Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Screening for "Frailty – Sarcopenia – Nutrition - Physical activity" among older population in Henan province, China: a study protocol of a prospective, observational cohort study

Xinying Yang
Henan Provincial People's Hospital
Xianjing Xu
Henan Provincial People's Hospital
KaiKun Liu
Henan Provincial People's Hospital
Deyong Li
Henan Provincial People's Hospital
Xiangwei Li
Shanghai Jiao Tong University
Xuanchao Cao
Henan Provincial People's Hospital
Hongyan Duan
dhy13526553388@zzu.edu.cn
Henan Provincial People's Hospital

Study protocol

Keywords: frailty, sarcopenia, nutrition, physical activity, older adults, cohort study, Henan Province

Posted Date: September 25th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10825785/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background Frailty and sarcopenia are closely interconnected geriatric syndromes that increase the risk of functional decline, adverse clinical events, and poor prognoses. Malnutrition and insufficient physical activity are critical modifiable factors; however, current research rarely explores their integrated relationships within the “frailty–sarcopenia–nutrition–physical activity” axis. Local epidemiological evidence for the older population in the Henan Province is insufficient to support targeted prevention and management. As part of the Comprehensive Geriatric Assessment in Chronic Disease Management for Older Adults in China: A Registry Study (CGACDM - Older Adults in China), this prospective multicenter observational cohort study aims to investigate the prevalence of frailty and sarcopenia among adults aged 65 years and older in Henan, examine their associations with nutritional status and physical activity, identify key predictive factors, and provide evidence for region-adapted geriatric health strategies.

Methods We will enroll 30,000 participants from multiple medical institutions in Henan from January 2026 with a 3-year study period and 6-month regular follow-up. Frailty will be assessed using the FRAIL scale, sarcopenia will be diagnosed per the Asian Working Group for Sarcopenia (AWGS) 2025 criteria, nutritional status will be evaluated using the Short-Form Mini Nutritional Assessment (MNA-SF), and physical activity will be measured using the Physical Activity Scale for the Elderly (PASE) scale. Data on routine clinical examinations and long-term endpoints, including all-cause death, rehospitalization, falls, and cardiovascular events, will be collected. Data will be managed on a provincial geriatric quality control platform and analyzed using SPSS and R software with regression and Cox proportional hazards models.

Discussion This large-scale cohort study will fill regional evidence gaps, clarify the interactive mechanisms between nutrition, physical activity, and geriatric syndromes, and support precision nutrition and exercise interventions. These findings will help establish a localized prevention and control system to reduce the public health burden of age-related disabilities and promote healthy aging.

Clinical trial registration Clinical trial number: NCT07033871; Registration date: June 14, 2025; Registry: ClinicalTrials.gov (https://www.clinicaltrials.gov/)

Background

The global population is experiencing a significant demographic shift, marked by a considerable increase in both the absolute number and proportion of older individuals. China has emerged as one of the nations experiencing the most rapid population aging and has one of the largest older populations globally[1]. The demographic segment of individuals aged ≥ 60 years in China is expected to increase two-fold, rising from 168 million in 2010, which constitutes 12.4% of the total population, to 402 million by 2040, representing 28% of the total population [2]. Faced with such a severe aging situation, achieving the goal of “aging without frailty, frailty without illness, and illness without life-threatening conditions” has become an urgent social challenge to be addressed in China.

Frailty and sarcopenia are geriatric syndromes intricately linked to the aging process and present a substantial public health challenge for the aging population [3, 4]. Frailty reflects a decline in physiological reserves and resilience[5]. Sarcopenia is characterized by progressive loss of skeletal muscle mass and function[6]. Sarcopenia is a fundamental pathological alteration within the detrimental cycle that leads to frailty in older adults and ultimately results in functional disability. There is a significant overlap between the two in terms of mechanisms, clinical outcomes, and interventions[7, 8]. Numerous international studies have indicated that most individuals with sarcopenia exhibit frailty; conversely, frail older adults are at an elevated risk of developing sarcopenia[9]. Deterioration of muscle function exacerbates frailty, which further compromises physical function, metabolism, and vascular health, thereby increasing the risk of developing multiple chronic conditions including cardiovascular disease (CVD)[10]. Consequently, these two conditions frequently coexist within individuals and exert mutual influence[11]. However, existing studies have mostly focused on the individual effects of frailty or sarcopenia and overlooked the combined effects of these factors on chronic diseases.

Research has shown that prompt intervention and appropriate guidance can effectively reverse frailty and sarcopenia[12]. A growing body of research and clinical guidelines advocates for multimodal exercise strategies combining aerobic and resistance training, together with optimized nutritional support, such as sufficient protein intake and optional supplementation with branched-chain amino acids or β-hydroxy-β-methylbutyrate[13].

From a nutritional standpoint, proteins are fundamental substrates for skeletal muscle anabolism. Chronic inadequate protein intake disturbs the homeostatic balance between muscle protein synthesis and breakdown, thereby contributing to reductions in muscle mass and strength[14]. A deficiency in micronutrients such as vitamin D and omega-3 fatty acids further accelerates the progression of sarcopenia and frailty by affecting muscle cell differentiation and inflammatory factor levels [15]. Meanwhile, sufficient energy supply contributes to sustaining metabolic homeostasis in the body, thereby mitigating the acceleration of muscle wasting induced by a negative nitrogen balance. Additionally, weight loss and compromised immune function resulting from malnutrition are critical early indicators of frailty[16].

Conversely, consistent physical activity, particularly resistance exercise, can trigger the proliferation and differentiation of skeletal muscle satellite cells via mechanical stress, thus promoting gains in muscle mass and strength[17]. Aerobic training enhances aerobic capacity and vascular function, attenuates chronic systemic inflammation, and slows the deterioration of physiological reserves[18]. In contrast, persistent sedentary lifestyles and inadequate physical activity may induce skeletal muscle disuse atrophy, further compromising the body’s adaptability to stress and increasing susceptibility to both frailty and sarcopenia[19, 20]. Nutrition and physical activity do not act independently; adequate nutrient intake can provide material support for physical activity, whereas regular exercise can enhance the absorption and utilization efficiency of nutrients and both work synergistically to maintain skeletal muscle health and body function.

