International Journal of Health Sciences and Research
[Indexed, Peer-Reviewed Journal]
Volume 15; Issue: 9; September 2025
Website: www.ijhsr.org
Original Research Article *ISSN: 2249-9571*

Gender-Based Differences in Musculoskeletal Disorders among Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Study from North India

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DOI: https://doi.org/10.52403/ijhsr.20250917

ABSTRACT

AIM: This study aims to evaluate the prevalence of musculoskeletal diseases among patients with Type 2 Diabetes Mellitus according to gender. In order to promote gender-sensitive diabetes care, it attempts to investigate the ways in which sex-specific characteristics such as hormones, body composition, and lifestyle contribute to these issues.
METHOD AND MATERIALS: This 12-month cross-sectional analytical investigation was carried out in the orthopaedic outpatient clinics at RML-IMS and KGMU in Lucknow. Convenient sampling was used to register 400 adult patients with Type 2 Diabetes Mellitus. Laboratory testing (FBS, PPBS, HbA1c), radiographic evaluations, anthropometric measures, and thorough clinical evaluations were also carried out. To evaluate gender-based differences, the data were statistically analysed, with significance defined at $p < 0.05$.
RESULTS: Tendinitis (37%) and adhesive capsulitis (35.5%) were the most prevalent musculoskeletal conditions among 400 T2DM patients. Dupuytren's contracture (12.5%), carpal tunnel syndrome (9.3%), and cheiroarthropathy (2.3%) were next in line. There was notable gender-based disparities: tendinitis was more common in females ($p = 0.021$), whereas adhesive capsulitis was more common in males ($p = 0.003$).
CONCLUSION: Glycaemic management, BMI, and lifestyle all have an impact on the study's findings, which show notable gender-based variations in musculoskeletal problems among T2DM patients. Including gender-sensitive methods can improve diabetes management results and early detection
KEYWORDS: Type 2 Diabetes Mellitus, Musculoskeletal Disorders, Gender Differences, Tendinitis, Adhesive Capsulitis, Gender Medicine, Diabetic Complications

INTRODUCTION

The most prevalent and clinically significant metabolic disease, type 2 diabetes (T2D), has emerged as a global pandemic in recent decades and is a significant global healthcare burden. An estimated 382 million people worldwide suffered from diabetes in 2013. [1] The frequency of type 2 diabetes is alarmingly rising, with estimates indicating that by 2035, over 590 million people will have been diagnosed with the illness. [1, 2] Diabetes is a "metabolic

disorder of multiple aetiology characterised by chronic hyperglycemia with disturbance of carbohydrate, fat, and protein metabolism resulting from defects in insulin secretion, insulin action, or both," according to the World Health Organisation (WHO). [3] Type 2 diabetes is the most common variety of the disease, accounting for an estimated 90% of cases. Type 1 diabetes (T1D) accounts for the bulk of the remaining 10% of cases, however there are other uncommon forms as well. [4] Insulin resistance in peripheral tissues and decreased insulin synthesis and secretion by pancreatic beta-cells are the main causes of type 2 diabetes. [5, 6] The aetiology of type 2 diabetes is generally believed to be associated with diets that involve excessive nutrient consumption mixed with insufficient energy expenditure, as around 90% of patients are fat or overweight at the time of diagnosis. [7]

