



BMJ Open Predictors of frailty among Chinese community-dwelling older adults with type 2 diabetes: a cross-sectional survey

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ABSTRACT

Objectives To assess the prevalence of frailty and identify predictors of frailty among Chinese community-dwelling older adults with type 2 diabetes.

Design A cross-sectional design.

Setting Two community health centres in central China.

Participants 291 community-dwelling older adults aged ≥65 years with type 2 diabetes.

Main outcome measures Data were collected via face-to-face interviews, anthropometric measurements, laboratory tests and community health files. The main outcome measure was frailty, as assessed by the frailty phenotype criteria. The multivariate logistic regression model was used to identify the predictors of frailty.

Results The prevalence of prefrailty and frailty were 51.5% and 19.2%, respectively. The significant predictors of frailty included alcohol drinking (ex-drinker) (OR 4.461, 95% CI 1.079 to 18.438), glycosylated haemoglobin (OR 1.434, 95% CI 1.045 to 1.968), nutritional status (malnutrition risk/malnutrition) (OR 8.062, 95% CI 2.470 to 26.317), depressive symptoms (OR 1.438, 95% CI 1.166 to 1.773) and exercise behaviour (OR 0.796, 95% CI 0.716 to 0.884).

Conclusions A high prevalence of frailty was found among older adults with type 2 diabetes in the Chinese community. Frailty identification and multifaceted interventions should be developed for this population, taking into consideration proper glycaemic control, nutritional instruction, depressive symptoms improvement and enhancement of self-care behaviours.

INTRODUCTION

Across the world, the estimated number of people aged 65–99 years with diabetes was 136 million (19.3%) in 2019, and this number is estimated to increase to 195 million in 2030 and 276 million in 2045.¹ China had the world's largest number of adults with diabetes,¹ and the prevalence of older Chinese adults with diabetes over the age of 60 was 20.2% in the latest national survey.² Elderly people with type 2 diabetes are at risk for developing frailty,³ a geriatric syndrome manifesting as a reduction in one's physical strength, endurance and physiological function that increases the likelihood of developing functional dependency and death.⁴

Strengths and limitations of this study

- The study evaluated an extensive list of sociodemographic factors, lifestyle and clinical characteristics, nutritional status, depressive symptoms and diabetes self-care behaviours that could influence the frailty status of community-dwelling older adults with type 2 diabetes.
- The study examined which domains of diabetes self-care behaviours were associated with frailty among diabetic older adults.
- The study is a cross-sectional study, so a causal relationship between factors associated with frailty could not be established.
- The study was conducted in one city of China, which may affect the generalisability of the findings.

Diabetic people are more likely to be frail than their non-diabetic counterparts.^{5 6} This relationship between diabetes and frailty may be explained by the fact that diabetes impairs skeletal muscle function, vascular function and hormonal milieu, as well as accelerates sarcopenia, thereby leading to increased frailty.^{3 7 8}

Frailty is associated with higher disability, mortality, cardiovascular events and health-care utilisation among older adults with type 2 diabetes.^{9 10} Identifying the associated factors for frailty among older adults with diabetes may help to improve their health outcomes. A few studies have shown that sociodemographic factors (eg, age, education level),^{6 11} physical factors (eg, systolic blood pressure, bodyweight, abdominal obesity)^{6 11 12} and biological factors (eg, glycosylated haemoglobin (HbA1c), albumin, high-density lipoprotein cholesterol)^{6 11} were associated with frailty in diabetic older adults. Until now, important, modifiable factors such as nutritional status, psychological well-being and self-care behavioural factors were rarely studied among community-dwelling diabetic older adults.

The association between malnutrition and frailty has been established among community-dwelling older adults.^{13 14} Depression is another common factor associated with frailty among the elderly.^{15 16} However, there is a lack of understanding of the impact of malnutrition and depression on frailty among the specific diabetic older population. Diabetic older adults should adopt numerous diabetes self-care behaviours to control their disease; these behaviours include proper diet, regular exercise, self-monitoring of blood glucose, proper foot care and strict adherence to prescribed medications.¹⁷ Nevertheless, there is a dearth of studies on which domains of diabetes self-care behaviours are preferentially associated with frailty. Examining these associations is important for developing specific interventions to reduce the risk of frailty for diabetic older people.

