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Review Article

Integrated traditional Chinese and western medicine approaches to sarcopenia: recent advances in comprehensive intervention

Dongming Yang[1*], Weiqin Zhang[2*], Di Zhang[3*], Xiaohua Wu[1], Zhongju Xu[2]

[1]Department of Nutrition, Pudong Gongli Hospital Affiliated to Shanghai University of Medicine and Health Sciences, Shanghai 200135, China; [2]Department of Traditional Chinese Medicine, Pudong Gongli Hospital Affiliated to Shanghai University of Medicine and Health Sciences, Shanghai 200135, China; [3]Department of Health Care Center, Pudong Gongli Hospital Affiliated to Shanghai University of Medicine and Health Sciences, Shanghai 200135, China. [*]Equal contributors.

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Abstract: Sarcopenia is an age-related syndrome characterized by the loss of skeletal muscle mass, reduction in muscle strength, and/or impairment of physical performance, which severely compromises the quality of life for older adults. With the accelerating pace of global population aging, sarcopenia is a major public health challenge. In recent years, international consensus statements and guidelines have been continuously updated-from the original definition proposed by the European Working Group on Sarcopenia in Older People (EWGSOP), through the 2019 diagnostic criteria of the Asian Working Group for Sarcopenia (AWGS 2019), to the conceptual shift from "sarcopenia" toward "muscle health" proposed in 2025 - reflecting the progressively deepening understanding of this condition. The release of the latest edition of the Chinese guideline for the diagnosis and treatment of sarcopenia, together with the Chinese expert consensus on dietary and nutritional prescriptions and exercise interventions for sarcopenia, has provided localized evidence-based references for the prevention and management of sarcopenia in China. Based on the latest research, this article systematically elaborates an integrated traditional Chinese and western medicine intervention model for sarcopenia, structured around the framework of "risk stratification-comprehensive assessment-graded intervention-follow-up and referral", to give guidelines for clinical management.

Keywords: Sarcopenia, risk stratification, nutritional support, resistance training, integrated traditional Chinese and Western medicine

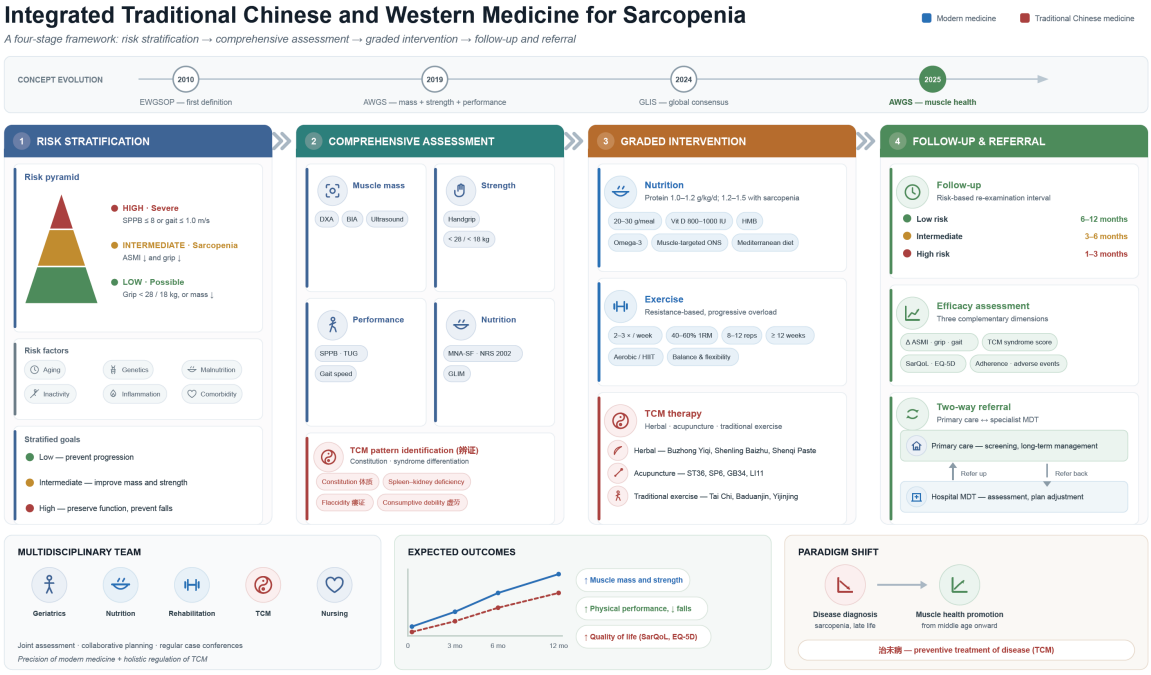
Introduction

Sarcopenia is an age-related syndrome characterized by progressive loss of skeletal muscle mass and declining muscle strength, which seriously impairs the quality of life and prognosis of older adults. In 2010, the International Working Group on Sarcopenia (ICWGR) formally defined sarcopenia for the first time [1], and the European Working Group on Sarcopenia in Older People (EWGSOP) subsequently issued the first consensus definition [2]. Over the past decade, understanding of this condition has continued to deepen, diagnostic criteria have become increasingly refined, and the range of available interventions has expanded.

In 2019, the Asian Working Group for Sarcopenia (AWGS) published a consensus on diagnosis and treatment, emphasizing the importance of the three-dimensional assessment of muscle mass, muscle strength, and physical performance [3]. In 2024, the Global Leadership Initiative in Sarcopenia (GLIS) established a conceptual definition of sarcopenia, underscoring the central role of muscle in maintaining healthy function [4]. In the 2025 AWGS consensus update, the focus shifted from the diagnosis of sarcopenia in later life toward the proactive promotion of muscle health beginning in middle age, a transition that reflects the growing influence of preventive medicine and the concept of healthy aging [5].

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Graphical Abstract



Modern medicine regards nutritional support and exercise therapy as the cornerstones of management [6-9], and evidence indicates that combined interventions can produce synergistic effects [8-10]. Traditional Chinese medicine (TCM) approaches the prevention and treatment of sarcopenia by tonifying the spleen and kidney and by replenishing qi and nourishing blood, and recent studies have suggested potential benefits of traditional Chinese medicine [11-15]. Grounded in current guidelines, consensus statements, and evidence-based medicine, this article elaborates an integrative TCM-western medicine model across four dimensions-risk stratification, comprehensive assessment, graded intervention, and follow-up and referral-and discusses its clinical application and future directions.

Risk stratification and management priorities for sarcopenia

Criteria for risk stratification

Based on the AWGS 2019 consensus and the Chinese guidelines for the diagnosis and treatment of sarcopenia [16, 17], sarcopenia severity can be classified into three categories defined by the presence and combination of specific diagnostic indicators. This graded classification spans a spectrum from a single abnormality to a more extensive syndrome involving both muscle characteristics and physical performance.

(1) Possible sarcopenia (at risk): Characterized by a single abnormality-reduced muscle strength or reduced muscle mass. A handgrip strength below the lower limit of normal (men <28 kg, women <18 kg) or a reduced muscle mass is present, but the two criteria are not simultaneously met; either abnormality alone is sufficient to assign this category, which represents the least extensive presentation.

(2) At risk/possible sarcopenia: Characterized by a single abnormality, namely reduced muscle strength or reduced muscle mass. Handgrip strength below the lower limit of normal (men <28 kg, women <18 kg) or reduced muscle mass is present, but the two diagnostic criteria are not simultaneously fulfilled. In other words, either reduced handgrip strength or reduced muscle mass alone is sufficient to assign an at-risk/possible state, and the category does not require the coexistence of both abnormalities. This level, therefore, reflects a less extensive presentation in which only one of the two core diagnostic features is identifiable.

