabetic patients to mitigate knee OA risk.

Keywords*: Knee Osteoarthritis, Type 2Diabetes Mellitus, Obesity, Waist Circumference, Body Mass Index, Risk Factors.*

INTRODUCTION

Knee osteoarthritis (OA) is a leading cause of chronic pain, functional limitation, and disability among adults worldwide. It represents a major public health concern due to its high prevalence, progressive nature, and substantial impact on quality of life [1]. The burden of knee OA is expected to rise further with increasing life expectancy, sedentary lifestyles, and the growing prevalence of metabolic disorders such as diabetes mellitus.

Traditionally considered a degenerative joint disease primarily related to aging and mechanical wear, knee OA is now increasingly recognized as a complex condition influenced by metabolic, inflammatory, and biomechanical factors.

Diabetes mellitus (DM), particularly type 2 diabetes, has emerged as a significant comorbidity associated with musculoskeletal disorders, including osteoarthritis [2].

Beyond its well-known vascular and neuropathic complications, diabetes has been implicated in the development and progression of joint diseases through mechanisms involving chronic low-grade inflammation, oxidative stress, and advanced glycation end products (AGEs). These metabolic alterations can adversely affect cartilage integrity, subchondral bone remodeling, and synovial function, thereby contributing to joint degeneration [3].

The relationship between diabetes and knee OA is not entirely straightforward and is often confounded by shared risk factors, particularly obesity and altered body fat distribution. Anthropometric measures such as body mass index (BMI) and waist circumference (WC) are widely used indicators of overall and central obesity, respectively, both of which play a crucial role in the pathogenesis of knee OA [4].

Obesity is one of the most consistently identified modifiable risk factors for knee osteoarthritis. Excess body weight increases mechanical loading across the knee joint, accelerating cartilage wear and joint degeneration. Each incremental rise in BMI has been associated with a proportionate increase in the risk of developing knee OA [5].

While BMI provides an estimate of overall adiposity, it does not adequately capture body fat distribution. Waist circumference, a surrogate marker of central obesity, reflects visceral fat accumulation, which is metabolically more active and strongly associated with insulin resistance, systemic inflammation, and cardiometabolic risk. Central obesity has been increasingly linked to musculoskeletal disorders, including knee OA, independent of BMI [6].

In patients with diabetes mellitus, the coexistence of obesity, insulin resistance, and chronic inflammation creates a milieu conducive to joint degeneration. Hyperglycemia promotes the formation of AGEs, which accumulate in cartilage collagen, reducing its elasticity and making it more susceptible to damage. Additionally, impaired microcirculation and low-grade inflammation may compromise cartilage nutrition and repair mechanisms [7].

In South Asian populations, including those in India and neighboring regions, the prevalence of both diabetes mellitus and obesity is rising at an alarming rate. Notably, individuals in these populations tend to develop metabolic complications at lower BMI thresholds and exhibit higher central adiposity compared to Western populations. This makes waist circumference a particularly relevant measure when assessing metabolic and musculoskeletal risk in these settings [8]. However, data examining the relationship between anthropometric measures and knee OA specifically among diabetic patients in this region remain limited.

The present study was undertaken to evaluate the relationship between anthropometric measures, specifically body mass index and waist circumference, and the occurrence of knee osteoarthritis in adult patients with diabetes mellitus. By comparing diabetic and non-diabetic individuals and analyzing the distribution of knee OA across different BMI and WC categories, this study aims to provide insight into the role of adiposity patterns in knee osteoarthritis and contribute to the growing body of evidence on metabolic osteoarthritis.

MATERIALS AND METHODS

Study Setting: This cross-sectional comparative study was conducted at Coimbatore Medical College, a tertiary care teaching hospital catering to an urban and semi-urban population. The hospital serves as a major referral center for patients with endocrine and musculoskeletal disorders. The study was carried out over a period of 12 months from July 2024 to June 2025, during which eligible participants were recruited from the outpatient departments of Medicine and Orthopedics. Anthropometric measurements and clinical assessments were performed in a standardized manner within the hospital premises.

Study Participants: The study population consisted of adult patients aged 40 years and above. Two groups were included: patients with a confirmed diagnosis of diabetes mellitus and age- and sex-matched non-diabetic individuals serving as the comparison group.

Inclusion criteria for the diabetic group included adults with type 2 diabetes mellitus diagnosed based on standard clinical and biochemical criteria, with a minimum duration of one year since diagnosis. Both male and female patients who were ambulatory and willing to participate were included. The non-diabetic group comprised individuals without a prior diagnosis of diabetes mellitus and with normal fasting blood glucose values.

