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Frailty assessment and individualized exercise prescription in cardiac rehabilitation: current evidence and future directions

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Abstract:
Frailty is an increasingly important clinical consideration in cardiac rehabilitation (CR), particularly among older adults and patients with heart failure, coronary artery disease, valvular disorders, and multiple chronic conditions. It is characterized by reduced physiological reserve and increased vulnerability to adverse outcomes following relatively minor physical or psychological stressors. Frail cardiac patients may experience muscle weakness, slow gait, impaired balance, fatigue, reduced exercise tolerance, nutritional deficiencies, cognitive difficulties, and limitations in activities of daily living. These factors can affect rehabilitation participation, exercise tolerance, adherence, and long-term functional recovery. Traditional cardiac rehabilitation programmes have primarily emphasized aerobic conditioning, cardiovascular risk-factor management, and general exercise capacity. However, these approaches may not adequately address the multidimensional impairments associated with frailty. Contemporary rehabilitation therefore requires systematic frailty screening, comprehensive functional assessment, and individualized exercise prescription based on the patient's dominant limitations, clinical stability, comorbidities, and personal goals. Validated instruments such as the Fried Frailty Phenotype, Clinical Frailty Scale, Edmonton Frail Scale, FRAIL questionnaire, Frailty Index, and Short Physical Performance Battery can support identification and monitoring of frailty. Exercise interventions for frail cardiac patients should generally combine progressive resistance training, aerobic conditioning, balance activities, functional mobility exercises, and flexibility training, with nutritional and psychosocial support when indicated. Evidence from the REHAB-HF trial and recent systematic reviews suggests that multidomain rehabilitation can improve physical function and frailty-related outcomes in selected patients with cardiovascular disease. A 2024 systematic review found that frailty is common among CR participants and that frailty status can improve following programme participation, although considerable variation exists in assessment tools and intervention design. More recent European guidance explicitly recommends offering CR to eligible patients with frailty rather than withholding rehabilitation because of frailty or comorbidities. This review examines the concepts and mechanisms of frailty, clinical assessment methods, and evidence for exercise-based interventions, individualized prescription strategies, safety considerations, multidisciplinary care, implementation barriers, and future research priorities. It proposes a practical framework for integrating frailty assessment into routine cardiac rehabilitation and translating assessment findings into progressive, patient-centred exercise programmes.

Keywords:
Frailty, Cardiac Rehabilitation, Individualized Exercise Prescription, Heart Failure, Resistance Training, Physical Function, Older Adults, Frailty Assessment, Multidomain Rehabilitation.

1. Introduction:

Cardiovascular disease is a major cause of disability, hospitalization, reduced functional independence, and premature mortality worldwide. Advances in cardiovascular medicine, including pharmacological treatment, coronary revascularization, cardiac surgery, and device-based therapies, have improved survival, however,

many patients continue to experience reduced physical capacity, muscle weakness, fatigue, exercise intolerance, and difficulty performing routine activities. These limitations are particularly common among older adults and individuals with heart failure, coronary artery disease, valvular heart disease, and multiple chronic conditions. Cardiac rehabilitation is an established component of comprehensive cardiovascular management and aims to improve exercise capacity, reduce cardiovascular risk, support psychological recovery, and promote long-term participation in physical activity. Nevertheless, conventional rehabilitation approaches may not fully address the complex functional limitations associated with frailty. Frailty is a multidimensional condition characterized by reduced physiological reserve and increased vulnerability to stressors, resulting in a greater likelihood of falls, disability, hospitalization, and adverse health outcomes. It can develop through interacting changes in skeletal muscle, cardiovascular function, metabolism, nutrition, cognition, immunity, and physical activity. In cardiac populations, frailty may exist before a cardiovascular event, develop during prolonged hospitalization, or worsen following acute illness and deconditioning. The 2024 systematic review by MacEachern et al. found that frailty was common among cardiac rehabilitation participants, with pooled prevalence estimates varying according to the assessment instrument. The review also found that frailty improved following participation in cardiac rehabilitation, although the available studies differed considerably in their definitions, measurements, and intervention approaches (MacEachern et al., 2024). More recent evidence has strengthened the case for a frailty-sensitive approach. The 2026 European Society of Cardiology cardiac rehabilitation guideline recommends that patients with frailty who have an indication for CR should receive rehabilitation to improve frailty status and that rehabilitation should not be withheld because of frailty or comorbidities. It also emphasizes individualized, multidisciplinary programmes that address strength, balance, mobility, nutrition, and relevant coexisting conditions (European Society of Cardiology, 2026). This shift reflects an important change in clinical thinking: the objective of rehabilitation is not simply to improve cardiovascular performance, but also to preserve or restore the physical reserve required for independent living. Frailty assessment should therefore be incorporated into routine CR evaluation, and exercise should be prescribed according to the patient's functional profile rather than age or diagnosis alone.

2. Understanding Frailty in Cardiovascular Disease:

Frailty is not synonymous with ageing, disability, multimorbidity, or dependence, although these conditions frequently coexist. Ageing is a biological process, multimorbidity refers to the presence of multiple chronic diseases, disability describes difficulty performing activities, and frailty represents reduced physiological reserve and diminished ability to recover from stress. A patient may have several chronic conditions without being frail, while another patient with relatively few diagnosed conditions may have marked weakness, slow gait, exhaustion, and reduced functional capacity. Frailty is dynamic rather than fixed. It can worsen during hospitalization, acute cardiovascular events, prolonged inactivity, or inadequate nutritional intake, but it may also improve through appropriately designed exercise, nutritional intervention, and management of contributing medical conditions. In cardiovascular populations, frailty is particularly important because cardiac disease and frailty can reinforce each other. Reduced cardiac output, congestion, breathlessness, and fatigue may decrease physical activity, leading to muscle loss and deconditioning. In turn, reduced muscle strength and impaired mobility increase the physical effort required for daily activities, potentially worsening fatigue and limiting participation in rehabilitation. This cycle can contribute to repeated hospitalization, dependence, and reduced quality of life. The clinical importance of frailty is supported by the systematic review of MacEachern et al. (2024), which found that frailty at CR admission was associated with poorer physical health outcomes and increased mortality risk in observational studies. However, the review also demonstrated that frailer patients can improve during CR, supporting the view that frailty should be treated as a potentially modifiable clinical state rather than an automatic reason to exclude patients from exercise-based rehabilitation.