(3) Sarcopenia (intermediate risk): Defined by a concurrent reduction of both muscle mass and

muscle strength. Reduced muscle mass is defined as an appendicular skeletal muscle index (ASMI) <7.0 kg/m^2 in men and <5.4 kg/m^2 in women by dual-energy X-ray absorptiometry (DXA), or <7.0 kg/m^2 in men and <5.7 kg/m^2 in women by bioelectrical impedance analysis (BIA), with handgrip strength concurrently below the aforementioned thresholds. Satisfying both criteria simultaneously distinguishes this category from possible sarcopenia.

(4) Intermediate risk/sarcopenia: Defined by a concurrent reduction in muscle mass and muscle strength. Reduced muscle mass is defined as an appendicular skeletal muscle index (ASMI) <7.0 kg/m^2 in men and <5.4 kg/m^2 in women when measured by dual-energy X-ray absorptiometry (DXA), or <7.0 kg/m^2 in men and <5.7 kg/m^2 in women when measured by bioelectrical impedance analysis (BIA). Handgrip strength is concurrently below the aforementioned lower limits of normal. Thus, both the muscle mass criterion and the muscle strength criterion are satisfied simultaneously in this category. This simultaneous fulfilment distinguishes intermediate risk/sarcopenia from the at-risk/possible category, in which only one of these diagnostic criteria is present.

(5) Severe sarcopenia (high risk): Sarcopenia accompanied by impaired physical performance, commonly defined by a Short Physical Performance Battery (SPPB) score ≤8 or a gait speed ≤1.0 m/s. This category represents the most advanced level of the three-tier classification, combining the diagnostic features of sarcopenia with measurable limitations in physical performance.

(6) High risk/severe sarcopenia: This category refers to sarcopenia accompanied by impaired physical performance. Impaired physical performance is commonly defined using a Short Physical Performance Battery (SPPB) score ≤8 or a gait speed ≤1.0 m/s as the cut-off value. In this category, the coexistence of sarcopenia and functional impairment defines a more severe level of the condition. The SPPB score and gait speed serve as objective measures for identifying impaired physical performance and for assigning the high-risk/severe sarcopenia designation. This category, therefore, represents the most advanced level of the three-tier classification, as it combines the diagnostic features of sarcopenia with measurable limitations in physical performance.

Assessment of risk factors

Beyond the diagnostic criteria above, evaluation of a patient with sarcopenia should include assessment of risk factors [18]. These can be broadly classified into modifiable factors, non-modifiable factors, and comorbid conditions. Modifiable factors - those amenable to intervention-include malnutrition, physical inactivity, chronic inflammatory states, vitamin D deficiency, and hormonal abnormalities. Previous studies indicated that insufficient protein intake and lack of resistance training are the principal modifiable contributors to sarcopenia [19]. Chronic inflammatory states characterized by elevated tumor necrosis factor-α (TNF-α) and interleukin-6 (IL-6) are also closely associated with its occurrence [19]; accordingly, anti-inflammatory strategies may represent a therapeutic target.

In addition to the diagnostic criteria presented above, the evaluation of a patient with sarcopenia should also include an assessment of the patient's risk factors [18]. These risk factors can be broadly classified into three categories: modifiable factors, non-modifiable factors, and comorbidities [20]. This categorization is intended to encompass the different types of risk factors that may be relevant to the condition. The modifiable factors refer to those that are potentially amenable to change or intervention. They include malnutrition, physical inactivity, chronic inflammatory states, vitamin D deficiency, and hormonal abnormalities. Findings from previous studies have shown that, among these modifiable factors, insufficient protein intake and a lack of resistance training are the principal modifiable factors for the development of sarcopenia. In addition, chronic inflammatory states, such as those characterized by elevated levels of TNF-α and IL-6, are closely associated with the occurrence of sarcopenia [19]. In light of this association, anti-inflammatory treatment may represent a therapeutic target for clinical management of sarcopenia [19, 21].

Diabetes mellitus, chronic heart failure, chronic obstructive pulmonary disease, chronic kidney disease, and malignant tumors are all common comorbidities in patients with sarcopenia. These chronic diseases are frequently identified together with sarcopenia and represent an important group of coexisting conditions in this patient population. Chronic diseases can

increase the risk of sarcopenia or accelerate its progression [22-24]. In other words, the presence of a chronic disease may make the development of sarcopenia more likely, and in patients who already have sarcopenia, it may lead to a more rapid worsening of the condition. Studies have shown that patients with sarcopenia and coexisting chronic diseases have poorer prognoses. As a result, more aggressive intervention is required for these patients [24].

Treatment goals across risk strata

Treatment goals should be individualized according to the risk stratum. In other words, the objectives of treatment are determined by the particular risk category of the patient, rather than being applied uniformly to all individuals with sarcopenia. For individuals with possible sarcopenia, the goal is to prevent disease progression, with an emphasis on improving lifestyle, correcting nutritional deficiencies, and increasing physical activity. At this stage, the main focus is on preventing the condition from worsening, and the recommended measures center on lifestyle improvement, nutritional correction, and increased physical activity. Active intervention at this stage may reverse abnormal factors and prevent the onset and progression of sarcopenia [25]. This suggests that early and active management has the potential to normalize abnormal findings and to stop the development and worsening of sarcopenia in these individuals.

For patients with sarcopenia, the goal is to improve muscle mass and strength and to preserve physical performance, which requires combined nutritional support and exercise therapy. In this group, the aims are directed at enhancing muscle mass and strength and maintaining physical performance, and these aims can be pursued through a combination of nutritional support and exercise therapy. Systematic intervention at this stage can significantly improve muscle function and activities of daily living [26, 27]. Therefore, when patients already have sarcopenia, a systematic approach is associated with meaningful improvements in muscle function and in the performance of daily activities.

For patients with severe sarcopenia, the goal is to improve physical performance and to prevent falls and disability. Notably, patients at this stage frequently present with multiple chronic conditions, making management more difficult and often necessitating multidisciplinary care [28, 29]. The coexistence of several chronic diseases in these patients complicates treatment and frequently requires the involvement of a multidisciplinary team [28, 29].

Risk stratification framework and the corresponding management priorities are summarized in **Table 1**.

Comprehensive assessment strategy for sarcopenia

Muscle assessment

Assessment of muscle mass: DXA is regarded as the gold standard for the assessment of muscle mass, meaning that it is the established reference method against which other techniques are compared in the quantitative evaluation of muscle mass. In contrast, BIA is widely used in clinical practice because it is convenient to perform and can be applied easily in routine settings [30]. In recent years, emerging techniques such as ultrasound measurement of muscle thickness have also been applied to muscle mass assessment. These ultrasound-based methods offer several advantages: they are non-invasive, meaning that they do not require invasive procedures; they provide real-time information; and they are reproducible, allowing repeated measurements to be obtained consistently [31]. Studies have shown that ultrasound-measured thigh muscle thickness correlates well with conventional DXA measurements. This correlation indicates that ultrasound-measured thigh muscle thickness may be used as an alternative method for the assessment of muscle mass [83, 84].

Assessment of muscle strength: Handgrip strength is the most commonly used measure of muscle strength and is closely associated with overall muscle strength and prognosis [2, 3]. Because handgrip strength is closely related to overall muscle strength, it can serve as a proxy for generalized muscle status, and its link with prognosis suggests that it may also provide useful information about future outcomes. Grip strength of the dominant hand is usually measured with a standard dynamometer, and the maximum of three measurements is recorded. During measurement, three trials are gener-

Table 1. Risk stratification and management priorities for sarcopenia

Risk stratum	Diagnostic category	Diagnostic criteria	Risk factors	Recommended management priorities
Low	Possible sarcopenia	Abnormality in either muscle mass or muscle strength	No obvious risk factors	Preventive intervention, risk factor management, and periodic functional screening
Intermediate	Sarcopenia	Reduced muscle mass plus reduced muscle strength	1-2 risk factors (advanced age or low BMI given priority)	Exercise plus nutritional intervention plus referral for specialist assessment
High	Severe sarcopenia	Sarcopenia plus impaired physical performance	≥3 risk factors plus low physical activity/malnutrition	Immediate resistance training plus nutritional supplementation plus etiological treatment plus fall/frailty monitoring; hospitalization or specialist multidisciplinary management may be required

Note: BMI, body mass index.