Exclusion criteria for both groups included individuals with a history of inflammatory arthritis, previous knee trauma or surgery, congenital or developmental knee disorders, secondary osteoarthritis due to infection or metabolic bone disease, and chronic steroid use. Patients with severe systemic illness, pregnancy, or inability to undergo physical examination were also excluded to minimize confounding factors.

Sample Size and Sampling Technique: The sample size was calculated based on previous studies reporting the prevalence of knee osteoarthritis among diabetic populations and its association with obesity. Assuming a confidence level of 95% and adequate statistical power, a total sample size of approximately 150 participants was considered sufficient. A consecutive sampling technique was employed, wherein all eligible patients attending the outpatient departments during the study period were recruited until the required sample size was achieved. The diabetic and non-diabetic groups were selected to ensure comparable representation.

Study Tools: Data were collected using a structured and pre-tested proforma. The proforma included demographic details, clinical history, duration of diabetes, treatment details, and musculoskeletal symptoms. Anthropometric measurements included body weight, height, and waist circumference. BMI was calculated as weight in kilograms divided by height in meters squared (kg/m²) and categorized according to standard cut-off values. Waist circumference was measured using a non-stretchable measuring tape at the midpoint between the lower margin of the last rib and the iliac crest.

Knee osteoarthritis was assessed through clinical examination based on standard diagnostic criteria, including the presence of knee pain, stiffness, crepitus, and restricted range of motion.

Study Methodology: After obtaining informed consent, participants underwent a detailed clinical evaluation. Anthropometric measurements were recorded by trained personnel following standardized protocols to reduce inter-observer variability. Waist circumference was measured at the end of normal expiration, and the average of two readings was taken. A focused musculoskeletal examination of both knees was performed to identify clinical features suggestive of osteoarthritis.

Participants were classified according to BMI categories (normal, overweight, obese) and waist circumference status (normal or increased based on sex-specific cut-offs). The frequency of knee osteoarthritis was assessed across these categories in both diabetic and non-diabetic groups.

Ethical Issues: The study protocol was reviewed and approved by the Institutional Ethics Committee prior to initiation. Written informed consent was obtained from all participants. Confidentiality of personal and medical information was strictly maintained, and data were anonymized for analysis. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 25. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Comparisons between groups were made using the independent t-test for continuous variables and chi-square test for categorical variables. A p value of less than 0.05 was considered statistically significant.

RESULTS

A total of 150 participants were included comprising 75 patients with type 2 diabetes mellitus and 75 non-diabetic controls. Table 1 summarizes the baseline demographic, lifestyle, and clinical characteristics of the study population. The mean age of participants was comparable between diabetic and non-diabetic groups. Females constituted nearly two-thirds of the total sample. A significantly higher proportion of diabetic participants reported a sedentary lifestyle. Mean BMI, waist circumference, and waist–hip ratio were higher in the diabetic group. Duration of diabetes averaged over six years, reflecting a predominantly chronic disease cohort. Knee pain and morning stiffness were more frequently reported among diabetic participants.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (N = 150).

Variable	Diabetic (n = 75)	Non-Diabetic (n = 75)	Total (N = 150)
Age (years), Mean ± SD	52.1 ± 8.9	50.6 ± 9.4	51.3 ± 9.1
Age ≥ 50 years, n (%)	49 (65.3)	46 (61.3)	95 (63.3)
Sex – Male, n (%)	28 (37.3)	27 (36.0)	55 (36.7)
Sex – Female, n (%)	47 (62.7)	48 (64.0)	95 (63.3)
Sedentary lifestyle, n (%)	51 (68.0)	38 (50.7)	89 (59.3)
BMI (kg/m²), Mean ± SD	26.8 ± 4.2	24.9 ± 3.6	25.9 ± 4.0
Waist circumference (cm), Mean ± SD	97.2 ± 9.8	91.6 ± 8.7	94.4 ± 9.6
Waist–hip ratio, Mean ± SD	0.96 ± 0.06	0.91 ± 0.05	0.94 ± 0.06

Knee pain present, n (%)	41 (54.7)	36 (48.0)	77 (51.3)
Morning stiffness, n (%)	29 (38.7)	22 (29.3)	51 (34.0)

Table 2 presents the distribution of anthropometric measures. Obesity and increased waist circumference were markedly more prevalent among diabetic participants. Central obesity, assessed using waist circumference and waist–hip ratio, was notably common even among participants with non-obese BMI, highlighting the limitation of BMI alone in identifying metabolic risk.