In China, there is an increasing number of older people with type 2 diabetes living in the community, and the health management of the diabetic elderly population is the focus of many community health services; however, frailty is not among the physical conditions that is routinely screened for in this population.¹⁸ Little is known about the frailty status among the community-dwelling older adults with type 2 diabetes in China. To our knowledge, only one study reported the prevalence of frailty in a community-dwelling diabetic population in mainland China; however, that study included a sample of diabetic people aged 55 years and older, identifying the risk factors of frailty among an elevated blood glucose (pre-diabetes and diabetes) population.⁵ Therefore, the aims of this study were to assess the prevalence of frailty and explore the predictors of frailty among Chinese community-dwelling older adults with type 2 diabetes.

METHODS

Study design and setting

A cross-sectional design was used. The participants were recruited from two community health centres of Xianning City of Hubei Province in China from June to October 2019. Both community health centres provided primary healthcare services for older people in urban and rural communities.

Data collection and ethical considerations

The researcher contacted the directors of two community health centres and explained the aims of this study. After permission was granted, the public health nurses and physicians were invited to assist with data collection. Health centre staff helped to recruit participants by phone, informing the eligible diabetic older adults of the study purpose. Eligible individuals were then invited to the community health centres to complete the survey if they consented to participate. As another means of recruitment, when older adults with type 2 diabetes went to the community health centres for a physical check-up, follow-up blood glucose monitoring, or health education, they were also invited to participate in this study, if

eligible. Once the written informed consent was obtained from each participant, the survey was administered by trained investigators. The information in this survey was obtained from the participants' self-reporting, anthropometric measurements, and laboratory test results, which were supplemented by the community health files.

Participants

Older adults with type 2 diabetes were identified from the electronic files of the two community health centres. The inclusion criteria of this study were as follows: (1) at least 65 years old and living in the community; (2) diagnosed with type 2 diabetes, as confirmed by a physician based on the WHO diagnostic criteria, 1999; (3) received their diagnosis at least 6 months prior to joining the study. The diabetic older adults were excluded if they: (1) could not walk independently; (2) had severe vision and hearing problems; (3) were unable to communicate with the investigators; (4) had dementia or mental health disorders and (5) had acute diabetic complications.

The sample size was calculated using the formula for cross-sectional studies,¹⁹ $n = \frac{Z^2 P(1-P)}{d^2}$. Where n is the sample size, Z is the statistic corresponding to level of confidence, P is expected prevalence, and d is precision. We assumed a confidence level of 95.0%, expected frailty prevalence of 20.0% for community-dwelling older adults with type 2 diabetes (determined by the presurvey), and precision of 5.0%, indicating that at least 246 participants were needed for this study.

Survey instrument

The personal information questionnaire was used to collect the participants' characteristics. The sociodemographic characteristics included age, gender, living place, education level, marital status, living status, working status, personal monthly income and medical insurance; the lifestyle and clinical characteristics included smoking, alcohol drinking, sleep duration at night, self-rated quality of sleep, duration of diabetes, number of comorbidities, polypharmacy, body mass index (BMI), waist circumference and HbA1c. Smoking status was categorised as current smoker (having smoked at least one cigarette per day), ex-smoker (having stopped smoking at least 1 year before the survey) and non-smoker (having never smoked in one's lifetime). Alcohol drinking status was categorised into current drinker (someone who reported consuming alcohol currently), ex-drinker (someone who had quit drinking at least 1 year prior to the survey) and non-drinker (someone who reported never consuming alcohol). Polypharmacy was defined as concurrent use of five or more drugs. BMI was calculated by weight (kg)/ (height (m))² and classified as underweight, normal, overweight and obese (<18.5, 18.5–23.9, 24.0–27.9 and ≥28.0 kg/m²), and high waist circumference was defined as ≥85 cm in men and ≥80 cm in women.²⁰

Frailty was measured using the modified frailty phenotype criteria, which was based on the phenotypic criteria proposed by Fried *et al.*²¹ The criteria included five

components: (1) unintentional weight loss: weight loss ≥ 4.5 kg in the past year, not due to dieting and exercise; (2) exhaustion: It was identified based on a response of '3–4 days or most of the time' during the week to either of the two questions: 'I felt that everything I did was an effort' and 'I could not get going'; (3) Slowness: average walking speed was tested by asking the participants to walk 6 m at their usual pace, at total of two times. Slowness was identified by walking speed for men (≤ 0.89 m/s) and women (≤ 0.79 m/s)²²; (4) Weakness: grip strength was measured with a dynamometer three times on each hand, and the maximum of the readings was used. Weakness was judged by grip strength for men (≤ 28 kg) and women (≤ 18 kg)²² and (5) low physical activity: the Chinese version of Physical Activity Scale for the Elderly (PASE)²³ was used to assess participants' physical activity level in the past week. Low physical activity was classified by PASE score for men (≤ 56.4) and women (≤ 58.8).²² One point was assigned for the presence of each component, and the summed score was used to classify participants as robust (score=0), prefrail (score=1–2) and frail (score=3–5).

