

Prevalence of sarcopenia and frailty and their effects on health status and quality of life in older adults with uncontrolled type 2 diabetes mellitus



Original article

Daravan Rongmuang^a, Jeraporn Tongdee^{a,*}, Truong Thanh Nam^b

^aDepartment of Adults and Elderly Nursing, Boromarajonani College of Nursing, Suratthani, Faculty of Nursing, Prabromarajchanok Institute, Suratthani, Thailand

^bDepartment of Nutrition and Food Safety, of Public Health, Can Tho University of Medicine and Pharmacy, Can Tho city, Vietnam

Received: 14 July 2025; Accepted: 21 August 2025; Published: 20 June 2026

Abstract: **Objective:** To determine the prevalence of sarcopenia and frailty in older adults with uncontrolled type 2 diabetes mellitus (T2DM) and examine their effects on health status and quality of life (QoL).

Methods: A purposive sample of 280 older adults with uncontrolled T2DM was recruited in this descriptive correlational study. The research instruments included a demographic questionnaire, the SARC-F questionnaire, the FRAIL scale, a visual analog scale (VAS) assessing health status, and the WHOQOL questionnaire. Uncontrolled T2DM was defined as hemoglobin A1c (HbA1c) >7% or fasting blood sugar >130 mg/dL after at least 8 h of fasting, in accordance with the American Diabetes Association guidelines. Sarcopenia and frailty were assessed using the SARC-F (≥ 4) and FRAIL scale (≥ 3), respectively. The data were analyzed using descriptive statistics and 2-way analysis of variance (ANOVA).

Results: The prevalence of sarcopenia and frailty was 11.4% and 5.4%, respectively. There was a statistically significant interaction effect between sarcopenia and frailty on health status, $F(2, 274) = 23.71, P < 0.001$, partial $\eta^2 = 0.148$, and QoL, $F(2, 274) = 5.59, P = 0.004$, partial $\eta^2 = 0.039$. There were significant main effects of sarcopenia and frailty on health status, $F(1, 274) = 57.19, P < 0.001$, and $F(2, 274) = 40.53, P < 0.001$, respectively. There were significant main effects of frailty on QoL, $F(2, 274) = 7.06, P = 0.001$, but there were no statistically significant main effects of sarcopenia on QoL: $F(1, 274) = 3.57, P = 0.06$.

Conclusions: Early detection of sarcopenia and frailty in older adults with uncontrolled T2DM is essential to promoting health and QoL. Future studies should develop interventions to prevent and delay sarcopenia and frailty in this population.

Keywords: diabetes mellitus • frailty • health status • quality of life • sarcopenia

© Shanxi Medical Periodical Press Co., Ltd.

1. Introduction

Sarcopenia and frailty are common geriatric syndromes with significant implications for older adults, particularly those with type 2 diabetes mellitus (T2DM). In the United States, the prevalence of sarcopenia among older adults with diabetes is 27.9%, compared to 15.7% in

nondiabetics.¹ In Thailand, the prevalence of sarcopenia in older adults with T2DM ranges from 1.3% to 25.6%, varying by setting and diagnostic criteria.^{2,3} Sarcopenia, is more prevalent in individuals with T2DM, with an estimated twofold increased risk compared to nondiabetic

How to cite this article: Rongmuang D, Tongdee J, Nam TT. Prevalence of sarcopenia and frailty and their effects on health status and quality of life in older adults with uncontrolled type 2 diabetes mellitus. *Front Nurs.* 2026;2:241–250.

*Corresponding author:

*E-mail: jena_192@hotmail.com (J. Tongdee).

peers (OR = 2.32)², emphasizing its clinical importance. The condition is more frequent among older adults in a hospital setting (33.4%) than among community-dwelling older adults (17.3%).⁴ The co-occurrence of these conditions contributes to functional decline, reduced quality of life (QoL), and increased morbidity and mortality. Risk factors for sarcopenia in older adults with T2DM include advanced age, male sex, low body mass index (BMI), malnutrition, insulin resistance, and poor glycemic control.^{1,4–6} Maintaining hemoglobin A1C (HbA1c) levels below 7%, as recommended by the American Diabetes Association, is crucial in mitigating complications.⁷ Hyperglycemia promotes chronic inflammation and the release of cytokines (e.g., TNF- α , IL-6, CRP), which drive muscle degradation. Muscle loss is another age-related change that is associated with a lower number of hormones such as growth hormone, IGF-1, and testosterone, both of which are related to muscle protein synthesis.⁸ This results in loss of muscle mass and aggravation of sarcopenia. Sarcopenia often underlies frailty, a state of increased vulnerability to stressors, which is common in older diabetic patients.⁶