Table 2. Nutritional assessment tools for sarcopenia risk

Tool	Target population/features	Key points
Mini Nutritional Assessment (MNA)/ Mini Nutritional Assessment-Short Form (MNA-SF) [36, 37]	Nutrition risk screening in older adults aged ≥65 years; applicable in both community and hospital settings	The full version comprises 18 items (diet, BMI, calf circumference, mobility, etc.)); the short form MNA-SF comprises 6 items: 11 points indicates risk of malnutrition/malnutrition, 12-13 points borderline, and 14 points normal
Nutrition Risk Screening 2002 (NRS 2002) [38]	Adult inpatients; recommended by ESPEN for completion within 24 h of admission	Initial screening with four questions (BMI <20.5, weight loss in the past 3 months, reduced intake in the past week, and severe illness) plus scoring of nutritional status, disease severity, and age. A total score ≥3 indicates the presence of nutritional risk
Malnutrition Universal Screening Tool (MUST) [39]	Adults, all settings (outpatient, community, and residential care)	Three items: BMI, weight loss, and the effect of acute disease; 0 = low risk, 1 = medium risk, and 2 = high risk
Patient-Generated Subjective Global Assessment (PG-SGA) [40, 41]	Patients with cancer, kidney disease, or stroke; patient self-assessment plus clinician assessment	Patient self-assessment component (weight, intake, symptoms, and activity) plus clinician assessment; graded and scored as A/B/C to guide nutritional intervention
Nutrition Risk in the Critically Ill (NUTRIC) score [42]	Critically ill adults (ICU); predicts benefit from nutrition therapy	Age, APACHE II, SOFA, comorbidities, days from hospital to ICU admission, and IL-6 (modified version); a score of 5-6 (including IL-6) indicates high nutritional risk
Subjective Global Assessment (SGA)/Global Leadership Initiative on Malnutrition (GLIM) [43, 44]	SGA: adults (surgical, oncology, and nephrology); GLIM: diagnosis of malnutrition in adults	SGA classifies patients as A/B/C based on medical history and physical examination; GLIM requires phenotypic criteria (weight loss, low BMI, and reduced muscle mass) plus definitive etiologic criteria (insufficient intake and disease burden)

Note: BMI, body mass index; ESPEN, European Society for Clinical Nutrition and Metabolism; APACHE II, Acute Physiology and Chronic Health Evaluation II; SOFA, Sequential Organ Failure Assessment; ICU, intensive care unit; IL-6, interleukin-6.

ally performed with the dynamometer, and the highest value obtained from these trials is recorded as the final grip strength. In addition to handgrip strength, the strength of other muscle groups, such as knee extensor strength, can be assessed to obtain a more comprehensive profile of muscle function [10]. When these additional muscle groups are evaluated together with handgrip strength, the overall assessment can provide a broader and more complete profile of muscle function.

Assessment of physical performance: The SPPB is a widely used tool for assessing physical performance, and it is among the most commonly adopted instruments for this type of evaluation. It comprises three main components: balance testing, gait speed testing, and the chair stand test. These components are combined to produce a total score that ranges from 0 to 12, with higher scores on this scale indicating better physical performance [34]. In addition to the SPPB, other assessment tools are commonly used in the evaluation of physical performance, including the timed up-and-go test (TUG) and usual gait speed testing. These tools represent additional options that are frequently selected in clinical practice. Each of these tools has specific characteristics that differentiate it from the others, and the choice of tool can therefore be selected according to the individual circumstances of the patient [18].

Nutritional assessment

Studies have shown that nutritional risk is common among patients with sarcopenia and that nutritional status is closely related to muscle function [35]. Generic nutrition risk screening and assessment tools can identify malnutrition or nutritional risk in older, hospitalized, chronically ill, and sarcopenic populations, and are frequently used in conjunction with the diagnostic criteria for sarcopenia.

Several recent studies have directly compared the ability of the above nutrition screening tools to identify sarcopenia, and this has important practical implications for nutrition risk screening in patients with sarcopenia. In one such study, Zhang et al. [45] compared the accuracy of Nutritional Risk Screening 2002 (NRS 2002) and Mini Nutritional Assessment-Short Form (MNA-SF) in identifying sarcopenia and additionally assessed the value of these two tools in predicting mortality among 430 older inpatients. The results showed that MNA-SF was superior to NRS 2002 in identifying sarcopenia. Whereas both NRS 2002 and MNA-SF predicted mortality in patients with sarcopenia, only NRS 2002 was an independent predictor of mortality. This finding suggests that, in clinical practice, MNA-SF is more suitable for the early screening of sarcopenia, whereas NRS 2002 is more valuable for prognostic assessment, that is, for predicting the likely course or outcome of the condition. Liang et al. [46] enrolled 268 older adults with multimorbidity to examine the concordance of NRS 2002, MNA-SF, and the Geriatric Nutritional Risk Index (GNRI) in nutrition risk screening. Specifically, the three scales were applied to evaluate whether they placed the same patients into similar nutrition risk categories. All three scales were found to be applicable for nutrition risk screening in older adults with multimorbidity. Among these scales, MNA-SF showed better concordance with NRS 2002, which indicates that MNA-SF is more suitable for nutrition risk screening in older patients with sarcopenia and multimorbidity. Taken together, the results of these studies support the use of MNA-SF for early identification in patients with sarcopenia, while NRS 2002 appears to be particularly useful for prognosis-related assessment.

The nutritional assessment tools commonly used in patients with sarcopenia are compared in **Table 2**.

Assessment of exercise function

The exercise function assessment system for sarcopenia is composed of several interrelated components, mainly comprising basic physical function testing, exercise tolerance assessment, exercise risk assessment, exercise adherence assessment, and assessment of exercise benefits and quality of life. These components collectively constitute a comprehensive evaluation framework that addresses different dimensions of exercise function. Basic physical function testing is the starting point of the assessment and quantifies the patient's baseline activities of daily living and physical performance; by measuring these baseline characteristics, this testing establishes the initial functional status from which subsequent assessments can be interpreted. Exercise tolerance

assessment defines the cardiopulmonary and muscular reserve capacity, thereby indicating the physiological reserve available during physical activity. Exercise risk assessment identifies the risk of falls and cardiovascular events before an exercise prescription is issued, thereby delineating the safe boundaries of exercise; this assessment provides a basis for determining the conditions under which exercise can be performed safely. Exercise adherence assessment evaluates feasibility at the behavioral and psychological levels and determines whether the prescription can be implemented and sustained; behavioral feasibility concerns the ability to perform and maintain exercise behaviors, while psychological feasibility concerns the mental and emotional factors that may support or hinder continued participation. Assessment of exercise benefits and quality of life quantifies the benefits of exercise intervention, symptom improvement, and changes in quality of life, and serves as an indicator for evaluating the effectiveness of prescribed exercise by capturing the extent to which it produces measurable changes in the patient's condition and well-being.

The exercise assessment methods recommended for patients with sarcopenia are listed in **Table 3**.