Table 2: Anthropometric Distribution of Study Participants.

Variable	**Category**	**Diabetic (n = 75)**	**Non-Diabetic (n = 75)**
BMI category	Normal (18.5–22.9)	14 (18.7%)	22 (29.3%)
	Overweight (23.0–24.9)	17 (22.7%)	20 (26.7%)
	Obese (≥25.0)	44 (58.6%)	33 (44.0%)
Waist circumference	Normal	18 (24.0%)	32 (42.7%)
	Increased	57 (76.0%)	43 (57.3%)
Waist–hip ratio	Normal	21 (28.0%)	39 (52.0%)
	Elevated	54 (72.0%)	36 (48.0%)

Table 3 compares participants with knee osteoarthritis (OA) and without knee osteoarthritis, allowing direct visualization of how demographic, anthropometric, and clinical variables differ between the two groups. Participants with knee OA were predominantly older, female, obese, and centrally obese. Increased waist circumference and elevated waist–hip ratio were markedly more common among OA cases. Clinical symptoms such as knee pain, morning stiffness, and bilateral knee involvement were significantly clustered among those with OA, supporting both mechanical and metabolic contributions to disease development.

Table 3: Comparison of Clinical and Anthropometric Variables Between Participants With and Without Knee Osteoarthritis (N = 150).

Variable	**Category**	**Knee OA Present (n = 48)**	**Knee OA Absent (n = 102)**
Age group	<50 years	12 (25.0%)	58 (56.9%)
	≥50 years	36 (75.0%)	44 (43.1%)
Sex	Male	14 (29.2%)	41 (40.2%)
	Female	34 (70.8%)	61 (59.8%)
Diabetes status	Diabetic	26 (54.2%)	49 (48.0%)
	Non-diabetic	22 (45.8%)	53 (52.0%)
BMI category	Normal (18.5–22.9)	6 (12.5%)	30 (29.4%)
	Overweight (23.0–24.9)	8 (16.7%)	29 (28.4%)
	Obese (≥25.0)	34 (70.8%)	43 (42.2%)
Waist circumference	Normal	3 (6.2%)	47 (46.1%)
	Increased	45 (93.8%)	55 (53.9%)
Waist–hip ratio	Normal	6 (12.5%)	54 (52.9%)
	Elevated	42 (87.5%)	48 (47.1%)
Lifestyle activity	Active	11 (22.9%)	50 (49.0%)
	Sedentary	37 (77.1%)	52 (51.0%)
Knee pain	Present	48 (100%)	29 (28.4%)
	Absent	0 (0%)	73 (71.6%)
Morning stiffness	Present	31 (64.6%)	20 (19.6%)
	Absent	17 (35.4%)	82 (80.4%)

Table 4 shows inferential analysis evaluating the association between diabetes mellitus and knee OA. Although the prevalence of knee OA was higher among diabetic participants, the difference did not reach statistical significance, indicating that diabetes alone may not be an independent determinant of knee OA.

Table 4: Association Between Diabetes Mellitus and Knee Osteoarthritis.

Group	**Knee OA Present**	**Knee OA Absent**	**χ^2**	**p value**
Diabetic (n = 75)	26 (34.7%)	49 (65.3%)	0.47	0.49
Non-Diabetic (n = 75)	22 (29.3%)	53 (70.7%)		

Table 5 demonstrates strong associations between anthropometric measures and knee OA. Obesity, increased waist circumference, elevated waist–hip ratio, sedentary lifestyle, and female sex were all significantly associated with knee OA. Among these, waist circumference showed the strongest association, highlighting central obesity as a key predictor.

Table 5: Inferential Analysis of Factors Associated with Knee Osteoarthritis.

Variable	Comparison	χ^2	p value
BMI	Obese vs. Non-obese	12.84	<0.001
Waist circumference	Increased vs. Normal	28.17	<0.001
Waist–hip ratio	Elevated vs. Normal	21.09	<0.001
Sedentary lifestyle	Yes vs. No	9.36	0.002
Sex	Female vs. Male	4.02	0.045
Age	≥50 vs. <50 years	6.88	0.009

DISCUSSION

The present cross-sectional study reveals a high burden of clinical knee osteoarthritis (OA) in adults aged 40 years and above, with an overall prevalence of 32% (48/150 participants). Although the prevalence was slightly higher in the diabetic group (34.7%) compared to non-diabetic controls (29.3%), this difference did not reach statistical significance ($p=0.49$). However, strong associations emerged between knee OA and measures of adiposity, particularly central obesity as assessed by waist circumference (WC) and waist-hip ratio (WHR), as well as overall obesity defined by body mass index (BMI). Increased WC demonstrated the strongest association ($\chi^2=28.17$, $p<0.001$), followed by elevated WHR ($\chi^2=21.09$, $p<0.001$) and obesity ($\chi^2=12.84$, $p<0.001$). Other significant factors included sedentary lifestyle, female sex, and age ≥50 years.