Male and female disparities in the propensity, development, and clinical presentation of diabetes mellitus are clearly influenced by the biological, cultural, lifestyle, environmental, and socioeconomic variances of the diverse groups being studied. Taking into account the sociocultural context of the communities, sedentary lifestyle, nutritional determinants, and genetic inheritance and epigenetic mechanisms affect risk and problems differently in both sexes. It has recently been noted that there may be gender-specific differences in diabetes mellitus, with evidence indicating that women often have higher body mass indexes (BMIs) and longer years of disease than men. [8] Accompanying the increasing evidence of clinically significant gender variations in the aetiology of type 2 diabetes mellitus, there has been a dramatic rise in the disease and its related comorbidities. Differences in diabetes risk and outcome by sex and gender are caused by both biological and psychological variables. Because these intricate components are interrelated and interact throughout life, it is very hard to always distinguish clearly between gender influences and external factors or variations in day-to-day living. [9] Furthermore, the fact that women frequently face discrimination in access to primary and secondary screening controls, as well as more generally in access to health care, may potentially have an impact on these figures in many regions of the world. Given that women typically have lower insulin sensitivity than men, which means they require more insulin units to maintain optimal glycaemic values and comply with therapeutic goals, diabetes mellitus appears to be less controlled in women when taking into account all metabolic parameters. [10]

In a Danish study, musculoskeletal discomfort was significantly more common in patients with type 2 diabetes than in the general population, which was matched for age, gender, and area. A key component of the therapy of type 2 diabetes was physical activity, which could only be improved with proper pain management. Despite being more common in women than in men, pain was linked to being overweight, leading a sedentary lifestyle, and having poorer physical function in both sexes. Losing weight may be a key component of treating musculoskeletal discomfort in people with type 2 diabetes. [11]

It was shown that individuals with diabetes had a higher prevalence of hand issues than persons without the disease. 3.5% of patients had reduced joint mobility, 6.3% had trigger finger, and 8.8% had carpal tunnel syndrome. Diabetes duration (≥10 years) was found to be linked to these illnesses ($p = 0.017$). It was consistently found that the hand deformity and the length of diabetes were related. Additionally, they discovered that dyslipidaemia and a higher prevalence of hand problems were significantly correlated ($p = 0.019$). The high prevalence of overweight in this cohort and advanced age appeared to be contributing factors to this connection with type 2 diabetes. The most often impacted joints were the hands, spine, and knees. They discovered that the presence of osteoarthritis was substantially correlated

with older age, female gender, and overweight ($p = 0.01$, $p = 0.009$, and $p = 0.004$, respectively). [12]

Understanding these gender-based disparities is essential for developing tailored prevention strategies and gender-sensitive treatment protocols. This study aims to investigate the correlation between gender and the prevalence of T2DM and its musculoskeletal disorder complication, thereby contributing to more equitable and effective diabetes care.

MATERIAL AND METHODS

Study Design and Setting

The study was carried out at Department of Physiology at King George's Medical University (KGMU) in collaboration with Department of Orthopaedics, Dr. Ram Manohar Lohia Institute of Medical Sciences (RML-IMS), Lucknow, India, were the sites of this 12-month hospital-based cross-sectional analytical study.

Study Population

Based on their presenting musculoskeletal problems, 400 adult patients were selected from the orthopaedic outpatient departments. Convenient sampling was used for recruitment in order to accommodate for any dropouts, even though 129 was the lowest estimated sample size.

Inclusion Criteria

Patients that are at least 18 years old, both male and female, Patients with type 2 diabetes mellitus who are known or recently diagnosed and visit orthopaedic outpatient departments

Exclusion Criteria

Individuals suffering from gestational diabetes mellitus (GDM) or type 1 diabetes, Trauma history, Musculoskeletal conditions that are congenital, Additional recognised diabetic consequences, such as heart disease, retinopathy, and nephropathy, Cancer, autoimmune disease, or chronic systemic sickness, Proven instances of reactive arthritis, gout, osteoarthritis, rheumatoid arthritis, or osteoporosis

METHODOLOGY

All recruited participants underwent detailed clinical evaluation, including assessment of:

- Anthropometric measurements: height, weight, and body mass index (BMI)
- Vital parameters: blood pressure
- Laboratory investigations: fasting blood sugar, post-prandial blood sugar, and glycosylated hemoglobin (HbA1c)
- Patients were classified as diabetic or non-diabetic based on documented blood glucose reports or newly advised investigations.