3. Frailty Models and Conceptual Frameworks:

3.1. Physical frailty phenotype:

The physical frailty phenotype describes frailty through five clinical characteristics: unintentional weight loss, self-reported exhaustion, low physical activity, slow walking speed, and reduced grip strength. Patients meeting three or more criteria are generally classified as frail, those meeting one or two as prefrail, and those meeting none as robust. This model is useful in cardiac rehabilitation because its components reflect physical changes that can be targeted through exercise, nutritional support, and activity promotion. Grip strength and gait speed provide objective information about muscle performance and mobility, while exhaustion and low activity capture symptoms and behavioural changes. However, interpretation must consider the effects of acute

illness, fluid retention, arthritis, neurological conditions, and other factors that can influence individual components.

3.2. Frailty deficit accumulation model:

The deficit accumulation model evaluates frailty by counting health deficits across multiple domains. These may include symptoms, diseases, functional limitations, cognitive impairment, nutritional problems, and laboratory abnormalities. The number of observed deficits is divided by the total number of deficits assessed to calculate a frailty index. This approach provides a broader representation of vulnerability than a purely physical phenotype and may be useful in patients with complex cardiovascular disease. Its limitations include the need for sufficiently comprehensive clinical information and variation in the items used to construct the index. In clinical practice, a frailty index may help characterize overall vulnerability, while physical performance tests are needed to guide specific exercise prescription.

3.3. Multidimensional frailty:

Multidimensional models recognize that frailty may involve physical, cognitive, psychological, social, and nutritional domains. For example, a patient may have reduced muscle strength and gait speed, mild cognitive impairment, depressive symptoms, inadequate dietary intake, and limited social support. These problems may interact and influence the ability to attend and complete rehabilitation. A multidimensional approach is particularly relevant in cardiac rehabilitation because successful participation requires more than physiological exercise tolerance. It also depends on the patient's understanding of instructions, confidence, transport access, motivation, social support, and ability to manage symptoms at home. Fig. 1 illustrating how physical, cognitive, psychological, nutritional, and social vulnerabilities interact to reduce physiological reserve and functional independence, and how individualized cardiac rehabilitation may address these interconnected limitations.

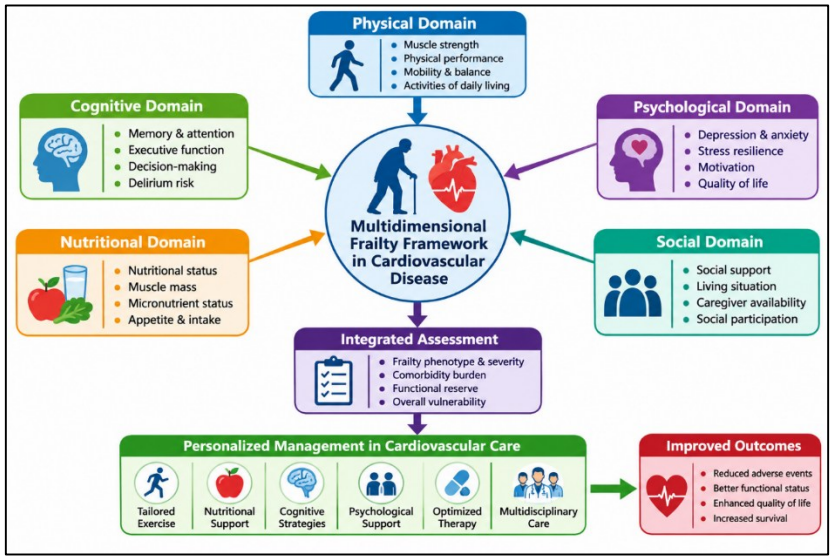


Figure. 1: Multidimensional frailty framework in cardiovascular disease

4. Mechanisms Contributing to Frailty in Cardiac Patients:

4.1. Skeletal muscle dysfunction:

Skeletal muscle dysfunction is a major contributor to physical frailty. Older adults with cardiovascular disease may experience reduced muscle mass, impaired muscle quality, lower force production, and diminished muscular endurance. In heart failure, skeletal muscle abnormalities may occur alongside reduced cardiac output, inflammation, neurohormonal activation, and reduced physical activity. These changes can reduce the ability to perform activities such as standing from a chair, climbing stairs, carrying objects, and walking at a normal speed. Muscle weakness can also increase the relative effort required for daily activities, resulting in early fatigue and avoidance of movement. Progressive resistance training is therefore an important component of individualized exercise prescription, particularly when weakness and impaired transfer ability are prominent.

4.2. Cardiovascular and autonomic dysfunction:

Cardiovascular limitations may contribute to frailty through reduced exercise reserve, impaired peripheral perfusion, chronotropic incompetence, and abnormal blood pressure responses. Patients with heart failure may experience breathlessness, fatigue, and limited tolerance for sustained activity. Some patients also develop orthostatic hypotension or dizziness during position changes, increasing the difficulty of standing and walking. Exercise prescription should account for these limitations through symptom-guided progression, appropriate monitoring, and careful adjustment of exercise duration and intensity.

4.3. Inflammation and metabolic changes:

Chronic low-grade inflammation, insulin resistance, oxidative stress, and altered protein metabolism may contribute to muscle catabolism and reduced physiological reserve. These mechanisms can be particularly relevant in patients with diabetes, obesity, chronic kidney disease, and heart failure. Inflammation and metabolic abnormalities may also interact with inadequate nutrition and inactivity, accelerating functional decline. Exercise and nutritional interventions may improve selected metabolic and functional outcomes, although the extent to which these changes directly reverse frailty varies across patient groups.

4.4. Nutritional vulnerability:

Inadequate energy and protein intake may contribute to loss of muscle mass and strength. Some cardiac patients experience poor appetite, dietary restrictions, early satiety, nausea, or difficulty preparing meals. In heart failure, fluid retention may also complicate interpretation of body weight and nutritional status. Nutritional assessment should therefore consider recent weight change, appetite, dietary intake, muscle loss, and relevant clinical conditions rather than relying on body weight alone. Dietitians should be involved when malnutrition, unintended weight loss, or complex dietary requirements are identified.

4.5. Cognitive and psychological factors:

Cognitive impairment, depression, anxiety, fear of falling, and reduced confidence can interfere with rehabilitation participation. Patients may avoid activity because they fear breathlessness, fatigue, falls, or another cardiovascular event. Cognitive difficulties may affect the ability to understand exercise instructions, remember precautions, or follow a home programme. These factors should be identified during assessment and addressed through simplified instructions, repetition, caregiver involvement, psychological support, and achievable functional goals.