Frailty, characterized by decreased physiological reserves and increased vulnerability to stressors, often coexists with sarcopenia and may share overlapping pathophysiological pathways. It is defined by 5 key symptoms including muscle weakness, low physical activity, slow walking speed, fatigue, and unintentional weight loss.⁹ The prevalence of frailty syndrome among elderly individuals with T2DM varies across studies, ranging from 8% to 30%, with up to 66% classified as pre-frail.^{10,11} In Northern Thailand, a community-based study of older adults found frailty in 13.9% and pre-frailty in 50.9%, although this was not specific to diabetics.¹² Sarcopenia and frailty in T2DM patients are associated with adverse health outcomes, including increased risk of hospitalization and new disabilities regarding activities of daily living.¹³ These conditions negatively impact physical activity levels and nutritional status.¹⁴ The combined presence of sarcopenia and frailty in older adults with uncontrolled T2DM poses serious risks to both physical and mental health. Physically, these conditions impair mobility, reduce health perception, and increase dependence. Psychologically, these conditions contribute to cognitive decline, depression, anxiety, and feelings of being a burden. Social isolation and caregiver burden are also common, adding to the economic and emotional toll on families and health systems.¹⁵ Therefore, early detection and intervention for sarcopenia and frailty in older adults with T2DM may improve prognosis and QoL.⁶

Recent studies have emphasized the high prevalence and impact of sarcopenia and frailty across diverse cultural settings. A meta-analysis of community-dwelling older adults in Asia using the Asian Working Group for

Sarcopenia (AWGS) criteria reported a sarcopenia prevalence of 15.9% in individuals with diabetes, compared to 10.8% in those without. Older adults with diabetes had a significantly higher risk of developing sarcopenia.¹⁶ Similarly, a study from Brazil using the European Working Group on Sarcopenia in Older People2 (EWG-SOP2) found 7% of participants were probable sarcopenic, 15% sarcopenic, and 2.5% severe sarcopenic.¹⁷ In Japan, sarcopenia was also associated with increased risk of hospitalization and depressive symptoms in older adults with diabetes.¹⁸ However, prevalence estimates vary widely across studies. This variation may be due to differences in diagnostic criteria, screening tools, and population characteristics. To address these gaps, the present study aimed to determine the prevalence of sarcopenia and frailty among older adults with uncontrolled T2DM in Southern Thailand. The study also examines how these conditions interact to affect health status and QoL. Findings contribute evidence to the global understanding of geriatric syndromes in diabetic populations and emphasize the importance of early screening and culturally appropriate interventions for older adults with diabetes.

2. Methods

2.1. Study design

This descriptive cross-sectional survey was used to examine the effects of sarcopenia and frailty on health status and QoL in older adults with uncontrolled T2DM.

2.2. Participants

A total of 280 older adults aged over 60 years with uncontrolled T2DM were recruited from community hospitals and health centers under the Ministry of Public Health in Suratthani, Thailand. The sample was determined using Epi-Info (Version 7) for the population survey, with the population of 11,244 patients with uncontrolled T2DM, the assumptions of a 2-sided confidence level of 95%, an acceptable margin of error at 5%, assumption of an expected frequency of 24.4%.¹⁹ The samples were collected using the quota sampling technique. The inclusion criteria were older adult diabetic patients with fasting blood sugar levels >130 mg/dL after at least 8 h of fasting, or HbA1C levels >7% over the past 3 months, no cognitive impairment as assessed by a 6-item cognitive assessment test with a total score <7 points and voluntary willingness to participate in the research. The exclusion criteria were illness-related depression as screened by the 15-item Thai Geriatric Depression Scale (TGDS-15). Participants who had total scores of 11 points or higher were excluded from the study.

2.3. Measures

The research instruments for data collection were as follows:

2.3.1. The demographic and clinical characteristics questionnaire

The questionnaire included items on age, gender, education level, occupation, monthly income, duration of T2DM, HbA1C level, weight, height, and comorbidities.

2.3.2. SARC-F

The SARC-F consisted of 5 domains: strength (S), assistance with walking (A), rising from a chair (R), climbing stairs (C), and falls (F), scored from 0 to 2. A score of ≥ 4 out of 10 points indicates a risk of sarcopenia.²⁰ The Thai version of the SARC-F was translated by Akarapornkrait et al.,²¹ and has content validity of 0.93 and has been validated in older adults in Thailand.

2.3.3. The simple frailty questionnaire

The Simple Frailty Questionnaire was used to determine frailty in older adults. The questionnaire includes 5 items: (1) fatigue, (2) resistance, (3) ability to walk (ambulation), (4) illnesses, and (5) weight loss.²² This tool was translated into Thai by Sriwong et al.²³ Each item demonstrated an item-level content validity index (I-CVI) of 1.0. The test-retest reliability coefficient was 0.88. For each question, the participants answered with either “yes” or “no,” scoring 1 or 0 points, respectively. Total scores can range from 0 to 5 points, in which a higher score means the older adult has more signs of frailty. To interpret the results, a score of 3 or higher means the older adult is frail, while a score of 2 means they are pre-frail.

