

*Original Article*

# Assessment of Calf Muscle Flexibility and Trigger Points in Patients With Type 2 Diabetes

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## ABSTRACT

**Background:** Calf muscle flexibility is important for ankle mobility, gait, balance, and functional lower-limb performance, while myofascial trigger points may contribute to pain sensitivity, muscle tightness, and movement restriction. Patients with type 2 diabetes may be vulnerable to lower-limb musculoskeletal dysfunction because of metabolic, neuromuscular, and activity-related factors. **Objective:** To assess calf muscle flexibility and trigger points in patients with type 2 diabetes and determine the association between trigger-point palpation and goniometric flexibility categories. **Methods:** This cross-sectional observational study was conducted over six months at PSRD Hospital Lahore and Surayya Azeem Hospital Lahore. A total of 135 patients with type 2 diabetes were recruited through convenience sampling. Calf muscle flexibility was assessed using goniometric measurement, and trigger points in the gastrocnemius and soleus muscles were identified through manual palpation. Data were analyzed using SPSS version 27. Frequencies, percentages, means, and standard deviations were calculated, and chi-square testing was used to assess associations between trigger-point status and flexibility categories. **Results:** The mean age of participants was  $42.19 \pm 2.07$  years. Most participants were female, married, obese, and had comorbidities. Trigger-point palpation was positive in 105 participants for both gastrocnemius and soleus muscles. Significant associations were found between trigger-point palpation and goniometric flexibility categories for both muscles ( $p < 0.001$ ). **Conclusion:** Trigger-point palpation was significantly associated with reduced calf muscle flexibility in patients with type 2 diabetes. These findings support combined assessment of myofascial trigger points and calf flexibility during lower-limb physiotherapy evaluation. **Keywords:** Type 2 diabetes mellitus; calf muscle flexibility; myofascial trigger points; gastrocnemius; soleus; goniometry; manual palpation.

## INTRODUCTION

Type 2 diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin resistance, or both, and is associated with multisystem complications affecting vascular, neural, renal, ocular, and musculoskeletal health. In addition to cardiometabolic consequences, patients with type 2 diabetes may experience reduced physical activity, altered muscle composition, impaired neuromuscular function, and progressive limitations in mobility, all of which may influence lower-limb performance and functional independence. Regular physical activity and preservation of musculoskeletal function are therefore clinically important in this population because they support glycemic control, mobility, balance, and participation in daily activities (1).

The calf muscle complex, primarily comprising the gastrocnemius and soleus muscles, plays a central role in ankle plantarflexion, postural control, gait propulsion, stair negotiation, running, and functional weight-bearing activities. The triceps surae contributes substantially to ankle joint control during the stance and push-off phases of gait, while adequate calf flexibility permits sufficient ankle dorsiflexion during walking, squatting, and other closed-chain activities. Restricted calf flexibility may reduce ankle dorsiflexion, alter lower-limb biomechanics, increase compensatory movement patterns, and affect balance and mobility, particularly in populations already vulnerable to musculoskeletal and metabolic impairment (2,3). Limited ankle dorsiflexion has also been associated with altered landing mechanics and functional movement constraints, suggesting that calf flexibility is an important clinical parameter in lower-limb assessment (4).

Myofascial trigger points are hyperirritable areas located within taut bands of skeletal muscle that may produce localized tenderness, referred pain, motor dysfunction, and autonomic responses when mechanically stimulated. Trigger points may be active or latent depending on whether they reproduce spontaneous or recognized pain, but both forms may contribute to altered muscle function, pain sensitivity, and restricted movement. The gastrocnemius and soleus muscles are clinically relevant sites for trigger-point assessment because they are repeatedly loaded during standing and gait and may develop increased sensitivity or tautness in association with biomechanical stress, fatigue, metabolic factors, or reduced mobility (5,6).

In patients with type 2 diabetes, the relationship between calf muscle flexibility and trigger points may be particularly important because diabetes-related changes in muscle quality, physical activity, body composition, and neuromuscular function can affect lower-limb performance. Previous evidence has shown reduced lower-limb muscle strength and altered muscle volume in patients with type 2 diabetes, particularly in relation to neuropathy, intramuscular fat, and metabolic status (7). Imaging-based research has also demonstrated measurable calf skeletal muscle alterations among male patients with type 2 diabetes across different disease courses, supporting the clinical relevance of evaluating calf muscle characteristics in this population (8). However, despite the functional importance of the calf muscles, limited attention has been given to the coexistence of calf muscle inflexibility and myofascial trigger points among patients with type 2 diabetes.