However, current research has mostly focused on the effects of nutrition or physical activity on the single outcomes of frailty and sarcopenia, lacking systematic and prospective exploration of the "frailty-sarcopenia-nutrition-physical activity" axis in the older population. In particular, the causal associations and interaction mechanisms between these four elements have not been clearly elucidated. In addition, there were significant differences in dietary habits and exercise patterns among older adults in different regions of China. Relevant data specific to the older population in Henan Province are particularly scarce, hindering the formulation of targeted prevention and control strategies for geriatric syndromes. Therefore, the present study aimed to conduct a prospective cohort study among the older population of Henan Province. Through multidimensional screening and long-term follow-up, this study aimed to reveal the dynamic associations and interaction effects among nutritional status, physical activity, frailty, and sarcopenia, thereby providing an evidence-based basis for the development of health management programs for localized older adults.

Objectives

To investigate the prevalence of frailty and sarcopenia among adults aged ≥ 65 years in Henan Province; to clarify the associations of frailty and sarcopenia with nutritional status and physical activity levels; to analyze the impacts of frailty, sarcopenia, and their related factors on the long-term prognosis of the older population; and to provide evidence-based support for the development of a frailty-sarcopenia prevention and control system suitable for older Chinese groups.

Secondary objectives are as follows:

1. To analyze the differences in the epidemiological characteristics of frailty and sarcopenia among older people aged ≥ 65 years seeking medical treatment in different medical institutions, stratified by sex, age group, and urban and rural regions in Henan Province, and to clarify the regional distribution patterns.
2. To explore the interaction mechanisms between various dimensions of nutritional status and different types of physical activity in the occurrence and progression of frailty and sarcopenia.
3. To screen the key modifiable factors affecting the occurrence, progression, and long-term prognosis of frailty and sarcopenia in the elderly.
4. To construct a risk prediction model for adverse prognosis in older adults based on frailty, sarcopenia, and related factors such as nutritional status and physical activity and to verify its predictive efficacy.
5. To put forward refined recommendations for nutritional intervention and exercise guidance based on the research results to provide practical support for optimizing the frailty-sarcopenia prevention and control system for older Chinese groups.

Methods

Trial design

We are performing a prospective multicenter observational study based on participants from the Comprehensive Geriatric Assessment in Chronic Disease Management for Older Adults in China: A Registry Study (CGACDM - Older Adults in China, NCT07033871), which is scheduled to commence at multiple medical institutions in Henan Province, China, from January 1, 2026, with a target enrollment of 30,000 older adults aged ≥ 65 years. These participants need to voluntarily participate in the "Frailty – Sarcopenia – Nutrition - Physical activity" study, sign the informed consent form, and fill in the relevant questionnaire. The participants are required to complete a series of assessments and examination items (including frailty, sarcopenia, nutritional evaluation, and physical activity surveys) to fully understand their health status. The details of this trial are presented in Table 1. The study complies with the principles of the Declaration of Helsinki. The protocol adheres to the SPIRIT checklist (Supplementary Table S1).

Table 1
Study summary

Study title	**Frailty and Sarcopenia in elderly patients**
Running title	Frailty – Sarcopenia – Nutrition - Physical activity study
Study design	A multicenter, Chinese observational cohort study
Study participants	Older adults aged 65 years or older
Sample size	30000 patients
Study sites	Multiple medical institutions in Henan Province
Planned study period	3 years
Follow-up duration	6 months
Ethics/registration number	Ethics Committee of Henan Provincial People's Hospital, Zhengzhou, China (Ethical Approval No. 15 of 2022). ClinicalTrials.gov Identifier: NCT07033871.
Research aims	The first research aim is to clarify the prevalence of frailty and sarcopenia among elderly people aged ≥ 65 years in Henan Province. The second aim is to explore the associations between frailty, sarcopenia and nutritional status, physical activity levels, as well as their impacts on the long-term prognosis of the elderly. A further research aim is to construct a frailty-sarcopenia prevention and control system suitable for the elderly population in China.

Ethics approvals and registration

This study is approved by the Ethics Committee of the Henan Provincial People’s Hospital in Zhengzhou, China (Approval No. 15, 2022). The research protocol has been registered in the Clinical Trial Registry

under the identifier NCT07033871. Each participating center will acquire written informed consent from the participants or their legal proxies in compliance with relevant national and institutional regulations. All finalized research data will be submitted to the Henan Provincial Platform for Quality Control of Geriatric Medicine.

Recruitment of patients

The Henan Provincial People's Hospital is responsible for the Henan Provincial Geriatrics Quality Control Center. We have established a province-wide geriatric quality control information platform with unified standards, data-driven operations, and efficient collaboration. To date, 110 hospitals at the provincial, municipal, and county levels have been incorporated into the Henan Provincial Geriatrics Quality Control Center. By leveraging information technology, we have consolidated and deepened the four-level geriatric medical quality control network covering "province - city - county - medical institution.” Diverse recruitment pathways will facilitate the identification of participants from a range of backgrounds and contexts.

Relevant information regarding this research may be presented via posters in public spaces, such as clinical zones, research venues, or recreational areas, as well as through traditional media and online platforms, with contact information included to enable direct communication between potential participants and investigators.

It will be explicitly emphasized that participants may voluntarily withdraw from the research at any point and for any reason, without compromising their subsequent clinical care, and will not be required to explain their decision. A signed copy of the informed consent form will be retained by the patient, and the original document will be stored securely by the research team. The investigators digitized all medical records by scanning and maintaining them in the formal archives.

Inclusion criteria: Older adults aged 65 years or older. Conscious, able to communicate normally, and able to cooperate in completing basic information surveys. Voluntarily participated in the study and signed informed consent forms.

Exclusion criteria: Patients with any of the following conditions will be excluded: Those with severe cognitive impairment (e.g., severe dementia) or mental illness who cannot cooperate in completing the survey or related measurements. Those who are unable to walk or complete the grip strength test due to severe osteoarthropathy (e.g., severe rheumatoid arthritis, recovery period after femoral neck fracture surgery), nervous system diseases (e.g., advanced Parkinson's disease, severe hemiplegia), Those who have acute infection, severe trauma, or major surgery within the past 3 months, and are in the recovery period, which may affect the assessment of muscle function. Patients with diseases with a short expected survival period (< 6 months), such as advanced malignant tumors and severe liver and kidney failure. Participation in other clinical trials within the past 1 month.

Variables collected

Baseline data Baseline demographic data of the participants, including name, sex, age, height, weight, occupation, medical history, clinical diagnosis, and treatment information.