2.3.4. Visual analog scale

General health status was assessed with a visual analog scale (VAS) based on the older adults' perception, with scores from 0 to 10. Health status was categorized into 3 levels: worst health (0–3.3 points), moderate health (3.4–6.6 points), and best health (6.7–10.0 points). The VAS is a valid self-administered instrument for collecting data on the health status of elderly people.²⁴

2.3.5. World Health Organization Quality of Life Brief - Thai Version (WHOQOL-BREF-THAI)

The instrument contains 26 questions covering 4 domains of QoL including physical health, psychological

health, social relationships, and environment; it was translated into Thai by Mahatnirunkunet et al.²⁵ The reliability is 0.84. The total scores range from 26 to 130 points interpreted as follows: 26–60 points means poor QoL; 61–95 points means moderate QoL and 96–130 points means good QoL.

Instruments were used with permission from the respective authors. All data collectors were trained to ensure standardized administration of questionnaires and consistent scoring procedures.

2.4. Ethical considerations

This study was approved by the ethics committee of Boromarajonani College of Nursing, Surat Thani, Faculty of Nursing, Praboromarajchanok Institute (IRB approval number: 2025/2). All participants provided written informed consent before participating in the study.

2.5. Statistical analysis

The demographic and clinical characteristics of the participants were summarized using descriptive statistics. Continuous variables (e.g., age, HbA1c levels) were reported as means and standard deviations (SD) for normally distributed data or medians and interquartile ranges (IQR) for skewed data (e.g., monthly income). Categorical variables (e.g., gender, sarcopenia, and frailty status) were presented as frequencies and percentages. The prevalence of sarcopenia and frailty was calculated as the proportion of participants meeting established diagnostic criteria for each condition. To examine the effects of sarcopenia and frailty on health status and QoL, a 2-way analysis of variance (ANOVA) was performed. The dependent variables were the health status and QoL scores, while sarcopenia (present or absent) and frailty (frail, pre-frail, or robust) were the independent variables. Before conducting the 2-way ANOVA, the following assumptions were tested. The normality assumption was verified through the Shapiro-Wilk test, which confirmed a normal distribution of the data. The results indicated that the residuals were normally distributed ($P > 0.05$ for all groups). Homogeneity of variance was examined using Levene's test, which assessed the equality of variances across the groups. The test results showed that the variances were equal ($P > 0.05$), supporting the use of ANOVA. Tukey's HSD post hoc tests were applied.

3. Results

A total of 280 older adults with uncontrolled T2DM participated in the study. As shown in Table 1, the mean age of the participants was 66.2 (SD = 4.8), and most

Demographic and clinical characteristics	<i>n</i>	Percentage (%)
<i>Age (mean = 66.2, SD = 4.8) min = 60, max = 78</i>		
60–69 years	205	73.2
70–79 years	75	26.8
<i>Gender</i>		
Male	97	34.6
Female	183	65.4
<i>Education level</i>		
Lower than elementary	2	0.7
Elementary school	178	63.6
High school	77	27.5
Bachelor's degree	23	8.2
<i>Occupation</i>		
Unemployed	108	38.6
Farmer	57	20.4
General laborer	74	26.4
Merchant	37	13.2
Retired government officer	4	1.4
<i>BMI (mean = 24.7, SD = 3.8) min = 17.2, max = 42.9</i>		
Underweight (<18.5 kg/m ²)	3	1.1
Normal (18.5–22.9 kg/m ²)	91	32.5
Overweight (23.0–24.9 kg/m ²)	96	34.3
Obese I (25.0–29.9 kg/m ²)	68	24.3
Obese II (>30.0 kg/m ²)	22	7.8
<i>Number of comorbidities</i>		
1–4	263	93.9
5–8	17	6.1
<i>Health status</i>		
Worst health	7	2.5
Moderate health	32	11.4
Best health	241	86.1

Note: BMI, body mass index; HbA1C, hemoglobin A1C; SD, standard deviation.

Table 1. The demographic and clinical characteristics of the participants (*n* = 280).

participants were aged between 60 years and 69 years (*n* = 205, 73.2%). Most of the participants were women (65.4%), had completed elementary school (63.6%), and were unemployed (38.6%). The mean BMI was 24.7 kg/m² (SD = 3.8). Most were overweight (34.3%) or had a normal BMI (32.5%). Most of the participants had between 1 and 4 comorbidities (93.9%). The majority of participants reported the best health (86.1%). The median monthly income was 6500 THB (IQR = 10,000), the mean duration of diabetes was 10.23 years (SD = 8.77), and the mean HbA1c level was 8.29 mg% (SD = 1.37). The prevalence of sarcopenia was 11.4%, and frailty was 5.4% (Table 2).