Previous studies have explored trigger points in lower-limb muscles, the effect of trigger-point therapy on ankle dorsiflexion, and the relationship between calf flexibility and functional status in other populations, including recreational runners, athletes, and individuals with musculoskeletal disorders (9–11). However, evidence remains limited regarding whether trigger-point presence is associated with reduced calf muscle flexibility specifically in patients with type 2 diabetes. This gap is clinically relevant because early identification of reduced calf flexibility and trigger points may help physiotherapists design targeted interventions such as stretching, manual therapy, trigger-point release, and functional mobility training. Therefore, this study aimed to assess calf muscle flexibility and trigger points in patients with type 2 diabetes and to determine the association between trigger-point palpation findings and goniometric measures of calf muscle flexibility.

## MATERIALS AND METHODS

This cross-sectional observational study was conducted over a six-month period at PSRD Hospital Lahore and Surayya Azeem Hospital Lahore. The study was designed to assess calf muscle flexibility and myofascial trigger points among patients with type 2 diabetes and to determine whether trigger-point palpation findings were associated with goniometric measures of flexibility in the gastrocnemius and soleus muscles. A convenience sampling technique was used to recruit eligible participants from the study settings.

The study included male and female participants aged 30–45 years with type 2 diabetes who voluntarily agreed to participate. Participants were excluded if they had diabetic complications, recent lower-limb

injury, or any condition affecting calf muscle function. Eligible participants were approached according to the recruitment process at the study sites, and written informed consent was obtained before data collection. Participant confidentiality was maintained throughout the study by handling collected information anonymously and using the data only for research purposes.

The sample size was calculated using Epitool with a 95% confidence interval and a 5% margin of error, resulting in a final sample of 135 participants. Demographic and clinical information was collected before physical assessment. The main study variables were trigger-point status and calf muscle flexibility. Trigger points were assessed through manual palpation of the gastrocnemius and soleus muscles and recorded as present or absent. Calf muscle flexibility was measured using goniometric assessment and categorized according to the recorded ankle range-of-motion values for the gastrocnemius and soleus muscles. The goniometric measurement categories used in the analysis were 0–10 degrees, 11–15 degrees, 16–20 degrees, and greater than 20 degrees for soleus assessment, and 0–10 degrees, 11–15 degrees, and 15–20 degrees for gastrocnemius assessment.

Data were entered and analyzed using SPSS version 27. Continuous variables, including age, height, and weight, were summarized using mean and standard deviation. Categorical variables, including sex, body mass index category, marital status, socioeconomic status, comorbidity status, trigger-point palpation findings, and goniometric flexibility categories, were summarized using frequencies and percentages. The association between trigger-point manual palpation and goniometric flexibility categories was assessed using the chi-square test. A p-value of less than 0.05 was considered statistically significant. Ethical approval and institutional permissions were obtained before data collection, and all participants provided written informed consent before inclusion in the study.

## RESULTS

A total of 135 patients with type 2 diabetes were included in the analysis. The mean age of participants was  $42.19 \pm 2.07$  years, with a mean height of  $168.25 \pm 5.00$  cm and mean weight of  $80.83 \pm 8.49$  kg. Most participants were female, married, obese, and belonged to the lower socioeconomic group. Comorbidities were reported in 77.8% of participants.

*Table 1. Demographic and Clinical Characteristics of Participants*

Variable	Category	n (%) / Mean $\pm$ SD
Age, years	—	42.19 $\pm$ 2.07
Height, cm	—	168.25 $\pm$ 5.00
Weight, kg	—	80.83 $\pm$ 8.49
Sex	Female	96 (71.1)
Sex	Male	39 (28.9)
BMI category	Obese	59 (43.7)
Marital status	Married	108 (80.0)
Marital status	Unmarried/other	27 (20.0)
Socioeconomic status	Lower	70 (51.9)
Socioeconomic status	Other	65 (48.1)
Comorbidity status	Present	105 (77.8)
Comorbidity status	Absent	30 (22.2)

SD, standard deviation; BMI, body mass index.

The study population was predominantly female, with 96 of 135 participants classified as female. Obesity was reported in 59 participants, while 108 participants were married. Lower socioeconomic status was reported in 70 participants, and comorbidities were present in 105 participants, indicating a clinically heterogeneous sample of patients with type 2 diabetes.

