

The Mediating Role of Activities of Daily Living in the Relationship Between Depressive Symptoms and Multidimensional Frailty in the Elderly with Multimorbidity

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Purpose: Previous studies have shown an association between depression and frailty in older adults, but the psychological and social dimensions of frailty are often overlooked, especially in the context of multimorbidity. This study aims to explore the association of depressive symptoms with multidimensional frailty and the mediating role of ADL.

Patients and Methods: Data were collected using a general information questionnaire, Tilburg Frailty Indicator (TFI), ADL was assessed with Barthel index, and Elderly Depression Rating Scale.

Results: Depressive symptoms were significantly correlated with multidimensional frailty (including each dimension) and ADL ($p < 0.05$). Regression analysis showed that depressive symptoms were directly associated with multidimensional frailty ($\beta = 0.484, p < 0.001$) and indirectly through ADL ($\beta = 0.442, p < 0.001$). Dimensions showed that depressive symptoms directly associated with physical frailty and mental frailty ($\beta = 0.454, 0.542, 0.118, p < 0.001$) indirectly through ADLs ($\beta = 0.250, 0.492, p < 0.001$). Bootstrap tests confirmed the robustness of these findings.

Conclusion: The findings confirm the importance of interventions targeting mental health and restoration of physical function to prevent multidimensional frailty in older adults with multimorbidity.

Keywords: multimorbidity, depressive symptoms, multidimensional frailty, activities of daily living, ADL, mediating role

Introduction

With the global aging of the population, the prevalence of chronic diseases has increased significantly, and the prevalence of multimorbidity (an individual having two or more chronic diseases simultaneously)¹ may also be rising rapidly, which seriously affects the quality of life and life expectancy. A meta-analysis shows that the prevalence of multimorbidity increases with age. It is 32.4% (16.1%, 48.7%) in the 60 - 69 - year - old group, 38.5% (23.6%, 53.4%) in the 70 - 79 - year - old group, and 40.2% (20.8%, 59.6%) in the group aged 80 and above.² In addition, a study based on the CHARLs database demonstrated that the prevalence of multimorbidity among Chinese older people increased to 92.24% until 2015, with an increasing trend.³ Multimorbidity poses a continuous and huge burden on individuals, families, the healthcare system, and society.⁴ Therefore, it is necessary to identify and manage modifiable risk factors for the co-existence of multiple chronic diseases.

In recent years, frailty has become a prevalent geriatric syndrome, characterized by a decline in the physiological reserve and function of multiple organ systems, thus increasing vulnerability to stressors.⁵ Multidimensional frailty is defined as a dynamic state that affects individuals who experience losses in one or more areas of human function (physical, psychological, and social).⁶ It is caused by the influence of a series of variables and increases the risk of adverse outcomes. Although there are few studies on the epidemiology of multidimensional frailty in China, a recent study demonstrated that the prevalence of multidimensional frailty in stroke patients at a hospital in Xuzhou, China, was

54.7%, and that it is prevalent in this population.⁷ Existing studies have shown that there is a two-way association between frailty and multimorbidity,⁸ more severe multimorbidity indicates greater frailty,⁸ and different multimorbidity patterns are crucial in the transition from the frail state to death in the elderly.⁹ It is worth noting that multidimensional frailty is closely related to the multimorbidity state,¹⁰ widely indicating aspects of physical, psychological, and social frailty. In summary, multimorbidity and frailty co-exist in elderly inpatients, and their interaction will increase the risk of adverse outcomes such as prolonged hospitalization, readmission, and death.¹¹ Therefore, early identification of multidimensional frailty can reduce the occurrence of adverse outcomes.

Depression is one of the common mental disorders in the elderly. According to statistics, in 2021, the total number of cases of depression among Chinese residents was 42.36 million, and the incidence and prevalence of depression are generally on the rise, especially in the 60–64 age group, where the incidence rate has risen significantly.^{12,13} It has been reported that there is a two-way correlation between depression and multimorbidity.¹⁴ A meta-analysis demonstrated that individuals with multimorbidity exhibit a threefold increased risk of developing depressive disorders compared to those without multimorbidity.¹⁵ These findings highlight the critical need for systematic depression screening in populations with multimorbidity. In addition, a longitudinal study has proven that depression is closely related to multidimensional frailty.¹⁶ Multidimensional frailty is a risk factor for depressive episodes and their increase, while depressive symptoms are also determinants of the occurrence of multidimensional frailty in later life.¹⁷ A recent study of multidimensional frailty in older adults in sub-Saharan African (SSA) countries similarly confirmed that depression exacerbates frailty in older adults.¹⁸ In the context of multimorbidity, the frail state and depressive state of the elderly may be further aggravated, affecting their overall health and quality of life.

Activities of daily living (ADL) dependence is an important indicator for assessing the independent living ability of the elderly. Impaired ADL not only affects the physiological function of the elderly but may also exacerbate their mental health problems. Research shows that patients with multidimensional frailty have a higher risk of ADL impairment.¹⁹ Although the bidirectional relationship between activities of daily living (ADL) and multidimensional frailty has been explored in only a limited number of studies, recent evidence provides valuable insights. For example, a longitudinal analysis of the China Health and Retirement Longitudinal Study (CHARLS) revealed that ADL disability predicted frailty after a 2-year follow-up, while frailty, in turn, predicted ADL disability after 4 years.²⁰ This reciprocal association implies that ADL may mediate frailty progression through shared risk factors, including chronic diseases, declining muscle function, and reduced physical activity.²⁰ Furthermore, frailty itself is linked to a higher prevalence of ADL disability due to its core features—weakness, exhaustion, and low activity levels—which can worsen functional limitations in daily life.²¹ ADL can directly or indirectly affect the quality of life of elderly people with multimorbidity through depression.²² In addition, consistent with another study, in the context of multimorbidity among middle-aged and elderly people in China, depression is significantly related to ADL,²³ and the degree of ADL dependence constitutes a risk factor for depressive symptoms.²⁴ A recent longitudinal study provides new insights, with ADLs significantly declining and depression levels significantly increasing in older adults. Initial levels of ADLs were significantly correlated with initial levels of depression ($r = 0.487$, $p < 0.001$), and rates of change in ADLs were also significantly correlated with rates of change in depression ($r = 0.844$, $p < 0.001$).²⁵ However, most studies focus on a single dimension of physical decline few studies have conclusively elucidated whether positive ADL as a negative mediator in the association between depression and multidimensional frailty.

