



P-ISSN: 3081-0604
E-ISSN: 3081-0612
JAP 2024; 1(1): 21-25
www.physiotherapyjournal.org
Received: 11-03-2025
Accepted: 12-04-2025

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Review of resistance training and balance exercises in frailty management

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DOI: <https://www.doi.org/10.33545/30810604.2024.v1.i1.A.4>

Abstract

Frailty is a clinical syndrome characterized by reduced physiological reserves, decreased strength, and increased vulnerability to stressors, particularly in older adults. As frailty progresses, individuals face heightened risks of falls, hospitalization, and loss of independence. Resistance training and balance exercises have emerged as cornerstone interventions for the prevention and management of frailty, targeting the decline in muscle strength, coordination, and postural control. This review explores the evidence supporting the role of structured resistance and balance training in frailty management. It examines physiological mechanisms, exercise protocols, and clinical outcomes, drawing from randomized controlled trials, geriatric rehabilitation guidelines, and current best practices. The paper further addresses program implementation, safety considerations, and recommendations for tailoring interventions to frail populations.

Keywords: Balance exercises, resistance training, frail populations, safety considerations, recommendations, physiological mechanisms, exercise protocols

1. Introduction

Frailty is a multidimensional geriatric condition characterized by progressive functional decline, reduced muscle mass and strength (sarcopenia), impaired balance, and diminished capacity to recover from illness or injury. Common among adults over the age of 65, frailty is associated with adverse outcomes such as falls, fractures, institutionalization, and mortality. It presents not only as a physical vulnerability but also often overlaps with cognitive and social impairments, making its management complex and multidisciplinary. Among the various therapeutic strategies for managing frailty, physical exercise particularly resistance training and balance-enhancing activities has consistently demonstrated effectiveness in improving functional independence, mobility, and quality of life. Unlike pharmacologic interventions, exercise directly addresses the root physiological deficits associated with frailty, such as muscular atrophy, reduced bone density, and impaired neuromuscular coordination. Exercise-based interventions can reverse or delay frailty progression when applied appropriately and consistently. This paper reviews the role of resistance training and balance exercises in frailty management, focusing on evidence from clinical studies, mechanisms of benefit, and program design considerations. It aims to provide healthcare professionals, rehabilitation specialists, and policymakers with practical insights into incorporating these interventions within geriatric care frameworks.

2. Pathophysiology of Frailty and the Role of Exercise

Frailty represents a complex, systemic deterioration in physiological function that renders older adults more susceptible to adverse health outcomes. It is most commonly described through two dominant models: the phenotypic model proposed by Fried *et al.*, which includes criteria such as weight loss, exhaustion, low grip strength, slow walking speed, and low physical activity; and the cumulative deficit model, which considers a broader range of physical, psychological, and social impairments.

At the core of physical frailty lies sarcopenia the age-related loss of skeletal muscle mass and strength. Sarcopenia is driven by factors such as chronic inflammation, hormonal imbalances (e.g., reduced growth hormone and testosterone), mitochondrial dysfunction, malnutrition, and physical inactivity. This muscle decline contributes to slower gait, increased fall risk, and diminished ability to perform Activities of Daily Living (ADLs).

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In parallel, the deterioration of neuromuscular control and proprioceptive function compromises balance, further exacerbating instability.

Chronic sedentary behavior accelerates these processes. Without regular mechanical loading and neuromuscular engagement, muscle fibers atrophy, neuromuscular junctions degenerate, and metabolic flexibility is reduced. Over time, even minor stressors like infections or minor injuries can result in disproportionate functional setbacks—a hallmark of frailty.

Exercise, especially resistance and balance training, directly counteracts many of these mechanisms. Resistance training induces muscle hypertrophy, enhances neuromuscular recruitment and improves insulin sensitivity and mitochondrial efficiency. It increases muscle strength, which is strongly associated with improved mobility and reduced fall risk in frail older adults. Similarly, balance training improves proprioceptive feedback, vestibular function, and central coordination, enabling better postural control and reducing instability during movement transitions.

Moreover, regular exercise has systemic benefits: It reduces chronic inflammation (by lowering cytokines like IL-6 and TNF- α), enhances cardiovascular health, and improves psychological wellbeing. These multifactorial effects underscore the potential of structured exercise not only to prevent but in many cases to reverse the clinical manifestations of frailty.

In summary, understanding the physiological basis of frailty highlights the critical role that targeted exercise interventions play in restoring functional capacity. The next sections will explore in detail how resistance and balance training can be implemented effectively and safely in this vulnerable population.