5. Prevalence and Clinical Importance of Frailty in Cardiac Rehabilitation:

Frailty is common among patients referred to cardiac rehabilitation, although reported prevalence varies according to population characteristics, diagnosis, setting, and assessment tool. In the 2024 systematic review and meta-analysis by MacEachern et al., 34 studies involving 19,360 participants were included. The pooled prevalence of frailty was approximately 40% when measured using the physical frailty phenotype and approximately 46% when assessed using the Frailty Index or Kihon Checklist. The authors also reported that frailty improved following CR participation, with a pooled standardized mean difference of 0.68 in the studies contributing to that analysis. However, the evidence base included relatively few randomized trials and substantial variation in assessment methods (MacEachern et al., 2024). These findings have important implications for rehabilitation services. Frailty should not be considered an unusual condition limited to geriatric wards, it is likely to be encountered routinely in cardiac rehabilitation, especially among older adults and patients with heart failure. Frail patients may have lower baseline exercise capacity, greater symptom burden, more comorbidities, and additional barriers to attendance. They may also require more individualized supervision and a longer period of progression. Nevertheless, the evidence indicates that frail patients can benefit from rehabilitation and that excluding them may deny an important opportunity to improve physical function and independence.

5.1. Frailty Screening and Comprehensive Assessment:

Frailty assessment should begin with screening and proceed to more detailed evaluation when a patient is identified as potentially frail. Screening tools are generally brief and can be incorporated into routine clinical workflows, whereas comprehensive assessment examines the severity and contributing domains of frailty. No single instrument is universally suitable for every cardiac rehabilitation population. The choice should reflect the clinical purpose, time available, staff training, patient characteristics, and need for repeated measurement. A screening questionnaire may identify vulnerability, while objective physical performance testing can help determine which exercise components should receive priority. A multidimensional assessment is particularly

important when frailty coexists with cognitive impairment, nutritional problems, depression, falls, or social barriers. Recent reviews have highlighted considerable variation in the tools used in CR research, reinforcing the need for greater standardization and consistent reporting (Carson et al., 2025, MacEachern et al., 2024).

Table. 1: Common frailty assessment instruments and their clinical applications in cardiac rehabilitation

Assessment tool	Main domains	Clinical application	Important limitation
Fried Frailty Phenotype	Weight loss, exhaustion, activity, gait speed, grip strength	Identifies physical frailty and prefrailty	Requires physical measurements and standardized criteria
Clinical Frailty Scale	Global function, dependence, cognition, comorbidity	Rapid clinical grading of frailty	Requires clinical judgement and knowledge of baseline status
FRAIL questionnaire	Fatigue, resistance, ambulation, illnesses, weight loss	Brief screening in busy clinical settings	Does not provide detailed physical performance data
Edmonton Frail Scale	Cognition, health status, independence, social support, medication, mood, nutrition, function	Multidimensional frailty screening	Requires more time than brief screening tools
Frailty Index	Accumulation of health deficits	Characterizes overall vulnerability	Requires sufficient clinical data and consistent item selection
Short Physical Performance Battery	Balance, gait speed, chair stands	Quantifies lower-limb physical performance	Does not independently assess all cognitive or social domains
Grip strength	Handgrip force	Identifies reduced muscular strength	May be affected by arthritis, hand pain, and neurological disorders
Gait speed	Walking speed	Assesses mobility and physical performance	Influenced by pain, balance, footwear, and walking aids

5.2. Fried Frailty Phenotype in Cardiac Rehabilitation:

The Fried Frailty Phenotype is one of the most widely used physical frailty models. It evaluates five components: unintentional weight loss, exhaustion, weakness, slow walking speed, and low physical activity. The model is particularly relevant to cardiac rehabilitation because it identifies several deficits that can be targeted through exercise and supportive interventions. Grip strength can be used to evaluate weakness, gait speed can assess mobility, and activity questionnaires can identify low habitual activity. Exhaustion and unintended weight loss provide additional information about systemic vulnerability. A patient meeting three or more criteria is generally considered frail, while one or two criteria indicate prefrailty. The phenotype is useful for identifying physical frailty, but it does not fully capture cognitive, psychological, and social vulnerability. In addition, acute cardiovascular illness may temporarily influence walking speed, fatigue, and physical activity. Clinicians should therefore distinguish between a patient's usual pre-illness functional state and current post-hospitalization performance.

5.3. Clinical Frailty Scale

The Clinical Frailty Scale (CFS) is a clinician-rated instrument that grades frailty according to overall fitness, function, and dependence. It is commonly scored from 1 to 9, ranging from very fit to terminally ill, with intermediate categories representing varying levels of vulnerability and frailty. The CFS is practical because it can be completed relatively quickly and incorporates information about mobility, daily activities, and dependence. In cardiac rehabilitation, it may help clinicians identify patients who need additional support or a modified starting exercise dose. However, it requires clinical judgement and should reflect the patient's baseline state rather than temporary disability caused by an acute event. A patient who becomes temporarily

dependent after cardiac surgery should not automatically be classified as chronically frail without considering preoperative function and recovery trajectory. The CFS is best used alongside physical performance tests and a detailed history.

5.4. FRAIL Questionnaire and Edmonton Frail Scale:

The FRAIL questionnaire evaluates fatigue, resistance, ambulation, illnesses, and weight loss. It is brief and may be useful for initial screening in busy outpatient cardiac rehabilitation services. The Edmonton Frail Scale assesses a broader range of domains, including cognition, general health, functional independence, social support, medication use, nutrition, mood, continence, and physical performance. It may be more suitable when a multidimensional assessment is required. Both instruments can help identify patients who require more detailed evaluation, but neither should replace clinical assessment of cardiovascular stability or direct measurement of exercise capacity. A positive frailty screen should lead to an individualized assessment rather than an automatic decision to reduce or withhold exercise.

5.5. Short Physical Performance Battery and Functional Testing:

The Short Physical Performance Battery (SPPB) is particularly useful in cardiac rehabilitation because it assesses lower-limb performance through balance testing, gait speed, and repeated chair stands. It provides a standardized measure of physical function and can help clinicians identify limitations that are relevant to daily activities. The SPPB may be useful for baseline assessment, monitoring response to rehabilitation, and identifying patients who require additional strength or balance training. Other functional measures include the Timed Up and Go test, five-times sit-to-stand test, six-minute walk test, and gait speed assessment. These tests should be selected according to the patient's functional level and safety. The 6-minute walk test provides information about submaximal walking capacity, whereas chair-rise and balance tests provide complementary information about lower-limb strength and postural control. The combination of these measures can help clinicians distinguish between patients whose main limitation is aerobic endurance and those whose mobility is restricted by weakness or balance impairment.