Mini-Nutritional Assessment (MNA) was used to assess the nutritional status of older adults.²⁴ It consists of 18 items grouped into four parts: anthropometric assessment, general assessment, dietary assessment and self-assessment. The total score ranges from 0 to 30 and is used to classify the elderly as well-nourished (≥ 24), at risk of malnutrition (17–23.5) or malnourished (< 17). The Chinese version of MNA has been proven to be reliable and valid in the community-dwelling older population.²⁵

Geriatric Depression Scale-15 (GDS-15) was used to evaluate the depressive symptoms of older adults.²⁶ The scale contains 15 items that require the subjects to answer with 'yes' or 'no'. The maximum score of the scale is 15, and a higher score indicates more severe depressive symptoms. The Chinese version of GDS-15 is a reliable and valid screening tool for assessing geriatric depressive symptoms in the Chinese population.²⁷

The Chinese version of Summary of Diabetes Self-Care Activities (SDSCA)²⁸ was used to measure self-care behaviours of the older adults with type 2 diabetes; this instrument was modified from the original SDSCA.¹⁷ It is a brief self-report questionnaire that includes 11 items assessing the following aspects: general diet, specific diet, exercise, blood-glucose testing, foot care and medication care in the past week. The total score of this scale ranges from 0 to 77, and a higher score indicates better diabetes self-care behaviours. It showed good validity and test-retest reliability in Chinese patients with type 2 diabetes.²⁸

Anthropometric measurements, including height or knee height, weight, mid-arm circumference, calf circumference and waist circumference, were measured by the trained investigators according to the measurement manual. Knee height was measured and converted to the estimated height using specific equations²⁹ for the older adults with severe spinal curvature. All the HbA1c measures were obtained after the participants were recruited into the study. The blood collection and HbA1c

measurements were administered by the community health centre laboratories when the participants came to the centres for this survey.

Data analysis

The SPSS V.21.0 (SPSS) was used for data analysis. Frailty was defined as the dependent variable with 1=robust (0 on the frailty phenotype criteria), 2=prefrail (1–2), 3=frail (≥ 3). Sociodemographic, lifestyle and clinical characteristics, malnutrition, depressive symptoms and diabetes self-care behaviours were considered potential factors for frailty. Raw data were evaluated for normality and multicollinearity before data analysis. Data were described as n (%) for categorical variables and median (IQR) or mean \pm SD for continuous variables. To test the statistical difference among groups, univariate analyses were conducted using χ^2 test for categorical variables and Kruskal-Wallis H test for continuous variables. Variables that showed statistical significance of $p < 0.1$ in the univariate analyses were included in the multinomial logistic regression, which estimated the prevalence OR for prefrail relative to robust and for frail relative to robust. The statistical significance was set at $p < 0.05$ for the logistic regression.

Patient and public involvement

Patients were not involved in the development of research question or the design of the study. Anthropometric measurements and HbA1c test results were provided to the participants, community physicians and nurses.

RESULTS

As shown in [figure 1](#), a total of 302 eligible older adults consented to participate in this study. Eleven participants did not complete the questionnaires due to temporary issues and limited time, so the final sample consisted of 291 participants. Among these participants, 85 (29.2%) were robust, 150 (51.5%) were prefrail and 56 (19.2%) were frail.

Characteristics of the participants

The median age of participants was 69 years (IQR 67–72), with a range from 65 to 85 years. Among the participants, 154 (52.9%) were female. The majority of the participants were living in urban areas (84.5%), had junior high school or higher education (63.9%), had a spouse (80.1%), lived with others (86.9%), were currently not working (92.1%), had a personal monthly income below 3000 yuan (66.3%) and had urban employees' insurance (58.1%) ([table 1](#)).

Regarding the lifestyle characteristics, most of the participants were non-smokers (63.6%), non-drinkers (57.4%), with 5–8 hour sleep duration at night per day (66.0%) and had good/very good sleep quality (61.2%) ([table 2](#)). Considering clinical characteristics, the median duration of diabetes was 10 years (IQR 4–16), and the median number of comorbidities was 5 (IQR 3–6).