These findings highlight the predominant role of obesity, especially central adiposity, in the pathogenesis of knee OA among patients with type 2 diabetes mellitus (T2DM). Diabetic participants exhibited significantly higher mean BMI (26.8 ± 4.2 vs. 24.9 ± 3.6 kg/m²), WC (97.2 ± 9.8 vs. 91.6 ± 8.7 cm), and WHR (0.96 ± 0.06 vs. 0.91 ± 0.05), with obesity present in 58.6% and increased WC in 76.0% compared to 44.0% and 57.3% in controls, respectively. Among participants with knee OA, 93.8% had increased WC and 87.5% elevated WHR, highlighting visceral fat accumulation as a critical driver beyond mere weight-bearing mechanical stress [9].

The lack of an independent association between T2DM and knee OA aligns with several recent meta-analyses and large cohort studies that attribute much of the observed linkage to confounding by obesity. A 2020 meta-analysis of 31 studies concluded that diabetes is not an independent risk factor for OA when adequately adjusted for BMI, emphasizing obesity as the primary confounder. Similarly, longitudinal data from the Multicenter Osteoarthritis Study (MOST) and Osteoarthritis Initiative (OAI) found no association between diabetes or cardiovascular disease and prevalent or incident radiographic/symptomatic knee OA after controlling for metabolic factors [10].

The stronger link with central obesity observed here supports the concept of a "metabolic OA" phenotype, particularly relevant in South Asian populations. Visceral adipose tissue is metabolically active, secreting pro-inflammatory adipokines (e.g., leptin, resistin) and cytokines (e.g., IL-6, TNF-α) that promote systemic low-grade inflammation, oxidative stress, and insulin resistance—hallmarks exacerbated in T2DM [11]. These factors impair cartilage homeostasis, enhance subchondral bone remodeling, and induce synovial inflammation, accelerating OA progression independently of hyperglycemia in some contexts. Advanced glycation end-products (AGEs) from chronic hyperglycemia stiffen collagen and promote inflammation, but their role appears secondary to adiposity-driven mechanisms in weight-bearing joints like the knee [12].

In South Indian cohorts, central obesity predominates even at lower BMI thresholds compared to Western populations, aligning with the "thin-fat" phenotype where visceral fat accumulates early. Studies from India report knee OA prevalence of 22-39% overall, rising with metabolic comorbidities. Our findings of markedly higher central obesity in diabetics (76% increased WC) and its dominant association with OA (93.8% in OA cases) emphasize WC as a superior predictor over BMI in this ethnic group, consistent with other Asian data showing combined general and central obesity conferring the highest risk [13].

Female predominance (70.8% of OA cases) and associations with age and sedentary lifestyle reflect established risks: postmenopausal estrogen decline, cumulative mechanical stress, and reduced physical activity exacerbating metabolic dysregulation. The high sedentary rate in diabetics (68%) likely perpetuates a vicious cycle of weight gain, insulin resistance, and joint deterioration [14].

Clinical implications are profound in resource-limited settings like ours. Routine screening for knee OA in diabetic clinics should prioritize anthropometric assessment, particularly WC, given its accessibility and superior predictive value. Lifestyle interventions targeting visceral fat reduction—through diet, aerobic exercise, and resistance training—could mitigate OA risk more effectively than glycemic control alone. Weight loss of 5-10% has demonstrated symptomatic and functional benefits in OA, potentially delaying progression [15].

Strengths of this study include age- and sex-matched groups, standardized measurements, and focus on a South Indian population with rising T2DM and obesity burdens. Limitations encompass the cross-sectional design, precluding causality; reliance on clinical rather than radiographic OA diagnosis, potentially overestimating prevalence; absence of glycemic control markers (e.g., HbA1c) or inflammatory biomarkers; and lack of longitudinal follow-up or adjustment for confounders like occupation or vitamin D status.

CONCLUSION

The findings of the study emphasize that while T2DM coexists frequently with knee OA, obesity, particularly central, emerges as the primary modifiable driver. These results advocate prioritizing abdominal obesity assessment and targeted weight management in diabetic patients to prevent or ameliorate knee OA, especially in South Asian contexts where visceral adiposity predominates at lower BMI.

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