Routine inspections Routine blood, urinary, and stool tests, biochemical tests, coagulation function, glycosylated hemoglobin, myocardial injury markers, tumor markers, thyroid function, electrocardiogram (ECG), B-mode ultrasound, color Doppler ultrasound, Computed Tomography (CT), Computed Tomographic Angiography (CTA), Magnetic Resonance Imaging (MRI), pulmonary function, bone mineral density, and other examinations of the participants will be collected. All tests and examinations are not mandatory. If the patient undergoes only one examination, we will collect the corresponding results.

“Frailty – Sarcopenia – Nutrition - Physical activity” assessment

Frailty

Frailty will be assessed using the FRAIL scale[21], combining the 5 items addressing Fatigue, Resistance, Ambulation, weight loss, and morbidity counts. People fulfilling 1 or 2 criteria may be classified as “pre-frail” and those fulfilling 3 or more criteria as frail (Table 2).

Table 2
FRAIL Scale

Serial Number	Item	Inquiry Method
1	Fatigue (F)	Have you felt fatigued or tired most days in the past month?
2	Resistance (R)	Do you have difficulty climbing a flight of stairs (about 10 steps) without resting?
3	Ambulation (A)	Do you have difficulty walking 100 meters on a flat surface?
4	Illness (I)	Do you have 5 or more chronic illnesses?
5	Loss of weight (L)	Have you lost 5 or more pounds (approximately 2.3 kilograms) in the past 6 months without trying?
Scoring Criteria: 0 items: Robust (non-frail); 1–2 items: Pre-frail; 3–5 items: Frail.		

Sarcopenia

Sarcopenia will be diagnosed based on the updated definition of the Asian Working Group for Sarcopenia (AWGS) 2025[13] and Chinese Guidelines for the Diagnosis and Treatment of Sarcopenia (2024 Edition)[22]. The AWGS 2025 consensus defines sarcopenia as a combination of low muscle mass and low muscle strength and classifies physical performance measures, such as the five-times

chair stand test, as outcome indicators rather than diagnostic criteria. Based on these scenarios, sarcopenia screening is designed in two directions. When screening participants in the community, the SARC-F scale will be used. The SARC-F questionnaire assesses 5 components: strength, assistance in walking, rising from a chair, climbing stairs, and falling (Table 3). A SARC-F score ≥ 4 is defined as sarcopenia. When the screening participants are in the hospital, we will use indicators such as handgrip, calf circumference (CC), five-times chair stand test, and 6-meter gait speed (Table 4).

Table 3
SARC-F scale

Components	Questions	0	1	2
Strength	How much difficulty do you have lifting and carrying 10 pounds?	None	Some	A lot or unable
Assistance in walking	How much difficulty do you have walking across a room?	None	Some	A lot, use aids or unable
Rise from a chair	How much difficulty do you have transferring from a chair or bed?	None	Some	A lot or unable without help
Climb stairs	How much difficulty do you have climbing a flight of 10 stairs	None	Some	A lot or unable
Falls	How many times have you fallen in the past year?	None	1–3 falls	4 or more falls
Scoring Criteria: score ≥ 4 was defined as sarcopenia.				

Table 4
Measurements of muscle strength, muscle mass and physical performance

Measurement	Cut off values	
	Age ≥ 65 years	
	Men	Women
Muscle strength		
Handgrip (kg)	< 28.0	< 18.0
Muscle mass		
calf circumference (cm)	< 34	< 33
Physical performance (outcomes)		
Five-times chair stand test (seconds)	≥ 12	≥ 12
Gait speed, 6-m walk test (m s − 1)	< 1.0	< 1.0
Low muscle strength: Possible sarcopenia		
Low muscle mass + low muscle strength: sarcopenia		

Nutritional

The Short-Form Mini Nutritional Assessment (MNA-SF) screening score was used to assess nutritional status[23]. The six items in this well-validated MNA are conventionally used as short screening tools for classifying geriatric patients at risk of malnutrition (Table 5).

Table 5
Mini Nutritional Assessment Short-Form (MNA-SF)

Item	Questions	Scoring
1. Food intake	Have you had a loss of appetite, digestive problems, chewing or swallowing difficulties over the past 3 months?	0 = Severe decrease in food intake 1 = Moderate decrease in food intake 2 = No decrease in food intake
2. Weight loss	Have you lost weight recently?	0 = Weight loss > 3 kg in past 3 months 1 = Unknown weight loss 2 = Weight loss ≤ 3 kg in past 3 months 3 = No weight loss
3. Mobility	How is your mobility?	0 = Bed or chair bound 1 = Able to get out of bed/chair but does not go out 2 = Goes out
4. Stress or acute disease	Have you suffered from psychological stress or acute disease in the past 3 months?	0 = Yes 2 = No
5. Neuropsychological problems	Do you have neuropsychological problems (e.g., dementia, depression)?	0 = Severe dementia or depression 1 = Mild dementia 2 = No psychological problems
6. Body Mass Index (BMI)	Calculate BMI (weight in kg / height² in m)	0 = BMI < 19 kg/m² 1 = BMI 19–21 kg/m² 2 = BMI 21–23 kg/m² 3 = BMI > 23 kg/m² *Alternative for bedridden patients unable to measure height/weight: CC* *0 = CC < 31 cm*
Total Score Interpretation: 12–14 points: Normal nutritional status; 8–11 points: At risk of malnutrition; 0–7 points: Malnourished		

Item	Questions	Scoring
		3 = CC ≥ 31 cm
Total Score Interpretation: 12–14 points: Normal nutritional status; 8–11 points: At risk of malnutrition; 0–7 points: Malnourished		

Physical activity

The Physical Activity Scale for the Elderly (PASE), initially designed by Washburn et al. in 1993, serves as a dedicated instrument for evaluating physical activity (PA) among older populations in epidemiological research[24]. As a frequently used self-report instrument for evaluating PA, it yields detailed data on the frequency, duration, and intensity of various forms of PA. Comprising 10 items, the PASE questionnaire assesses three distinct domains of physical activity over a 7-day recall period: leisure activities (5 items), household-related tasks (4 items), and occupation-associated activities (1 item). Participation in leisure activities is recorded as frequency (never, seldom, sometimes, and often) and duration (less than an hour, 2–4 hours, or more than 4 hours); household activities including housework, lawn work, home repair, outdoor gardening, and care for others are recorded as yes or no answers; and paid or unpaid work is recorded as total hours of work per day[25]. The overall PASE score is derived by weighting responses regarding activity engagement (binary yes/no indicators) or daily time invested in each activity using the corresponding item coefficients established in the initial developmental study. The participants were categorized into three levels of total physical activity according to their total PASE scores: low (0–100), moderate (100–250), and high (> 250)[26]. (Tables 6 and 7).

