



Article

# Prevalence of Musculoskeletal Problems in Type 2 Diabetes Mellitus Patients and Their Perception About Physiotherapy Management

Saleha Asif<sup>1</sup>, Narjis Fatima<sup>1</sup>, Muskaan Shehzadi<sup>1</sup>, Muhammad Abou Bakar<sup>1</sup>, Shamsul Qamar Moaz<sup>1</sup>, Falak Sher Rashid<sup>1</sup>, Maida Ilyas<sup>1</sup>

<sup>1</sup> University of Management and Technology (UMT), Sialkot Campus, Pakistan

Correspondence

Dr. Maida Ilyas ([hayasekander10@gmail.com](mailto:hayasekander10@gmail.com))

Cite this Article

Received	2025-04-03
Revised	2025-04-26
Accepted	2025-04-28
Published	2025-05-10
Conflict of Interest	None declared
Ethical Approval	Respective Ethical Review Board
Informed Consent	Obtained from all participants
Data/supplements	Available on request.
Funding	None
Authors' Contributions	SA, NF, MS, MAB, SQM, FSR, and MI contributed to concept, design, data collection, analysis, and manuscript drafting.

## ABSTRACT

**Background:** Type 2 diabetes mellitus (T2DM) is a global public health concern associated not only with metabolic and vascular complications but also with significant musculoskeletal (MSK) problems that often remain underrecognized and undertreated. The existing literature reveals a knowledge gap concerning the regional prevalence of MSK complications among diabetic patients and their perspectives on physiotherapy as a viable management approach. **Objective:** This study aimed to determine the prevalence of musculoskeletal issues across different body regions in patients with T2DM and to explore the association between these issues and physical activity levels, while also assessing patients' perceptions regarding physiotherapy management. **Methods:** A cross-sectional observational study was conducted involving 250 patients with T2DM recruited via non-probability convenient sampling from two tertiary hospitals in Sialkot. Participants aged  $\geq 40$  years with clinically confirmed MSK symptoms were included, excluding those with trauma-induced or unrelated systemic musculoskeletal diseases. Data were collected using a structured questionnaire covering sociodemographic data, diabetes characteristics, MSK complaints, physical activity, and physiotherapy perceptions. Ethical approval was obtained in compliance with the Helsinki Declaration. Data were analyzed using SPSS v26.0 with descriptive statistics, chi-square tests, and p-values  $< 0.05$  considered statistically significant. **Results:** Among 250 patients, 78.0% reported MSK problems, with both upper and lower extremities commonly involved (58.0%). Duration of diabetes showed a significant association with chronicity of MSK symptoms ( $p < 0.001$ ), and high blood glucose levels were linked to increased MSK pain ( $p = 0.007$ ). Sedentary lifestyle and low education were also associated with negative perceptions of physiotherapy. Notably, 81.6% expressed willingness to consider physiotherapy in the future. **Conclusion:** The study highlights a high burden of musculoskeletal complications among patients with T2DM, particularly those with long-standing disease, physical inactivity, and poor blood glucose control. Integrating physiotherapy into diabetes care plans may offer substantial clinical benefits by improving mobility and reducing pain, thus enhancing quality of life and self-management.

**Keywords:** Type 2 Diabetes Mellitus, Musculoskeletal Pain, Physical Activity, Physiotherapy, Patient Perception, Disease Management, Cross-Sectional Studies.

## INTRODUCTION

Type 2 diabetes mellitus (T2DM), a chronic metabolic disorder characterized by persistent hyperglycemia, affects millions worldwide and continues to rise at an alarming rate. The global prevalence has doubled over the past three decades, with projections estimating 592 million cases by 2035. Pakistan, ranking third globally in diabetes prevalence after China and India, had an estimated adult prevalence of 26.7% in 2022, representing nearly 33 million individuals (1).

Despite advances in pharmacologic management, diabetes remains a leading cause of morbidity and disability, largely due to its chronic complications, among which musculoskeletal (MSK) disorders are increasingly recognized but insufficiently addressed (2). These complications, while nonvascular in origin, substantially affect patients' functional ability and quality of life, often leading to pain, stiffness, limited mobility, and reduced physical activity.