The descriptive statistics for health status and QoL as dependent variables showed that the older adults

with at risk of sarcopenia reported an overall health status score of 6.7 and a QoL score of 110.8. Among the robust group had a mean health score was 6.8, and the mean QoL score was 111.2. The pre-frail group had a mean health status score of 6.1, and a mean QoL score of 106.5. The frail group at risk of sarcopenia reported an overall health status score of 4.9 and a QoL score of 104.8. Among robust participants, the mean health status score was 6.8, and the mean QoL score was 116.3. The pre-frail group had a mean health status score of 4.4, and a mean QoL score of 104.7, whereas the frail group had the lowest mean health status score of 2.5, and a mean QoL score of 87.6 (Table 3).

These results indicate that older adults with sarcopenia, especially those who are frail, tend to have

Variable	<i>n</i>	Percentage (%)
Sarcopenia		
SARC-F 0–3 points	248	88.6
SARC-F ≥4 points	32	11.4
Frailty		
Robust (0–1)	238	85.0
Pre-Frail (2)	27	9.6
Frail (≥3)	15	5.4

Note: T2D, type 2 diabetes.

Table 2. Prevalence of sarcopenia and frailty in older adults with uncontrolled T2D (*n* = 280).

worse health status and QoL compared to those without sarcopenia.

There were significant main effects of sarcopenia and frailty on health status, $F(1, 274) = 57.19$, $P < 0.001$ and $F(2, 274) = 40.53$, $P < 0.001$, respectively (Table 4). The interaction effect between sarcopenia and frailty was also significant on health status $F(2, 274) = 23.71$, $P < 0.001$, $\eta^2_p = 0.148$, suggesting that the combined impact of sarcopenia and frailty on health status is more than additive. Frailty had a stronger effect ($\eta^2_p = 0.228$) than sarcopenia ($\eta^2_p = 0.173$) (Table 4). Post hoc comparisons using Tukey's HSD test indicated that participants classified as frail had significantly lower health status scores compared to both robust ($P < 0.001$) and pre-frail groups ($P < 0.001$). These findings highlight the substantial impact of frailty on perceived health status, particularly among older adults with coexisting sarcopenia. The data indicate the need for targeted interventions addressing both sarcopenia and frailty to improve health outcomes in older adults with uncontrolled T2DM.

There were significant main effects of frailty on QoL $F(2, 274) = 7.06$, $P = 0.001$, while there were no statistically significant main effects of sarcopenia on QoL $F(1, 274) = 3.57$, $P = 0.06$, the result approached conventional significance and may reflect a limited statistical power to detect small to moderate effects. In contrast, the interaction effect between sarcopenia and frailty was statistically significant ($F(2, 274) = 5.59$, $P = 0.004$, $\eta^2_p = 0.039$), suggesting a synergistic impact of these conditions on QoL outcomes (Table 5). Post hoc analysis using Tukey's HSD revealed that frail older adults had significantly lower QoL scores compared to their robust ($P < 0.001$). There was no significant difference between the robust and pre-frail groups ($P = 0.111$), as well as between frail and pre-frail groups ($P = 0.06$). The data suggest that these conditions' combined impact influence QoL more than either factor alone. Frailty had a greater impact on QoL compared to sarcopenia, with frail individuals reporting significantly lower QoL scores.

The interaction effect highlights that frailty exacerbates the negative impacts of sarcopenia on QoL. These results underscore the need for interventions targeting frailty and sarcopenia to enhance QoL in older adults with uncontrolled T2DM.

There were statistically significant interaction effects of sarcopenia and frailty on health status, $F(1, 276) = 57.19$, $P < 0.001$, and QoL, $F(2, 276) = 9.12$, $P = 0.003$. There were significant main effects of sarcopenia and frailty on health status ($F(1, 276) = 55.71$, $P < 0.001$; $F(1, 276) = 39.76$, $P < 0.001$), and QoL ($F(1, 276) = 6.62$, $P = 0.011$; $F(1, 276) = 9.09$, $P = 0.003$).

4. Discussion

This study provides critical insights into the prevalence and impact of sarcopenia and frailty on health status and QoL among older adults with T2DM. The discussion is based on key findings, their implications, and integration into the current knowledge of sarcopenia and frailty in older adults with T2DM.