Table 6
PASE Score Form

leisure		Type of Activity	Activity Weight	Activity Frequency	Weight times Frequency
	1	**Seated Activities**	**0**		**0**
	2	**Walk outside home**	20	a	20*a
	3	**Light sport / recreational activities**	21	a	21*a
	4	**Moderate sport/recreational activities**	23	a	23*a
	5	**Strenuous sport / recreational activities**	23	a	23*a
	6	**Muscle strength / endurance exercises**	30	a	30*a
household activities	**7**	**Light housework**	25	b	25*b
	8	**Heavy housework or chores**	25	b	25*b
	9a	**Home repairs**	30	b	30*b
	9b	**Lawn work or yard care**	36	b	36*b
	9c	**Outdoor gardening**	20	b	20*b
	9d	**Caring for another person**	35	b	35*b
work-related	**10**	**Work for pay or as volunteer**	21	c	21*c
					PASE SCORE:

Activity Frequency Values:

a. Use hours per day conversion table below

b. 1 = activity reported in past week, 0 = activity not reported

c. For work involving mainly walking, the activity frequency value = daily working hours; for work involving mainly sitting with only slight upper extremity movements, the activity frequency value = 0.

Table 7
Activity time to hours per day conversion table

Days of Activity	Hours Per Day of Activity	Hours Per Day
0. Never		**0**
1. Seldom	1. Less than 1 hour	0.11
	2. 1–2 hours	0.32
	3. 2–4 hours	0.64
	4. More than 4 hours	1.07
2. Sometimes	1. Less than 1 hour	0.25
	2. 1–2 hours	0.75
	3. 2–4 hours	1.50
	4. More than 4 hours	2.50
3. Often	1. Less than 1 hour	0.43
	2. 1–2 hours	1.29
	3. 2–4 hours	2.57
	4. More than 4 hours	4.29

Outcome measures

Longer term follow-up Corresponding exercise and nutritional guidance will be provided based on the evaluation results. At 3, 6, 9, and 12 months after enrollment in the clinical study, adverse events and changes in frailty and sarcopenia status will be assessed via telephone and outpatient follow-up. At each follow-up after registration, the researchers will ask the patients whether they had any symptoms since the last follow-up or whether there is a report issued by the health care department that meets the endpoint events. The evaluation schedule will indicate the preferred modalities for each follow-up visit, and all outcomes will be collected.

Clinical outcomes Endpoint assessment in the present study will be conducted in accordance with the Technical Specification for Long-Term Follow-up of Endpoint Events in Large Population Cohorts (T/CPMA 002-2019). The study endpoints will comprise all-cause mortality, unplanned readmission, emergency medical care, fall-related adverse events (such as traumatic brain injury, fracture, and functional disability), and major clinical events, including stroke, heart failure, myocardial infarction, and malignancy. For all-cause mortality, details including the cause of death, clinical confirmation, date, and location of death were documented. For readmission events, the clinical diagnosis, admission date, and discharge date were recorded. For emergency care episodes, the clinical diagnosis and date of

treatment were noted. For other clinical events, the specific diagnosis and date of onset were systematically recorded.

Data management, data protection and patient confidentiality

All clinical information and outcome indicators (including baseline and follow-up data at all time points) will be obtained from the Henan Provincial Platform for Quality Control of Geriatric Medicine. The data displayed on the system will contain no identifiable personal information about the participants. After screening by the principal investigators of each research center, eligible participants are required to complete the relevant examinations. Researchers will be responsible for uploading participants' medical records to the data processing center in the form of electronic case report forms (eCRFs), with each form corresponding to a unique identification code. Researchers can access the study data through the project data processing center using individually authorized accounts and confidential passwords. The system ensures data security and participants' privacy protection through technical measures, such as access permission control and encrypted data transmission.

Sample size and power calculation

Using the AWGS criteria, previous studies have shown that the overall prevalence ranges from 5.5% to 25.7%, with a higher prevalence in men (5.1–21.0%) than in women (4.1–16.3%)[27–29]. According to previous literature, among inpatients aged 65 years and older admitted to internal medicine departments, 43% were classified as pre-frail and 20% as frail[30]. We calculated the sample size based on the incidence rates of frailty and sarcopenia using the PASS software, with the Confidence Interval Width set to 0.1, and the proportion set to 0.2, resulting in a required sample size of 246. Considering a 20% loss to follow-up, 295 participants were enrolled in each hospital. A total of 110 hospitals at provincial, municipal and county levels are involved in this multicenter cohort; therefore, approximately 30 000 participants will be recruited in the present study.

Statistical analysis

Data on the baseline characteristics, epidemiological information, nutritional status, physical activity, and follow-up outcomes of the study participants will be collected, organized, and verified to assess data completeness and plausibility. Multiple imputations will used to handle missing values. Statistical significance was set at a P-value < 0.05. significant. Statistical analyses will be conducted using IBM SPSS software (version 30.0; SPSS Inc., Chicago, IL, USA) and R version 4.5.1 (R Foundation for Statistical Computing, Vienna, Austria).

Objective 1: To analyze the differences in epidemiological characteristics between frailty and sarcopenia. Continuous variables will be initially assessed for normality; normally distributed data will be reported as mean ± SD, whereas data exhibiting skewed distribution will be described using the median (M) and IQR (P25, P75). Stratified analyses will be performed according to sex, age, urban/rural residence, and type of medical institution. Categorical variables will be presented in terms of frequency and composition ratio. For comparisons among groups, the chi-square test (or Fisher's exact test when any expected count was < 5 for a 2 × 2 table) will be used for categorical variables, and the Student's t-test or Mann–Whitney U test will be used for continuous variables.

Objective 2: To determine the associations of frailty and sarcopenia with nutritional status and physical activity level. Multivariate logistic regression analyses will be performed with the incidence and progression of frailty and sarcopenia as dependent variables and various dimensions of nutritional status and different types of physical activity as independent variables to investigate the correlations between these variables and the occurrence and development of frailty and sarcopenia.

Objective 3: To identify key modifiable factors associated with frailty, sarcopenia, and long-term prognosis. The incidence of frailty, sarcopenia, progression of frailty/sarcopenia, and long-term adverse prognosis in older adults will be used as dependent variables. Modifiable factors, including nutritional status and physical activity, and confounding factors, such as age, sex, and history of comorbidities, will be included in the analysis. Variables associated with each endpoint will be initially screened using univariate analysis, and those with $P < 0.20$ were entered into multivariate models. Backward stepwise logistic regression or Cox regression analysis will be applied for multivariate screening, and key modifiable factors independently associated with each end point ($P < 0.05$) will be identified to provide evidence for the development of subsequent intervention strategies.