Given the interrelated nature of these factors, it is crucial to understand the mediating role of ADL in the relationship between depressive symptoms and multidimensional frailty. Through a literature search, we explored this relationship on the basis of existing complementary theoretical frameworks such as the biopsychosocial model and activity limitation theory. On the basis of the biopsychosocial model,²⁶ we suggest that depressive symptoms affect muscle strength and mobility through biological mechanisms (eg, HPA axis malactivation, systemic inflammation),²⁷ psychological mechanisms such as negative self-perception and hopelessness, and social mechanisms such as reduced opportunities for social interactions, exacerbated loneliness, and ultimately worsening of a debilitating state across multiple domains.²⁸ On this basis, and in conjunction with activity-limitation theory, we propose that hypothesise that depressive symptoms may be exacerbated by impairing motivation and ability to perform activities of daily living,²³ such as dressing, eating and

personal hygiene, and that this behavioural restriction in turn exacerbates physical decline and muscle atrophy,²⁹ which directly impacts on physical debility in the short term, reduces autonomy and increases isolation,³⁰ which in turn leads to a more severe deterioration in physical, psychological and social functioning.³¹ In addition, the cumulative effects of multimorbidity exacerbate these effects by exacerbating depressive symptoms and functional decline.^{8,14,22}

This understanding can provide information for the development of targeted interventions aimed at improving the functional status and overall health of elderly patients with multimorbidity, and promoting the improvement of their mental health and quality of life. For example, a multidisciplinary team approach involving nurses, psychologists, occupational therapists, and social workers could be used to assess and monitor depressive symptoms and activities of daily living. This collaborative approach ensures that each multimorbid patient's ongoing care is planned and adapted to their specific depressive profile and ADL limitations, thereby improving their quality of life.³²

In the context of multimorbidity, we proposed the following hypotheses: H1: Depressive symptoms directly associated with multidimensional frailty. H2: Depressive symptoms associated with ADL. H3: Depressive symptoms are associated with multidimensional frailty, with ADL serving as a mediating variable in this relationship. The present study was conducted in multimorbid coexisting older adults using a convenience sampling method, by a general information questionnaire, Tilburg Frailty Indicator (TFI), ADL was assessed with Barthel index, and Elderly Depression Rating Scale. As this study was a cross-sectional study and data were collected in the same area, it was not possible to speculate on the causal relationship between depressive symptoms, multidimensional frailty and ADLs, and the results are not representative of the general phenomenon of multimorbidity coexisting in older adults in China.

Materials and Methods

Sample and Data Collection

A convenience sampling method was used to select 510 elderly inpatients from a tertiary hospital in Wuxi from September 2023 to June 2024. According to the following criteria, a total of 476 subjects were finally included: (1) aged 60 years or older; (2) participants had multiple chronic diseases, defined as any combination of 13 specific chronic diseases, including hypertension, dyslipidemia, diabetes, cancer, chronic lung disease, liver disease, heart disease, stroke, kidney disease, gastrointestinal disease, mood and mental health problems, arthritis or rheumatic diseases, and asthma (As evidenced by a study utilizing the China Health and Retirement Longitudinal Study database).³³ (3) subjects with memory-related diseases (such as Alzheimer's disease, brain atrophy, Parkinson's disease) and physical disabilities - Individuals with limitations in mobility, endurance, dexterity or physical function due to long-term or permanent impairment of body functions, structures or systems, which may be caused by congenital or acquired health conditions, such as cerebral palsy, spinal cord injury, multiple sclerosis, arthritis, epilepsy, etc.³⁴ were excluded.³³ The research included 9 variables, per observational research sample calculation guidelines. The minimum sample size was determined to be 57 cases, accounting for a 20% loss-to-follow-up rate and considering 5–10 times the number of independent variables.³⁵

Research Methods

General Information

Based on existing research,^{10,36} we included several potential influencing factors in the relationship between depression and multidimensional frailty in patients with multiple chronic diseases as control variables. These factors include sociodemographic characteristics and socioeconomic status. Sociodemographic characteristics included age (years), gender (1 = male, 2 = female), BMI and marital status (1 = unmarried, 2 = married, 3 = divorced or widowed). Socioeconomic status includes education level (1 = no education, 2 = primary school or below, 3 = junior high school, 4 = high school and above) and medical insurance type (1 = rural cooperative medical insurance, 2 = urban residents' medical insurance, 3 = employee medical insurance, 4 = other commercial medical insurance).