TCM syndrome differentiation assessment

Traditional Chinese medicine (TCM) does not possess a single, specific disease name that corresponds directly and precisely to sarcopenia. However, when this condition is assessed according to its principal clinical manifestations-namely, the wasting of skeletal muscle tissue and the accompanying loss of muscle strength-it can be assigned to several traditional categories of disease. These categories include "flaccidity syndrome" (wei zheng), "consumptive debility" (xu lao), and "emaciation" (lei shou) [63]. In older adults, multiple etiologic factors are considered to underlie the development of sarcopenia. Among these factors are the physiological decline associated with advancing age, a deficiency of qi, blood, and body fluids, long-term bed rest, an imbalance between physical labor and rest, and inappropriate dietary habits. habits. All of these factors together are regarded as the causative background from which sarcopenia arises. With respect to pathogenesis, a deficiency of the spleen and the kidney constitutes the fundamental pathological mechanism of sarcopenia. This means that a weakened state of these two organs is considered to be the root of the disorder. At the same time, deficiency of qi and blood, which leads to inadequate nourishment of the muscles, represents the core pathological process through which the disease develops and progresses [13]. The theory of constitution in traditional Chinese medicine further explains the background context of disease onset. According to this theory, certain types of constitutional imbalance are identified as risk factors for sarcopenia. Specifically, constitutions marked by qi deficiency, yang deficiency, yin deficiency, dampness-heat, blood stasis, and qi stagnation are all considered to increase the risk of developing the condition. Conversely, a balanced constitution is regarded as a protective factor, meaning that individuals with such a constitution are relatively less likely to develop sarcopenia [64]. Clinical surveys that have investigated syndrome patterns in patients with sarcopenia have additionally shown that the most common presentations are patterns of spleen-stomach weakness and liver-kidney deficiency. In the majority of cases, the syndromes identified are of the deficiency type, indicating that the predominant clinical picture in sarcopenia is one of depletion rather than excess [65, 66].

Modern medical assessment relies primarily on quantitative indicators that can be measured and recorded objectively, such as muscle mass, handgrip strength, and gait speed (as described above). Although this approach is objective and reproducible, offering standardized comparisons across individuals and time points, it has limited explanatory power regarding why the disease develops in a particular person and how prevention and treatment should be individualized according to that person's underlying condition. By contrast, TCM constitution identification and syndrome differentiation assessment, which are characterized by the holistic view and the concept of preventive treatment of disease, can precisely compensate for this shortcoming. Because these TCM methods consider the individual as an integrated whole and emphasize early intervention before disease fully manifests, they are able to provide explanatory and individualized insights that

Table 3. Exercise assessment methods for sarcopenia

Assessment domain	Test method	Measurement parameter	Normal value/cut-off value	Clinical significance
Basic physical function testing	Handgrip strength [2, 3]	Maximum isometric contraction measured with a dynamometer; the maximum value of the dominant hand is recorded	Low handgrip strength: AWGS 2019, men <28 kg/women <18 kg; EWGSOP2, men <27 kg/ women <16 kg	A core diagnostic indicator of sarcopenia and the basis of the resistance exercise prescription
	Timed up-and-go test (TUG) [18]	Time taken to stand up from a chair, walk 3 m, turn around, return, and sit down	Normal value <12 s; >20 s indicates significant functional impairment	Closely associated with fall risk and an important indicator for assessing activities of daily living
	Five-times sit-to-stand test (5TSTS) [18]	Time taken to stand up from and sit down on a chair five consecutive times	Normal value <12 s	Mainly assesses lower-limb muscle strength and function, and is highly sensitive for the evaluation of lower-limb function in patients with sarcopenia
	Six-minute walk test (6MWT) [18]	Maximum walking distance achieved within 6 min	>400 m in healthy older adults	Reflects cardiopulmonary endurance and overall exercise function, and is the gold standard for assessing aerobic capacity
	Gait analysis [18]	Gait speed, stride length, cadence, step width, and other parameters	Normal gait speed ≥1.0 m/s; <0.8 m/s indicates a marked decline in motor function	Gait speed is closely related to the severity and prognosis of sarcopenia
Exercise tolerance assessment	Cardiopulmonary exercise testing (CPET) [47, 48]	Maximal oxygen uptake (V02max), anaerobic threshold, and cardiopulmonary reserve assessed during incremental exercise	-	Precisely quantifies exercise tolerance and provides a basis for formulating the exercise prescription
	Submaximal exercise testing	Step test, cycle ergometer test, etc.	-	Indirectly assesses cardiopulmonary function
	Repeated muscle strength testing [49]	Fatigue during repeated handgrip or repeated squats	-	Muscle endurance is closely related to activities of daily living and is an important complement to the assessment of sarcopenia
	Isokinetic muscle strength testing [50]	Strength and endurance at different angular velocities assessed with an isokinetic dynamometer	-	Allows precise quantification of muscle function

Exercise risk assessment [51]	Berg Balance Scale (BBS) [52, 85]	14 balance test items	Total score of 56; <45 indicates increased fall risk	A reliable tool for assessing balance function and fall risk in older patients
	Fall Risk Assessment Tool (FRAT) [53]	Comprehensive assessment of multiple factors, including fall history, medication use, gait and balance, and cognitive status	-	Fall risk screening and prevention
	Joint stability assessment [54]	Stability of weight-bearing joints, such as the knee and ankle; identification of joint instability and ligament laxity	-	Identifies joint instability and ligament laxity
	Skeletal status assessment [2]	Bone mineral density or fracture risk tools	-	Identifies osteoporosis and fracture risk
	Cardiovascular risk assessment (literature-based)	Electrocardiography, ultrasonography, etc. (if indicated)	-	Defines the safe range of exercise
Exercise adherence assessment [51, 55, 56]	Exercise history	Habits/type/frequency/duration	-	Predicts future adherence
	Exercise motivation	Exercise motivation scale	-	A key determinant of adherence
	Barriers to exercise	Pain/time/environment/social support	-	Enables targeted interventions to improve adherence
	Exercise self-efficacy	Exercise self-efficacy scale	-	Positively correlated with adherence
Exercise benefits and quality of life	Sarcopenia-specific quality of life (SarQoL) [57-59]	A 23-item disease-specific questionnaire covering physical, functional, and emotional domains	Lower scores indicate poorer quality of life	Sensitive to the response to sarcopenia interventions
	Generic health-related quality of life (EQ-5D) [60]	Five-dimensional health utility	Utility values can be converted	Enables cross-disease cost-effectiveness comparisons
	Generic quality of life (SF-36/SF-12) [61, 62]	Multidimensional health questionnaire	-	Reflects changes in quality of life before and after intervention

Note: AWGS, Asian Working Group for Sarcopenia; EWGSOP2, European Working Group on Sarcopenia in Older People 2; EQ-5D, EuroQol-5 Dimension; SarQoL, Sarcopenia and Quality of Life; SF-36/SF-12, 36-/12-Item Short Form Health Survey.

Table 4. Comparison between modern medicine and TCM assessment

Dimension	Modern exercise assessment (quantitative level)	TCM constitution/syndrome assessment (pattern differentiation level)
Core question	What the patient can do, how much load is appropriate, whether it is safe, whether it can be sustained, and what benefit is obtained	Why the individual is susceptible and what the current pathogenesis is
Advantages	Objective, quantifiable, and suitable for longitudinal follow-up	Individualized, oriented toward preventive treatment of disease, and able to explain the background of onset
Limitations	Difficult to explain individual variability and the root cause of the disease	Relatively subjective, and the criteria for syndrome classification remain to be standardized

Note: TCM, traditional Chinese medicine.

quantitative measures alone cannot offer. Specifically, TCM constitution identification can move the risk window forward, enabling susceptibility to be recognized at an earlier stage than would otherwise be possible [67]. In parallel, TCM syndrome differentiation can provide early warning of adverse outcomes, helping clinicians anticipate unfavorable progression before it becomes clinically obvious [68]. Thus, the logical sequence is as follows: first, constitutional deviations are identified to clarify an individual's inherent susceptibility; then, the syndrome pattern is determined on the basis of the four diagnostic methods, including tongue and pulse examination. This two-step TCM assessment can provide a basis for subsequently formulating individualized treatment regimens, dynamically adjusting those regimens as the patient's condition evolves, and predicting therapeutic efficacy more accurately. In practical assessment, TCM-derived indicators such as constitution identification and syndrome scores can be integrated into the comprehensive assessment workflow of modern medicine. These indicators can be collected simultaneously with modern medical indicators-such as muscle mass, handgrip strength, and gait speed-thereby allowing the two sets of information to be interpreted together. The result is a multidimensional integrated assessment model that incorporates both biomedical and TCM perspectives.