Screening and Diagnostic Criteria

A history, physical examination, and, if required, radiographic evaluations were used to screen each subject for certain musculoskeletal problems. The following clinical criteria were used in the diagnosis process:

- The symptoms of adhesive capsulitis include limited active and passive glenohumeral mobility in a capsular pattern (external rotation > abduction > internal rotation) and unilateral or bilateral shoulder pain without any history of trauma.
- Diabetic Cheiroarthropathy: Positive prayer sign or tabletop sign indicating palmar fibrosis and joint contractures, along with limited joint motion.
- Digital flexion contracture, thickened pre-tendinous bands, palmar/digital nodules, or palpable thickening of the palmar fascia are all signs of Dupuytren's contracture.
- Carpal Tunnel Syndrome (CTS): Positive Phalen's test (paraesthesia brought on by wrist flexion) and/or Tinel's sign (pain that feels like an electric shock while tapping the carpal tunnel).
- Trigger finger, also known as flexor tenosynovitis, is characterised by a palpable nodule or thickened flexor tendon that hurts or locks when flexion

and extension movements are performed.

Patients with flexor tenosynovitis were included in the larger "tendinitis" group, which also included patients with de Quervain's tenosynovitis, trochanteric bursitis, pre-patellar bursitis, anserine bursitis, olecranon bursitis, bicipital tendinitis, epicondylitis (medial/lateral), and other upper and lower limb conditions.

Orthopaedic consultants validated the clinical evaluations. Appropriate testing was recommended for patients without current blood glucose records, and results were gathered during follow-up. Using the created questionnaire, personal information, pertinent medical history (such as comorbidities, family history, and lifestyle factors), and clinical findings were methodically documented and analysed on the basis of gender.

RESULTS

The analysis comprised 400 examples in all. Middle-aged people made up the majority of the population: 7.5% (n = 30) were between the ages of 30 and 39, 44.8% (n = 179) were between the ages of 40 and 49, 38.8% (n = 155) were between the ages of 50 and 59, and 9.0% (n = 36) were 60 years of age or older. In terms of sex distribution, women made up 44.0% (n = 176) and men 56.0% (n = 224) of the sample. It is commonly acknowledged that reporting demographic information like age and sex is crucial to comprehending the features of the study population and assessing how broadly the results can be applied.

Table – 1: Age & Sex Distribution of Cases

Variable		No.	%
Age	30 - 39 yr	30	7.5
	40 - 49 yr	179	44.8
	50 - 59 yr	155	38.8
	>= 60 yr	36	9.0
Gender	Male	224	56.0
	Female	176	44.0

Table-2. Distribution of musculoskeletal disorders, lifestyle activity levels, glycemic status, and BMI/obesity status among patients with type 2 diabetes.

Category	Subcategory	No.	%
Musculoskeletal Disorders	Adhesive Capsulitis	142	35.5
	Cheiroarthropathy	9	2.3
	Dupuytren's contracture	50	12.5
	Tendinitis	148	37.0
	Carpal tunnel syndrome	37	9.3
Lifestyle	Heavy (> 6 METs)	5	1.3
	Light & Moderate (1.6–5.9 METs)	51	12.8
	Sedentary (1–1.5 METs)	344	86.0
Glycemic Status	Controlled	97	48.5
	Uncontrolled (HbA1c > 7%)	103	51.5
BMI	Normal weight (18.5–24.9)	71	17.8
	Overweight (25–29.9)	289	72.3
	Obesity (≥ 30)	40	10.0
Obesity Status	Non-Obese	360	90.0
	Obese	40	10.0

The most common musculoskeletal conditions in this study of patients with type 2 diabetes (Table 2) were adhesive capsulitis (35.5%, 142/400) and tendinitis (37.0%, 148/400). These were followed by Dupuytren's contracture (12.5%, 50/400), carpal tunnel syndrome (9.3%, 37/400), and cheiroarthropathy (2.3%, 9/400). There were 86.0% (344/400) of participants who were sedentary (1–1.5 METs), 12.8% (51/400) who were light to moderately active (1.6–5.9 METs), and just 1.3%