Tilburg Frailty Indicator (TFI)

TFI was developed by Gobbens et al³⁷ in 2010 to assess multidimensional frailty in patients. The scale includes 15 items across three domains: physical, psychological, and social frailty. The total score ranges from 0 to 15, with each item

scored as either “0” or “1”, physical frailty: eight items correspond to physical frailty (self-conscious health condition, weight loss, walk, poise, hearing, eyesight, strength in hand and physical fatigue), with points ranging from 0 to 8; four items correspond to psychological frailty (coping capacity, cognition, and depressive and anxiety symptoms), with points ranging from 0 to 4; and three items correspond to social frailty (living alone, social relations and support), with points ranging from 0 to 3, a total score of ≥ 5 indicates multidimensional frailty.⁶ In 2013, Xi Xing et al³⁸ translated the scale into Chinese and validated it in older adults with chronic diseases. The Chinese version showed good reliability with a Cronbach’s α coefficient of 0.686,³⁸ making it a valid tool for assessing multidimensional frailty in older adults with chronic conditions in China. It should be noted that the 15 items in the TFI scale do not overlap with the 15 diseases in multimorbidity.³⁹

5 - Item Geriatric Depression Scale (GDS - 5)

GDS-5 simplified by Holy et al,⁴⁰ is used to assess depression in the elderly. The scale consists of five items, each scored as either “0” or “1”. The total score ranges from 0 to 5, with higher scores indicating more severe depression. A score of ≥ 2 indicates the presence of depressive symptoms. The scale has a Cronbach’s α coefficient of 0.613,⁴⁰ demonstrating its validity for depression screening in older adults. The GDS-5 has high applicability and ease of use as a brief scale, especially in time-constrained scenarios (eg, emergency department or community screening).⁴¹ Despite its low internal consistency, its rapid screening and high sensitivity may be more important than high internal consistency.⁴¹ For example, studies have shown that the GDS-5 has high sensitivity and specificity in the emergency department, allowing rapid identification of high-risk populations.⁴¹

The Activities of Daily Living (ADL) Assessment

The ADL scale is a widely used tool for assessing functional independence in daily living activities among older adults. It contains 13 items, with 6 items focusing on basic ADL (BADL) and 8 items on instrumental ADL (IADL).⁴² Higher total scores indicate better functional independence.⁴³ However, the Barthel Index (BI), a commonly used ADL assessment tool in clinical practice in China, includes 10 items:⁴⁴ eating, bathing, grooming, dressing, bowel control, bladder control, using the toilet, transferring between bed and chair, walking on the floor, and climbing stairs. Each item can be scored as 0, 5, 10, or 15 points, with a total score of 100 points. A score of 100 is defined as normal, 61–99 as mild functional impairment, 41–60 as moderate functional impairment, and ≤ 40 as severe functional impairment.⁴⁴ The Cronbach’s α coefficient for the BI is 0.70–0.91,⁴⁵ indicating excellent internal consistency. This reliability coefficient suggests that the BI is a valid and reliable tool for assessing the functional status of elderly individuals in the Chinese context.⁴⁶

Statistical Methods

SPSS 27.0 was used for statistical analysis of the data in this study. Initially, descriptive statistical analysis was performed on the variables. The mean \pm standard deviation ($M \pm SD$) was used to describe index data, and percentages or proportions were used to describe count data. The *t*-test (normally distributed data), Mann–Whitney *U*-test (non-normal data) or chi-square test (categorical variables) was used to compare the differences in characteristics between different multidimensional frailty subgroups. Subsequently, Spearman correlation analysis was employed to assess the bivariate correlations among ADL, depressive symptoms, and multidimensional frailty, which included physical, mental, and social frailty. This non-parametric approach was chosen because ADL scores and depressive symptom severity (assessed by a Likert-based questionnaire), violated the assumption of normality and were tested for normality with the Shapiro–Wilk test for ADL and depressive symptom scores ($p < 0.05$). In contrast to Pearson’s correlation, Spearman’s method accommodates non-continuous or non-normally distributed variables by analysing rank order relationships, thus providing robustness to monotonic trends.⁴⁷ If certain variables are not continuous, regression models can still be appropriate with appropriate adjustments. For example, ordinal regression can be used for ordinal variables, and classification-based regression models can handle categorical variables. Moreover, Spearman correlation results can provide preliminary insights into variable relationships, aiding in the selection of variables for regression analysis. The combination of Spearman correlation and regression modeling offers a flexible and comprehensive approach to understanding the relationships among ADL, depressive symptoms, and multidimensional frailty in the context of this study.

Despite some variables not being continuous, the use of linear regression analysis in this study is still appropriate. Linear regression can accommodate categorical variables through the use of dummy coding or other methods. For example, categorical variables like sex can be included in the regression model by converting them into binary variables (eg, 1=male, 2=female). This allows the model to estimate the effect of these variables on the dependent variable while controlling for other factors. Additionally, linear regression is a versatile tool that can handle a mix of continuous and categorical variables, making it suitable for the complex relationships present in this study.⁴⁸ All models adjusted for age, gender, BMI, education, marital status and medical insurance. Finally, mediation analysis was performed using Model 4 in the PROCESS 4.0 macro. After controlling for covariates, depression was designated as the independent variable (X), multidimensional frailty as the outcome variable (Y), and activities of daily living dependence (M) as the mediating variable. The bootstrap method with 5000 resamples was used to test the mediating effect and estimate the confidence interval, and the significance of the direct, indirect, and total effects was determined based on the confidence interval (whether it included 0). A p - value < 0.05 was considered statistically significant.