*Table 2. Trigger-Point Palpation Findings in Gastrocnemius and Soleus Muscles*

Muscle	Present, n (%)	Absent, n (%)	Total, n (%)
Gastrocnemius	105 (77.8)	30 (22.2)	135 (100.0)

Muscle	Present, n (%)	Absent, n (%)	Total, n (%)
Soleus	105 (77.8)	30 (22.2)	135 (100.0)

Trigger-point palpation was positive in 105 participants for the gastrocnemius muscle and 105 participants for the soleus muscle. The same prevalence pattern was observed for both muscles, with 77.8% of participants showing positive trigger-point palpation and 22.2% showing no trigger-point palpation.

**Table 3. Distribution of Goniometric Flexibility Categories**

Muscle	0–10°, n (%)	11–15°, n (%)	16–20°, n (%)	>20°, n (%)	Total, n (%)
Soleus	68 (50.4)	37 (27.4)	29 (21.5)	1 (0.7)	135 (100.0)

Muscle	0–10°, n (%)	11–15°, n (%)	15–20°, n (%)	Total, n (%)
Gastrocnemius	86 (63.7)	19 (14.1)	30 (22.2)	135 (100.0)

Goniometric assessment showed that reduced flexibility categories were common in both calf muscles. For the soleus muscle, 68 participants were in the 0–10° category and 37 were in the 11–15° category. For the gastrocnemius muscle, 86 participants were in the 0–10° category and 19 were in the 11–15° category. Only one participant was recorded in the >20° soleus category.

**Table 4. Association Between Gastrocnemius Trigger-Point Palpation and Soleus Flexibility**

Gastrocnemius Trigger Point	0–10°, n	11–15°, n	16–20°, n	>20°, n	Total, n	$\chi^2$	df	p-value
Present	68	37	0	0	105	135.000	3	<0.001
Absent	0	0	29	1	30	135.000	3	<0.001
Total	68	37	29	1	135	135.000	3	<0.001

$\chi^2$ , chi-square test; df, degrees of freedom.

Gastrocnemius trigger-point palpation was significantly associated with soleus goniometric flexibility categories. All 105 participants with positive gastrocnemius trigger-point palpation were distributed within the 0–10° and 11–15° soleus flexibility categories, while all 30 participants without gastrocnemius trigger points were distributed within the 16–20° and >20° categories.

**Table 5. Association Between Gastrocnemius Trigger-Point Palpation and Gastrocnemius Flexibility**

Gastrocnemius Trigger Point	0–10°, n	11–15°, n	15–20°, n	Total, n	$\chi^2$	df	p-value
Present	86	19	0	105	135.000	2	<0.001
Absent	0	0	30	30	135.000	2	<0.001
Total	86	19	30	135	135.000	2	<0.001

$\chi^2$ , chi-square test; df, degrees of freedom.

Gastrocnemius trigger-point palpation was significantly associated with gastrocnemius flexibility categories. Among participants with positive gastrocnemius trigger-point palpation, 86 were in the 0–10° category and 19 were in the 11–15° category. In contrast, all 30 participants without gastrocnemius trigger points were recorded in the 15–20° flexibility category.

**Table 6. Association Between Soleus Trigger-Point Palpation and Soleus Flexibility**

Soleus Trigger Point	0–10°, n	11–15°, n	16–20°, n	>20°, n	Total, n	$\chi^2$	df	p-value
Present	68	37	0	0	105	135.000	3	<0.001
Absent	0	0	29	1	30	135.000	3	<0.001
Total	68	37	29	1	135	135.000	3	<0.001

$\chi^2$ , chi-square test; df, degrees of freedom.

Soleus trigger-point palpation was significantly associated with soleus flexibility categories. Participants with positive soleus trigger-point palpation were limited to the 0–10° and 11–15° goniometric categories, whereas participants without soleus trigger points were recorded in the 16–20° and >20° categories.

Soleus trigger-point palpation was significantly associated with gastrocnemius flexibility categories. All participants with positive soleus trigger-point palpation were found in the lower gastrocnemius