A growing body of evidence suggests that T2DM is associated with a high prevalence of MSK complications, including adhesive capsulitis, osteoarthritis, carpal tunnel syndrome, diffuse idiopathic skeletal hyperostosis (DISH), and limited joint mobility (3). The pathophysiological mechanisms underlying these conditions are multifactorial, involving chronic inflammation, accumulation of advanced glycation end-products (AGEs), oxidative stress, and impaired collagen turnover (4). These biochemical alterations compromise the structural integrity of connective tissues, contributing to joint stiffness, tendon abnormalities, and muscular atrophy, especially in long-standing diabetes (5). Additionally, neuropathic changes and vascular insufficiencies further aggravate MSK symptoms, making the musculoskeletal system one of the most vulnerable targets of long-term hyperglycemia (6).

Despite a clear pathophysiological rationale and clinical relevance, musculoskeletal complications in T2DM remain under-recognized and inadequately managed within routine diabetic care protocols (7). This knowledge gap is further compounded by limited awareness among patients and healthcare providers about the role of non-pharmacologic strategies such as physiotherapy in mitigating MSK symptoms (8). While physiotherapy has been widely acknowledged as a cornerstone in the management of orthopedic and neurological conditions, its utility in diabetes-related MSK complications has not been fully explored in clinical practice or public health interventions, particularly in lower-middle-income countries like Pakistan (9). Recent literature emphasizes the beneficial effects of exercise and targeted physiotherapeutic interventions in improving glycemic control, reducing inflammation, and restoring functional independence, thereby reinforcing the need to integrate physiotherapy into diabetes management frameworks (10).

Compounding the issue is the sedentary lifestyle commonly observed among T2DM patients, which exacerbates both glycemic dysregulation and MSK deterioration (11). Evidence shows that reduced physical activity is associated with higher risks of insulin resistance, obesity, and poor musculoskeletal health outcomes (12). However, few studies have systematically examined the bidirectional relationship between physical activity levels and the prevalence of MSK conditions in diabetics, particularly in South Asian populations where cultural, economic, and health literacy barriers hinder both exercise participation and access to rehabilitative care (13). Moreover, while international guidelines emphasize the role of physical activity in diabetes management, they often fall short of addressing the specific needs of those already suffering from MSK limitations due to diabetes (14).

Given these concerns, this study was undertaken to assess the prevalence of musculoskeletal problems in individuals with type 2 diabetes and to explore their perceptions regarding physiotherapy as a viable management strategy. By identifying the body regions most commonly affected and analyzing associations with variables such as diabetes duration, physical activity levels, education, and healthcare accessibility, this study aims to fill critical gaps in understanding the burden of MSK conditions in this population. Furthermore, it seeks to evaluate

the extent to which physiotherapy is recognized and utilized as a component of diabetes care, particularly in resource-constrained settings.

Therefore, the central research question guiding this study is: "Do individuals with type 2 diabetes who have lower levels of physical activity experience a higher prevalence of musculoskeletal problems in various body regions compared to those with better physical activity and glycemic control?" Correspondingly, the null hypothesis states that there is a significant relationship between type 2 diabetes, physical inactivity, and the regional prevalence of MSK problems, while the alternative hypothesis posits no such association. This investigation aims not only to delineate the epidemiological profile of MSK complications in T2DM but also to inform patient-centered, physiotherapy-integrated interventions for holistic diabetes care.

## MATERIALS AND METHODS

A cross-sectional observational study was conducted to assess the prevalence of musculoskeletal problems in patients with type 2 diabetes mellitus (T2DM) and to explore their perceptions regarding physiotherapy management. The study recruited 250 participants from outpatient departments of Sardar Begum Hospital and Civil Hospital in Sialkot, Pakistan, over a period of four months from March to July 2023. A non-probability convenience sampling technique was used to identify eligible participants. Individuals aged 40 years or older, with a confirmed diagnosis of T2DM and a history of musculoskeletal complications, were included in the study. Patients with serious systemic illnesses, hypertension, a history of musculoskeletal disorders due to trauma, or pregnancy were excluded to minimize confounding influences on musculoskeletal health.