Results

Sociodemographic Characteristics and Key Variables of the Participants

Table 1 shows the descriptive statistical data of the participants. A total of 476 elderly patients with multimorbidity were included. The population in this area was all of Han ethnicity, so it was not included in the variable analysis. There were 258 elderly people in the frailty group, with an average age of 72.30 years, 44 males and 174 females. There were 218 elderly people in the non - frailty group, with an average age of 68.3 years, 104 males and 154 females. The prevalence

Table 1 Sociodemographic Characteristics and Key Variables of the Participants (n = 476)

Variables	Frailty Group (n=258)	Non-Frailty Group (n=218)	Statistic	P
Age, Mean ± SD	68.30 ± 6.57	72.30 ± 7.41	$t=-6.24$	<0.001
Sex [n(%)]			$\chi^2=22.34$	<0.001
Female	174 (79.82)	154 (59.69)		
Male	44 (20.18)	104 (40.31)		
BMI [M(Q ₁ , Q ₃), kg/m ²]	24.03 (22.10, 25.59)	25.10 (23.03, 27.34)	$Z=-3.27$	<0.001
Education [n(%)]			$\chi^2=27.56$	<0.001
Uneducated	4 (1.83)	28 (10.85)		
Primary	36 (16.51)	70 (27.13)		
Middle	122 (55.96)	102 (39.53)		
High school	56 (25.69)	58 (22.48)		
And above				
Marital status [n(%)]			$F=11.729$	0.001
Unmarried	2 (0.92)	0 (0.00)		
Married	196 (89.91)	208 (80.62)		
Divorced or widowed	20 (9.17)	50 (19.38)		
Medical insurance [n(%)]			$F=12.878$	0.003
Countryside	10 (4.59)	28 (10.85)		
Urban residents	196 (89.91)	226 (87.60)		
Employee	10 (4.59)	2 (0.78)		
Other	2 (0.92)	2 (0.78)		
Depressive symptoms [n(%)]			$\chi^2=74.85$	<0.001
No	186 (85.32)	122 (47.29)		
Yes	32 (14.68)	136 (52.71)		
ADL, M (Q ₁ , Q ₃)	95.00 (90.00, 95.00)	90.00 (90.00, 95.00)	$Z=-7.49$	<0.001

Notes: Age, a normally distributed continuous variable, was expressed as mean ± standard deviation (SD) and analyzed using the t-test. BMI and ADL, a non-normally distributed continuous variable, were reported as median (Q₁, Q₃) and analyzed with the Mann-Whitney U-test.; categorical variables are expressed as n (%) and analyzed by chi - square tests or Fisher exact test (Expected cell counts in contingency tables were <5 for some subgroups, violating the chi-square test's assumption of adequate expected frequencies).

Abbreviations: ADL, Activities of Daily Living; BMI, Body Mass Index.

of multidimensional frailty was 54.20%. There were significant differences in age, gender, education level, marital status, medical insurance type, depressive symptoms, and ADL between the frailty group and the non - frailty group ($p < 0.05$).

Bivariate Correlation Matrix of Depressive Symptoms, ADL, and Multidimensional Frailty

The results of the Spearman correlation analysis shown in Table 2 indicate that there are significant correlations among depressive symptoms, ADL, and multidimensional frailty ($p < 0.01$). Specifically, depressive symptoms are negatively correlated with ADL ($r = -0.278, p < 0.01$) and positively correlated with multidimensional frailty ($r = 0.509, p < 0.01$). ADL is negatively correlated with multidimensional frailty ($r = -0.405, p < 0.01$). For each component of multidimensional frailty: physical frailty is significantly correlated with depressive symptoms and ADL ($r = 0.300, -0.455, p < 0.01$); mental frailty is significantly correlated with depressive symptoms and ADL ($r = 0.507, -0.229, p < 0.01$); social frailty is significantly correlated with depressive symptoms and ADL ($r = 0.269, -0.098, p < 0.01, p < 0.05$).

The Mediating Role of ADL Between Depressive Symptoms and Multidimensional Frailty

Regression analysis was used to explore the mediating role of ADL in the relationship between depressive symptoms and multidimensional frailty (including physical frailty, mental frailty and social frailty). Table 3 and Figure 1 show the results of the mediation analysis between ADL, depressive symptoms, and multidimensional frailty after controlling for

Table 2 Bivariate Correlation Matrix of Depressive Symptoms, ADL, and Multidimensional Frailty (n = 476)

Variables	Depressive Symptoms	ADL	Multidimensional Frailty	Physical Frailty	Mental Frailty	Social Frailty
Depressive symptoms	1					
ADL	-0.278**	1				
Multidimensional frailty	0.509**	-0.405**	1			
Physical frailty	0.300**	-0.455**	0.811**	1		
Mental frailty	0.507**	-0.229**	0.746**	0.325**	1	
Social frailty	0.269**	-0.098*	0.426**	0.092*		1

Notes: * p - value < 0.05 , ** p - value < 0.01 .

Abbreviation: ADL, Activities of Daily Living.

Table 3 Analysis Results of the Mediating Role of ADL Between Depressive Symptoms and Multidimensional Frailty (n = 476)

Pathway	B	SE	β	t	p
Model 1 (Outcome: Multidimensional frailty)					
Depressive symptoms	1.114	0.084	0.486	13.229	<0.001
Model 2 (Outcome: ADL)					
Depressive symptoms	-2.303	0.440	-0.232	-5.229	<0.001
Model 3 (Outcome: Multidimensional frailty)					
Depressive symptoms	1.016	0.085	0.443	12.016	<0.001
ADL	-0.043	0.009	-0.184	-4.933	<0.001

Notes: Model 1, Depressive symptoms \rightarrow Multidimensional frailty; Model 2, Depressive symptoms \rightarrow ADL; Model 3, Depressive symptoms, ADL \rightarrow Multidimensional frailty. All models adjusted for age, gender, BMI, education, marital status and medical insurance.

Abbreviation: ADL, Activities of Daily Living.