3. Evidence-based benefits of resistance training in frailty

Resistance training, also known as strength training, involves the application of external force to muscle groups through weight-bearing, elastic bands, bodyweight, or resistance machines to stimulate muscular contraction. In the context of frailty management, resistance training serves as one of the most effective strategies to combat sarcopenia and restore physical function in older adults.

A growing body of evidence from clinical trials and systematic reviews supports the use of resistance training in reversing components of frailty. Numerous studies have demonstrated improvements in muscle strength, gait speed, mobility, and ability to perform daily living activities in frail and pre-frail populations following structured resistance training programs. For instance, Fiatarone *et al.* (1994) ^[2] conducted a landmark randomized controlled trial that demonstrated significant gains in muscle strength and walking speed in frail nursing home residents who engaged in high-intensity resistance training. Participants in this study, with an average age of over 85 years, showed remarkable improvements after just 10 weeks of intervention.

Another meta-analysis by Peterson *et al.* (2010) ^[3] revealed that resistance training leads to a mean increase in muscle strength of 30-50% in older adults, with notable enhancements in leg press strength and chair stand performance—key indicators of lower-body function relevant to fall prevention and independent mobility. These

improvements are critical, as lower extremity weakness is a major contributor to functional decline and fall-related injuries in frail individuals.

In addition to muscular strength, resistance training also improves bone density, which is particularly beneficial for frail older adults at risk of osteoporotic fractures. Mechanical loading during resistance exercises stimulates osteoblast activity and helps maintain skeletal integrity, thereby contributing to fracture prevention.

Importantly, resistance training has shown positive effects on neuromuscular coordination and reaction time, factors that are often impaired in frail individuals. Improved motor unit recruitment and synchronization help enhance the efficiency and safety of movement, making older adults more confident and less fearful of falling.

Programs designed for frailty typically include multi-joint exercises such as squats, leg presses, chest presses, and rows, often adapted for safety using lower weights, more repetitions, and extended rest periods. The American College of Sports Medicine (ACSM) and the American Geriatrics Society recommend at least two non-consecutive days per week of resistance training for older adults, with 1-3 sets of 8-15 repetitions per muscle group.

Safety is paramount in this population. Proper supervision, gradual progression, medical clearance, and the use of assistive devices (where necessary) are essential to minimize risks. Despite concerns, studies report a low incidence of adverse events when resistance training is appropriately tailored to the frailty level and comorbidities of the individual.

In conclusion, resistance training is not only safe but profoundly effective in mitigating the muscular and functional decline associated with frailty. By enhancing strength, endurance, and mobility, it empowers older adults to reclaim autonomy and reduce dependence on caregivers or institutional care.

4. Role of balance exercises in fall prevention and functional stability

Balance impairment is a defining feature of frailty and a primary contributor to falls, which represent one of the most serious threats to health and independence in older adults. Falls are the leading cause of injury-related hospitalizations and long-term disability among the elderly, and frail individuals are particularly susceptible due to impaired postural control, reduced reflex responses, and compromised neuromuscular coordination.

Balance exercises, therefore, play a central role in frailty management by addressing these vulnerabilities and enhancing functional stability. Unlike resistance training, which primarily focuses on increasing muscle strength, balance training targets the sensory and motor systems responsible for maintaining upright posture, including the visual, vestibular, and proprioceptive systems. These interventions aim to improve an individual's ability to control body position during both static and dynamic activities.

Research consistently supports the effectiveness of balance exercises in reducing fall risk. Programs incorporating activities such as tandem stance, single-leg standing, heel-to-toe walking, stepping over obstacles, and multidirectional weight shifts have demonstrated improvements in sway control, reaction time, and gait stability. A Cochrane review by Sherrington *et al.* (2019) ^[4] concluded that exercise

programs with a high balance challenge component significantly reduce the rate of falls in older adults, especially when performed at least three hours per week over six months or more.

Several therapeutic models have incorporated balance training into broader frailty interventions. For instance, the Otago Exercise Programme, developed in New Zealand, includes a series of progressive balance and strength exercises performed in the home setting. It has shown remarkable success in reducing fall incidence and improving physical performance among community-dwelling older adults. Similarly, Tai Chi, a low-impact, slow-motion exercise involving weight shifting and coordinated movement, has been shown in randomized trials to improve postural control, lower extremity strength, and overall balance in frail seniors.

Balance exercises also contribute to improvements in functional mobility. Enhanced postural control enables smoother and safer transitions between movements such as sitting to standing, turning, or climbing stairs-activities that are commonly compromised in frail individuals. Moreover, improved balance correlates with greater walking confidence and reduced fear of falling, both of which influence activity levels and overall quality of life.