The findings reveal that 11.4% of the participants in this study had sarcopenia, and 5.4% of the participants had frailty. The prevalence of sarcopenia in this study was lower than that reported in other populations, which range from 15.9% to 24%.^{6,26,27} This discrepancy may reflect differences in sample characteristics and the reliance on the SARC-F screening tool, which possesses only moderate sensitivity. Moreover, the absence of objective diagnostic methods, such as dual-energy X-ray absorptiometry (DXA) or handgrip strength testing, may have contributed to the potential underestimation of sarcopenia prevalence. Additionally, the use of purposive sampling may have excluded institutionalized or severely ill individuals, introducing potential selection bias. These differences underscore the heterogeneity of both sarcopenia and frailty, while highlighting the need for the development of standardized diagnostic criteria within populations. These findings emphasize a wide range of pathomechanisms that contribute to T2DM-associated sarcopenia and frailty. Secondly, metabolic derangements harmful to the skeletal muscle occur in poorly controlled diabetes (the mean HbA1c of 8.29% in the current study). In muscle cells, the insulin resistance of the body stores glucose, impairing the delivery of energy for muscle maintenance and repair.²⁸

Moreover, unregulated hyperglycemia promotes the formation of advanced glycation end products (AGE) that can localize in muscle tissues, leading to stiffness, which decreases elasticity and function.^{29,30} These metabolic disorders in turn contribute to increased proteolysis of muscle proteins, impaired muscle protein synthesis, and, ultimately, sarcopenia. Hormonal changes associated

Sarcopenia	Frailty	Health status mean (SD)	QoL (mean, SD)	<i>n</i>
No risk of sarcopenia	Robust	6.8 (0.79)	111.2 (13.27)	223
	Pre-frail	6.1 (1.41)	106.5 (15.44)	20
	Frail	6.4 (1.34)	110.8 (24.82)	5
	Total	6.7 (0.89)	110.8 (13.72)	248
At risk of sarcopenia	Robust	6.8 (0.78)	116.3 (11.93)	15
	Pre-frail	4.4 (1.13)	104.7 (23.40)	7
	Frail	2.5 (2.56)	87.6 (14.69)	10
	Total	4.9 (2.46)	104.8 (19.82)	32
Total	All categories	6.5 (1.30)	110.1 (14.62)	280

Note: QoL, quality of life; SD, standard deviation.

Table 3. Health status and QoL as dependent variable (*n* = 280).

Source	SS	df	MS	<i>F</i>	<i>P</i> -value	Effect size
Sarcopenia	54.5	1	54.5	57.19	<0.001	0.173
Frailty	77.2	2	38.6	40.53	<0.001	0.228
Sarcopenia × frailty interaction	45.2	2	22.6	23.71	<0.001	0.148
Error	260.9	274	0.95			
Total	12,328.0	280				

Note: $R^2 = 0.447$; adjusted $R^2 = 0.437$; effect size = η^2 or partial η^2 ; MS, mean squares; SS, sum of squares.

Table 4. The health status among different symptoms

Source	SS	df	MS	<i>F</i>	<i>P</i> -value	Effect size
Sarcopenia	693.5	1	693.5	3.57	0.060	0.013
Frailty	2745.6	2	1372.8	7.06	0.001	0.049
Sarcopenia × frailty interaction	2175.3	2	1087.6	5.59	0.004	0.039
Error	53,285.1	274	194.5			
Total	3,454,043.0	280				

Note: $R^2 = 0.107$; adjusted $R^2 = 0.091$; effect size = partial η^2 .

Abbreviations: MS, mean squares; QoL, quality of life; SS, sum of squares.

Table 5. QoL among different symptoms (*n* = 280).

with age and diabetes contribute to muscle wasting as well. Lowered anabolic hormones, such as GH, IGF-1, and testosterone, reduce muscle protein synthesis and maintenance.^{31,32} Furthermore, protein malnutrition is frequent in older adults with uncontrolled diabetes and is intrinsically important in developing sarcopenia.³³ All of the above serve as risk factors for the sarcopenia process and severity, as well as frailty, which may ultimately culminate in loss of function and dependence.

Sarcopenia and frailty interact in ways that exacerbate adverse health outcomes, especially as they synergistically worsen health status and QoL. These results support previous findings showing that uncontrolled glycaemia accelerates sarcopenia and frailty through

low-grade inflammation, insulin resistance, and metabolic disturbance.^{6,8} Chronic hyperglycemia and insulin resistance drive muscle protein degradation and suppress muscle protein synthesis, while a pro-inflammatory condition tied to diabetes hastens muscle loss and frailty progression. Aging-related anabolic resistance and nutritional deficits further amplify these risks. Therefore, optimizing glycemic control and nutritional strategies is essential to counteract skeletal muscle loss and the progression of frailty. Conversely, optimizing and ensuring adequate protein and micronutrient intake, and promoting resistance training may mitigate sarcopenia and frailty in this population.^{34,35} Beyond biological mechanisms, this study revealed a significant interaction

between sarcopenia and frailty in affecting QoL. This suggests a compounded burden when both conditions are present. While sarcopenia alone did not show a significant main effect on QoL ($P = 0.060$), this borderline result may reflect a Type II error or under detection due to the moderate sensitivity of the SARC-F tool. Post hoc power analysis supported adequate power for moderate effects, but smaller effects may have gone undetected. These findings underscore the value of examining synergistic effects and highlight the need for longitudinal designs to clarify causal pathways.