Objective 4: To construct and validate a risk prediction model for adverse long-term prognosis in older adults. A risk-prediction model will be developed with adverse long-term prognosis in older adults as the dependent variable, frailty and sarcopenia as core independent variables, and key modifiable factors (including nutritional status and physical activity) as candidate independent variables. Corresponding weights will be assigned to each independent predictor according to the regression coefficients (β values) derived from the multivariate logistic regression (or Cox regression) analysis, and a simplified clinical scoring system will be established. A nomogram will be used for the visual presentation of the model. The predictive performance of the model will be evaluated using a combination of internal and external validation methods. Internal validation will be performed using the bootstrap method with 10,000 re-samplings to assess model stability. An independent prospective cohort study will be conducted for external validation. The discriminative ability of the model will be assessed using the area under the receiver operating characteristic (ROC) curve. Calibration will be evaluated using the Hosmer–Lemeshow goodness-of-fit test and calibration curves. Clinical utility will be assessed using decision curve analysis (DCA).

Withdrawal from the program

Participants will be informed that they may withdraw from the study at any time without being required to offer an explanation. For those who remain enrolled, follow-up will be performed via telephone correspondence, mail, electronic communication, or review of medical records. Participants who discontinue participation will be excluded from subsequent data analysis. Any feasible follow-up approach confirmed by the participants will be documented.

Patient and public involvement

Our research interest in this domain is partially motivated by the clinical demand to establish innovative treatment protocols derived from real-world clinical databases, with the ultimate aim of developing personalized therapeutic approaches for older adults presenting with frailty and sarcopenia. A plain language summary of the research results will be distributed to the participants upon completion of the study. As a multicenter prospective observational cohort investigation, this study will not impose any intervention or additional burden on the enrolled patients. All participants will be invited to provide feedback on the study upon completion of the research questionnaire.

Dissemination

The results of this study will be disseminated nationally and internationally through peer-reviewed publications in medical journals and abstract presentations at international conferences that focus on geriatric medicine.

Discussion

This study focuses on the older population in the Henan Province and used a prospective cohort design to investigate the dynamic associations, interactions, and long-term prognostic impacts of four core components: frailty, sarcopenia, nutrition, and physical activity. This study aims to provide evidence-based support for the establishment of a localized health management system for older adults. Considering the global trend of population aging and practical needs in the field of older adult health in China, the design and expected findings of this study have important theoretical value and practical significance.

Scientificity and innovation of the study design

Rationality of study participants and sample size

This study covers medical institutions at the provincial, municipal, and county levels in Henan Province, and 30,000 participants aged ≥ 65 years will be recruited through multiple channels based on the

provincial geriatric medicine quality control platform. The sample size was calculated and determined using PASS software based on the epidemiological prevalence of frailty and sarcopenia, with a 20% loss to follow-up rate fully considered during the follow-up period to ensure adequate statistical power to effectively reveal the associations of frailty and sarcopenia with nutritional status, physical activity, and long-term adverse outcomes. Furthermore, the participants included individuals of different sexes, ages, urban and rural residences, and sources from different levels of medical institutions, which reflects the heterogeneity of the older population in Henan Province. This study provides a large sample and a representative foundation for clarifying the prevalence characteristics, distribution patterns, and influencing factors of frailty and sarcopenia among older adults in the province.

Systematic and prospective design of the study content

This study overcomes the limitations of previous research, which mostly focused on single dimensions and cross-sectional analyses, by establishing an integrated four-dimensional framework for frailty, sarcopenia, nutrition, and physical activity. Rather than being restricted to prevalence descriptions and simple correlation analyses, this prospective cohort study conducts a standardized follow-up every 6 months for a total of 3 years, dynamically tracking the evolutionary trajectories of the four core components, and systematically analyzing their predictive value for long-term clinical outcomes, including all-cause mortality, unplanned readmission, fall-related adverse events, and acute exacerbation of chronic diseases.

In addition, this study further refines the stratified indicators of nutritional and physical activity dimensions, explores their interactive effects and underlying mechanisms in the occurrence and progression of frailty and sarcopenia, and accurately identifies modifiable targets to provide evidence supporting the development of individualized nutritional optimization strategies and exercise prescriptions. Furthermore, a risk-prediction model for adverse outcomes in older adults will be constructed based on multidimensional indicators and externally validated, providing feasible tools and methods for health risk stratification, early warning, and precise health management in the older population.

Reliability and applicability of the assessment tools

This study strictly adopted internationally recognized and validated standardized assessment tools, which provide strong support for the reliability of the research data and comparability of the results.

Frailty

Currently, frailty assessment tools are based on two major categories: phenotypic [31] and cumulative deficit models [32]. Among phenotypic models, the Fried Frailty Phenotype (FFP) requires objective measurement equipment and standardized operating conditions for large-scale community or outpatient screening[33]. The Frailty Index (FI) assesses frailty by calculating the cumulative proportion of accumulated health deficits; although it provides comprehensive information, it requires the collection of dozens of variables and complex data acquisition, rendering it unsuitable for rapid screening[34]. Among

the various simple tools, the FRAIL scale has emerged as an ideal option for large-scale frailty screening owing to its distinct advantages[35]. First, the FRAIL scale is concise and efficient, consisting entirely of self-reported or easily administered items, with a single assessment taking only 1–2 min. Second, multiple studies have confirmed its favorable concordance with the Fried Frailty Phenotype and FI. It can accurately distinguish between frail, pre-frail, and non-frail individuals, and its predictive performance for long-term adverse health outcomes is comparable to that of more complex scales[36]. It can be reliably completed by community-dwelling older adults, hospitalized patients, and individuals with chronic conditions, effectively reducing assessment bias and ensuring the reliability and comparability of screening data[37].