6. Integrating Frailty Assessment into the Cardiac Rehabilitation Pathway:

Frailty assessment should be integrated into the initial CR evaluation rather than treated as a separate geriatric procedure. The process should begin with review of the cardiovascular diagnosis, recent hospitalization, medication, symptoms, comorbidities, and clinical stability. A brief frailty screen can then identify patients who require more detailed assessment. Patients with a positive screen should undergo evaluation of muscle strength, gait speed, balance, functional transfers, nutritional status, cognition, mood, falls history, and social support. The results should be used to define the patient's dominant functional limitations and to establish individualized goals. For example, a patient with severe lower-limb weakness and difficulty rising from a chair may require an initial emphasis on supported resistance exercise and transfer practice. A patient with slow gait and poor balance may need supervised mobility and balance training before progressing to more demanding walking activities. A patient with low endurance but preserved strength and balance may begin with shorter aerobic intervals and gradual duration progression. The assessment should be repeated during rehabilitation to determine whether the programme is improving the targeted domains.

Table. 2: Suggested frailty assessment pathway for cardiac rehabilitation

Stage	Assessment activity	Clinical purpose	Resulting action
1. Medical screening	Diagnosis, symptoms, medications, haemodynamic stability, comorbidities	Establish exercise safety	Identify precautions and referral needs
2. Frailty screening	CFS, FRAIL questionnaire, or Fried phenotype	Identify possible frailty	Proceed to comprehensive assessment if indicated
3. Physical assessment	Grip strength, gait speed, SPPB, chair-rise, balance	Identify functional deficits	Prioritize exercise components
4. Multidomain assessment	Nutrition, cognition, mood, falls, social support	Identify non-physical barriers	Arrange multidisciplinary interventions
5. Goal setting	Patient priorities and daily activity limitations	Define meaningful outcomes	Establish measurable rehabilitation goals

6. Individualized prescription	FITT-based aerobic, resistance, balance, and mobility plan	Match exercise to capacity and risk	Begin supervised progressive training
7. Reassessment	Repeat selected frailty and functional measures	Monitor response and safety	Adjust dose, complexity, and support
8. Transition and maintenance	Home exercise, follow-up, community resources	Maintain long-term gains	Support independent physical activity

7. Principles of Individualized Exercise Prescription:

Exercise prescription for frail cardiac patients should be based on the principle that the safest and most effective starting dose is determined by current functional capacity rather than chronological age alone. The FITT framework frequency, intensity, time, and type provides a practical structure for designing individualized programmes. However, the exercise plan should also consider progression, recovery, supervision, patient preference, and the dominant functional limitations. Patients with severe weakness may initially require low-load resistance exercises and supported transfers, while those with reduced endurance may benefit from short aerobic intervals. Individuals with impaired balance may require additional postural-control exercises before undertaking more complex mobility tasks. The 2026 ACC scientific statement on exercise prescription emphasizes that exercise recommendations for older adults should be personalized to health status and degree of frailty, for frail individuals, the initial focus should include strength, balance, mobility, and flexibility before progression towards conventional endurance exercise. The 2026 ESC cardiac rehabilitation guideline similarly supports personalized programmes that account for frailty, comorbidities, functional capacity, and patient-specific needs.

8. Resistance Training for Frail Cardiac Patients:

Resistance training is a central component of exercise prescription when muscle weakness, reduced grip strength, impaired chair-rise performance, or difficulty with transfers is present. It can include sit-to-stand exercises, knee extension, supported squats, heel raises, hip abduction, resistance-band exercises, and machine-based training when appropriate. Initial resistance should be low enough to permit controlled movement without excessive breath-holding or symptom exacerbation. Patients may begin with one set of approximately 8–12 repetitions, adjusted according to baseline strength and tolerance. In very frail individuals, fewer repetitions or partial movement ranges may be necessary initially. Training can be performed two or three days per week, allowing adequate recovery between sessions. Progression may involve increasing repetitions, sets, resistance, or functional complexity, but only when the patient can maintain good technique and appropriate symptom response. The use of the Valsalva manoeuvre should be discouraged, and patients should be instructed to breathe continuously during exertion. Resistance exercise should be integrated with functional activities so that strength gains translate into improved daily performance.

8.1. Aerobic Exercise Prescription:

Aerobic exercise supports cardiovascular fitness, walking capacity, metabolic health, and participation in daily activity. For frail patients, however, continuous moderate-intensity exercise may initially be too demanding. Short bouts of walking, stationary cycling, or other low-impact activities may be more appropriate. Exercise duration can begin with several short intervals and progress gradually as tolerance improves. Intensity should be determined using a combination of clinical assessment, heart rate response, perceived exertion, symptoms, and the patient's cardiovascular condition. Heart rate targets may be less reliable in patients taking beta-blockers, those with chronotropic incompetence, or those with atrial fibrillation. In these patients, perceived exertion and symptom monitoring become particularly important. Patients with heart failure may need closer monitoring of fatigue, breathlessness, weight changes, and signs of fluid overload. Aerobic training should not be omitted simply because a patient is frail, rather, it should be modified to match the individual's physiological reserve.

8.2. Balance, Mobility, and Functional Training

Balance and mobility training are important because frailty often involves impaired postural control, slow gait, reduced stepping ability, and difficulty performing transfers. Exercises may include supported standing, controlled weight shifting, tandem stance, heel-to-toe walking, step-ups, turning, obstacle negotiation, and repeated chair rises. The choice of exercise should be based on the patient's balance level and risk of falling. Initial tasks should be performed with stable support and close supervision where needed. Progression may involve reducing hand support, increasing movement range, changing direction, or introducing more complex

tasks. Functional training should focus on activities that matter to the patient, such as standing from a chair, walking to the bathroom, climbing stairs, or carrying light objects. Balance and functional training should complement rather than replace aerobic and resistance exercise.