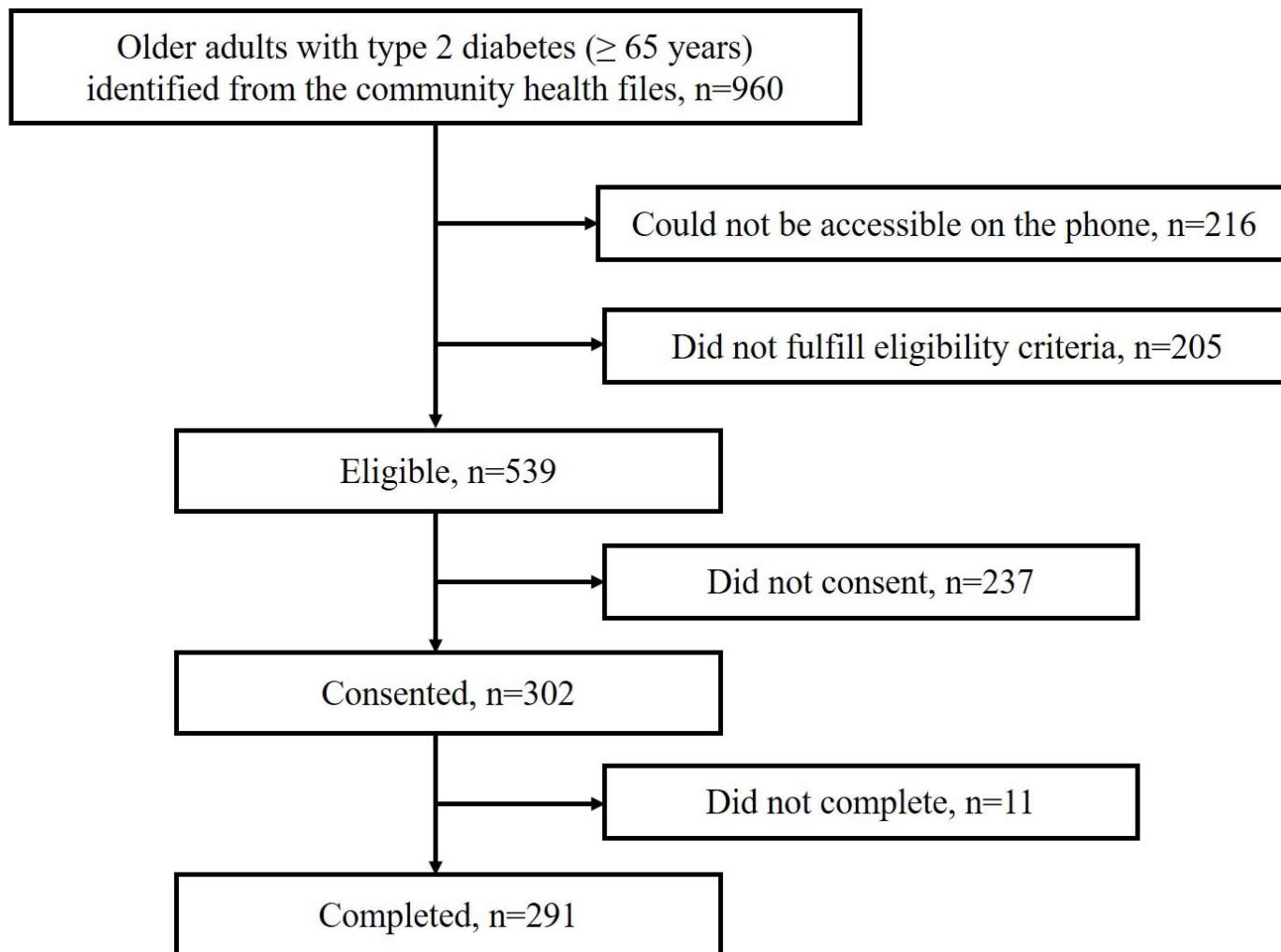


Figure 1 Flow chart of inclusion of participants.

Among all participants, 29.6% had polypharmacy, 43.6% had normal BMI and 17.5% had a normal waist circumference. The median score of HbA1c was 6.66% (IQR 5.87–7.47) (table 2).