The complementary roles of modern exercise assessment and TCM syndrome differentiation are summarized in **Table 4**.

Graded intervention integrating traditional Chinese and western medicine

Nutritional support

Protein: Protein serves as a key substrate for muscle synthesis, providing the necessary amino acid building blocks for the construction and repair of muscle tissue, and protein supplementation has been shown to promote muscle protein synthesis (MPS) while simultaneously reducing protein breakdown. In older adults, however, the anabolic response to dietary protein is attenuated, a phenomenon referred to as "anabolic resistance" [6]. This means that the muscle becomes less responsive to the stimulatory effects of protein or amino acids on MPS, so older individuals require approximately 67% higher protein intake than younger individuals to achieve a comparable anabolic response [7]. For healthy older adults, an intake of 1.0-1.2 g/kg/d is recommended [18]; in patients with confirmed sarcopenia, this recommendation increases to 1.2-1.5 g/kg/d. High-quality protein sources, such as whey, egg, and soy products, should be evenly distributed across three meals-for example, 20-30 g of high-quality protein per meal-so that muscle protein synthesis is stimulated repeatedly throughout the day. In addition, post-exercise protein supplementation may enhance the anabolic effect, further supporting muscle maintenance and repair [18].

Specific nutrients: β-Hydroxy-β-methylbutyrate (HMB), a key amino acid metabolite, can inhibit muscle proteolysis, reduce inflammation, and stabilize cell membranes, thereby contributing to the maintenance of muscle structural integrity and the attenuation of muscle degradation [6]. Given that these cellular processes are central to muscle protein balance, HMB has attracted interest as a potential nutritional strategy for preserving muscle health. However, the effect of long-term HMB supplementation alone on improving muscle mass and strength remains unclear, and synergistic action with nutrients such as vitamin D may be required for HMB to exert a meaningful influence on these outcomes [7]. In other words, although the metabolic properties of HMB suggest a possible protective role in muscle tissue, the evidence for its independent long-term benefit on muscle mass and strength is not yet sufficient to support a definitive conclusion.

Vitamin D regulates muscle cell function and reduces inflammation, but the evidence indicates that its effect on improving muscle strength and function is modest. When the serum 25-hydroxyvitamin D level is below 50 nmol/L, supplementation of 800-1000 IU/day may be considered. Higher doses (800 IU/day) may be more effective but may increase the risk of falls, and should therefore be used with caution [18, 32].

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to address deficient or insufficient vitamin D status and to support normal muscle physiology. Current evidence, therefore, suggests that vitamin D alone may not produce pronounced improvements in muscle strength or physical function, although correcting insufficiency remains clinically relevant. Higher doses (800 IU/day) may be more effective but may increase the risk of falls, and should therefore be used with caution [18, 32]. The balance between possible benefit and risk, therefore, requires careful clinical judgment when vitamin D supplementation is considered.

Omega-3 polyunsaturated fatty acids may enhance MPS and muscle function by improving muscle cell membrane structure and activating the mechanistic target of rapamycin (mTOR) signaling pathway [7]. Several studies have shown that supplementation with eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (0.7-3.4 g/d) increases muscle mass and strength; however, the results are inconsistent and may be influenced by baseline status, dose, and population characteristics such as sex and age [7, 69].

Omega-3 polyunsaturated fatty acids may enhance MPS and muscle function by improving muscle cell membrane structure and activating the mTOR signaling pathway, which are mechanisms involved in the regulation of protein synthesis in muscle [7]. Several studies have shown that supplementation with EPA and DHA (0.7-3.4 g/d) increases muscle mass and strength; however, the results are inconsistent and may be influenced by baseline status, dose, and population characteristics such as sex and age [7, 69]. The variability across studies highlights the complexity of nutritional interventions in older populations and the need to account for individual characteristics when evaluating efficacy. These inconsistencies indicate that the response to omega-3 supplementation is not uniform across all individuals, and the conditions that benefit from it need to be clarified.

Antioxidants, such as vitamins E and C and polyphenols, may modulate oxidative stress by scavenging reactive oxygen species, enhancing endogenous antioxidant systems, and inhibiting oxidase activity. They improve muscle mass and function by reducing oxidative damage to muscle cells, protecting mitochondrial function, and inhibiting ubiquitin-proteasome system-mediated protein degradation. However, high-dose vitamins C and E may blunt exercise-induced muscle adaptation [32, 70].

Antioxidants, such as vitamins E and C and polyphenols, may modulate oxidative stress by scavenging reactive oxygen species, enhancing endogenous antioxidant systems, and inhibiting oxidase activity. Through these effects, they improve muscle mass and function by reducing oxidative damage to muscle cells, protecting mitochondrial function, and inhibiting ubiquitin-proteasome system-mediated protein degradation. However, high-dose vitamins C and E may blunt exercise-induced muscle adaptation, suggesting that antioxidant supplementation does not always enhance muscle outcomes and may interfere with adaptive processes [32, 70]. Nevertheless, the potential for high-dose antioxidant supplements to attenuate beneficial exercise adaptations warrants attention when formulating supplementation strategies.

Muscle-targeted oral nutritional supplements (MT-ONS) combine multiple macro- and micronutrients with the aim of increasing energy and nutrient intake, and help to prevent muscle loss in frail older adults and to improve muscle mass, strength, and body composition in patients with sarcopenia. Oral nutritional supplements (ONS) should be initiated promptly when dietary intake is insufficient to meet requirements [69]. MT-ONS, either alone or combined with exercise, can significantly increase muscle mass, strength, and physical performance in patients with sarcopenia, reduce health care resource utilization during rehabilitation, and improve inflammatory markers [6, 71]. Some investigators support MT-ONS as a first-line treatment for sarcopenia, particularly in combination with individualized exercise [71]. Muscle-targeted oral nutritional supplements (MT-ONS) combine multiple macro- and micronutrients with the aim of increasing energy and nutrient intake, and help to prevent muscle loss in frail older adults and to improve muscle mass, strength, and body composition in patients with sarcopenia. Because the adequacy of dietary intake is fundamental to the preservation of muscle mass and function, ONS should be initiated promptly when dietary intake is insufficient to meet requirements [69]. MT-ONS, either alone or combined with exercise, can sig-

nificantly increase muscle mass, strength, and physical performance in patients with sarcopenia, reduce health care resource utilization during rehabilitation, and improve inflammatory markers [6, 71]. Overall, MT-ONS represents a comprehensive approach that addresses multiple nutrient deficits simultaneously, which may explain its favorable effects on multiple sarcopenia-related outcomes. Some investigators support MT-ONS as a first-line treatment for sarcopenia, particularly in combination with individualized exercise [71], which underscores the integrated role of nutritional therapy in comprehensive sarcopenia care.

Overall dietary patterns: Compared to single nutrients, overall dietary patterns may better meet the long-term requirements of muscle health management, because they capture the cumulative and interactive effects of habitual food choices. Since muscle health depends on a sustained and balanced supply of nutrients over time, dietary patterns that reflect habitual intake may be more relevant than short-term supplementation with individual nutrients. Through the overall dietary structure, these patterns exert multidimensional effects on sarcopenia, influencing muscle health through a combination of dietary components rather than through any isolated nutrient. The Mediterranean diet, which is rich in fish, olive oil, vegetables, and fruits, is associated with better muscle strength and function. The mechanism underlying this relationship may be related to the synergistic action of multiple nutrients-protein, antioxidants, and omega-3 fatty acids-that are supplied together in this dietary pattern and may interact to support muscle health [32].