(5/400) who were heavy/vigorous (>6 METs). 48.5% (97/200) of the 200 diabetic individuals whose glycaemic control was evaluated had regulated levels, while 51.5% (103/200) showed uncontrolled state (HbA1c > 7%). Participants' BMIs showed that 10.0% (40/400) were obese (BMI > 30), 17.8% (71/400) were in the normal weight range (BMI 18.5–24.9), and 72.3% (289/400) were overweight (BMI 25–29.9). The binary obesity classification, which classified 90.0% of people as non-obese and 10.0% as obese, supported these obesity findings.

Table – 3: Association of Musculoskeletal Disorders with gender among all Cases

Musculoskeletal Disorders		Gender				chi sq	p-value
		Male		Female			
		No.	%	No.	%		
Adhesive Capsulitis	No	137	61.2%	121	68.8%	2.48	0.115
	Yes	87	38.8%	55	31.3%		
Cheiroarthropathy	No	218	97.3%	173	98.3%	0.43	0.514
	Yes	6	2.7%	3	1.7%		
Dupuytren's contracture	No	196	87.5%	154	87.5%	0.00	1.000
	Yes	28	12.5%	22	12.5%		
Tendinitis	No	142	63.4%	110	62.5%	0.03	0.854
	Yes	82	36.6%	66	37.5%		
carpal tunnel syndrome	No	208	92.9%	155	88.1%	2.69	0.101
	Yes	16	7.1%	21	11.9%		