Malnutrition, depressive symptoms and diabetes self-care behaviours

Of all participants, 96 (33.0%) were at risk of malnutrition, 6 (2.1%) were malnourished, and 189 (64.9%) were nourished. The median score of depressive symptoms was 3 (IQR 1–5). The total score for diabetes self-care behaviours ranged from 12 to 70, with an average of 40.25±10.08. Among the six subdimensions of diabetes self-care behaviours, the two dimensions with the lowest level were blood-glucose testing (0 (0–2)) and foot care (0 (0–7)) (table 3).

Univariate analyses for influencing factors of frailty

Univariate analyses were conducted to explore the associated factors for frailty according to the criterion of inclusion ($p < 0.10$). Significant sociodemographic differences among groups were found for education level ($p = 0.077$), personal monthly income ($p = 0.026$) and medical insurance ($p = 0.034$) (table 1). Regarding the lifestyle and

clinical characteristics, significant group differences included alcohol drinking ($p = 0.004$), sleep duration at night ($p = 0.046$), self-rated sleep quality ($p = 0.065$), duration of diabetes ($p = 0.036$), comorbidities ($p = 0.030$), polypharmacy ($p = 0.025$) and HbA1c ($p = 0.055$) (table 2). As shown in table 3, significant group differences were noted for malnutrition risk/malnutrition ($p < 0.001$), depressive symptoms ($p < 0.001$), exercise ($p < 0.001$), foot care ($p = 0.007$) and medication care ($p = 0.060$).

Predictors of frailty

The predictors of prefrailty for older adults with type 2 diabetes in this study included alcohol drinking (ex-drinker) ($p = 0.017$), malnutrition risk/malnutrition ($p = 0.026$), depressive symptoms ($p = 0.003$) and exercise ($p = 0.008$) (table 4). The following predictors were found for the condition of frailty: alcohol drinking (ex-drinker) ($p = 0.039$), HbA1c ($p = 0.026$), malnutrition risk/malnutrition ($p = 0.001$), depressive symptoms ($p = 0.001$) and exercise ($p < 0.001$) (table 4).

DISCUSSION

In this study, we assessed frailty status and its associated factors among Chinese community-dwelling older adults

Table 1 Sociodemographic characteristics of the participants by different frailty statuses

Variables	Total (n=291) N (%)	Robust (n=85) N (%)	Prefrail (n=150) N (%)	Frail (n=56) N (%)	P value
Age (years)					0.295
65–69	154 (52.9)	52 (61.2)	74 (49.3)	28 (50.0)	
70–74	91 (31.3)	25 (29.4)	49 (32.7)	17 (30.4)	
≥75	46 (15.8)	8 (9.4)	27 (18.0)	11 (19.6)	
Gender					0.270
Male	137 (47.1)	41 (48.2)	75 (50.0)	21 (37.5)	
Female	154 (52.9)	44 (51.8)	75 (50.0)	35 (62.5)	
Living place					0.434
Urban	246 (84.5)	75 (88.2)	126 (84.0)	45 (80.4)	
Rural	45 (15.5)	10 (11.8)	24 (16.0)	11 (19.6)	
Education level					0.077
Illiterate	42 (14.4)	8 (9.4)	18 (12.0)	16 (28.6)	
Elementary school	63 (21.6)	18 (21.2)	34 (22.7)	11 (19.6)	
Junior high school	95 (32.6)	27 (31.8)	50 (33.3)	18 (32.1)	
Senior high school	55 (18.9)	19 (22.4)	28 (18.7)	8 (14.3)	
College or over	36 (12.4)	13 (15.3)	20 (13.3)	3 (5.4)	
Marital status					0.658
Spouse	233 (80.1)	66 (77.6)	120 (80.0)	47 (83.9)	
No spouse	58 (19.9)	19 (22.4)	30 (20.0)	9 (16.1)	
Living status					0.279
Living with others	253 (86.9)	71 (83.5)	135 (90.0)	47 (83.9)	
Living alone	38 (13.1)	14 (16.5)	15 (10.0)	9 (16.1)	
Currently working					0.197
Yes	23 (7.9)	10 (11.8)	11 (7.3)	2 (3.6)	
No	268 (92.1)	75 (88.2)	139 (92.7)	54 (96.4)	
Personal monthly income (Chinese yuan)					0.026
<1000	43 (14.8)	7 (8.2)	20 (13.3)	16 (28.6)	
1000–1999	50 (17.2)	14 (16.5)	27 (18.0)	9 (16.1)	
2000–2999	100 (34.4)	34 (40.0)	47 (31.3)	19 (33.9)	
≥3000	98 (33.7)	30 (35.3)	56 (37.3)	12 (21.4)	
Medical insurance					0.034
Urban residential insurance	79 (27.1)	17 (20.0)	42 (28.0)	20 (35.7)	
Urban employees' insurance	169 (58.1)	56 (65.9)	90 (60.0)	23 (41.1)	
New rural cooperative medical insurance	43 (14.8)	12 (14.1)	18 (12.0)	13 (23.2)	