In this study, frailty was a stronger predictor of health status and QoL than sarcopenia, consistent with previous studies.^{6,14} This may be attributed to the multidimensional nature of frailty, which affects not only physical function but also psychological, cognitive, and social domains. Symptoms such as fatigue, slowness, and unintentional weight loss increase fall risk and contribute to depression and social isolation, leading to greater QoL decline. In contrast, sarcopenia is primarily characterized by loss of muscle mass and strength and may not affect function until later stages.³⁶ Frailty reflects broader physiological vulnerability, including nutritional deficits, polypharmacy, and cognitive decline, which further diminish QoL. The significant interaction between frailty and sarcopenia suggests compounded effects, even when sarcopenia alone is not significant. Targeting frailty may help mitigate the QoL impact of coexisting sarcopenia, supporting integrated interventions that address both conditions.

An important strength of the present study is the thorough assessment of sarcopenia and frailty using well-defined and population-adapted diagnostic tools. This ensures that the assessment is valid, is relevant to culture, and can be trusted. Although this study adds important knowledge, some limitations should be considered. First, the cross-sectional design prevents us from making causal inferences about the relationships between sarcopenia, frailty, and health outcomes. Longitudinal studies are required to clarify the temporal features of these conditions. Second, this study population may not fully represent all older adults with T2DM, thereby limiting generalizability. Future studies should include different populations to confirm these results. In addition, the study was based on self-reported measures, which can be biased. Objective measures of muscle mass, strength, and physical function would strengthen the validity of future studies.

These findings emphasize the need for targeted interventions to manage sarcopenia and frailty in older adults with diabetes. Resistance training should use low-to-moderate loads and include both static and dynamic balance exercises, such as heel-to-toe walking, tandem stance, and single-leg stance. Functional activities like stair climbing, reaching, walking, cycling,

and low-impact aerobics are also recommended. These exercises should be performed 2–3 times per week for 20–30 min per session. Nutritional support is essential. Daily protein intake should be 1.2–1.5 g/kg/d of high-quality protein such as eggs, dairy, lean meat, and soy. Vitamin D intake should be optimized 800–1000 IU/day. In addition, effective glycemic control is critical to slow the progression of both sarcopenia and frailty.^{37–39}

Such maneuvers could include resistance exercise, improved glycemic control, and dietary strategies with greater availability of amino acids/anti-inflammatory foods. Longer periods are needed for future studies to clarify the correlations between QoL, sarcopenia, and frailty, as well as the impact of personalized interventions on the reduction of their prevalence. Although sarcopenia and frailty are often not measured, these factors have a major role in the etiology of poor control of T2DM. This key investigation represents a first step toward evaluating and more fully characterizing individual interventional strategies that will ultimately offer more insight into the impact of these overlapping geriatric specificities on the treatment of T2DM.

4.1. Limitation

This study used a cross-sectional design, which limits the ability to infer causality between sarcopenia, frailty, and health outcomes. The purposive sampling method, although appropriate for the study context, may have introduced selection bias. This is due to the lack of randomization and the potential exclusion of severely ill or institutionalized individuals. The prevalence of sarcopenia observed in this study (11.4%) was relatively low compared to previous reports. This discrepancy may be explained using the SARC-F questionnaire, a self-reported tool that primarily captures physical symptoms. As a result, it may underestimate sarcopenia, particularly in individuals with subclinical presentations. To improve diagnostic accuracy, future studies should consider using objective tools such as bioelectrical impedance analysis (BIA) or DXA to assess muscle mass. Additionally, as the data were collected from a single province, the generalizability of the findings to other geographic or ethnically diverse populations may be limited. Future research should involve longitudinal and multi-site studies to confirm these findings. It should also explore mediating and moderating effects to better understand causal pathways.

5. Conclusions

This study highlighted the prevalence of sarcopenia risk and frailty in older adults with T2DM. The study findings also reveal the additional adverse impact of these

conditions on the health status and QoL of the elderly and the need for integrated management of individuals with comorbid chronic conditions. Clinicians have the potential to improve outcomes among this at-risk population by targeting the physiological and metabolic pathways driving sarcopenia and frailty. Future studies are encouraged to address the feasibility and establish the efficacy of targeted interventions that slow the development or progression of sarcopenia and frailty, ultimately benefiting the health of the older population with T2DM.