8.3. Multicomponent Exercise as the Preferred Framework:

Frailty is a multidomain condition, therefore, a single exercise modality is unlikely to address all its components. Multicomponent exercise programmes combine resistance, aerobic, balance, mobility, and flexibility activities. This approach is supported by the REHAB-HF trial, which evaluated a tailored rehabilitation intervention in older patients hospitalized for acute heart failure. The intervention targeted strength, balance, mobility, and endurance and produced greater improvements in physical function than usual care (Kitzman et al., 2021). The trial is important because it demonstrated that functional rehabilitation can be organized around several domains rather than relying exclusively on conventional aerobic exercise. Recent evidence also supports multicomponent programmes in frail older adults with heart failure, although the number of available studies remains limited and intervention protocols are heterogeneous (Sáez-Nieto et al., 2026, Liu et al., 2025). A multicomponent framework should nevertheless remain individualized. The proportion of time devoted to each component should reflect the patient's assessment findings. For example, a patient with severe weakness may initially receive a greater proportion of resistance and transfer training, while a patient with marked breathlessness and preserved muscle strength may require a stronger aerobic component.

9. Individualizing Exercise According to Frailty Severity:

9.1. Robust or prefrail patients:

Patients who are robust or prefrail may generally tolerate a conventional cardiac rehabilitation programme with progressive aerobic and resistance training. However, the presence of early weakness, reduced activity, or exhaustion should be addressed before substantial functional decline develops. Exercise should include aerobic conditioning, resistance exercise, balance activities, and strategies to increase daily physical activity. Progression can follow standard CR principles, provided cardiovascular stability and movement quality are maintained. The objective is to prevent progression of vulnerability and preserve functional reserve.

9.2. Mild frailty:

Patients with mild frailty may demonstrate slow gait, reduced grip strength, low activity, or difficulty with repeated transfers but remain independently mobile. Their programme should combine moderate amounts of aerobic exercise with progressive resistance training and balance activities. Shorter exercise bouts may be appropriate initially, particularly when fatigue or breathlessness limits continuous activity. Functional goals should include improving walking tolerance, chair-rise performance, stair negotiation, and confidence with everyday activities. The therapist should monitor recovery between sessions and modify the programme if fatigue persists or symptoms worsen.

9.3. Moderate frailty:

Patients with moderate frailty may require assistance with some daily activities, have substantially reduced gait speed, or demonstrate poor balance and lower-limb strength. Their initial programme should prioritize safe transfers, supported standing, low-load strengthening, and short bouts of walking or cycling. Balance training should be supervised, and walking aids should be used when clinically appropriate. Exercise sessions may need to be shorter and divided into several activity periods with planned rest intervals. Progression should be based on improved movement quality, reduced assistance requirements, and tolerance of daily activities rather than on exercise intensity alone.

9.4. Severe frailty:

Patients with severe frailty may have substantial dependence, very low exercise tolerance, recurrent falls, cognitive impairment, or multiple unstable comorbidities. Rehabilitation should begin with a careful medical and functional review. Depending on clinical stability, the initial intervention may involve assisted transfers, supported standing, active or assisted limb movements, low-load resistance activity, and brief walking practice. The programme should be coordinated with geriatric, cardiology, nursing, nutrition, and other relevant services. Goals may focus on maintaining current function, improving transfer safety, reducing avoidable deconditioning, and supporting the patient's ability to perform essential activities. Severe frailty should not automatically exclude a patient from rehabilitation, but it does require careful selection of setting, supervision, and treatment goals. The table 3 presents an illustrative clinical framework, not a validated universal

prescription. Exercise dose must be individualized according to cardiovascular diagnosis, stability, functional assessment, comorbidities, and professional supervision.

Table. 3: Illustrative individualized exercise prescription according to frailty and functional status

Frailty/functional profile	Initial exercise priorities	Suggested starting approach	Progression criteria
Robust or prefrail	Aerobic conditioning, resistance, balance	Conventional CR programme with individualized FITT prescription	Improved exercise tolerance and strength without adverse symptoms
Mild frailty	Strength, gait, balance, endurance	Low-to-moderate resistance, short aerobic intervals, balance practice	Better chair-rise performance, gait speed, and session tolerance
Moderate frailty	Transfers, supported strength, balance, mobility	Supported sit-to-stand, low-load resistance, short walking bouts	Reduced assistance, improved stability, and better recovery
Severe frailty	Essential mobility, transfer safety, preservation of function	Assisted movement, supported standing, very short activity bouts	Safe completion of basic tasks and stable symptom response
Frailty with predominant breathlessness	Aerobic tolerance and breathing control	Short interval walking or cycling with rest periods	Longer activity duration without disproportionate dyspnea
Frailty with predominant weakness	Progressive resistance and task-specific strength	Low-load strengthening and repeated functional movements	Increased repetitions or resistance with controlled technique
Frailty with falls or balance impairment	Postural control, gait safety, lower-limb strength	Supported static and dynamic balance activities	Improved stability and safe progression to more complex tasks

10. The Role of Nutrition in Frailty-Oriented Cardiac Rehabilitation:

Exercise alone may be insufficient to address frailty when nutritional inadequacy, unintended weight loss, or muscle loss is present. Nutritional assessment should therefore be integrated into the rehabilitation pathway. Clinicians should review recent weight changes, appetite, dietary intake, swallowing or dental problems, gastrointestinal symptoms, and barriers to food access. In patients with heart failure, body weight may be influenced by fluid retention or diuretic treatment, so changes in weight should be interpreted alongside clinical status and nutritional indicators. Adequate energy and protein intake supports muscle repair and adaptation to resistance training. However, nutritional recommendations must be individualized according to renal function, diabetes, obesity, fluid restrictions, and other medical considerations. Dietitians can help develop a plan that supports muscle maintenance while respecting cardiovascular and metabolic requirements. The combination of exercise and nutrition is particularly important in patients with sarcopenia or malnutrition, where progressive strengthening may not produce the desired adaptation if dietary intake remains inadequate. Nutritional intervention should be coordinated with the treating team rather than relying on unsupervised supplementation.

10.1. Sarcopenia and Its Relationship With Frailty:

Sarcopenia refers to a progressive loss of skeletal muscle strength and muscle quantity or quality, with poor physical performance indicating more severe disease. It overlaps with physical frailty but is not identical to it. A patient may have sarcopenia without meeting the criteria for multidimensional frailty, while a frail patient may have important cognitive, nutritional, or social deficits in addition to muscle impairment. In cardiovascular disease, sarcopenia can contribute to poor exercise tolerance, reduced walking speed, and difficulty with transfers, and increased dependence. Heart failure may accelerate muscle dysfunction through inactivity, inflammation, metabolic abnormalities, and reduced peripheral perfusion. Assessment should include muscle strength, such as grip strength or chair-rise performance, and muscle quantity when appropriate and available. Exercise prescription should prioritize progressive resistance training while retaining aerobic and balance components. The 2026 review by Fukumoto highlights the importance of addressing frailty and sarcopenia

together in older adults with cardiovascular disease and describes cardiac rehabilitation as a potential strategy for improving physical function and reducing vulnerability (Fukumoto, 2026).