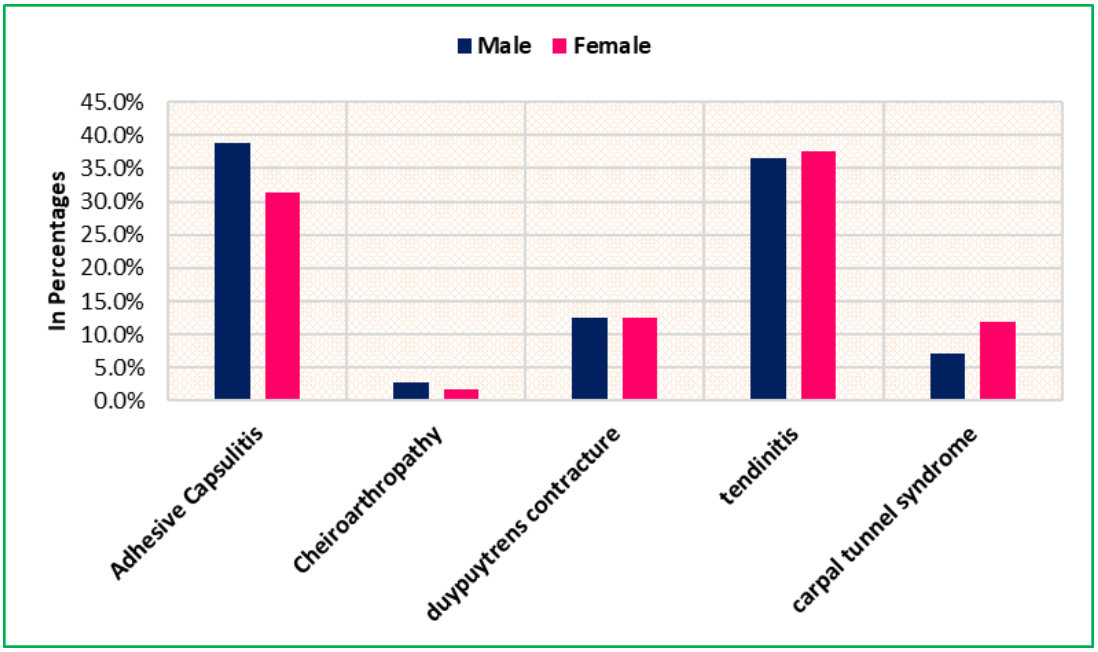

Fig-1 Association of Musculoskeletal Disorders with gender among all Cases

No statistically significant correlations between gender and any of the illnesses evaluated were found in the results. The test found that $\chi^2(1, N = 400) = 2.48$, $p = 0.115$ for adhesive capsulitis, $\chi^2(1, N = 400) = 0.43$, $p = 0.514$ for cheiroarthropathy, $\chi^2(1, N = 400) = 0.00$, $p = 1.000$ for Dupuytren's contracture, $\chi^2(1, N = 400) = 0.03$, $p = 0.854$ for tendinitis, and $\chi^2(1, N = 400) = 0.03$, $p = 0.854$ for carpal tunnel syndrome.

Table – 4: Association of Musculoskeletal Disorders with gender among T2DM Cases

Musculoskeletal Disorders		Gender				chi sq	p-value
		Male		Female			
		No.	%	No.	%		
Adhesive Capsulitis	No	49	45.4%	61	66.3%	8.80	0.003
	Yes	59	54.6%	31	33.7%		
Cheiroarthropathy	No	106	98.1%	90	97.8%	0.03	0.871

	Yes	2	1.9%	2	2.2%		
Dupuytren's contracture	No	83	76.9%	77	83.7%	1.45	0.228
	Yes	25	23.1%	15	16.3%		
Tendinitis	No	80	74.1%	54	58.7%	5.31	0.021
	Yes	28	25.9%	38	41.3%		
Carpal tunnel syndrome	No	98	90.7%	77	83.7%	2.25	0.133
	Yes	10	9.3%	15	16.3%		

The correlation between gender and the frequency of several musculoskeletal diseases in individuals with type 2 diabetes mellitus (T2DM) is shown in Table 4. Males had higher prevalence rates of adhesive capsulitis (χ^2 = 8.80, p = 0.003) and tendinitis (χ^2 = 5.31, p = 0.021), both of which showed statistically significant gender differences. However, as all p-values were higher than the 0.05 cutoff, no significant relationships were discovered for carpal tunnel syndrome (χ^2 = 2.25, p = 0.133), Dupuytren's contracture (χ^2 = 1.45, p = 0.228), or cheiroarthropathy (χ^2 = 0.03, p = 0.871).

DISCUSSION

The aetiology of diabetes and the progression of its consequences are fundamentally influenced by gender medicine. By controlling insulin secretion and action, glucose homeostasis, and the development of diabetes and its consequences, sex hormones contribute, at least in part, to these sex disparities. Understanding how the endocrine regulatory system and homeostasis interact is crucial for advancing the creation of gender-specific diabetes treatment options. [8] By comparing the distribution of musculoskeletal disorders (MSDs) in patients with type 2 diabetes mellitus (T2DM) to those without the disease and examining correlations with important variables like gender, obesity, glycaemic control, lifestyle, dietary practices, and length of diabetes, this study sought to close that gap.

The most frequent consequence among non-diabetics in our study was tendinitis, which was followed by carpal tunnel syndrome, shoulder adhesive capsulitis, Dupuytren's contracture, and cheiroarthropathy. Musculoskeletal diseases were positively correlated with gender, weight, lifestyle choices, glycaemic management, and length of diabetes: Males with diabetes are more likely than females to develop adhesive shoulder capsulitis. However, compared to men, diabetic women are more likely to have tendinitis. Compared to diabetics of normal weight, those who are overweight or obese are more likely to develop adhesive capsulitis (frozen shoulder), dupuytren's contracture, and tendinitis.