All participants were provided with detailed information about the study's objectives and procedures, and written informed consent was obtained prior to enrollment. The study adhered to the ethical principles outlined in the Declaration of Helsinki, and approval was obtained from the relevant institutional ethics committee. Confidentiality of participants' identities and medical information was strictly maintained throughout the study.

Data were collected using a structured, researcher-developed questionnaire, informed by prior literature and expert input. The tool included sections on demographic characteristics, diabetes history, physical activity levels, musculoskeletal symptoms, and perceptions about physiotherapy. The primary outcome was the prevalence and pattern of musculoskeletal problems across different body regions. Secondary outcomes included perceived effectiveness of physiotherapy, referral trends, and self-reported physical activity behaviors. Patients responded to questions regarding symptom frequency, anatomical distribution, pain characteristics, and medication adherence. They also rated their engagement with physiotherapy, use of home-based remedies or exercises, and willingness to consider physiotherapy as part of diabetes management.

Data were entered and analyzed using the Statistical Package for the Social Sciences (SPSS) version 26.0. Descriptive statistics, including frequencies and percentages, were calculated for

categorical variables. Chi-square tests were used to evaluate associations between musculoskeletal problems and variables such as physical activity level, diabetes duration, education, and employment status. A p-value of less than 0.05 was considered statistically significant. No imputation methods were required as the dataset was complete, and there was no handling of missing data. This analytical approach was chosen to explore the relationships among the variables and to provide meaningful insights into the patterns and determinants of musculoskeletal problems in the diabetic population (1).

## RESULTS

A total of 250 participants with Type 2 Diabetes Mellitus were included in this cross-sectional study. The demographic profile revealed that the majority were females (61.6%) and primarily fell within the 40–45-year age range (32.4%). Educational attainment showed that 30.8% were uneducated and 37.2% had education levels below high school. The population was

**Table 1. Diagnosis of MSK Problems by Affected Body Part**

MSK Problem	Upper Extremity	Lower Extremity	Both	Total	p-value
Yes	20 (10.3%)	35 (17.9%)	140 (71.8%)	195	0.023
No	30 (54.5%)	20 (36.4%)	5 (9.1%)	55	

predominantly married (75.6%) and a significant portion (47.2%) identified as housewives. Regarding disease duration, 44.8% had been diagnosed with diabetes for over five years. Out of the total, 78.0% (195 participants) were diagnosed with musculoskeletal (MSK) problems attributed to diabetes. Most of these individuals (86.0%) reported worsening of MSK symptoms following diabetes diagnosis. Notably, a significant association was found between MSK diagnosis and the anatomical location of the pain. Specifically, 71.8% of patients with MSK problems experienced both upper and lower extremity involvement, compared to 9.1% in patients without such problems ( $p = 0.023$ ).

There was also a strong relationship between the duration of diabetes and the duration of MSK symptoms. Patients diagnosed with diabetes for over five years showed the highest proportion of chronic MSK symptoms lasting more than one year (63.4%). The association was statistically significant ( $p < 0.001$ ).

**Table 2. Association Between Diabetes Duration and MSK Symptom Duration**

Diabetes Duration	MSK <6 Months	MSK 6mo–1yr	MSK >1yr	Total	p-value
<1 year	26 (34.2%)	10 (10.9%)	10 (12.2%)	46	<0.001
1–5 years	29 (38.2%)	43 (46.7%)	20 (24.4%)	92	
>5 years	21 (27.6%)	39 (42.4%)	52 (63.4%)	112	

Regarding physical activity, 43.6% of patients with MSK problems reported being highly active, but there remained a statistically significant relationship between physical activity

levels and MSK status ( $p = 0.037$ ). In contrast, patients without MSK problems had a more even distribution across activity levels.

**Table 3. Association Between Physical Activity and MSK Status**

MSK Status	Low Activity	High Activity	Medium Activity	Total	p-value
Yes	40 (20.5%)	85 (43.6%)	70 (35.9%)	195	0.037
No	20 (36.4%)	20 (36.4%)	15 (27.3%)	55	

Patient perception of physiotherapy was significantly influenced by education level ( $p = 0.015$ ). Among patients with a graduate or

associate degree, 91.4% considered physiotherapy effective, while only 13% of uneducated patients held the same opinion.