For maximum benefit, balance exercises should be progressive in difficulty, task-specific, and performed regularly under appropriate supervision. They can be implemented individually or as part of a multicomponent fall prevention program, often in combination with resistance training and aerobic conditioning. In more advanced cases of frailty, balance training may involve the use of assistive tools such as balance boards, foam surfaces, or supportive harness systems to ensure safety while challenging stability.

In conclusion, balance training is a crucial intervention in the frailty spectrum, offering meaningful reductions in fall risk and improvements in postural control and mobility. It empowers older adults to maintain autonomy, move safely in their environments, and sustain engagement in daily activities-key outcomes in delaying institutionalization and preserving quality of life.

5. Combined impact of resistance and Balance training in frailty rehabilitation

While resistance training and balance exercises independently offer substantial benefits in the management of frailty, their combined implementation yields synergistic effects that are greater than the sum of their parts. Frailty is a multifaceted condition affecting strength, stability, coordination, and endurance. Addressing these domains concurrently enhances functional capacity and fosters greater resilience against daily challenges and environmental hazards.

Multicomponent exercise interventions that integrate both resistance and balance training have been shown to be the most effective strategies for improving physical performance, reducing fall risk, and enhancing independence in frail older adults. Clinical guidelines from the World Health Organization (WHO) and the American Geriatrics Society strongly endorse the use of integrated programs that combine strength, balance, and mobility training as the gold standard for frailty rehabilitation.

Several large-scale studies support this approach. For example, the LIFE study (Lifestyle Interventions and

Independence for Elders) demonstrated that a structured exercise program combining walking, resistance training, balance activities, and flexibility training significantly reduced the incidence of major mobility disability among older adults at risk. Similarly, multidomain programs like Vivifrail, implemented across Europe, have reported improvements in gait speed, chair stand performance, and functional independence through tailored combinations of strength and balance routines.

The rationale for combining both modalities lies in their complementary mechanisms. Resistance training builds the muscle power needed for tasks such as lifting, climbing, or standing from a seated position, while balance training fine-tunes the control and coordination needed to perform these tasks safely. For instance, stronger quadriceps enable a patient to rise from a chair, but it is balance and proprioception that prevent a fall during that movement. When practiced together, these two domains reinforce one another, supporting motor learning, postural efficiency, and movement confidence.

From a practical standpoint, combination training programs are often structured into multistage circuits or progressive modules, beginning with low-intensity tasks and gradually advancing to more complex exercises. Examples include performing heel raises while holding light weights, or integrating step-ups with directional changes. Functional exercises such as stair climbing, sit-to-stand transitions, and reaching tasks can simultaneously challenge both strength and balance in a real-world context.

Importantly, these programs also address psychosocial aspects of frailty. Improvements in physical function often lead to enhanced self-efficacy, reduced fear of falling, and increased willingness to participate in social and recreational activities. These effects contribute to improved mood and cognitive stimulation, creating a positive feedback loop that extends beyond mere physical health.

To optimize outcomes, combined programs should be personalized based on initial frailty status, comorbidities, and functional goals. Supervised settings-whether in outpatient clinics, senior centers, or home-based models with telehealth oversight-ensure safety and maximize adherence. Programs should also be adaptable, as progression and regression may occur based on fluctuating health status.

In summary, the integration of resistance and balance training forms the foundation of modern frailty rehabilitation. By targeting multiple physiological domains simultaneously, this approach offers a robust, efficient, and sustainable method for preserving function, preventing decline, and promoting independence among older adults with frailty.

6. Program Design and Implementation Considerations

Designing and implementing effective exercise programs for frailty management requires a thoughtful, patient-centered approach that balances clinical evidence, safety, feasibility, and individual goals. Given the heterogeneity of frailty among older adults-with variations in physical function, cognition, comorbidities, and living conditions-intervention plans must be flexible and responsive to individual capacities and limitations.

An ideal frailty intervention begins with a comprehensive assessment, which includes evaluating gait speed, grip strength, balance, and ability to perform activities of daily

living (ADLs). Tools such as the Fried Frailty Criteria, Short Physical Performance Battery (SPPB), and Timed Up and Go (TUG) test are commonly used to classify frailty status and guide program intensity. Cognitive screening and nutritional status should also be considered, as both significantly influence physical performance and exercise tolerance.

The exercise prescription should follow the FITT principle-Frequency, Intensity, Time, and Type. Most guidelines recommend engaging in multicomponent exercise sessions at least two to three times per week, with each session lasting 30 to 60 minutes. Intensity should begin at a low to moderate level and progress gradually, prioritizing safety and comfort. Resistance exercises typically involve 1-3 sets of 8-15 repetitions per muscle group, while balance activities may start with static holds and advance to dynamic challenges such as multidirectional stepping or obstacle navigation.