Sarcopenia

For the sarcopenia assessment protocol, this study strictly referred to AWGS 2025 and established a stratified, graded, and practice-oriented evaluation system tailored to the characteristics of the study population and application scenarios[13]. The screening age was lowered to 65 years, with corresponding diagnostic cutoff values applied according to the age strata. This design aligns better with the physiological pattern of a gradual decline in muscle mass and strength from midlife onward, enabling earlier risk stratification for sarcopenia. In strict accordance with the consensus, only physical function was recorded as an outcome measure and was not included in the diagnostic criteria. This approach not only ensures consistency with the latest international guidelines but also better reflects the impact of sarcopenia on functional outcomes. Regarding assessment tools, a scenario-based, differentiated strategy was adopted: the SARC-F scale was used as a simple and efficient screening tool for community-dwelling populations, suitable for large-scale rapid preliminary screening; for hospital-based populations, objective measures, such as handgrip strength and calf circumference, were used for precise evaluation. Together, these form a stepped assessment model of “community screening and hospital confirmation.”

Nutrition

Nutritional assessment tools for older adults must balance practicality and specificity, making the MNA-SF the optimal choice for this study. Compared with full MNA, which is cumbersome and time-consuming, and biochemical indicators such as serum albumin, which are easily affected by inflammation and chronic diseases and involve relatively high costs, MNA-SF has been fully clinically validated[23, 38]. It retains the core nutritional assessment dimensions while achieving a balance between ease of administration and accuracy. With only six core items and no need for specialized equipment, the scale can be completed rapidly, making it highly efficient for large-scale baseline screening and long-term follow-up. These items are tailored to the physiological characteristics of older adults and can accurately classify individuals into normal nutrition, risk of malnutrition, and malnourished groups. Additionally, it aligns well with the assessment of frailty, sarcopenia, and physical activity. It can not only precisely identify high-nutrition-risk populations but also provide reliable data for

multidimensional correlation analyses, supporting robust research conclusions and the development of localized health management strategies for older adults.

Physical activity

PASE will be used to assess physical activity behavior in this study, representing the optimal choice for this prospective screening investigation. Compared to commonly used objective measures (e.g., accelerometers and pedometers), PASE does not require specialized equipment, thus avoiding limitations such as high cost, inconvenient wear, and poor suitability for large-scale screening. In contrast to traditional comprehensive physical activity questionnaires, it features concise items and a simple administration, allowing rapid assessment through brief interviews and effectively improving screening efficiency and participant compliance. Specifically designed for older adults, the PASE covers age-appropriate activity domains, including daily living, household tasks, and leisure-time exercise, enabling accurate quantification of physical activity intensity and total volume[39]. This study provides a theoretical basis for the development of personalized exercise prescriptions.

Potential value of the expected outcomes

Theoretical value

This study aims to clarify the prevalence characteristics and regional distribution patterns of frailty and sarcopenia among older adults in the Henan Province, enriching the epidemiological data on geriatric syndromes in different regions of China. Elucidating the intrinsic associations and interactive mechanisms underlying the “frailty–sarcopenia–nutrition–physical activity” axis is expected to improve the theoretical framework of geriatric syndrome pathogenesis and provide novel perspectives for future related research. A risk prediction model based on large-scale cohort data will offer a new quantitative tool for geriatric health risk assessment, thereby promoting the advancement of risk prediction research in the field of geriatrics.

Practical implications

The findings of this study will directly provide targeted evidence-based support for geriatric health management in Henan Province and nationwide. Based on the key influencing factors and interactions identified in this study, localized and refined prevention and control strategies for frailty and sarcopenia, including nutritional intervention programs and exercise guidance protocols, can be formulated. These strategies can be integrated into provincial-, municipal-, and county-level geriatric medical quality control networks. Through standardized health management procedures, early screening, timely intervention, and long-term monitoring of frailty and sarcopenia in the older population can be achieved, ultimately advancing the goal of "healthy aging" and alleviating the public health burden caused by population aging.

Limitations

This study has some limitations. First, this study is a prospective observational cohort study that can only analyze the correlations among variables; it is difficult to clarify the causal pathways underlying nutrition, physical activity, frailty, and sarcopenia. Future randomized controlled intervention trials will be designed to verify the effects of personalized nutritional supplementation combined with resistance training and other regimens for the prevention, delay, and reversal of frailty and sarcopenia. Second, owing to the lack of advanced measuring devices, such as Bioelectrical Impedance Analysis (BIA) and Dual-Energy X-ray Absorptiometry (DXA) in primary medical institutions, this study used CC as a surrogate indicator of muscle mass. Previous studies have reported that calf circumference is consistent with measurements obtained using BIA and DXA[40, 41]. Third, several core indicators in this study will be assessed using subjective questionnaires, such as the PASE and FRAIL scales, which are susceptible to recall and reporting bias among participants and may reduce data precision. To minimize measurement bias, we implemented standardized assessor training, uniform evaluation procedures, double-entry data verification, and intraclass correlation coefficient (ICC) testing for reliability. Fourth, although this study enrolled participants from multiple regions and various medical institutions in Henan Province, the voluntary participation rate of healthy community-dwelling older adults is relatively low, resulting in a selection bias that may limit the generalizability of the results. To improve sample representativeness and generalizability, this study will expand recruitment channels, strengthen publicity at the primary care level, and enhance collaboration with communities.

Abbreviations

CGACDM - Older Adults in China
Comprehensive Geriatric Assessment in Chronic Disease Management for Older Adults in China:A Registry Study
CVD
cardiovascular disease
FFP
Fried Frailty Phenotype
FI
Frailty Index
AWGS
Asian Working Group for Sarcopenia
CC
calf circumference
BIA
Bioelectrical Impedance Analysis
DXA
Dual-Energy X-ray Absorptiometry
MNA-SF
Short-Form Mini Nutritional Assessment

PASE
Physical Activity Scale for the Elderly
ECG
Electrocardiogram
CT
Computed Tomography
CTA
Computed Tomographic Angiography
MRI
Magnetic Resonance Imaging
eCRFs
case report forms
ICC
intraclass correlation coefficient
ROC
receiver operating characteristic curve
DCA
decision curve analysis

Declarations

Ethics approval and consent to participate

Ethics Committee of Henan Provincial People's Hospital, Zhengzhou, China (Ethical Approval No. 15, 2022). ClinicalTrials.gov Identifier: NCT07033871.

Consent for publication

Written informed consent will be obtained from all participants before their inclusion in the study.

Competing interests

The authors declare that they have no competing interests.

Funding

This work was supported by grants from the Henan Clinical Research-Oriented Doctor Program (HNCRD202503), Natural Science Foundation of Henan Province (252300421607) and Medical Science and Technology Research Initiative of the Henan Provincial Health Commission (LHGJ20240076). These grant applications were evaluated via face-to-face expert-panel interview before funding award. No

separate independent anonymous written external peer-review was organised by the funding agencies as part of the grant-approval process.