Exercise intervention

Resistance training: Resistance training is a core component of the exercise prescription for sarcopenia [17] and represents the method with the most consistent evidence for improving muscle strength and physical performance [26, 72]. Among the exercise strategies commonly incorporated into the management of sarcopenia, resistance training has accumulated the most consistent body of evidence supporting its benefits for both muscle strength and physical performance. The mechanical tension generated by resistance training activates the phosphoinositide 3-kinase (PI3K)/protein kinase B (Akt)/mechanistic target of rapamycin (mTOR) and related pathways through mechanosensation and signal transduction, promoting myofibrillar protein synthesis and improving motor unit recruitment, neuromuscular coordination, insulin sensitivity, and mitochondrial function [27, 73]. When skeletal muscle is subjected to repeated resistance loads, the mechanical stimulus is perceived by the muscle cell and transduced into intracellular signaling events, which in turn stimulate the synthesis of myofibrillar proteins and enhance the recruitment of motor units, coordination between the nervous system and muscle, and metabolic functions such as insulin sensitivity and mitochondrial function. Early effects are mainly manifested as neural adaptation and increased muscle strength, while increases in muscle mass generally appear later; therefore, efficacy evaluation should simultaneously observe muscle mass, handgrip strength, lower-limb strength, gait speed, and SPPB. In the early phase of training, gains in strength are driven primarily by neural adaptations, including more efficient recruitment and coordination of motor units, whereas structural changes in muscle size become evident only after a longer period of consistent training. Because these adaptations occur on different time scales, the evaluation of resistance training efficacy should include simultaneous assessments of muscle mass, handgrip strength, lower-limb strength, gait speed, and the Short Physical Performance Battery (SPPB). Current recommendations generally suggest 2-3 sessions per week, starting at 40%-60% of one-repetition maximum (1RM), with 8-12 repetitions per exercise for 1-3 sets, for a duration of at least 12 weeks, with the load progressively increased according to tolerance [69, 73].

Aerobic training: Aerobic exercise improves cardiorespiratory fitness, muscle perfusion, mitochondrial oxidative capacity, and insulin sensitivity. Cardiorespiratory fitness reflects the ability of the heart and lungs to deliver oxygen to working muscles during sustained activity. Muscle perfusion describes the blood supply to skeletal muscle, which supports the delivery of oxygen and substrates. Mitochondrial oxidative capacity indicates the ability of muscle mitochondria to generate energy through aerobic metabolism. Insulin sensitivity refers to the responsiveness of tissues to the action of insulin.

In this context, aerobic exercise is particularly suitable for sedentary individuals and for those with diabetes or sarcopenic obesity [74, 75]. High-intensity interval training (HIIT) is a form of aerobic training that alternates periods of high-intensity exercise with recovery periods. Within a shorter period of time, HIIT can enhance cardiorespiratory and metabolic stimulation, offering a more time-efficient mode of aerobic conditioning. In addition, HIIT may activate the AMP-activated protein kinase (AMPK)/peroxisome proliferator-activated receptor-γ coactivator-1α (PGC-1α)-related mitochondrial biogenesis pathway, a pathway that is involved in the generation of new mitochondria and the regulation of mitochondrial function [76]. However, direct evidence for HIIT in patients with confirmed sarcopenia is more limited than that for resistance training. This number of studies specifically examining HIIT in individuals with confirmed sarcopenia is relatively small, and the available evidence is less complete. In addition, the use of HIIT in very old, severely frail, or high cardiovascular risk patients requires prior evaluation of individual health status and exercise capacity before implementation [76].

Balance and flexibility training: Balance and coordination training improves gait stability and reduces fall risk primarily by enhancing proprioception, postural control, movement sequencing, and muscle group coordination. These capacities together support the maintenance of an upright posture and the ability to adjust body position during movement, which in turn contributes to a steadier walking pattern and a lower likelihood of falling. The available evidence indicates that its effects on gait speed, TUG, SPPB, sit-to-stand performance, and balance are relatively consistent; however, its effects on muscle mass and maximal muscle strength are inferior to those of progressive resistance training. This means that, although balance and coordination training can produce reliable improvements in functional performance and balance-related outcomes, it is less effective as a primary stimulus for increasing muscle size and peak force generation. Therefore, rather than serving as the main intervention for muscle hypertrophy or maximal strength, it is more appropriately used as a functional complement within multicomponent exercise programs, where it contributes to movement control and fall prevention alongside other training methods [27, 30].

Formulation of the exercise prescription: The formulation of an exercise prescription should follow the principle of individualization [69]. In practice, it should be tailored to the functional status, commodities, and preferences of the patient, and not standardized for all patients. Functional status encompasses the patient's current level of physical functioning, comorbidities refer to coexisting diseases or conditions that may influence exercise participation, and preferences relate to the patient's own choices and goals. Different exercise training modalities have differing effects on muscle strength and physical performance in older adults with sarcopenia. Resistance training is most effective for improving muscle strength, understood as the ability of muscles to generate force during activity, whereas balance training is more advantageous for improving physical performance, understood as the capacity to carry out daily tasks that require postural stability and coordination. These methods do not produce identical benefits, and their relative value depends on the targeted outcome. For high-risk older adults, a single method is often insufficient to simultaneously address strength, cardiorespiratory endurance, balance, and activities of daily living. In these individuals, the needs to improve strength, cardiorespiratory endurance, balance, and the capacity to perform activities of daily living may coexist, and one type of exercise alone is unlikely to cover all of these areas. Therefore, the exercise prescription for sarcopenia should be based on resistance training, with aerobic, coordination, or interval training added according to cardiorespiratory endurance, balance impairment, and functional goals. Hence, resistance training provides the foundation of the prescription, while aerobic, coordination, or interval training are incorporated only as needed, based on the patient's cardiorespiratory endurance, balance impairment, and functional goals. The goal is to combine methods in a targeted manner, not to simply superimpose multiple methods without considering the patient's specific limitations and objectives [27, 52, 73].

Traditional Chinese medicine interventions

Chinese herbal medicine: Chinese herbal treatment of sarcopenia focuses mainly on strengthening the spleen and replenishing qi, tonifying the kidney and replenishing essence, activating blood circulation and removing blood sta-

sis, and dispelling dampness and unblocking the collaterals. Related studies have found that Chinese herbal medicine can improve muscle mass and some measures of muscle strength and function [15, 77]. In a meta-analysis of 1,440 patients, Zhang et al. found that treatment with Chinese herbal compound formulas (such as Buzhong Yiqi Decoction, Bazhen Decoction, and Shenling Baizhu Powder) increased the overall response rate and improved muscle mass and some aspects of muscle function; the potential mechanisms include promoting protein synthesis, inhibiting protein degradation, ameliorating inflammation, and regulating mitochondrial function [77]. Li et al. found that Shenqi Paste, a compound of medicinal and food homology, improved muscle mass, slowed handgrip decline, and improved nutritional status, plausibly via myokine regulation and the inflammatory microenvironment [78].

Acupuncture: Acupuncture may influence muscle health through neuromuscular activation, regional blood flow, inflammatory regulation, and improved gastrointestinal function. Niu et al. [16] found that acupuncture at Zusanli (ST36), Sanyinjiao (SP6), Yanglingquan (GB34), and Quchi (LI11) effectively improved muscle mass, handgrip strength, and gait speed, and reduced C-reactive protein levels, suggesting that it may act through anti-inflammatory effects and improvement of neuromuscular function. It could be an important complementary therapy for frail older adults who cannot tolerate conventional treatment. In addition, Zheng et al. [31] conducted a study in patients with gastrointestinal cancer-related sarcopenia and found that electroacupuncture combined with nutritional intervention effectively improved muscle mass, strength, physical function, and nutritional status, with superior efficacy to nutritional intervention alone and a favorable safety profile. These studies provide direct clinical evidence for the integrated TCM and western medicine intervention of sarcopenia. It is worth noting, however, that most of the current evidence derives from clinical observations and is limited by the number and quality of studies, and therefore requires further verification.