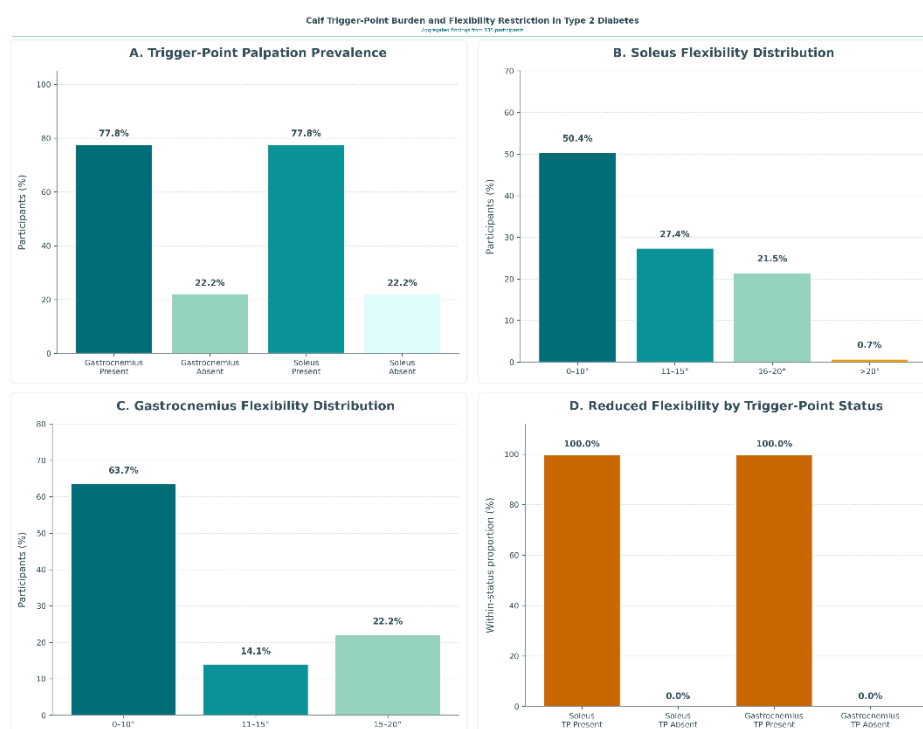
flexibility categories, while all participants without soleus trigger points were recorded in the highest reported gastrocnemius flexibility category.

**Table 7. Association Between Soleus Trigger-Point Palpation and Gastrocnemius Flexibility**

Soleus Trigger Point	0–10°, n	11–15°, n	15–20°, n	Total, n	χ <sup>2</sup>	df	p-value
Present	86	19	0	105	135.000	2	<0.001
Absent	0	0	30	30	135.000	2	<0.001
Total	86	19	30	135	135.000	2	<0.001

χ<sup>2</sup>, chi-square test; df, degrees of freedom.

Overall, the results demonstrate a consistent association between positive trigger-point palpation and reduced calf muscle flexibility in patients with type 2 diabetes. Across both gastrocnemius and soleus assessments, participants with trigger points were concentrated in lower goniometric categories, while participants without trigger points were concentrated in higher flexibility categories. The associations were statistically significant across all reported cross-tabulations.



**Figure 1** Panel A shows identical trigger-point prevalence in gastrocnemius and soleus muscles, with 105 of 135 participants positive for trigger points in each muscle. Panels B and C show that participants were concentrated in lower goniometric flexibility categories, particularly 0–10° for soleus and gastrocnemius. Panel D summarizes the complete separation observed in the reported cross-tabulations, where trigger-point-positive participants were consistently distributed in reduced-flexibility categories, while trigger-point-negative participants were distributed in higher flexibility categories.

## DISCUSSION

The present study assessed calf muscle flexibility and myofascial trigger points in patients with type 2 diabetes and found a consistent association between positive trigger-point palpation and reduced goniometric flexibility in both the gastrocnemius and soleus muscles. Trigger-point palpation was positive in 105 of 135 participants for both muscles, indicating a high burden of clinically detectable myofascial involvement in this sample. Across all cross-tabulations, participants with positive trigger-point palpation were concentrated in lower flexibility categories, whereas participants without trigger points were distributed in higher goniometric categories. These findings suggest that calf muscle trigger points and reduced ankle-related flexibility may coexist in patients with type 2 diabetes and may be clinically relevant during physiotherapy screening and lower-limb functional assessment.

The high frequency of trigger-point palpation observed in this study is broadly consistent with previous evidence showing that latent trigger points are common in lower-limb muscles, including the triceps surae, even in populations without overt symptoms. Zuñil-Escobar et al. reported a notable prevalence of latent trigger points in lower-limb muscles among asymptomatic participants, and their findings also indicated sex-related differences in trigger-point distribution, which is relevant to the present sample because most participants were female (12). Similarly, Grieve et al. described latent myofascial trigger points in the triceps surae and upper trapezius and emphasized the need for clear diagnostic criteria during palpation-based assessment (13). The present findings extend this clinical concern to patients with type 2 diabetes, although direct comparison should be cautious because the current study focused on a diabetic population and used a cross-sectional design.