Italic values indicate $P < 0.1$.

with type 2 diabetes. We found the prevalence of prefrailty and frailty were 51.5% and 19.2%, respectively. Our result was comparable with the Beijing study (the prevalence of frailty was 19.32%),⁵ however, the Beijing study applied the accumulation of deficits method (Frailty Index \geq 0.25) to measure frailty among diabetic people aged \geq 55 years. By using the Fried frailty phenotype for assessing frailty, the prevalence of frailty in people with diabetes aged 65 and older was 25.0%–32.0%, as reported in the American

studies.^{21 30} In addition, studies conducted in Singapore and Spain showed lower frailty prevalence of 8.2% and 11.2%, respectively,^{6 10} but, these two studies also recruited younger diabetic adults (ie, younger than 65 years). The explanation for the wide variation in the prevalence of frailty in community-dwelling diabetic elderly populations is probably related to frailty instrument differences, sample difference and socioeconomic differences among the studies.

Table 2 Lifestyle and clinical characteristics of the participants by different frailty statuses

Variables	Total (n=291) N (%) / median (IQR)	Robust (n=85)	Prefrail (n=150)	Frail (n=56)	P value
Smoking					0.612
Non-smoker	185 (63.6)	54 (63.5)	93 (62.0)	38 (67.9)	
Ex-smoker	69 (23.7)	17 (20.0)	39 (26.0)	13 (23.2)	
Current smoker	37 (12.7)	14 (16.5)	18 (12.0)	5 (8.9)	
Alcohol drinking					0.004
Non-drinker	167 (57.4)	50 (58.8)	76 (50.7)	41 (73.2)	
Ex-drinker	46 (15.8)	7 (8.2)	30 (20.0)	9 (16.1)	
Current drinker	78 (26.8)	28 (32.9)	44 (29.3)	6 (10.7)	
Sleep duration at night (hours)					0.046
<5	75 (25.8)	14 (16.5)	39 (26.0)	22 (39.3)	
5–8	192 (66.0)	64 (75.3)	99 (66.0)	29 (51.8)	
>8	24 (8.2)	7 (8.2)	12 (8.0)	5 (8.9)	
Self-rated sleep quality					0.065
Very good	33 (11.3)	14 (16.5)	17 (11.3)	2 (3.6)	
Good	145 (49.8)	44 (51.8)	77 (51.3)	24 (42.9)	
Bad	89 (30.6)	24 (28.2)	42 (28.0)	23 (41.1)	
Very bad	24 (8.2)	3 (3.5)	14 (9.3)	7 (12.5)	
Duration of diabetes (years)	10 (4–16)	9 (4–16)	11 (5–16)	7 (4–13)	0.036
No of comorbidities	5 (3–6)	4 (3–6)	5 (3–6)	5 (4–7)	0.030
Polypharmacy					0.025
No	205 (70.4)	68 (80.0)	104 (69.3)	33 (58.9)	
Yes	86 (29.6)	17 (20.0)	46 (30.7)	23 (41.1)	
BMI (kg/m ²)					0.321
<18.5	11 (3.8)	0 (0)	8 (5.3)	3 (5.4)	
18.5–23.9	127 (43.6)	37 (43.5)	65 (43.3)	25 (44.6)	
24–27.9	114 (39.2)	38 (44.7)	58 (38.7)	18 (32.1)	
≥28	39 (13.4)	10 (11.8)	19 (12.7)	10 (17.9)	
Waist circumference					0.285
Normal	51 (17.5)	11 (12.9)	27 (18.0)	13 (23.2)	
High	240 (82.5)	74 (87.1)	123 (82.0)	43 (76.8)	
HbA1c (%)	6.66 (5.87–7.47)	6.74 (5.96–7.20)	6.48 (5.72–7.26)	6.97 (5.95–8.42)	0.055

Italic values indicate P<0.1.

BMI, body mass index; HbA1c, glycated haemoglobin.