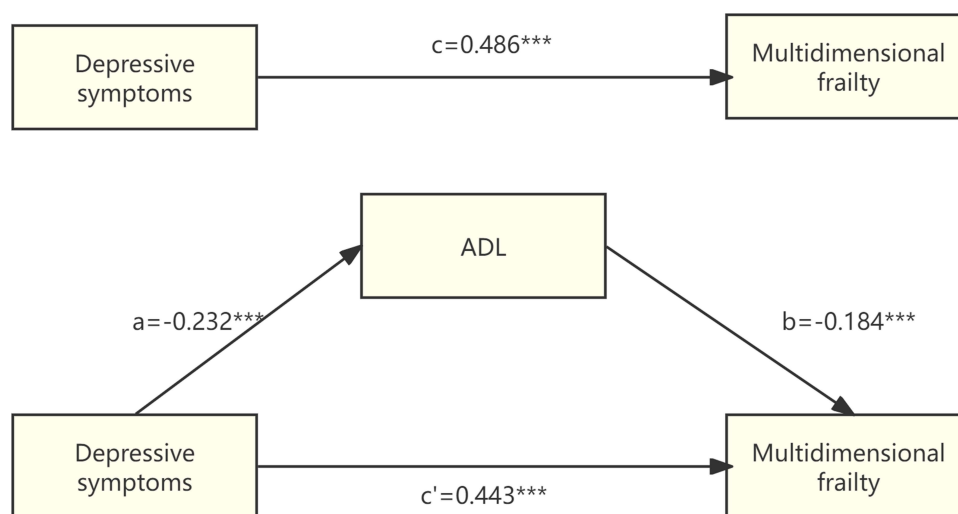


Figure 1 Relationship between depressive symptoms, ADL and multidimensional frailty. *** p - value < 0.001.

covariates. All models adjusted for age, gender, BMI, education, marital status and medical insurance. In the total-effect regression, depressive symptoms were significantly associated with multidimensional frailty ($\beta = 0.486$, $p < 0.001$). When ADL was considered, this relationship is still significant but slightly weakened ($\beta = 0.443$, $p < 0.001$). Analysing multidimensional frailty individual dimensions, the results of Tables 4–6 (Figures 2–3) show the results of mediation analyses of individual frailty dimensions with depressive symptoms and ADLs, respectively. All models adjusted for age, gender, BMI, education, marital status and medical insurance. In full-effects regression, depressive symptoms were significantly associated with physical frailty, mental frailty, and social frailty ($\beta = 0.454$, 0.542 , 0.118 , $p < 0.001$). This relationship remained significant when ADLs were considered, this relationship remains important only in cases of physical and mental frailty, but is slightly diminished ($\beta = 0.250$, 0.492 , $p < 0.001$). In the presence of ADLs as mediators, the association between depressive symptoms and social frailty was no longer statistically significant.

The findings underscore the pivotal role of Activities of Daily Living (ADLs) as mediators in the relationship between depressive symptoms and multidimensional frailty, encompassing both physical and mental dimensions. This has crucial implications for designing interventions for older adults with multimorbidity.

We will elaborate on the following two aspects. Practical Approaches: tailored rehabilitation programmes: Implementing programmes that integrate strength training, balance exercises, and ADL task practice can enhance

Table 4 Analysis Results of the Mediating Role of ADL Between Depressive Symptoms and Physical Frailty (n = 476)

Pathway	B	SE	β	t	p
Model 1 (Outcome: Physical frailty)					
Depressive symptoms	0.454	0.062	0.301	7.374	<0.001
Model 2 (Outcome: ADL)					
Depressive symptoms	-2.303	0.440	-0.232	-5.229	<0.001
Model 3 (Outcome: Physical frailty)					
Depressive symptoms	0.377	0.062	0.250	6.125	<0.001
ADL	-0.033	0.006	-0.219	-5.306	<0.001

Notes: Model 1, Depressive symptoms \rightarrow Physical frailty; Model 2, Depressive symptoms \rightarrow ADL; Model 3, Depressive symptoms, ADL \rightarrow Physical frailty. All models adjusted for age, gender, BMI, education, marital status and medical insurance.

Abbreviation: ADL, Activities of Daily Living.

Table 5 Analysis Results of the Mediating Role of ADL Between Depressive Symptoms and Mental Frailty (n = 476)

Pathway	B	SE	β	t	p
Model 1 (Outcome: Mental frailty)					
Depressive symptoms	0.542	0.041	0.513	13.208	<0.001
Model 2 (Outcome: ADL)					
Depressive symptoms	-2.303	0.440	-0.232	-5.229	<0.001
Model 3 (Outcome: Mental frailty)					
Depressive symptoms	0.519	0.042	0.492	12.359	<0.001
ADL	-0.010	0.004	-0.092	-2.281	0.023

Notes: Model 1, Depressive symptoms→ Mental frailty; Model 2, Depressive symptoms→ADL; Model 3, Depressive symptoms, ADL→ Mental frailty. All models adjusted for age, gender, BMI, education, marital status and medical insurance.

Abbreviation: ADL, Activities of Daily Living.

Table 6 Analysis Results of the Mediating Role of ADL Between Depressive Symptoms and Social Frailty (n = 476)

Pathway	B	SE	β	t	p
Model 1 (Outcome: Social frailty)					
Depressive symptoms	0.118	0.023	0.209	5.096	<0.001
Model 2 (Outcome: ADL)					
Depressive symptoms	-2.303	0.440	-0.232	-5.229	<0.001
Model 3 (Outcome: Social frailty)					
Depressive symptoms	0.120	0.024	0.211	5.011	<0.001
ADL	0.001	0.002	0.011	0.264	0.792

Notes: Model 1, Depressive symptoms→ Social frailty; Model 2, Depressive symptoms→ADL; Model 3, Depressive symptoms, ADL→ Social frailty. All models adjusted for age, gender, BMI, education, marital status and medical insurance.