The majority of participants in this study were middle-aged men, with 56% of them being male and 44.8% being between the ages of 40 and 49. This demographic profile is consistent with other regional and Indian studies on the problems associated with type 2 diabetes. A study by Gutch et al. identified the mean age for beginning of MSDs in diabetics as 51 years, which corresponds closely with our findings. [13] Furthermore, our analysis offered a more nuanced view of gender-specific trends, whereas Ajay Kumar Singh et al. discovered a higher prevalence of MSDs in diabetic males than females. [14] In line with the findings of Bhatt et al. (2016), who identified tendinitis and shoulder abnormalities as the most common problems in diabetic populations, tendinitis (37%) and adhesive capsulitis (35.5%) were the most common MSDs among all those evaluated. [15]

Conversely, cheiroarthropathy (2.3%), carpal tunnel syndrome (9.3%), and Dupuytren's contracture (12.5%) were less prevalent, reflecting prevalence trends seen in earlier research. Interestingly, adhesive capsulitis was the most common condition among diabetics, indicating a disease-specific relationship, even though tendinitis was more common overall.

Significant correlations between gender and a number of MSDs were found in this investigation, especially in the diabetic subgroup. Male diabetics were more likely to have adhesive capsulitis ($p = 0.003$), whereas female diabetics were substantially more likely to have tendinitis ($p = 0.021$). These gender disparities may result from a confluence of hormonal factors, recurrent stressors associated with the job, and variations in body composition. Majjad et al. also found that diabetic females had greater incidences of tendinitis, which may indicate that postmenopausal hormonal changes and a higher body mass index make them more susceptible. [16] The rates of diabetic peripheral neuropathy [72.34% for women and 27.65% for men (p value<0.002)], diabetic nephropathy [56.28% for women and 43.71% for men (p value<0.000)], and ischaemic heart disease [57.98% for women and 42.01% for men (p value<0.001)] also showed significant gender differences, according to Ebadi et al. [18] At least one chronic vascular issue was present in 46.35% of men and 41.6% of women with diabetes when microvascular and macrovascular complications were taken into account jointly (p value of the gender differences =0.113). With the exception of sclerodactyly, which was equally common in both sexes, and carpal tunnel syndrome and osteoarthritis, which were more common in men, the prevalence of musculoskeletal disorders was higher in women (54.5%) than in men (45.3%). Osteoarthritis (23.5%) and adhesive capsulitis (20%) were the most prevalent musculoskeletal conditions. These were followed by olecranon bursitis (0.5), carpal tunnel syndrome (8.7%), trigger finger (7.7%), sclerodactyly (3.7%), Dupuytren's contracture (3%), and Charcot's joint (2%). [17]

The risk of type 2 diabetes is tightly linked to significant sex variations in physical activity, diet, and health behaviour. The findings highlight how important exercise is for preventing or lessening musculoskeletal problems in people with diabetes. 86% of patients reported leading a sedentary lifestyle (1–1.5 METs), which was a concerning trend according to lifestyle analysis. Carpal tunnel syndrome ($p < 0.001$), adhesive capsulitis ($p = 0.001$), and cheiroarthropathy ($p = 0.011$) were all substantially correlated with sedentary behaviour. Dietary practices did not significantly correlate with MSDs in this group, in contrast to other covariates. No particular dietary pattern was associated with an elevated risk, despite the fact that 63% of participants ate a non-vegetarian diet. This element is still not well covered in the literature and might benefit from more research. Women are generally less active, but they eat a healthier diet by eating more fruits and vegetables and less meat, according to sex-stratified health research data [18]. Only women had a higher risk of incident type 2 diabetes over a ten-year period in prospective cohort research with separate analysis for men and women. The risk was twofold for women who regularly drank soft drinks as opposed to non-alcoholic ones. [19] However, overall, it has been discovered that women with diabetes have a somewhat lower rate of mortality owing to sugar-sweetened beverages than men [20].