References

1. Dai S, Shu D, Meng F, et al. Higher risk of sarcopenia in older adults with type 2 diabetes: NHANES 1999-2018. *Obes Facts*. 2023;16:237–248.
2. Yuenyongchaiwat K, Boonsinsukh R. Type 2 diabetes mellitus related to decreased peripheral and respiratory muscle strength in sarcopenic Thai elderly. *Curr Aging Sci*. 2021;14:235–241.
3. Wiriya B, Piaseu N, Neelapaichit N, Tantiprasoplap S. Prevalence and predictors of sarcopenia in older people with type 2 diabetes. *Pac Rim Int J Nurs Res*. 2019;23:297–309.
4. Whaikid P, Piaseu N. The prevalence and factors associated with sarcopenia in Thai older adults: a systematic review and meta-analysis. *Int J Nurs Sci*. 2023;11:31–45.
5. Alfaro-Alvarado FA, Rosas-Barrientos JV, Ocharan-Hernández ME, Díaz-Chiguer D, Vargas-De-León C. Association between sarcopenia and poor glycemic control in older adults with type 2 diabetes mellitus. *Diseases*. 2023;11:175.
6. Umegaki H. Sarcopenia and frailty in older patients with diabetes mellitus. *Geriatr Gerontol Int*. 2016;16:293–299.
7. Boye KS, Thieu VT, Lage MJ, Miller H, Paczkowski R. The association between sustained HbA1c control and long-term complications among individuals with type 2 diabetes: a retrospective study. *Adv Ther*. 2022;39:2208–2221.
8. Bian X, He J, Zhang R, Yuan S, Dou K. The combined effect of systemic immune-inflammation index and type 2 diabetes mellitus on the prognosis of patients undergoing percutaneous coronary intervention: a large-scale cohort study. *J Inflamm Res*. 2023;16:6415–6429.
9. Gobbens RJJ, van Assen MALM. Associations between multidimensional frailty and quality of life among Dutch older people. *Arch Gerontol Geriatr*. 2017;73:69–76.
10. Liu Y, Zhang L, Li X, et al. Prevalence and risk factors of frailty in older adults with diabetes: a systematic review and meta-analysis. *PLoS One*. 2024;19:e0309837.
11. Alaca B, Koçak MZ, Gürler M. Clinical significance and prevalence of frailty syndrome in type 2 diabetes patients. *Osmangazi J Med*. 2021;44:169–176.
12. Thinuan P, Siviroj P, Lertrakarnnon P, Lorga T. Prevalence and potential predictors of frailty among community-dwelling older persons in Northern Thailand: a cross-sectional study. *Int J Environ Res Public Health*. 2020;17:4077.
13. Liccini A, Malmstrom TK. Frailty and sarcopenia as predictors of adverse health outcomes in persons with diabetes mellitus. *J Am Med Dir Assoc*. 2016;17:846–851.
14. Casals-Vázquez C, Suárez-Cadenas E, Estébanez Carvajal FM, Aguilar Trujillo MP, Jiménez Arcos MM, Vázquez Sánchez MÁ. Relationship between quality of life, physical activity, nutrition, glycemic control and sarcopenia in older adults with type 2 diabetes mellitus. *Nutr Hosp*. 2017;34:1198–1204 (in Spanish).
15. Larsson H, Rämngård M, Kumlien C, Blomqvist K. Spouses' existential loneliness when caring for a frail partner late in life – A hermeneutical approach. *Int J Qual Stud Health Well-being*. 2020;15:1734166.
16. Chung SM, Moon JS, Chang MC. Prevalence of sarcopenia and its association with diabetes: a meta-analysis of community-dwelling Asian population. *Front Med (Lausanne)*. 2021;8:681232.
17. Sousa IM, Burgel CF, Silva FM, Fayh APT. Prognostic value of isolated sarcopenia or malnutrition-sarcopenia syndrome for clinical outcomes in hospitalized patients. *Nutrients*. 2022;14:2207.
18. Ida S, Murata K, Nakai M, et al. Relationship between sarcopenia and depression in older patients with diabetes: an investigation using the Japanese version of SARC-F. *Geriatr Gerontol Int*. 2018;18:1318–1322.
19. Hegazy MT, Ibrahim MH, Fathy SA, Ragheb CS, Fayed SE. Prevalence of sarcopenia among

Ethical approval

This study was approved by the ethics committee of Boromarajonani College of Nursing, Surat Thani, Faculty of Nursing, Praboromarajchanok Institute (IRB approval number: 2025/2).

Conflicts of interest

All contributing authors declare no conflicts of interest.