Abbreviation: ADL: Activities of Daily Living.

physical capabilities while alleviating depressive symptoms. Behavioural activation therapy: This therapeutic approach, when combined with ADL-focused activities, can foster engagement and improve both mental resilience and physical functioning. While ADLs do not mediate the social frailty dimension, social debility may arise from factors beyond functional limitations, such as isolation or inadequate social support. To address this: social interventions: initiatives like group therapy, community engagement programmes, and peer support can directly target social withdrawal linked to depression. Comprehensive Geriatric Care: Integrating social work and mental health services into geriatric care ensures that social and psychological needs are adequately addressed.

Bootstrap Tests for Mediation Models

Bootstrap was used to examine the indirect, direct, and total effects. As shown in Table 7, the bootstrap method indicated that the direct effect of depressive symptoms on multidimensional frailty was 1.016 (95% CI: 0.850, 1.182), while the total effect was 1.114 (95% CI: 0.949, 1.279). The indirect effect of ADL - mediated multidimensional frailty by depressive symptoms was 0.098 (95% CI: 0.014, 0.087). This indicates that the mediating role of ADL between depressive symptoms and multidimensional frailty was established as a partial mediating effect, accounting for 8.649%. The results demonstrated the robustness of the mediation model. We also performed Bootstrap tests for other

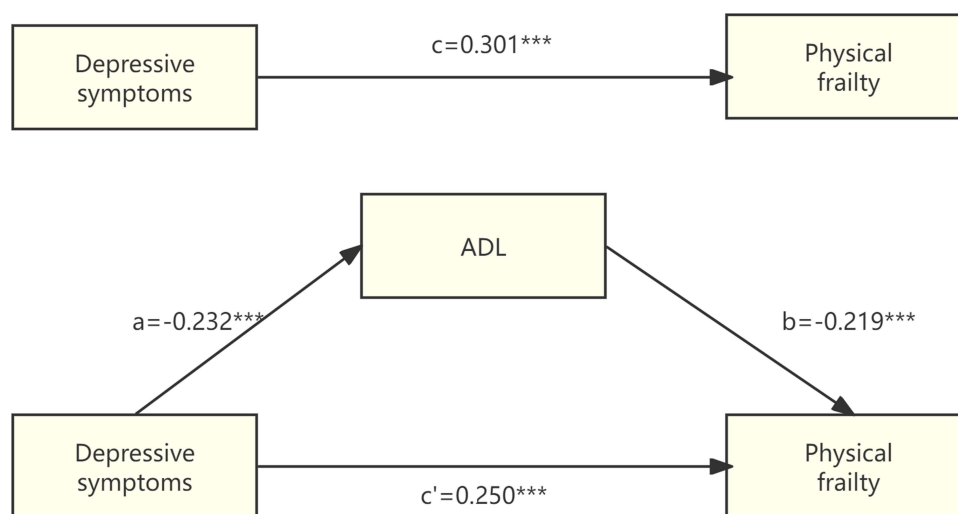


Figure 2 Relationship between depressive symptoms, ADL and physical frailty. ****p* - value < 0.001.

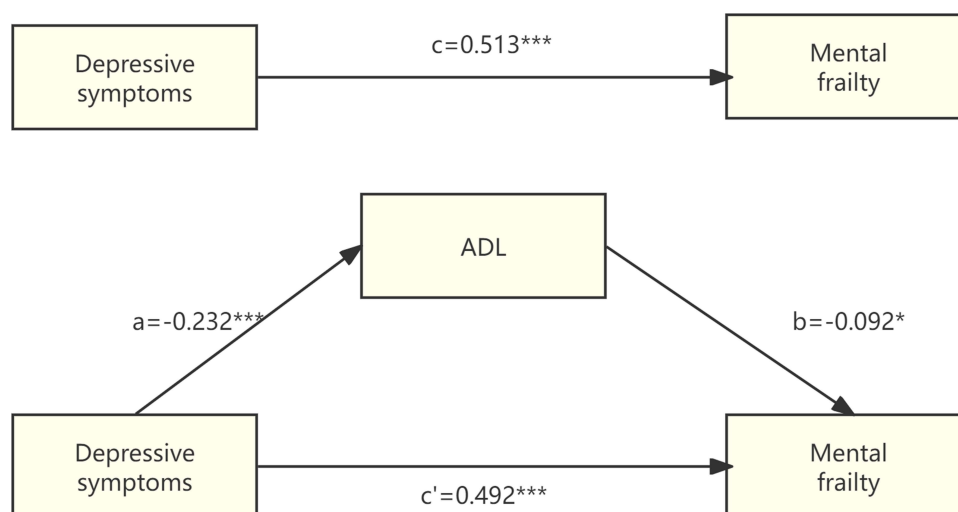


Figure 3 Relationship between depressive symptoms, ADL and mental frailty. ****p* - value < 0.001; **p* - value < 0.05.

multidimensional frailty dimensions, the bootstrap method indicated that the direct effect of depressive symptoms on physical frailty was 0.377 (95% CI: 0.256, 0.497), while the total effect was 0.454 (95% CI: 0.333, 0.574). The indirect effect of ADL-mediated physical frailty by depressive symptoms was 0.077 (95% CI: 0.020, 0.103). This indicates that the mediating role of ADL between depressive symptoms and physical frailty was established as a partial mediating effect, accounting for 16.912%. The results demonstrated the robustness of the mediation model. In addition, the bootstrap method indicated that the direct effect of depressive symptoms on mental frailty was 0.519 (95% CI: 0.437, 0.602), while the total effect was 0.542 (95% CI: 0.461, 0.622). The indirect effect of ADL-mediated physical frailty by depressive symptoms was 0.023 (95% CI: -0.001, 0.048). This indicates that the mediating role of ADL between depressive symptoms and mental frailty was established as a partial mediating effect, accounting for 4.156%. The results demonstrated the robustness of the mediation model.