There is a gender difference in the prevalence of type 2 diabetes. Although men are more likely than women to have diabetes worldwide, type 2 diabetes affects more women than men [21]. According to the stage of reproductive life, the gender gap in diabetes prevalence is reversed: more men have the disease before puberty, whereas more women have it after menopause and in old age. This result is explained by the combined effect of the rising frequency of diabetes with age and the fact that most populations have more elderly women than males. This is a significant finding since, as was previously said, women have higher reduced glucose tolerance following meals. Therefore, one runs the danger of underestimating a much more obvious phenomena when determining the prevalence of diabetes in women by

using just fasting blood glucose as a screening and excluding post-prandial blood glucose levels [22]. Another important factor that surfaced was glucose regulation. 51.5% of the 200 diabetic patients had uncontrolled HbA1c levels (>7%), and there was a strong correlation between tendinitis and inadequate glycaemic management ($p = 0.003$). Kudsi et al. (2020) found that most diabetics with MSDs had poorly managed blood glucose, which is consistent with these findings. Patients who have elevated blood sugar levels are more susceptible to MSDs because they cause stiffness and inflammation by promoting the non-enzymatic glycation of collagen and other connective tissues. Given that type 2 diabetes is more common in women, it is crucial to emphasise that men are more likely to have diabetes complications involving ketosis or diabetic ketoacidosis [23]. Fascinatingly, changes in glucose homeostasis following meals are also linked to an increase in visceral adipose tissue, and the latter only serves to promote insulin resistance in women, which further affects value control.[23]

Another important effect was the length of diabetes. In line with findings from Majjad et al. and Kiani (2016), who discovered strong correlations between the onset of joint and soft-tissue problems and diabetes for more than ten years, patients with diabetes had a significantly higher prevalence of the majority of MSDs. [17] Adhesive capsulitis, which was seen even in newly diagnosed diabetics (less than a year), especially those with poor glycaemic control, was an intriguing exception in our study. This implies that when blood glucose levels are not regulated, several problems may appear quickly and severely.

It was discovered that musculoskeletal morbidity was significantly influenced by obesity and excess weight. Ten percent of the patients were obese, and more than 72 percent were overweight; MSDs were more common in these groups. Studies like those by Yogesh Karoli et al., which found that elevated BMI was significantly linked to conditions including tendinitis and frozen shoulder, maybe as a result of mechanical strain and chronic inflammation, provide strong support for these findings. [24] Women with diabetes are more likely than men to be obese due to a lack of oestrogen and rising insulin resistance [25]. It is evident that variations in body composition and fat accumulation between the sexes play a role in the gender-specific diversification of diabetes risk [26] Increasing trunk fat is typically linked to the clustering of cardiometabolic risk variables in cross-sectional population-based studies, but increasing leg fat has been linked to decreased cardiometabolic risk, particularly in women. [26, 27]

Limitations: The study may have been improved with a multicentric approach that included primary health centres. Results from a study with a larger sample size and a wider geographic scope would have been more accurate. It would have been easier to establish the association factors with the aid of genetic investigations.

CONCLUSION

This study clearly shows that the prevalence of musculoskeletal disorders (MSDs) in people with type 2 diabetes mellitus (T2DM) is correlated with gender, with tendinitis and adhesive capsulitis being more common in women and men, respectively. Body composition, sex hormones, and lifestyle choices like physical inactivity all affect these disparities. The results emphasise how crucial it is to incorporate gender-specific viewpoints in the detection and treatment of diabetes complications. This makes gender medicine a useful framework for creating more accurate and fair treatment plans.

Declaration by Authors

Ethical Approval: Approved
Acknowledgement: None
Source of Funding: None
Conflict of Interest: The authors declare no conflict of interest.

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How to cite this article: Nabila Nishat, Mohd. Ammar Aslam, R. Sushma Swaraj, Afreen Saif. Gender-Based differences in musculoskeletal disorders among patients with type 2 diabetes mellitus: a cross-sectional study from North India. *Int J Health Sci Res.* 2025; 15(9):130-139. DOI: *10.52403/ijhsr.20250917*

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