Traditional Chinese exercise: Traditional Chinese exercise combines low-intensity aerobic activity, muscle strength training, balance training, breathing regulation, and psychological adjustment, and is particularly suitable for very old, frail, chronically ill, and exercise-intolerant individuals. Compared to conventional resistance training, traditional Chinese exercise has the advantages of gentle movements, low space requirements, and high cultural acceptability, which facilitate long-term adherence. A meta-analysis showed [79] that Yijinjing, Tai Chi, and Baduanjin improved sit-to-stand performance, gait speed, balance function, and muscle strength in patients with sarcopenia, with good safety.

The combination of traditional Chinese exercise with nutritional support has been preliminarily explored in practice. Wang et al. [33] found in patients undergoing maintenance hemodialysis that Baduanjin combined with nutritional support significantly improved handgrip strength and gait speed and reduced inflammatory markers. This suggests that the effect of traditional exercise on sarcopenia may not be limited to mechanical training, but may also involve inflammatory regulation and improvement of the muscle microenvironment. However, the primary trials included in several meta-analyses overlap substantially, and some Yijinjing studies may have originated from the same cohort and therefore cannot be counted repeatedly as independent evidence. The “optimal form, frequency, or duration” derived from small-sample subgroups can only generate hypotheses and is not sufficient to establish a definitive prescription.

Combined intervention strategies

Nutrition combined with exercise: Nutritional support and exercise intervention exert synergistic effects; that is, their combined application produces a benefit that is greater than the sum of their individual effects, so they are not merely additive. A combined intervention may therefore be more effective than either nutritional support or exercise intervention alone. Evidence from multiple studies has shown that combined nutritional supplementation and exercise intervention significantly improves muscle mass, muscle strength, and physical function, including aspects such as mobility and the ability to perform daily activities, in patients with sarcopenia [6, 8, 9]. These improvements are reflected in widely recognized key indicators of sarcopenia and are directly relevant to patient outcomes. On the basis of currently

available evidence, nutritional intervention and exercise training may be considered concurrently-as integrated elements of a management plan-to improve muscle mass, muscle strength, and quality of life in older adults with sarcopenia.

Integration of modern medicine and traditional Chinese medicine: Modern medicine intervenes in sarcopenia from the perspectives of nutrition and exercise physiology; that is, modern medical approaches to this condition are based on the assessment and regulation of nutritional status and on the physiological effects of exercise. TCM, by contrast, acts through holistic regulation and syndrome differentiation-based treatment, which means that TCM views the human body as an integrated whole and makes treatment decisions according to specific syndrome patterns identified in individual patients. The combination of the two provides complementary interventions targeting different links in the chain of muscle decline. Their combined use may therefore produce the best outcomes. Studies have shown that integrated TCM and western medicine treatment not only improves muscle function and quality of life but also enhances treatment adherence in patients with sarcopenia [15, 16, 31].

Multidisciplinary collaboration: Older patients with sarcopenia frequently present with multiple chronic conditions and functional decline, making it difficult for a single specialty to fully address their diagnostic and therapeutic needs. It is recommended to establish a multidisciplinary team comprising geriatricians, nutritionists, rehabilitation therapists, TCM physicians, and nursing staff, and to achieve shared management of patients with sarcopenia through joint assessment, collaborative formulation of intervention plans, regular case conferences, and dynamic adjustment. This approach is particularly suitable for patients at high risk, those with comorbidities, or those with complex etiologies [17, 20].

This model leverages the evidence-based strengths of modern medicine in screening, risk stratification, and nutritional and exercise intervention alongside TCM strengths in syndrome differentiation and holistic regulation, providing comprehensive integrated management for patients with sarcopenia complicated by multiple diseases and functional decline.

The main traditional Chinese and western medicine interventions for sarcopenia, together with their proposed mechanisms and levels of evidence, are summarized in **Table 5**.

Follow-up and referral mechanisms

Follow-up strategy

Individualized follow-up plans should be developed according to the risk stratum of the patient. That is, the follow-up plan is formulated on the basis of the risk stratum assigned to the individual patient, so that the plan reflects the patient's own level of risk rather than being the same for all patients. The follow-up frequency should be determined by risk stratification, meaning that the interval of follow-up visits is set according to the patient's risk stratum. Thus, for low-risk individuals, re-examination is recommended every 6-12 months; for intermediate-risk individuals, re-examination is recommended every 3-6 months; and for high-risk individuals, re-examination is recommended every 1-3 months [20, 25]. In terms of content, follow-up should include assessment of muscle function, assessment of nutritional status, evaluation of intervention adherence, and monitoring of adverse events. These components together define the scope of the follow-up evaluation, covering the assessment of muscle function, the assessment of nutritional status, the evaluation of intervention adherence, and the monitoring of adverse events.

Efficacy assessment

Efficacy should be assessed with a multidimensional evaluation system of "objective indicators plus TCM syndrome scores plus patient-reported benefits". Objective indicators mainly include changes from baseline in ASMI measured by DXA, handgrip strength, gait speed, and SPPB. TCM assessment is based on the improvement of syndrome scores (e.g.,), spleen deficiency, and kidney deficiency). Patient-reported benefits are quantified with instruments such as Sarcopenia and Quality of Life (SarQoL) and EuroQol-5 Dimension (EQ-5D). The dynamic changes in these multidimensional indicators can comprehensively reflect improvements in muscle strength, physical performance, nutritional status, and subjective quality of life. It is recommended that the baseline assessment be completed before the intervention begins

Table 5. Summary of major traditional Chinese and western medicine interventions for sarcopenia: approaches, proposed mechanisms, and levels of evidence

Category	Intervention/Approach	Proposed Mechanism(s)	Level of Evidence
TCM herbal medicine	Chinese herbal compounds (e.g., "Buzhong Yiqi Decoction, Bazhen Decoction, Shenling Baizhu Powder); Shen-Qi Paste"	Promote protein synthesis, inhibit proteolysis, ameliorate inflammation, regulate mitochondrial function, modulate myokines	Low-moderate (meta-analyses of RCTs)
Acupuncture	Acupoints ST36, SP6, GB34, LI11; electroacupuncture combined with nutrition	Neuromuscular activation, regional blood-flow improvement, inflammatory regulation, gastrointestinal function	Low-moderate (systematic reviews/meta-analyses)
Traditional Chinese exercise	Tai Chi, Baduanjin, Yijinjing	Low-intensity aerobic + resistance + balance training, breathing regulation; inflammatory and muscle-microenvironment modulation	Low-moderate (meta-analyses of RCTs)
Protein supplementation	1.0-1.2 g/kg/d (healthy older); 1.2-1.5 g/kg/d (sarcopenia); high-quality protein evenly distributed	Provide anabolism substrate; stimulate muscle protein synthesis; overcome anabolism resistance	High (randomized controlled trials)
HMB	β-Hydroxy-β-methylbutyrate	Inhibit muscle proteolysis, reduce inflammation, and stabilize cell membranes	Moderate
Vitamin D	800-1000 IU/day when 25(OH)D <50 nmol/L	Regulate muscle cell function, reduce inflammation (modest effect on strength)	Moderate (in deficient individuals)
Omega-3 PUFA	EPA/DHA 0.7-3.4 g/d	Improve membrane structure, activate mTOR signaling, enhance muscle protein synthesis	Low-moderate (results inconsistent)
Muscle-targeted ONS (MT-ONS)	Multi-macro- and micro-nutrient oral nutritional supplements	Increase energy/nutrient intake, preserve muscle mass and strength	Moderate
Mediterranean diet	Fish, olive oil, vegetables, fruits	Synergistic action of protein, antioxidants, omega-3 fatty acids	Moderate
Resistance training	2-3 sessions/week, 40-60% 1RM, 8-12 reps, ≥12 weeks	Mechanical tension → PI3K/Akt/mTOR pathway; myofibrillar synthesis; neural adaptation	High (most consistent evidence)
Aerobic training/HIIT	Aerobic exercise; high-intensity interval training	Improve cardiorespiratory fitness, mitochondrial biogenesis (AMPK/PGC-1α)	Moderate
Balance & flexibility training	Proprioception, coordination, balance exercises	Enhance postural control, reduce fall risk (functional complement)	Moderate
Combined nutrition + exercise	Concurrent nutritional support and exercise prescription	Synergistic effects on muscle mass, strength, and function	High (combined interventions)