10.2. Cardiac Rehabilitation in Older Adults with Heart Failure:

Older adults with heart failure represent a particularly important population for frailty-oriented rehabilitation. They may experience breathlessness, fatigue, reduced muscle strength, impaired balance, low exercise capacity, and repeated hospital admissions. Some patients also have chronic kidney disease, diabetes, anaemia, arthritis, cognitive impairment, or nutritional vulnerability. These conditions can influence exercise tolerance and require individualized planning. The REHAB-HF trial demonstrated that a tailored multidomain intervention targeting strength, balance, mobility, and endurance improved physical function in older patients hospitalized with acute heart failure (Kitzman et al., 2021). More recent systematic evidence also suggests that exercise training can improve symptoms, physical function, muscle strength, and frailty-related outcomes in frail older adults with heart failure, although the evidence remains limited by small study numbers and variation in interventions (Sáez-Nieto et al., 2026). Exercise should be initiated when the patient is clinically stable and appropriately treated. In patients recovering from acute decompensation, the timing and intensity of rehabilitation should be determined by the medical team. Programmes may begin with short bouts of low-intensity activity and progress towards more sustained aerobic and resistance exercise as tolerated.

10.3. Cardiac Rehabilitation Following Myocardial Infarction and Coronary Revascularization:

Frailty may influence recovery after myocardial infarction, percutaneous coronary intervention, and coronary artery bypass graft surgery. Older patients may have pre-existing weakness and reduced mobility that become more pronounced following hospitalization and bed rest. Assessment should consider pre-event function, current mobility, pain, vascular access precautions, wound healing, and cardiovascular stability. Patients with preserved functional capacity may enter a conventional CR programme with appropriate modifications. Those with frailty may need additional transfer practice, lower-limb strengthening, balance training, and shorter aerobic intervals. Rehabilitation should also address fear of exertion and confidence, as some patients avoid activity because they associate physical effort with another cardiovascular event. Education should explain the difference between expected exertional responses and symptoms requiring medical review. The objective is to restore safe activity while avoiding unnecessary restriction that may worsen deconditioning.

10.4. Frailty After Cardiac Surgery and Hospitalization:

Cardiac surgery and prolonged hospitalization can contribute to acute functional decline through inflammation, pain, immobility, reduced nutritional intake, sleep disturbance, and loss of muscle strength. Patients may experience difficulty standing, walking, climbing stairs, and completing self-care activities after discharge. Frailty assessment should distinguish pre-existing frailty from new functional decline associated with hospitalization. Early mobilization, when medically appropriate, can help reduce the consequences of inactivity. Initial rehabilitation may include bed mobility, sitting balance, standing, assisted walking, and low-load functional exercise. Progression should respect surgical precautions and the patient's cardiovascular response. A coordinated transition from inpatient mobilization to outpatient or home-based cardiac rehabilitation is important to prevent gaps in care. Patients with severe postoperative weakness may benefit from a staged programme that initially emphasizes functional independence before progressing to more demanding aerobic exercise.

10.5. Safety and Risk Management During Exercise:

Exercise prescription in frail cardiac patients requires careful attention to medical stability, symptoms, medication effects, balance, and recovery. Before each session, clinicians should review recent changes in symptoms, hospitalization, medication, fluid status, and functional ability. Heart rate, blood pressure, oxygen saturation, and perceived exertion should be monitored according to clinical need and the patient's risk profile. Patients with acute decompensated heart failure, unstable angina, uncontrolled arrhythmias, severe uncontrolled hypertension, active thromboembolic disease, unexplained syncope, or other acute clinical instability should not begin routine exercise training until medically evaluated and stabilized. The 2026 ESC heart failure guideline emphasizes that exercise training should be initiated in clinically stable patients and individualized according to risk, comorbidities, preferences, and exercise tolerance (European Society of Cardiology, 2026). During exercise, sessions should be stopped and the patient assessed if chest pain, severe or disproportionate breathlessness, dizziness, presyncope, symptomatic palpitations, unusual fatigue, or a concerning blood pressure response occurs. Frail patients may require longer warm-up and cool-down periods, lower initial workloads, planned rest intervals, and closer supervision. Falls prevention measures should

include suitable footwear, stable support surfaces, appropriate walking aids, and guarding during balance activities.

11. Medication-Related Considerations:

Medication can influence exercise response and functional performance in frail cardiac patients. Beta-blockers may blunt heart rate response, making heart rate-based exercise targets less reliable. Diuretics may contribute to volume changes, dehydration, electrolyte abnormalities, or orthostatic symptoms. Vasodilators and antihypertensive medications may affect blood pressure during position changes or exercise. Antiarrhythmic medications may alter heart rate response, while anticoagulants can increase the consequences of falls or injury. Clinicians should review medication lists and report concerning symptoms or unexpected exercise responses to the prescribing team. Exercise professionals should not independently discontinue or adjust prescribed cardiovascular medication. Where appropriate, exercise intensity can be guided by perceived exertion, symptoms, workload, and functional response rather than heart rate alone.

12. Cognitive Function, Depression, and Psychosocial Vulnerability:

Frailty-oriented cardiac rehabilitation should consider cognitive and psychological factors because they can influence safety, adherence, and long-term outcomes. Cognitive impairment may affect the patient's ability to remember instructions, recognize warning symptoms, or follow a home exercise programme. Depression and anxiety may reduce motivation and increase fear of physical activity. Social isolation and lack of caregiver support may make it difficult to attend sessions or maintain exercise after programme completion. Assessment should include questions about mood, memory, confidence, social support, and practical barriers. Patients with cognitive difficulties may benefit from shorter instructions, visual demonstrations, repetition, and caregiver involvement. Psychological support, peer groups, and counselling may improve confidence and engagement. Exercise goals should be realistic and meaningful, with progress communicated in a way that reinforces the patient's sense of achievement.

12.1. Adherence and Patient-Centred Goal Setting:

Adherence is a major determinant of the effectiveness of cardiac rehabilitation. Frail patients may face barriers such as fatigue, transport difficulties, fear of falling, pain, financial limitations, low confidence, and competing medical appointments. These barriers should be identified early rather than interpreted simply as lack of motivation. Patient-centred goals can improve engagement by connecting exercise with activities that matter to the individual. Examples include standing from a chair independently, walking to a nearby shop, climbing a short flight of stairs, or completing household activities with less assistance. Goals should be specific, measurable, achievable, relevant, and time-bound. Progress should be reviewed regularly, and exercise programmes should be modified when the patient experiences excessive fatigue or difficulty completing the prescribed tasks. Home-based options and remote follow-up may improve access for selected patients, but safety and the availability of support must be considered.