Discussion

This study explored the association between depressive symptoms and multidimensional frailty among elderly people with multimorbidity and analyzed the mediating role of activities of daily living (ADL) in this relationship. The results

Table 7 Bootstrap Tests for Mediation Models

Paths	Coefficient	Boot SE	P	95% CI		Proportion (%)
				LLCI	ULCI	
Multidimensional frailty						
Indirect effect	0.098	0.019	<0.001	0.014	0.087	8.798
Direct effect	1.016	0.085	<0.001	0.850	1.182	91.202
Total effect	1.114	0.084	<0.001	0.949	1.279	
Physical frailty						
Indirect effect	0.077	0.021	<0.001	0.020	0.103	16.912
Direct effect	0.377	0.063	<0.001	0.256	0.497	83.088
Total effect	0.454	0.062	<0.001	0.333	0.574	
Mental frailty						
Indirect effect	0.023	0.013	0.073	-0.001	0.048	4.156
Direct effect	0.519	0.042	<0.001	0.437	0.602	95.844
Total effect	0.542	0.041	<0.001	0.461	0.622	

Abbreviations: LLCI, lower level for confidence interval; ULCI, upper level for confidence interval.

showed a significant positive correlation between depressive symptoms and multidimensional frailty, and ADL played a partial mediating role in this relationship. Specifically, elderly people with lower ADL scores were more likely to exhibit multidimensional frailty, while higher ADL scores were associated with a lower level of multidimensional frailty. Great importance should be attached to the depressive symptoms of the elderly. Through early identification and intervention, their ADL can be improved, thus effectively preventing and delaying the occurrence and development of multidimensional frailty.

In this study, the incidence of multidimensional frailty among elderly people with multimorbidity was as high as 54.20%, and the frailty rate was higher than that in previous studies.^{49,50} However, a study has demonstrated that multiple chronic diseases are usually not unidirectionally related to frailty but are bidirectionally associated.⁶ Multimorbidity is more likely to lead to frailty than a single chronic disease. When elderly people have delayed medical treatment or long-term chronic accumulation of certain inflammatory diseases,^{51,52} the incidence of frailty will increase. In addition, previous studies on frailty assessment mostly focused on the physiological level.⁵³ However, in this study, a multidimensional frailty assessment tool was used to evaluate elderly people with multimorbidity from the perspectives of physiological, psychological, and social function decline, so the prevalence rate was higher than that in previous studies.

This study showed that there was a significant positive association between depressive symptoms and multidimensional frailty in the context of multimorbidity. A positive association exists between the degree of depressive symptoms and the level of multidimensional frailty in elderly individuals. This finding aligns with previous research and underscores the close relationship between mental health factors and declines in physiological, psychological, and social functioning.^{53,54} From a neurobiological perspective, depressive symptoms and frailty are interconnected through shared mechanisms, including neuronal dysfunction, dopamine secretion, mitochondrial function, and inflammation,^{55,56} which can lead to the decline of various body organs, weaken the physical function of the elderly, and accelerate the process of frailty. In addition, the disease burden and accompanying symptoms of chronic diseases, such as disease recurrence, headache, dizziness, and physical activity impairment, can all lead to the occurrence of depressive symptoms.^{7,57} Depressive symptoms may cause memory decline, reduced physical activity, and decreased social participation in the elderly.⁵⁸ Prolonged social isolation will further increase the psychological burden,⁵⁹ all of which significantly increase the risk of frailty in physiological, psychological, and social dimensions.

This study clarified that ADL played an important mediating role in the process of depressive symptoms affecting multidimensional frailty. That is, depressive symptoms exacerbated the degree of multidimensional frailty by reducing the ADL of the elderly. A study indicated that in the context of multimorbidity, the ADL scores were significantly lower than those of the healthy population. It is worth noting that among the elderly with depressive symptoms, the daily activity level was even lower than that of the elderly without depressive symptoms.⁶⁰ The depression - induced low mood and lack of motivation were directly reflected in the decline of the elderly's daily self - care ability. Simple activities such as dressing and washing may become extremely difficult for depressed elderly people.⁶¹ The limitation of ADL is not only a decline in physical function but also triggers some other chain reactions. Elderly people with impaired ADL have an increased psychological burden, which exacerbates depressive symptoms.⁶² A recent longitudinal study provides new insights, individuals with poorer initial functioning are more likely to be depressed, and the faster the rate of decline in ADL functioning, the more pronounced the increase in depression.²⁵ Depression may not only be triggered by a decline in ADL functioning, but the rate of degradation of the ADLs is also influenced by feedback from the level of depression in older adults, creating a possible positive feedback loop.²⁵ At the same time, due to the impairment of daily life functions, the increased dependence on others leads to changes in social patterns and a reduction in social support,⁶³ accelerating the process of frailty in the psychosocial dimension. Although the results of the regression equations in this study showed that ADLs did not mediate in depressive symptoms and social frailty, there was a negative correlation between ADLs and social frailty in the correlation analyses. The impairment of ADL and the reduction of physical activity are another important driving factors for muscle atrophy and muscle mass impairment, possibly due to increased anabolic resistance of muscles, all of which exacerbate the process of multidimensional frailty. The discovery of this mediating mechanism points the way for the formulation of intervention measures. It can be understood that improving ADL can effectively break the vicious cycle between depression and multidimensional frailty to a large extent.