Author Contribution

YXY and DHY were responsible for initiating the present study and substantially contributed to the study conception, methodological framework, protocol establishment, resource coordination, and preparation of the original draft. XXJ, LKK, and LDY refined the research design, optimized the methodology, and composed the preliminary manuscript. CXC provided support for project management, investigation organization, and critical revision of the paper. LXW participated in constructing the methodological structure and conducting in-depth revisions of the manuscript. All authors have read, evaluated, and approved the final version for publication.

Acknowledgement

We would like to acknowledge the participants of the CGACDM - Older Adults in China and the recruitment team.

Availability of data and materials

The complete documents - protocol and informed consent - will be available under request. Manuscript does not contain any data.

References

1. Tong X, Xu J, Gong E, Zhang X, Li Y, Shao R, Xi H. Frailty as a breakthrough point for multimorbidity management among older adults: challenges and opportunities in China. BMJ. 2024;387:e076767. https://doi.org/10.1136/bmj-2023-076767.
2. World Health Organization. China country assessment report on ageing and health. 2015. https://apps.who.int/iris/handle/10665/194271
3. Zheng X, Zhang K, Ma J. The Longitudinal Relationship between Frailty, Loneliness and Cardiovascular Disease: A Prospective Cohort Study. J Nutr Health Aging. 2023;27(12):1212–8. https://doi.org/10.1007/s12603-023-2037-3.
4. Sayer AA, Cooper R, Arai H, Cawthon PM, Ntsama Essomba M-J, Fielding RA, Grounds MD, Witham MD, Cruz-Jentoft AJ, Sarcopenia. Nat Rev Dis Primers. 2024;10(1):68. https://doi.org/10.1038/s41572-024-00550-w.
5. Wilkinson TJ, Miksza J, Zaccardi F, Lawson C, Nixon AC, Young HML, Khunti K, Smith AC. Associations between frailty trajectories and cardiovascular, renal, and mortality outcomes in

chronic kidney disease. J Cachexia Sarcopenia Muscle. 2022;13(5):2426–35. https://doi.org/10.1002/jcsm.13047.

6. Hu Y, Peng W, Ren R, Wang Y, Wang G. Sarcopenia and mild cognitive impairment among elderly adults: The first longitudinal evidence from CHARLS. J Cachexia Sarcopenia Muscle. 2022;13(6):2944–52. https://doi.org/10.1002/jcsm.13081.
7. Álvarez-Bustos A, Carnicero-Carreño JA, Davies B, Garcia-Garcia FJ, Rodríguez-Artalejo F, Rodríguez-Mañas L, Alonso-Bouzón C. Role of sarcopenia in the frailty transitions in older adults: a population-based cohort study. J Cachexia Sarcopenia Muscle. 2022;13(5):2352–60. https://doi.org/10.1002/jcsm.13055.
8. Bhurchandi S, Kumar S, Agrawal S, Acharya S, Jain S, Talwar D, Lomte S. Correlation of Sarcopenia With Modified Frailty Index as a Predictor of Outcome in Critically Ill Elderly Patients: A Cross-Sectional Study. Cureus. 2021;13(10):e19065. https://doi.org/10.7759/cureus.19065.
9. Ye L, Liang R, Liu X, Li J, Yue J, Zhang X. Frailty and sarcopenia: A bibliometric analysis of their association and potential targets for intervention. Ageing Res Rev. 2023;92:102111. https://doi.org/10.1016/j.arr.2023.102111.
10. Ferrucci L, Fabbri E. Inflammageing: chronic inflammation in ageing, cardiovascular disease, and frailty. Nat Rev Cardiol. 2018;15(9):505–22. https://doi.org/10.1038/s41569-018-0064-2.
11. Sato R, Vatic M, Peixoto da Fonseca GW, Anker SD, von Haehling S. Biological basis and treatment of frailty and sarcopenia. Cardiovasc Res. 2024;120(9):982–98. https://doi.org/10.1093/cvr/cvae073.
12. Luo YX, Zhou XH, Heng T, Yang LL, Zhu YH, Hu P, Yao XQ. Bidirectional transitions of sarcopenia states in older adults: The longitudinal evidence from CHARLS. J Cachexia Sarcopenia Muscle. 2024;15(5):1915–29. https://doi.org/10.1002/jcsm.13541.
13. Chen L-K, Hsiao F-Y, Akishita M, Assantachai P, Lee W-J, Lim WS, Muangpaisan W, Kim M, Merchant RA, Peng L-N, et al. A focus shift from sarcopenia to muscle health in the Asian Working Group for Sarcopenia 2025 Consensus Update. Nat Aging. 2025;5(11):2164–75. https://doi.org/10.1038/s43587-025-01004-y.
14. Cruz-Jentoft AJ, Kiesswetter E, Drey M, Sieber CC. Nutrition, frailty, and sarcopenia. Aging Clin Exp Res. 2017;29(1):43–8. https://doi.org/10.1007/s40520-016-0709-0.
15. Welch A. Micronutrient malnutrition across the life course, sarcopenia and frailty. Proc Nutr Soc. 2021;80(3):279–82. https://doi.org/10.1017/s0029665121001968.
16. Ganapathy A, Nieves JW. Nutrition and Sarcopenia—What Do We Know? Nutrients. 2020;12(6):1755. https://doi.org/10.3390/nu12061755.
17. Xue J, Han X, Zheng Y, Zhang Q, Kong L. Effectiveness of resistance training in modulating inflammatory biomarkers among Asian patients with sarcopenia: a systematic review and meta-analysis of randomized controlled trials. Front Immunol. 2024;15:1385902. https://doi.org/10.3389/fimmu.2024.1385902.
18. Guo Y, Qian H, Xin X, Liu Q. Effects of different exercise modalities on inflammatory markers in the obese and overweight populations: unraveling the mystery of exercise and inflammation. Front

Physiol. 2024;15:1405094. https://doi.org/10.3389/fphys.2024.1405094.