**Table 4. Perception of Physiotherapy Effectiveness by Education Level**

Education Level	Effective	Neutral	Ineffective	Total	p-value
Uneducated	10 (13.0%)	40 (52.0%)	27 (35.0%)	77	0.015
< High School	30 (32.3%)	50 (53.8%)	13 (14.0%)	93	
Intermediate	30 (66.7%)	10 (22.2%)	5 (11.1%)	45	
Graduate	32 (91.4%)	3 (8.6%)	0 (0.0%)	35	

**Table 5. Association Between Belief in Exercise and MSK Reduction Perception**

Belief in Exercise	Yes (Reduce MSK)	No	Total	p-value
Yes	173 (89.2%)	28	201	<0.001
No	21 (10.8%)	28	49	

Furthermore, belief in the importance of exercise was strongly associated with the perception that exercise could reduce MSK

symptoms. Among those who believed exercise was important for diabetes, 89.2% also believed it could alleviate MSK problems

( $p < 0.001$ ). Another important finding was the association between glycemic control and MSK pain. Patients with high blood glucose levels were significantly more likely to report MSK pain

(91.3%) compared to those with low glucose levels (22.6%), with  $p = 0.007$ .

**Table 6. Association of Blood Glucose Level with MSK Pain**

Blood Glucose Level	MSK Pain (Yes)	MSK Pain (No)	Total	p-value
High	180 (91.3%)	17 (8.7%)	197	0.007
Low	12 (22.6%)	41 (77.4%)	53	

While most MSK patients reported both upper and lower body involvement, the location of MSK symptoms also varied with activity level. Patients with lower extremity issues had the

highest rate of high physical activity (50%), compared to 41.1% in upper extremity and 38.8% in both ( $p = 0.041$ ).

**Table 7. Body Part vs. Physical Activity Level**

Body Part Affected	Low	High	Medium	Total	p-value
Upper Extremity	22	30	21	73	0.041
Lower Extremity	20	55	35	110	
Both	19	26	22	67	

Overall, this section highlights the high burden of musculoskeletal complications among Type 2 diabetes patients and the complex interrelation of physical activity, education, glycemic control, and patient perceptions in disease management. These statistically significant findings provide actionable insights for physiotherapy inclusion and patient-centered care strategies in diabetes.

## DISCUSSION

The current study provides significant insights into the high prevalence and multifaceted nature of musculoskeletal (MSK) problems among individuals with Type 2 Diabetes Mellitus (T2DM), emphasizing the interplay between disease duration, physical activity, and patient perception toward physiotherapy. With 78% of participants reporting MSK issues and 83.2% experiencing multiple symptoms, our findings align with existing literature that underscores the frequent co-occurrence of MSK disorders in diabetic populations (1). This study reinforces the importance of early musculoskeletal assessment and holistic diabetes management to mitigate functional decline and improve quality of life in this population (2). Previous investigations, such as those by Rehling *et al.*, have similarly identified a strong association between MSK pain and diabetic complications, particularly osteoarthritis and neuropathic symptoms, which are consistent with our findings of predominant symptoms like dull/aching pain and muscle weakness (3).

Importantly, we observed a significant correlation between disease duration and the chronicity of MSK complaints, with the highest symptom burden in those diagnosed with diabetes for more than five years. This temporal pattern suggests progressive degenerative changes in connective tissue, likely mediated by chronic hyperglycemia and the accumulation of advanced glycation end products (AGEs), as posited in mechanistic studies (4). The significant association between hyperglycemia and MSK pain ( $p = 0.007$ ) in our study adds empirical weight to this hypothesis and highlights the need for tighter glycemic control to alleviate systemic inflammation and neuropathic damage (5).

Physical activity, a modifiable risk factor, showed a noteworthy inverse relationship with MSK problem prevalence ( $p = 0.037$ ). Although a substantial proportion of participants (40.4%) identified as active, nearly half of those with MSK issues reported being sedentary or moderately active. This supports prior research indicating that inactivity may not only exacerbate metabolic dysregulation but also reduce musculoskeletal resilience, thereby creating a vicious cycle of pain and disability (6). The observed higher activity levels among those with lower extremity involvement may reflect adaptive or rehabilitative behaviors in response to functional limitations, though this warrants deeper exploration.