The observed association between trigger-point palpation and reduced flexibility is also supported by studies showing that myofascial trigger-point interventions may influence ankle dorsiflexion and calf muscle function. Grieve et al. reported immediate changes in restricted ankle dorsiflexion following triceps surae trigger-point therapy in recreational runners, suggesting that trigger-point-related calf dysfunction may be relevant to ankle mobility (14). Another pilot randomized study found that soleus trigger-point pressure release improved ankle dorsiflexion, supporting the clinical importance of soleus myofascial assessment when restricted ankle movement is present (15). Although these intervention studies cannot be directly equated with the present observational findings, they provide a plausible clinical basis for the association between trigger-point presence and reduced calf muscle flexibility.

Calf muscle flexibility is functionally important because the gastrocnemius and soleus contribute to ankle control, gait propulsion, balance, and closed-chain lower-limb movement. Fattahian et al. reported that calf flexibility is related to functional status in athletes with ankle injuries, indicating that reduced calf flexibility can have practical implications for movement performance (16). Alshami and Alhassany also found reduced calf muscle characteristics in patients with knee osteoarthritis, supporting the broader clinical relevance of calf muscle assessment in musculoskeletal populations (17). In the present study, participants with positive gastrocnemius or soleus trigger-point palpation were consistently located in lower goniometric categories, which may indicate a clinically meaningful clustering of myofascial tenderness and restricted flexibility.

The diabetic context is important when interpreting these findings. Type 2 diabetes is associated with neuromuscular, metabolic, and structural muscle changes that may influence lower-limb function. Almurthi et al. reported reduced lower-limb muscle strength and volume in patients with type 2 diabetes in relation to neuropathy, intramuscular fat, and vitamin D levels, highlighting that diabetic muscle dysfunction may be multifactorial (7). Zhao et al. also demonstrated measurable calf skeletal muscle changes in male patients with type 2 diabetes using T1 $\rho$  mapping, further supporting the need to evaluate calf muscle status in this population (8). Therefore, the association observed in the present study may reflect not only local trigger-point-related restriction but also broader diabetes-related changes in muscle quality, body composition, physical activity, pain sensitivity, or neuromuscular function.

Some findings in the literature differ from the present results. Martínez-Jiménez et al. examined the effects of myofascial induction therapy on ankle range of motion and pressure pain threshold in gastrocnemius trigger points and reported findings that do not fully align with a simple direct relationship between trigger-point treatment and ankle dorsiflexion change (18). Such differences may be due to variation in study design, population characteristics, trigger-point diagnostic criteria, intervention type, knee position during dorsiflexion testing, and outcome measurement procedures. This reinforces the need for standardized assessment methods when examining the relationship between trigger points and calf muscle flexibility.

A key strength of the present study is that it focused on a clinically relevant and underexplored musculoskeletal issue in patients with type 2 diabetes. The study also assessed both gastrocnemius and soleus muscles and used goniometric flexibility categories together with manual palpation findings.

However, several limitations should be acknowledged. The cross-sectional design prevents causal interpretation, so the findings cannot determine whether trigger points contributed to reduced flexibility or whether reduced flexibility, altered movement, obesity, comorbidities, or diabetes-related muscle changes contributed to trigger-point development. Convenience sampling may also limit generalizability. The manuscript did not report diabetes duration, HbA1c, neuropathy status, physical activity level, medication use, inter-rater reliability, examiner blinding, or detailed palpation criteria, all of which may influence interpretation. In addition, the complete separation observed in the cross-tabulations should be verified using the raw dataset to exclude coding overlap, classification bias, or non-independent categorization between trigger-point status and flexibility groups.

Despite these limitations, the findings suggest that calf muscle trigger-point assessment may be clinically useful when evaluating flexibility restriction in patients with type 2 diabetes. Physiotherapy assessment in this population may benefit from combined screening of ankle dorsiflexion, calf flexibility, myofascial tenderness, BMI-related loading factors, comorbidities, and functional mobility. Future studies should use larger and more diverse samples, standardized trigger-point diagnostic criteria, blinded assessors, reliability testing, and multivariable analysis to determine whether the observed association remains significant after adjustment for age, sex, BMI, diabetes duration, neuropathy, comorbidities, and physical activity level.

## CONCLUSION

This study found a significant association between calf muscle trigger-point palpation and reduced goniometric flexibility among patients with type 2 diabetes. Trigger-point palpation was positive in a large proportion of participants for both the gastrocnemius and soleus muscles, and positive palpation findings were consistently associated with lower flexibility categories. These findings support the clinical value of assessing both myofascial trigger points and calf muscle flexibility during lower-limb examination in patients with type 2 diabetes. However, because of the cross-sectional design, the results should be interpreted as an association rather than a causal relationship. Future studies using standardized palpation criteria, detailed diabetes-related clinical profiling, and adjusted statistical analysis are required to confirm these findings and clarify their implications for physiotherapy management.

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