Compared with previous studies,⁶⁴ this study has innovations and in-depth explorations in many aspects. Most previous studies focused on single - disease or only evaluated the relationship between frailty and depression from a single dimension, making it difficult to comprehensively reflect the complex health status of elderly people with multimorbidity. This study was carried out for the common and complex situation of multimorbidity, using a multidimensional frailty assessment method covering multiple aspects such as physical, cognitive, psychological, and social functions, comprehensively and meticulously depicting the frailty status of the elderly. Through this multidimensional perspective, we found that the impact of depressive symptoms on frailty was more extensive and profound, with different dimensions intertwined and influencing each other.

In addition, the in-depth exploration of the mediating role of ADL further enriched the understanding of this complex relationship and provided a new target for precise intervention. We recommend implementing specific measures to improve ADLs to reduce the effects of depression and multidimensional frailty in the following three areas: from occupational therapy, functional training for ADLs and occupational combined with housework simulation exercises (twice weekly, 8-week programme),⁶⁵ the intervention can enhance the ability to perform daily tasks independently, reduce depression levels, and mitigate the impact on multidimensional frailty. In terms of physical activity and exercise interventions, the multimodal exercise program, which combines resistance training, balance exercises and flexibility training for 45 minutes three times a week,⁶⁶ significantly improves gait speed and fall risk in frail older adults and reduces the severity of frailty.⁶⁷ In terms of social support: The community organises weekly activities for art projects such as painting, sculpture, choral singing and handicrafts,⁶⁸ which have a significant positive impact on the physical health, mental health and social activities of older people, promoting their health and independence.

The findings of this study also have implications for future health systems and public policies related to the care of the elderly. We recommend promoting the establishment of interdisciplinary integrated health services centred on multidisciplinary teamwork. From a clinical practice perspective, a multidisciplinary team approach, including nurses, psychologists, occupational therapists and social workers, can be used to assess and monitor depressive symptoms and activities of daily living. This collaborative approach ensures that each multimorbid patient's ongoing care is planned and adapted to their specific depressive conditions and limitations in activities of daily living, thereby improving their quality of life.³² From a community-based intervention perspective: research findings suggest that community-based interventions can be effective in helping older people to maintain their independence in their ability to perform activities of daily

living. These interventions may include home modifications, assistive devices, community programmes to promote social and physical activities, and tele-health technologies (eg virtual social networking platforms) to reduce the risk of loneliness and depression and enhance self-care by facilitating social engagement and ADL training for home-bound older persons, thereby reducing the risk of debilitating weakness and depression.^{69–72}

Although this study has achieved important results, it inevitably has limitations. The cross-sectional design used in the study cannot clarify the temporal sequence of causal relationships, and it is impossible to determine the causal sequence among depressive symptoms, ADL, and multidimensional frailty. Future research should adopt prospective cohort studies or intervention studies to conduct long-term follow-up of the elderly population to clarify the causal pathways among the three. At the same time, this study relied on questionnaires to collect data, which may have recall bias and reporting bias. Subsequent studies can combine objective physiological measurement indicators, such as accurately monitoring ADL using wearable devices and evaluating brain function changes with advanced neuroimaging techniques, to improve the accuracy and reliability of the data. Future research should expand the study scope to include multiple factors and their interactions, such as potential biases from socio-economic, cultural, or environmental influences. These may affect the relationship between depression, ADLs, and multidimensional frailty. To better understand older individuals' subjective experiences of depression and its impact on daily functioning, future studies might benefit from a qualitative or mixed-methods approach. Additionally, constructing a more comprehensive theoretical model and refining intervention strategies could enhance the quality of life and health for older adults with multimorbidity.

Conclusion

This study revealed the association with depressive symptoms on multidimensional frailty and the mediating role of ADL in the elderly population with multimorbidity. Depressive symptoms associated with multidimensional frailty through biological pathways, such as the inactivation of the hypothalamic axis and systemic inflammation. Psychologically, negative self-perception and hopelessness associated with depression also play a role. Socially, reduced opportunities for social interaction and increased loneliness due to depression contribute to multidimensional frailty. Moreover, depressive symptoms can worsen due to impaired motivation and ability to perform daily activities like dressing, eating, and personal hygiene. This behavioral limitation further exacerbates physical decline and muscle atrophy, directly affecting physical frailty in the short term, reducing autonomy, and increasing loneliness. This, in turn, leads to more severe deterioration in physical, psychological, and social functioning, worsening multidimensional frailty.

This result provides important theoretical basis for clinicians and elderly care service providers. Improving the ability to perform daily activities can go a long way in improving depressive symptoms and preventing multidimensional frailty. Interventions such as those from occupational therapy (functional training in activities of daily living and simulation exercises in combination with household chores), physical activity (resistance training, balance exercises and flexibility training) or social support (weekly art projects organised by the community) can be effective in improving ADLs, mitigating the effects of depressive symptoms and slowing down the process of multidimensional frailty. Incorporating multidisciplinary teamwork and psychosocial support into the geriatric care system at the policy level can amplify the impact of interventions, for example, by integrating psychologists into geriatric clinics or mandating annual screening for depression under national ageing initiatives.

However, we must point out the limitations of this study. The cross-sectional design prevented us from determining causality, and future studies need to further explore the mechanisms involved to provide a more comprehensive and accurate strategy for health management of older people.

Data Sharing Statement

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy.

Informed Consent Statement

Informed consent was obtained from all participants involved in the study.

Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Affiliated Hospital of Jiangnan University, Wuxi (LS2023085).

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Disclosure

The authors report no conflicts of interest in this work.

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