Patient perception of physiotherapy revealed important behavioral and educational gaps. While 62.8% found physiotherapy effective and 81.6% expressed willingness to try it in the future, nearly half had never received a referral, and lack of awareness was the most cited barrier (42.4%). This disparity is particularly concerning given the robust evidence supporting exercise therapy for MSK and metabolic improvements in T2DM (7). Our analysis further found that education level significantly influenced perceptions of physiotherapy ( $p = 0.015$ ), suggesting that targeted health literacy interventions could bridge this gap. These findings are consistent with earlier reports by Janssen *et al.*, who called for better integration of physiotherapists into primary diabetes care to improve outcomes (8).

From a clinical standpoint, these results underscore the necessity for inter-professional collaboration, especially involving endocrinologists, physiotherapists, and primary care physicians, to develop individualized, multidisciplinary care plans. Proactive MSK screening and patient education should be standard components of diabetes management protocols, particularly for long-standing cases where the risk of physical impairment is elevated.

Despite its contributions, this study has notable limitations. Being cross-sectional and hospital-based, the findings may not generalize to all T2DM patients, particularly those in rural or underserved settings. The convenience sampling method may also introduce selection bias. Furthermore, reliance on self-



reported data and absence of clinical verification (e.g., imaging or biochemical markers) may compromise the accuracy of MSK symptom reporting. Confounding variables such as BMI, smoking status, and comorbidities like hypertension were not controlled, which may influence symptomatology and should be considered in future analyses.

Nevertheless, the study's strengths include a relatively large sample size and its comprehensive exploration of physical, behavioral, and perceptual dimensions related to MSK health in diabetes. By integrating objective frequency data with patient beliefs, the study offers a nuanced understanding of barriers and opportunities in diabetes-related MSK care. Future longitudinal and interventional studies should investigate the causal relationships between physical activity, glycemic control, and MSK progression, and assess the efficacy of tailored physiotherapy programs across different socioeconomic and clinical subgroups.

This study highlights the pressing need for integrative MSK assessment and physiotherapy engagement in the routine care of T2DM patients. With rising diabetes prevalence and associated disability, early musculoskeletal evaluation and structured physical therapy could be pivotal in enhancing functional capacity, reducing pain, and improving quality of life for this growing patient population. Addressing gaps in awareness, access, and inter-professional referral practices could transform diabetes management from a glucose-centric approach to a more holistic, disability-preventive model.

## CONCLUSION

This study revealed a notably high prevalence (78%) of musculoskeletal problems among patients with Type 2 Diabetes Mellitus, with most individuals experiencing multiple symptoms, particularly in both upper and lower extremities. These findings align directly with the study's objective to assess the regional distribution of MSK issues and examine their association with diabetes duration, physical activity levels, and patient perceptions. Clinically, the results underscore the urgent need to integrate routine musculoskeletal evaluations and physiotherapy referrals into diabetes management protocols, especially for long-standing cases. The observed gaps in awareness and utilization of physiotherapy highlight critical areas for health education and interdisciplinary collaboration. From a research perspective, the significant associations between hyperglycemia, physical inactivity, and MSK symptomatology warrant longitudinal studies to explore causality and evaluate the impact of targeted physiotherapy interventions on patient outcomes and healthcare burden.