- ambulatory elderly Egyptian patients with type 2 diabetes mellitus. *Med J Cairo Univ.* 2023;91:765–776.
20. Malmstrom TK, Morley JE. SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. *J Am Med Dir Assoc.* 2013;14:531–532.
 21. Akarapornkrait P, Muangpaisan W, Boonpeng A, Daengdee D. Validation of the Thai version of SARC-F, MSRA-7, and MSRA-5 questionnaires compared to AWGS 2019 and sarcopenia risks in older patients at a medical outpatient clinic. *Osteoporos Sarcopenia.* 2020;6:205–211.
 22. Morley JE, Malmstrom TK, Miller DK. A simple frailty questionnaire (FRAIL) predicts outcomes in middle aged African Americans. *J Nutr Health Aging.* 2012;16:601–608.
 23. T Sriwong W, Mahavisessin W, Srinonprasert V, et al. Validity and reliability of the Thai version of the simple frailty questionnaire (T-FRAIL) with modifications to improve its diagnostic properties in the preoperative setting. *BMC Geriatr.* 2022;22:161.
 24. Kimura T, Hayashida K, Araki Y, Morita T, Yamaguchi N, Eboshida A. How valid is the self-administered visual analogue scale for assessing the health status of elderly people? *Hiroshima J Med Sci.* 2008;57(3–4):85–92.
 25. Mahatnirunkunet S, Tantipiwattanaskul W, Pumpaisanchai W, Wongsuwan K, Pohnmanarangkul R. Comparison of the World Health Organization Quality of Life Assessment (WHOQOL) 100 and WHOQOL-26 indicators. *J Ment Health Thail.* 1998;5:4–15.
 26. Ai Y, Xu R, Liu L. The prevalence and risk factors of sarcopenia in patients with type 2 diabetes mellitus: a systematic review and meta-analysis. *Diabetol Metab Syndr.* 2021;13:93.
 27. Fung FY, Koh YLE, Malhotra R, et al. Prevalence of and factors associated with sarcopenia among multi-ethnic ambulatory older Asians with type 2 diabetes mellitus in a primary care setting. *BMC Geriatr.* 2019;19:122.
 28. Rudrappa SS, Wilkinson DJ, Greenhaff PL, Smith K, Idris I, Atherton PJ. Human skeletal muscle disuse atrophy: effects on muscle protein synthesis, breakdown, and insulin resistance—a qualitative review. *Front Physiol.* 2016;7:361.
 29. Shou J, Chen PJ, Xiao WH. Mechanism of increased risk of insulin resistance in aging skeletal muscle. *Diabetol Metab Syndr.* 2020;12:14.
 30. Tack W, De Cock AM, Dirinck EL, Bastijns S, Ariën F, Perkisas S. Pathophysiological interactions between sarcopenia and type 2 diabetes: a two-way street influencing diagnosis and therapeutic options. *Diabetes Obes Metab.* 2024;26:407–416.
 31. van den Beld AW, Kaufman JM, Zillikens MC, Lamberts SWJ, Egan JM, van der Lely AJ. The physiology of endocrine systems with ageing. *Lancet Diabetes Endocrinol.* 2018;6:647–658.
 32. Al-Sofiani ME, Ganji SS, Kalyani RR. Body composition changes in diabetes and aging. *J Diabetes Complications.* 2019;33:451–459.
 33. Fanelli SM, Kelly OJ, Krok-Schoen JL, Taylor CA. Low protein intakes and poor diet quality associate with functional limitations in US adults with diabetes: a 2005-2016 NHANES analysis. *Nutrients.* 2021;13:2582.
 34. Miki A, Hashimoto Y, Matsumoto S, et al. Protein intake, especially vegetable protein intake, is associated with higher skeletal muscle mass in elderly patients with type 2 diabetes. *J Diabetes Res.* 2017;2017:7985728.
 35. Talar K, Hernández-Belmonte A, Vetrovsky T, Steffl M, Kalamacka E, Courel-Ibáñez J. Benefits of resistance training in early and late stages of frailty and sarcopenia: a systematic review and meta-analysis of randomized controlled studies. *J Clin Med.* 2021;10:1630.
 36. Carmeli E. Frailty and primary sarcopenia: a review. *Adv Exp Med Biol.* 2017;1020:53–68.
 37. Fu Z, Wang Y, Zhao L, Li Y, Song Q. Seeking optimal non-pharmacological interventions for sarcopenia: a systematic review and network meta-analysis. *Aging Clin Exp Res.* 2025;37:24.
 38. Cabrol-Molina J, Martín-Rodríguez A, Clemente-Suárez VJ. The effects of exercise intervention in older adults with and without sarcopenia: a systematic review. *Sports (Basel).* 2025;13:152.
 39. Nishikawa H, Fukunishi S, Asai A, et al. Sarcopenia, frailty and type 2 diabetes mellitus (Review). *Mol Med Rep.* 2021;24:854.