Alcohol drinking was one predictor of frailty and prefrailty among the diabetic older adults, and the frailty risk was significantly higher among ex-drinkers compared with non-drinkers. This association could be explained by the ‘sick quitter’ effect. The diabetic older adults in poor health may reduce alcohol consumption or quit drinking, so the ex-drinker group may contain people with previous alcoholism or with a poor health condition.³¹ In our study, it is interesting that current drinking status showed a protective effect (OR=0.266, p=0.055) on frailty compared with non-drinkers, although this factor didn’t satisfy the statistical significance in the logistic regression. Previous studies indicated alcohol use (especially moderate drinking) had a negative

association with physical frailty.^{32–34} Moreover, a recent study demonstrated moderate alcohol consumption may protect against frailty through an anti-inflammatory mechanism, which indicated that C reactive protein level partially mediated the relationship between moderate alcohol use and physical frailty.³⁵

Elevated HbA1c was associated with an increased risk of frailty among community-dwelling diabetic older adults, which was consistent with the previous study in diabetic older people.⁶ Hyperglycaemic could contribute to physical frailty through several potential mechanisms, such as increasing microvascular damage³⁶ or causing skeletal muscle mitochondrial dysfunction.³⁷ In contrast, Yanagita *et al*¹¹ reported

Table 3 Malnutrition, depressive symptoms and diabetes self-care behaviours of the participants by different frailty statuses

Variables	Possible range	Actual range	Total (n=291)	Robust (n=85)	Pre-frail (n=150)	Frail (n=56)	P value
			N (%) / median (IQR)				
Malnutrition risk/malnutrition							
No			189 (64.9)	76 (89.4)	96 (64.0)	17 (30.4)	<i><0.001</i>
Yes			102 (35.1)	9 (10.6)	54 (36.0)	39 (69.6)	
GDS-15 score	0–15	0–15	3 (1–5)	1 (0–3)	3 (1–5)	5 (4–8)	<i><0.001</i>
SDSCA score							
General diet score	0–14	0–14	14 (10–14)	14 (10–14)	14 (10–14)	14 (10–14)	0.465
Specific diet score	0–14	0–14	8 (7–12)	10 (7–13)	7 (7–12)	7 (7–12)	0.131
Exercise score	0–14	0–14	7 (7–14)	14 (7–14)	7 (7–14)	7 (0–7)	<i><0.001</i>
Blood-glucose testing score	0–14	0–14	0 (0–2)	0 (0–2)	0 (0–2)	0 (0–1)	0.183
Foot care score	0–14	0–14	0 (0–7)	0 (0–7)	0 (0–7)	0 (0–0)	0.007
Medication care score	0–7	0–7	7 (7–7)	7 (7–7)	7 (7–7)	7 (7–7)	0.060

Italic values indicate $P < 0.1$.

GDS-15, geriatric depression scale-15; SDSCA, summary of diabetes self-care activities.

low level of HbA1c was associated with frailty measured by the Clinical Frailty Scale among diabetic older adults. Zaslavsky *et al*³⁸ found a U-shaped relationship between glucose levels and physical frailty in older adults with diabetes, with the lowest risk of frailty at HbA1c levels of 7.6%. Overall, poor glucose control with hyperglycaemic or hypoglycaemic may increase the risk of frailty. Therefore, optimal glycaemic control needs to be individually determined for older adults with type 2 diabetes.³⁹ The global guideline for managing type 2 diabetes in older adults recommended that an HbA1c target up to 8.5% may be appropriate for frail diabetic elderly persons with functional dependency.⁴⁰ Recently, an international position statement on the management of frailty in diabetes mellitus patients recommended an HbA1c target range of 7.0%–8.0% for mild to moderate frail diabetic older adults, and 7.5%–8.5% for those with severe frailty.⁴¹

Malnutrition led to prefrailty and frailty among community-dwelling older adults with type 2 diabetes, which was comparable with the findings of a Spanish study.¹² In the current study, 35.1% of our participants were at risk for malnutrition or were malnourished, and 52.6% of them were overweight or obese. However, 39 (38.2%) of the participants who had malnutrition risk or were malnourished in this study were classified as either overweight or obese. This result suggests that the diabetic elderly can suffer from malnutrition status even if they are overweight or obese. Malnutrition is prevalent in diabetic older adults^{42–43} due to various reasons, such as ageing-related appetite reductions, swallowing difficulties, limited mobility and overly dietary restrictions.⁴⁴ We found that 45.4% of the diabetic older adults scored 0 points on the item of protein intake in this study, indicating that those people might have insufficient protein intake. Although