12.2. Multidisciplinary Management of Frailty:

Frailty is rarely addressed adequately by one professional discipline. A multidisciplinary cardiac rehabilitation team may include cardiologists, physiotherapists, nurses, dietitians, occupational therapists, psychologists, pharmacists, and geriatricians. Cardiologists and physicians assess cardiovascular stability and manage medical conditions. Physiotherapists evaluate physical performance and prescribe exercise. Nurses support symptom monitoring, education, and continuity of care. Dietitians address nutritional vulnerability and dietary requirements. Occupational therapists can evaluate daily activities, home safety, assistive devices, and energy conservation. Psychologists or counsellors can help manage depression, anxiety, and fear of activity. Geriatricians may contribute to complex frailty, cognitive impairment, falls, and multimorbidity management. The 2026 ESC cardiac rehabilitation guideline emphasizes multidisciplinary care and the need to tailor CR to frailty and coexisting conditions rather than excluding patients because of complexity (European Society of Cardiology, 2026).

12.3. Home-Based and Community-Based Frailty Rehabilitation:

Home-based and community-based cardiac rehabilitation can improve access for patients who face transport, geographical, or scheduling barriers. However, frailty may create additional challenges when exercise is performed without direct supervision. Before initiating a home programme, clinicians should assess the patient's functional capacity, falls history, cognition, home environment, access to support, and ability to follow instructions. Exercises may include supported sit-to-stand, heel raises, resistance-band training, short

walking intervals, and simple balance activities performed near a stable surface. Patients with severe instability or cognitive impairment may require caregiver supervision or centre-based rehabilitation. Remote follow-up can be used to review symptoms, adherence, and progress, but digital monitoring should not replace clinical assessment when new symptoms or deterioration occur. Community partnerships may also provide opportunities for supervised walking groups, strength classes, and ongoing activity after formal CR completion.

12.4. Technology and Digital Tools in Frailty Assessment:

Digital health technologies may improve the detection and monitoring of frailty in cardiac rehabilitation. Wearable accelerometers can provide information about daily activity, walking duration, sedentary behaviour, and step counts. Smartphone applications may support exercise reminders, symptom reporting, and communication with rehabilitation teams. Video-based assessment can assist with observation of gait, chair-rise performance, and balance tasks. Instrumented platforms and wearable inertial sensors may quantify gait speed, step variability, postural sway, and movement patterns. These tools may provide more frequent information than periodic clinic-based tests, potentially identifying functional deterioration earlier. However, digital technologies have limitations, including cost, data quality, technical literacy, device adherence, privacy, and lack of standardized interpretation. Digital tools should therefore complement validated clinical instruments rather than replace them. Research should establish whether technology-supported monitoring improves exercise adherence, frailty outcomes, falls, or healthcare utilization.

13. Current Evidence for Frailty-Oriented Cardiac Rehabilitation:

The evidence base for frailty-oriented cardiac rehabilitation has expanded, but it remains heterogeneous. MacEachern et al. (2024) included 34 studies and found that frailty was common among CR participants that frailty could improve after rehabilitation and that higher frailty at admission was associated with worse outcomes. The review also highlighted differences in frailty instruments and intervention design, limiting direct comparison between studies. Carson et al. (2025) similarly identified substantial variation in frailty assessment across CR research, with 26 different instruments reported in the included studies. The authors highlighted limitations in sex- and gender-based analysis and inconsistent assessment of barriers to programme completion (Carson et al., 2025). The REHAB-HF trial provides important randomized evidence that multidomain rehabilitation can improve physical function in older adults hospitalized for heart failure (Kitzman et al., 2021). More recent reviews focused on frail older adults with heart failure suggest that exercise programmes commonly combine aerobic, resistance, and balance training, but they also identify limitations in the reporting of exercise dose and intervention fidelity (Liu et al., 2025, Sáez-Nieto et al., 2026). A 2026 systematic review and meta-analysis of frailty-targeted cardiovascular rehabilitation included 16 studies and reported favourable signals for selected outcomes, including SPPB, 6-minute walk distance, frailty burden, and lower-limb strength. However, the certainty of evidence was rated very low, and the review did not establish clear benefits for all-cause mortality or several other distal outcomes (Wang et al., 2026). Collectively, these findings support integrating frailty assessment and individualized exercise into CR, while recognizing that the optimal prescription and long-term clinical effects require further investigation.

14. Practical Clinical Framework for Individualized Exercise Prescription:

A practical approach can be organized around the identification of the patient's dominant functional limitation. The first step is to establish medical stability and identify conditions that may alter exercise safety. The second is to screen for frailty and assess physical performance. The third is to identify the main limitation: weakness, poor endurance, impaired balance, mobility restriction, nutritional vulnerability, cognitive impairment, or a combination of these factors. The fourth is to prescribe a tailored exercise programme using the FITT framework. The fifth is to monitor symptoms, performance, and recovery, and to progress the programme according to predefined criteria. The sixth is to reassess frailty and functional outcomes at regular intervals. This approach allows the rehabilitation team to respond to the patient's changing needs rather than applying the same programme throughout the rehabilitation period.