19. Zhang G, Wang D, Chen J, Tong M, Wang J, Chang J, Gao X. Association of sleep duration and prevalence of sarcopenia: A large cross-sectional study. Prev Med Rep. 2024;42:102741. https://doi.org/10.1016/j.pmedr.2024.102741.
20. Moncion K, Rodrigues L, MacKay-Lyons M, Eng JJ, Billinger SA, Ploughman M, Bailey DM, Trivino M, Bayley M, Thiel A, et al. Exercise-Based Stroke Rehabilitation: Clinical Considerations Following the COVID-19 Pandemic. Neurorehabil Neural Repair. 2021;36(1):3–16. https://doi.org/10.1177/15459683211054175.
21. Morley JE, Malmstrom TK, Miller DK. A simple frailty questionnaire (FRAIL) predicts outcomes in middle aged African Americans. J Nutr Health Aging. 2012;17(7):601–8. https://doi.org/10.1007/s12603-012-0084-2.
22. Geriatrics Branch of Chinese Medical Association. Chinese Guidelines for the Diagnosis and Treatment of Sarcopenia. (2024). Chinese Medical Journal. 2025;105(3):181–203. https://doi.org/10.3760/cma.j.cn112137-20240724-01701
23. Rubenstein LZ, Harker JO, Salvà A, Guigoz Y, Vellas B. Screening for undernutrition in geriatric practice: developing the short-form mini-nutritional assessment (MNA-SF). J Gerontol Biol Sci Med Sci. 2001;56(6):M366–372. https://doi.org/10.1093/gerona/56.6.m366.
24. Washburn RA, Smith KW, Jette AM, Janney CA. The Physical Activity Scale for the Elderly (PASE): development and evaluation. J Clin Epidemiol. 1993;46(2):153–62. https://doi.org/10.1016/0895-4356(93)90053-4.
25. Li X, Wang P, Jiang Y, Yang Y, Wang F, Yan F, Li M, Peng W, Wang Y. Physical activity and health-related quality of life in older adults: depression as a mediator. BMC Geriatr. 2024;24(1):26. https://doi.org/10.1186/s12877-023-04452-6.
26. Logan S, Gottlieb B, Maitland S, Meegan D, Spriet L. The Physical Activity Scale for the Elderly (PASE) Questionnaire; Does It Predict Physical Health? Int J Environ Res Public Health. 2013;10(9):3967–86. https://doi.org/10.3390/ijerph10093967.
27. Woo J, Leung J, Morley JE. Defining Sarcopenia in Terms of Incident Adverse Outcomes. J Am Med Dir Assoc. 2015;16(3):247–52. https://doi.org/10.1016/j.jamda.2014.11.013.
28. Yu R, Leung J, Woo J. Incremental Predictive Value of Sarcopenia for Incident Fracture in an Elderly Chinese Cohort: Results From the Osteoporotic Fractures in Men (MrOs) Study. J Am Med Dir Assoc. 2014;15(8):551–8. https://doi.org/10.1016/j.jamda.2014.02.005.
29. Yoshimura N, Muraki S, Oka H, Iidaka T, Kodama R, Kawaguchi H, Nakamura K, Tanaka S, Akune T. Is osteoporosis a predictor for future sarcopenia or vice versa? Four-year observations between the second and third ROAD study surveys. Osteoporos Int. 2016;28(1):189–99. https://doi.org/10.1007/s00198-016-3823-0.
30. Bonjour T, Waeber G, Marques-Vidal P. Trends in prevalence and outcomes of frailty in a Swiss university hospital: a retrospective observational study. Age Ageing. 2021;50(4):1306–13. https://doi.org/10.1093/ageing/afaa278.

31. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, Seeman T, Tracy R, Kop WJ, Burk G, et al. Frailty in older adults: evidence for a phenotype. J Gerontol Biol Sci Med Sci. 2001;56(3):M146–156. https://doi.org/10.1093/gerona/56.3.m146.
32. Mitnitski AB, Mogilner AJ, Rockwood K. Accumulation of Deficits as a Proxy Measure of Aging. Sci World J. 2001;1:323–36. https://doi.org/10.1100/tsw.2001.58.
33. Xie H, Gao J, Zhang Y, Kumagai S, Zhao M, Li M, Chen S. Validation of a frailty phenotype screening questionnaire for rural Chinese older adults: a cross-sectional study. BMC Geriatr. 2025;26(1):45. https://doi.org/10.1186/s12877-025-06754-3.
34. Han CY, Sharma Y, Yaxley A, Baldwin C, Miller M. Use of the Patient-Generated Subjective Global Assessment to Identify Pre-Frailty and Frailty in Hospitalized Older Adults. J Nutr Health Aging. 2021;25(10):1229–34. https://doi.org/10.1007/s12603-021-1704-5.
35. Friedlaender A, Banna GL, Buffoni L, Addeo A. Poor-Performance Status Assessment of Patients with Non-small Cell Lung Cancer Remains Vague and Blurred in the Immunotherapy Era. Curr Oncol Rep. 2019;21(12):107. https://doi.org/10.1007/s11912-019-0852-9.
36. Nadziakiewicz P, Szczurek-Wasilewicz W, Szyguła-Jurkiewicz B. Heart Failure in Elderly Patients: Medical Management, Therapies and Biomarkers. Pharmaceuticals (Basel). 2024;18(1):32. https://doi.org/10.3390/ph18010032.
37. Köpke S, Kiah Hui Siew S, Yu J, Teo TL, Chua KC, Mahendran R, Rawtaer I. Technology and physical activity for preventing cognitive and physical decline in older adults: Protocol of a pilot RCT. PLoS ONE. 2024;19(2):e0293340. https://doi.org/10.1371/journal.pone.0293340.
38. Lee C, Park Y-H, Cho B. Leveraging network analysis to determine sex differences in factors associated with frailty among older adults living alone. BMC Geriatr. 2023;23(1):38. https://doi.org/10.1186/s12877-023-03755-y.
39. Dostálová R, Stillman C, Erickson KI, Slepička P, Mudrák J. The Relationship between Physical Activity, Self-Perceived Health, and Cognitive Function in Older Adults. Brain Sci. 2021;11(4):492. https://doi.org/10.3390/brainsci11040492.
40. Rose Berlin Piodena-Aportadera M, Lau S, Chew J, Lim JP, Ismail NH, Ding YY, Lim WS. Calf Circumference Measurement Protocols for Sarcopenia Screening: Differences in Agreement, Convergent Validity and Diagnostic Performance. Ann Geriatr Med Res. 2022;26(3):215–24. https://doi.org/10.4235/agmr.22.0057.
41. Kiss CM, Bertschi D, Beerli N, Berres M, Kressig RW, Fischer AM. Calf circumference as a surrogate indicator for detecting low muscle mass in hospitalized geriatric patients. Aging Clin Exp Res. 2024;36(1):25. https://doi.org/10.1007/s40520-024-02694-x.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryMaterial.docx