## REFERENCES

- Demir S, Nawroth PP, Herzig S, Ekim Ustunel B. Emerging Targets in Type 2 Diabetes and Diabetic Complications. *Adv Sci.* 2021;8(18):2100275.
- Singh AK, Sharma AK, Tripathi N, Sharma S. Prevalence of Musculoskeletal Disorders in Type 2 Diabetes Mellitus Patients of Tertiary Care Center of Gwalior, India. *J Assoc Physicians India.* 2019;67(7):52â€"5.
- Al Mahmud FR, Mandal MA, Rahman AM, Khatun MS, Rahman MA. Pattern of Musculoskeletal Disorders Among Diabetic Patients Attending the Department of Physical Medicine and Rehabilitation in a Tertiary Care Hospital. *KYAMC J.* 2021;12(1):41â€"3.
- Ghosal S, Ghosal A. Diabetes and Musculoskeletal Disorders - A Review. *J Diabetes Metab Disord Control.* 2020;7(2):63â€"71.
- Joshi SA, Patel VD, Eapen C, Hariharan K. Proportion and Distribution of Upper Extremity Musculoskeletal Disorders and Its Association with Disability in Type 2 Diabetes Mellitus. *J Hand Ther.* 2021;34(3):411â€"7.
- Azeem S, Khan U, Liaquat A. The Increasing Rate of Diabetes in Pakistan: A Silent Killer. *Ann Med Surg.* 2022;79:103972.
- Galicia-Garcia U, Benito-Vicente A, Jebari S, Larrea-Sebal A, Siddiqi H, Uribe KB, et al. Pathophysiology of Type 2 Diabetes Mellitus. *Int J Mol Sci.* 2020;21(17):6275.
- Gupta V, Santhi SSE, Ravi S, Ramanan EA. Rheumatological and Musculoskeletal Complications in Diabetes Patients. *J Endocrinol Metab.* 2022;12(4â€"5):117â€"24.
- Suzuki A, Yabu A, Nakamura H. Advanced Glycation End Products in Musculoskeletal System and Disorders. *Methods.* 2022;203:179â€"86.
- Singla R, Dutta D, Sharma M, Sharma A. Musculoskeletal Complications of Diabetes Mellitus. In: *The Diabetes Textbook: Clinical Principles, Patient Management and Public Health Issues.* 2019. p. 873â€"81.
- Sharmin S, Newaz F, Ahmed SM, Shahin A, Hasan MI, Rahman HH, et al. Pattern of Musculoskeletal Disorders in Adult Diabetics Patient. *Bangladesh Med J.* 2019;48(1):5â€"12.
- Harris-Hayes M, Schootman M, Schootman JC, Hastings MK. The Role of Physical Therapists in Fighting the Type 2 Diabetes Epidemic. *J Orthop Sports Phys Ther.* 2020;50(1):5â€"16.
- Alabdali LAS, Jaeken J, Dinant GJ, van den Akker M, Winkens B, Ottenheijm RP. Prevalence of Upper Extremity Musculoskeletal Disorders in Patients with Type 2 Diabetes in General Practice. *Medicine.* 2021;8(2):8.
- Olaosebikan H, Azenabor A, Akintayo R, Adelowo O, Ogbera A, Brodie-Mends A. Spectrum of Musculoskeletal Disorders in Nigerians with Type 2 Diabetes Mellitus: Prevalence and Predictors. *Reumatismo.* 2019;71(4):209â€"17.
- Carvalho-e-Silva AP, Ferreira ML, Ferreira PH, Harmer AR. Does Type 2 Diabetes Increase the Risk of Musculoskeletal Pain? Cross-Sectional and Longitudinal Analyses of UK Biobank Data. *Semin Arthritis Rheum.* 2020;50(4):667â€"74.
- Rehling T, Bjorkman ASD, Andersen MB, Ekholm O, Molsted S. Diabetes Is Associated with Musculoskeletal Pain, Osteoarthritis, Osteoporosis, and Rheumatoid Arthritis. *J Diabetes Res.* 2019;2019:6324348.