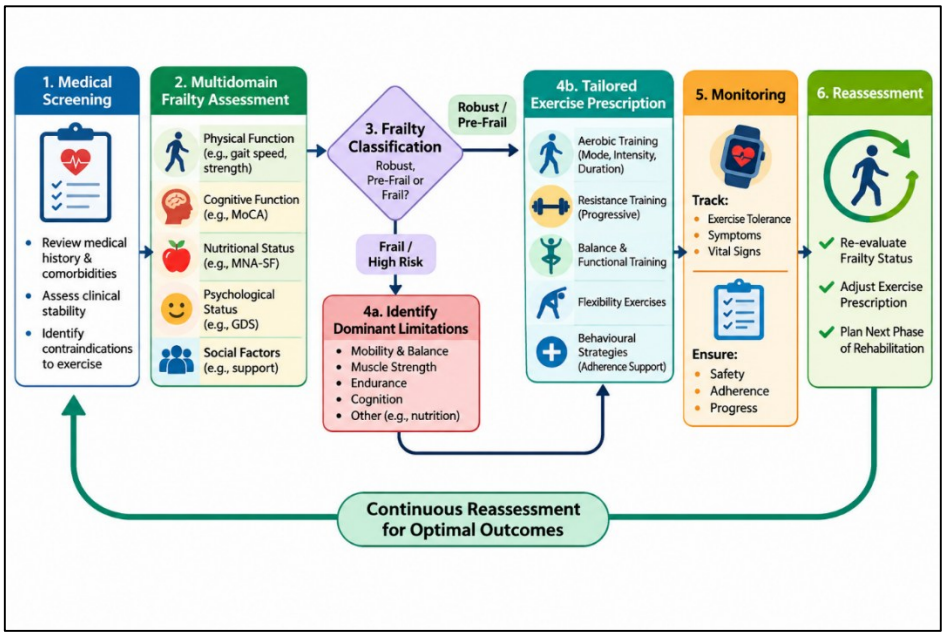


Figure. 2: Proposed clinical decision pathway for frailty assessment and individualized exercise prescription in cardiac rehabilitation, linking medical screening, multidomain assessment, identification of dominant limitations, tailored exercise, monitoring, and reassessment

15. Outcome Measures for Monitoring Rehabilitation Response:

Outcome assessment should include frailty status, physical performance, exercise capacity, patient-reported function, and relevant clinical outcomes. A single measure is unlikely to capture all dimensions of rehabilitation response. The SPPB can evaluate lower-limb performance, while gait speed and chair-rise testing provide more specific information about mobility and strength. The 6-minute walk test can assess submaximal exercise capacity, and grip strength may help monitor muscular performance. Patient-reported measures should assess fatigue, quality of life, confidence, daily activity limitations, and perceived independence. Falls, hospitalization, programme attendance, and adverse events should also be documented when relevant. Reassessment should use the same instrument and protocol wherever possible. The purpose is not merely to demonstrate numerical improvement, but to determine whether the patient can perform meaningful activities more safely and independently.

15.1. Barriers to Implementing Frailty Assessment in Cardiac Rehabilitation:

Several barriers may prevent routine frailty assessment in cardiac rehabilitation. These include limited appointment time, insufficient staff training, lack of standardized protocols, uncertainty about which assessment tool to use, and concerns that frail patients may be unable to tolerate exercise. Some programmes may also prioritize cardiovascular measures and give less attention to physical function, nutrition, cognition, and social factors. Patients may face transport difficulties, financial constraints, low confidence, and limited family support. Carson et al. (2025) identified physical limitations, emotional distress, cognitive concerns, health-system factors, personal and social circumstances, and transport as barriers to CR participation in frail populations. These challenges can be addressed through brief screening tools, staff education, multidisciplinary referral pathways, individualized scheduling, caregiver involvement, and flexible delivery models. Importantly, frailty should not be used as a reason to deny access to CR. Instead, it should guide the level of supervision, exercise starting dose, and additional support required.

16. Future Directions:

Future research should establish standardized frailty assessment protocols for cardiac rehabilitation and determine which instruments are most useful for different cardiovascular populations. Studies should examine whether a brief screening tool followed by targeted functional testing is more feasible than comprehensive frailty assessment for every patient. Large randomized trials should compare conventional CR with frailty-oriented programmes that incorporate progressive resistance, aerobic, balance, mobility, nutritional, and psychosocial interventions. Research should also determine the optimal exercise dose, frequency, progression criteria, and duration for patients with different frailty levels. Outcomes should extend beyond exercise capacity to include SPPB, gait speed, grip strength, chair-rise performance, falls, independence, quality of life, hospitalization, and mortality. Future studies should include women, patients with heart failure with preserved

ejection fraction, individuals with severe frailty, people from low- and middle-income countries, and patients with multimorbidity. The evidence base should also address sex and gender differences, socioeconomic barriers, cultural factors, and accessibility of rehabilitation. Digital tools and artificial intelligence may eventually support more frequent monitoring and adaptive exercise prescription, but such systems require validation and should not replace professional clinical judgement. Finally, implementation studies are needed to determine how frailty-oriented rehabilitation can be delivered sustainably in routine clinical services.

17. Clinical Recommendations:

Frailty screening should be incorporated into the initial assessment of eligible cardiac rehabilitation participants, particularly older adults and patients with heart failure, multimorbidity, recent hospitalization, or reduced physical function. A positive screening result should prompt assessment of strength, gait, balance, mobility, nutrition, cognition, mood, and social support. Exercise prescription should be individualized according to the patient's dominant functional limitations and cardiovascular stability. Progressive resistance training should be prioritized when weakness and impaired transfers are prominent, while aerobic exercise should be adapted to endurance limitations and symptoms. Balance and functional mobility training should be included when instability, falls, or gait impairment is identified. Nutritional and psychosocial interventions should be coordinated with exercise when relevant. The rehabilitation team should use repeated assessment to guide progression and should communicate with the treating medical team when symptoms or functional deterioration occur. Frailty should not be considered an automatic contraindication to rehabilitation, it should be treated as a reason to individualize care.

18. Conclusion:

Frailty is a common and clinically important condition among patients referred to cardiac rehabilitation. It reflects reduced physiological reserve and increased vulnerability to stress, and it may involve muscle weakness, reduced endurance, impaired balance, slow gait, nutritional vulnerability, cognitive difficulties, and psychosocial barriers. Traditional cardiac rehabilitation has provided substantial benefits through aerobic exercise and cardiovascular risk-factor management, but frail patients may require a broader approach that addresses physical function and independence. Validated instruments such as the Fried Frailty Phenotype, Clinical Frailty Scale, FRAIL questionnaire, Edmonton Frail Scale, Frailty Index, and SPPB can help identify and monitor frailty. The results should guide individualized exercise prescription rather than determine exclusion from rehabilitation. Progressive resistance training, aerobic conditioning, balance activities, functional mobility practice, and flexibility exercise should be combined according to the patient's clinical condition and dominant limitations. Nutritional support, psychological care, medication review, and multidisciplinary coordination may further improve programme participation and recovery. Evidence from REHAB-HF and recent systematic reviews supports the potential of multidomain rehabilitation to improve physical function and frailty-related outcomes, although uncertainty remains regarding optimal exercise dose and long-term effects on major clinical outcomes. Future cardiac rehabilitation should therefore adopt a frailty-sensitive model that combines standardized assessment, individualized exercise, repeated monitoring, and patient-centred goals. The ultimate aim is not merely to increase exercise capacity, but to improve the patient's ability to recover from illness, perform daily activities, maintain independence, and participate safely in community life.

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