Note: TCM, traditional Chinese medicine; RCT, randomized controlled trial; 25(OH)D, 25-hydroxyvitamin D; PUFA, polyunsaturated fatty acids; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid; mTOR, mechanistic target of rapamycin; PI3K, phosphoinositide 3-kinase; Akt, protein kinase B; AMPK, AMP-activated protein kinase; PGC-1α, peroxisome proliferator-activated receptor-γ coactivator-1α; HIIT, high-intensity interval training; 1RM, one-repetition maximum; ST36, Zusanli; SP6, Sanyinjiao; GB34, Yanglingquan; LI11, Quchi.

and that measurements be repeated at the predetermined frequency during subsequent follow-up, so as to compare the changes in each indicator and to determine the effectiveness of the comprehensive intervention.

Referral mechanisms

Referral should be two-way. This means that referral can occur in both directions: patients may be referred from primary care to higher-level institutions when more specialized evaluation or treatment is needed, and later returned to primary care when their condition becomes stable enough to be managed in that setting. Specifically, patients identified through primary care screening who meet the diagnostic criteria for sarcopenia, who reach the severe grade of the condition, who have multiple co-morbid conditions, who are at high nutritional risk, whose etiology is unclear, or who have failed to respond to primary care interventions should be promptly referred upward. The purpose of such upward referral is to ensure that these patients receive more specialized evaluation and management. They should be referred to a higher-level hospital that is equipped with specialized clinics in geriatrics, nutrition, rehabilitation medicine, or TCM. In this hospital setting, a multidisciplinary team can conduct a comprehensive assessment, integrate relevant findings from different clinical disciplines, and adjust the intervention plan accordingly. Once the patient's condition has stabilized and the treatment plan has been clarified, the patient can be referred back to the primary care institution. At the primary care level, continued long-term management can be provided, including ongoing monitoring, regular follow-up, and maintenance of the prescribed treatment approach [17, 20].

Future perspectives

Precision nutrition represents a promising frontier for sarcopenia management. Rather than uniform dietary prescriptions, precision nutrition seeks to tailor protein, energy, and micronutrient intake to an individual's metabolic phenotype, genetic background, and gut microbial configuration [7]. Recent metabolomics studies have begun to delineate sarcopenia-associated metabolic signatures-including perturbations in branched-chain amino acids, acylcarnitines, ceramides, and phospholipid species-that illuminate pathogenic mechanisms and hold potential as biomarkers for early identification and treatment monitoring [80]. Integrating metabolomic profiling with routine nutritional assessment could enable risk stratification beyond current muscle-mass and strength metrics and guide individualized supplementation (e.g., Leucine-enriched or omega-3-fortified regimens) with greater precision.

Parallel advances in microbiome research have highlighted the gut-muscle axis as a mechanistic and therapeutic link in age-related muscle loss. Sarcopenia is consistently associated with reduced gut microbial richness and altered abundance of taxa involved in short-chain fatty acid production, urolithin A metabolism, and bile acid transformation, suggesting that microbial metabolites directly modulate muscle protein turnover, inflammation, and mitochondrial function [81, 82]. Targeted modulation of the microbiota-through dietary fibre, probiotics, prebiotics, or exercise-may therefore complement conventional nutritional and resistance-training strategies. These biological axes align closely with traditional Chinese medicine principles of spleen-stomach regulation and syndrome differentiation, inviting integrative studies that pair modern phenotyping with TCM constitutional typing.

Ultimately, the future of integrated sarcopenia care lies in personalized intervention strategies that combine the strengths of modern medicine and TCM. Multidisciplinary, multimodal programs-linking nutrition, exercise, acupuncture, and herbal medicine within a single care pathway-should be evaluated through well-designed prospective cohorts and randomized trials reporting stratified, mechanism-informed outcomes. Closing the gap between the conceptual promise of integrated care and implementable, evidence-based practice will require not only larger and more rigorous studies but also standardized assessment tools, shared data platforms, and precision-medicine frameworks that account for individual heterogeneity in metabolism, microbiota, and traditional medicine phenotypes.

In summary, an integrated traditional Chinese and western medicine model structured around risk stratification, comprehensive assessment, graded intervention, and follow-up-and-referral offers a more holistic and individualized frame-

work for sarcopenia management than either system applied in isolation.

Looking forward, the research agenda is best framed along Population, Intervention, Comparison, and Outcome (PICO) dimensions. Future studies should extend beyond general older adults to under-represented and high-need subgroups - including the very old and frail, patients with multi-morbidity, maintenance hemodialysis recipients, cancer-related sarcopenia, sarcopenic obesity, and diabetes-and should embrace the 2025 AWGS shift toward middle-aged adults, where preventive muscle-health promotion may yield the greatest long-term dividend. For the intervention, a priority is the development of unified, standardized combination protocols: reproducible TCM formulae and acupuncture point prescriptions, individualized yet guideline-aligned exercise prescriptions (resistance-based with modality add-ons), and clear guidance on optimal dose, frequency, and duration, so that "integrated therapy" ceases to be an umbrella term and becomes a deliverable regimen. Multi-center, large-sample randomized controlled trials with adequate blinding and appropriate controls are needed to directly compare integrated, western-only, and TCM-only strategies, rather than relying on indirect or overlapping evidence. Greater emphasis should be placed on patient-reported benefits and economic evaluation-longitudinal quality-of-life trajectories, fall and disability incidence, health-care costs, and cost-utility-alongside the conventional muscle metrics, with longer follow-up to establish durability. Progress on these fronts, ideally through multidisciplinary collaboration linking geriatrics, nutrition, rehabilitation, TCM, and health economics, will be essential to translate the conceptual promise of integrated sarcopenia care into evidence-based, implementable practice.

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None.

Abbreviations

AWGS, Asian Working Group for Sarcopenia; EWGSOP, European Working Group on Sarcopenia in Older People; GLIS, Global Leadership Initiative in Sarcopenia; SPPB, Short Physical Performance Battery; DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis; ASMI, appendicular skeletal muscle index; TUG, timed up-and-go test; MNA-SF, Mini Nutritional Assessment-Short Form; NRS 2002, Nutritional Risk Screening 2002; GLIM, Global Leadership Initiative on Malnutrition; HMB, β-hydroxy-β-methylbutyrate; ONS, oral nutritional supplements; 1RM, one-repetition maximum; HIIT, high-intensity interval training; TCM, traditional Chinese medicine; MDT, multidisciplinary team; SarQoL, Sarcopenia and Quality of Life; EQ-5D, EuroQol-5 Dimension; Vit D, vitamin D.

Address correspondence to: Zhong-Ju Xu, Department of Traditional Chinese Medicine, Pudong Gongli Hospital Affiliated to Shanghai University of Medicine and Health Sciences, Shanghai 200135, China. Tel: +86-13641973165; E-mail: gl_xuzj@sumhs.edu.cn

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