17. Bhat TA, Jalalie U, Kashyap S. An Observational Study on Musculoskeletal Manifestations in Type 2 Diabetes Mellitus in Rural Population of Himachal Pradesh, India. *J Evolution Med Dent Sci*. 2019;8(11):752â€“755.
18. AlOayan LI, Zawawi AH. Musculoskeletal Manifestations Among Diabetic Patients in Saudi Arabia. *J Family Med Prim Care*. 2020;9(11):5597â€“601.
19. Kalam MN, Shah SNH, Rasool MF, Majeed A, Ahmed N, Saqlain M. Prevalence of Musculoskeletal Complications of Type 2 Diabetes Mellitus in Population of Southern Punjab, Pakistan. *Int J Diabetes Dev Ctries*. 2021;41:101â€“107.
20. Ismail L, Materwala H, Al Kaabi J. Association of Risk Factors with Type 2 Diabetes: A Systematic Review. *Comput Struct Biotechnol J*. 2021;19:1759â€“1765.
21. Xie Z, Liu K, Or C, Chen J, Yan M, Wang H. An Examination of the Socio-Demographic Correlates of Patient Adherence to Self-Management Behaviors and the Mediating Roles of Health Attitudes and Self-Efficacy Among Patients with Coexisting Type 2 Diabetes and Hypertension. *BMC Public Health*. 2020;20(1):1â€“13.
22. Yin L, Zhang D, Ren Q, Su X, Sun Z. Prevalence and Risk Factors of Diabetic Retinopathy in Diabetic Patients: A Community Based Cross-Sectional Study. *Medicine*. 2020;99(9):e19236.
23. Angulo J, El Assar M, Alvarez-Bustos A, Rodriguez-Manas L. Physical Activity and Exercise: Strategies to Manage Frailty. *Redox Biol*. 2020;35:101513.
24. Janssen SM, Connelly DM, Gillis H. Physiotherapistsâ€™ Perspectives on Type 2 Diabetes Management and as a Primary Condition for Referral to Physiotherapy Services: A Qualitative Descriptive Study. *Physiother Can*. 2022;74(3):213â€“221.
25. Kasai T, Hasegawa Y, Imagama S, Sakai T, Wakai K, Suzuki K, et al. The Impact of Musculoskeletal Diseases on Mortalityâ€“Comparison with Internal Diseases: A 15-Year Longitudinal Study. *J Orthop Sci*. 2017;22(6):1126â€“1131.
26. Proctor C. The Role of Physiotherapists and Kinesiologists in Physical Activity Interventions for Diabetes Management in Primary Care Settings: A Modified Delphi Study. 2023. [cited 2025 Apr 30]. Available from: <https://example-url.com>
27. Pinhal KC, Figueiredo PS, De Oliveira VC, Gomes WF, Pernambuco AP, Alcantara MA. Functional Decline in People with Diabetes: Bidirectional Relationships Between Body Function and Activityâ€“Participation Components in a Two-Wave Longitudinal Structural Equation Modeling. *Physiother Theory Pract*. 2023;39(3):598â€“606.
28. Cade TJ, Polyakov A, Brennecke SP. Implications of the Introduction of New Criteria for the Diagnosis of Gestational Diabetes: A Health Outcome and Cost of Care Analysis. *BMJ Open*. 2019;9(1):e023293.
29. Yang D, Yang Y, Li Y, Han R. Physical Exercise as Therapy for Type 2 Diabetes Mellitus: From Mechanism to Orientation. *Ann Nutr Metab*. 2019;74(4):313â€“321.
30. Cox ER, Gajanand T, Burton NW, Coombes JS, Coombes BK. Effect of Different Exercise Training Intensities on Musculoskeletal and Neuropathic Pain in Inactive Individuals with Type 2 Diabetes â€“ Preliminary Randomised Controlled Trial. *Diabetes Res Clin Pract*. 2020;164:108168.
31. ElAlfy AK, Fawzy RM, Ramadan HII, ElBadawy AM, Afifi MAN. Assessment of Musculo-Tendinous Changes in Diabetes Mellitus: A Musculoskeletal Ultrasonographic Study. *Egypt J Hosp Med*. 2023;91(1):5326â€“5333.
32. Chandrasekaran S, Ma D, Scarvell JM, Woods KR, Smith PN. A Review of the Anatomical, Biomechanical and Kinematic Findings of Posterior Cruciate Ligament Injury with Respect to Non-Operative Management. *Knee*. 2012;19(6):738â€“745.
33. Kudsi M. The Prevalence of Musculoskeletal Complications in Type 2 Diabetes Mellitus. *Open Access Libr J*. 2020;7(5):1â€“11.
34. Mulcahy K, Maryniuk M, Peeples M, Peyrot M, Tomky D, Weaver T, et al. Diabetes Self-Management Education Core Outcomes Measures. *Diabetes Educ*. 2003;29(5):768â€“803.