Table 4 Logistic regression model of predictors for prefrailty and frailty

	Pre-frail			Frail		
	OR	95% CI	P value	OR	95% CI	P value
Alcohol Drinking						
Ex-drinker	3.664	1.260 to 10.653	<i>0.017</i>	4.461	1.079 to 18.438	<i>0.039</i>
Current drinker	1.416	0.680 to 2.950	0.353	0.266	0.069 to 1.026	0.055
Non-drinker	1	–	–	1	–	–
HbA1c	0.830	0.644 to 1.071	0.152	1.434	1.045 to 1.968	<i>0.026</i>
Malnutrition risk/malnutrition						
Yes	2.806	1.133 to 6.950	<i>0.026</i>	8.062	2.470 to 26.317	<i>0.001</i>
No	1	–	–	1	–	–
GDS-15 score	1.285	1.087 to 1.520	<i>0.003</i>	1.438	1.166 to 1.773	<i>0.001</i>
Exercise score	0.906	0.843 to 0.974	<i>0.008</i>	0.796	0.716 to 0.884	<i><0.001</i>

Italic values indicate $P < 0.05$.

GDS-15, Geriatric Depression Scale-15; HbA1c, glycated haemoglobin.



malnutrition and physical frailty share some common screening items and physiology, they are not interchangeable syndromes and community-dwelling diabetic older people with malnutrition were more prone to be physically frail. Screening the nutritional status of diabetic older adults and providing them with appropriate dietary instructions would be an effective method for preventing physical frailty within this population.

Consistent with previous studies among older populations,^{15 16} this study highlighted the significant impact of depressive symptoms on prefrailty and frailty among the diabetic elderly. Recent evidence showed a reciprocal interaction between depression and frailty in older adults.¹⁶ Depression contributes to physical frailty due to the decrease in physical activities or weight loss, and in turn, physical frailty may cause functional dependence or disability, thus leading to depression. Diabetes can contribute to depression, which is a common condition in people with type 2 diabetes, especially in the elderly.^{45 46} Therefore, there is an urgent need for appropriate management of depressive symptoms in elderly diabetic adults in order to help slow the progression of physical frailty in this population.

We found exercise behaviour was a protective factor for frailty among community-dwelling diabetic older adults. A higher score of exercise behaviour was associated with a lower risk of prefrailty and frailty. Exercise can help reduce frailty through mechanisms of decreasing muscle inflammation, promoting anabolism and increasing muscle protein synthesis.⁴⁷ Education programmes for exercise training have shown to be effective at improving frailty in the elderly.⁴⁸ Pariser *et al*⁴⁹ conducted a diabetes self-management education programme composed of 10 weeks of aerobic and resistance exercise training, which effectively reduced HbA1c and frailty in diabetic older adults. In addition, the three different frailty groups (ie, robust, prefrail and frail) differed significantly in terms of medication care and foot self-care behaviours in this study. The association between medication care behaviour and frailty may be explained by the fact that adherence to medication is directly associated with the control of blood glucose, which has an impact on the progression of frailty. The association between foot self-care behaviour and frailty could be explained by the observation that the participants with a higher score on foot care were more likely to be active in self-management for complications prevention and concerned about their own health, contributing to a reduced risk of frailty.

This study has several limitations. First, this study is a cross-sectional study, therefore, the causal relationship of the associated factors with frailty could not be established. Second, information such as the older adults' physical activities and self-care behaviours were self-reported, so it may be subject to potential recall bias. Third, we excluded older adults who could not walk independently, as well as those with severe vision and hearing problems, so findings may not be generalisable to a more heterogeneous population. Fourth, the data collected from one city would likely not reflect the nation-wide prevalence of frailty. Fifth, information such as the amount of alcohol consumed weekly for current drinkers

and the date of drinking cessation, as well as the amount of previous alcohol consumption for ex-drinkers was not collected in this study. Future studies on the relationship between alcohol consumption and frailty in this population are warranted. Finally, future studies should explore the effects of clinical and behavioural factors on frailty among community-dwelling diabetic older adults using a prospective longitudinal design and a larger sample size.

CONCLUSIONS

Older adults with type 2 diabetes are at a high risk of frailty in Chinese elderly populations. Being an ex-drinker, having a higher level of HbA1c, experiencing malnutrition risk/malnutrition, and suffering from depressive symptoms were risk factors of frailty among the community-dwelling diabetic older adults; exercise self-care behaviour was found to be a protective factor for frailty. The findings of this study could help guide future studies to implement targeted and suitable interventions for preventing frailty among community-dwelling diabetic older adults.

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