Supervision is crucial during the initial stages, especially for individuals with severe frailty or fall history. Professional oversight by physiotherapists, geriatricians, or trained exercise specialists ensures correct technique, monitors for signs of overexertion or fatigue, and builds participant confidence. Over time, supervision can transition to partially guided or home-based formats with periodic reassessment.

Environment and accessibility are also key factors in implementation. Programs delivered in community centers, outpatient clinics, or senior residences may provide social stimulation and structured support. However, home-based programs-such as the Otago Exercise Programme or online telerehabilitation platforms-offer flexibility and convenience, especially for those with mobility or transportation barriers. Visual aids, instructional videos, and caregiver involvement can support adherence and safety in the home setting.

Motivation and adherence often present challenges in older adults, especially those with depression, cognitive decline, or low self-efficacy. Strategies to enhance engagement include goal setting, regular progress tracking, positive reinforcement, and integration of functional tasks relevant to daily life. Group classes, when feasible, may foster social bonding and improve consistency.

Safety precautions are vital, as frail individuals may be at higher risk for joint strain, dizziness, or cardiovascular events. Warm-up and cool-down routines, adequate hydration, use of supportive footwear, and modifications for joint pain or sensory impairments should be standard practice. Emergency protocols should be in place during supervised sessions, particularly for those with known comorbidities.

Finally, the success of any program depends on interdisciplinary collaboration among healthcare providers. Input from geriatricians, nutritionists, occupational therapists, and caregivers ensures that the exercise intervention aligns with the individual's overall care plan. Regular feedback loops allow for timely adjustments, preventing plateau or regression.

In conclusion, successful implementation of resistance and balance training in frailty care hinges on individualized design, continuous evaluation, and supportive delivery systems. When tailored to the person's needs and environment, exercise becomes not just a treatment but a sustainable tool for independence, resilience, and improved quality of life.

7. Challenges, Limitations, and Future Directions

Despite the compelling evidence supporting resistance and balance training in frailty management, several challenges and limitations hinder the widespread adoption and consistent implementation of these interventions. Addressing these barriers is essential to improve program reach, patient engagement, and long-term outcomes.

One of the foremost challenges is low awareness and underutilization of exercise-based therapy among both older adults and healthcare providers. Frailty is often viewed as an inevitable consequence of aging rather than a modifiable condition, leading to delayed referrals for physiotherapy or rehabilitation. Many older adults, particularly those with comorbidities or low confidence, may fear injury or believe they are too weak to begin exercising. This mindset, coupled with inadequate counseling from clinicians, results in missed opportunities for early intervention.

Accessibility and resource limitations are another significant hurdle. In many healthcare systems, particularly in low- and middle-income settings, there is a lack of trained professionals, infrastructure, and funding to support structured exercise programs for the elderly. Home-based interventions, though effective, require caregiver involvement, technological support (in the case of telerehabilitation), and periodic monitoring, which may not be feasible for all populations.

Adherence to exercise programs presents a persistent limitation. While short-term studies show high efficacy, long-term sustainability of improvements depends on consistent engagement, which is difficult to maintain in frail older adults. Cognitive impairment, depression, transportation difficulties, and competing health issues may all contribute to poor participation rates over time. Tailoring programs to individual preferences and capabilities, integrating social elements, and offering flexible delivery models may help mitigate these issues.

From a research perspective, more high-quality, longitudinal trials are needed to evaluate the sustained impact of resistance and balance training on outcomes such as hospitalization rates, healthcare costs, and mortality in frail populations. Many existing studies focus on short-term gains in strength or mobility, with limited follow-up on whether these benefits translate to reduced institutionalization or prolonged life expectancy.

Moreover, there remains a need for standardized protocols that can be adapted across settings while maintaining fidelity. Variability in program design, intensity, duration, and delivery method complicates comparisons across studies and limits the development of unified clinical guidelines.

Technology integration offers a promising avenue for future development. Wearable sensors, mobile health apps, and virtual coaching platforms can enhance monitoring, provide real-time feedback, and increase patient engagement. However, barriers such as digital literacy, affordability, and infrastructure must be addressed to ensure equitable access.

Finally, interdisciplinary collaboration and policy support are crucial to advance frailty care. Public health strategies should prioritize physical activity promotion for older adults, while healthcare systems must invest in training and resources to support exercise as a standard intervention in geriatric care. Inclusion of culturally sensitive, community-based approaches will further help reach underserved and diverse populations.

In summary, while resistance and balance training are proven interventions in frailty management, their optimal use requires addressing systemic, logistical, and behavioral challenges. The future lies in building integrated, accessible, and adaptable models that extend the benefits of physical rehabilitation to all older adults at risk of or living with frailty.

8. Conclusion

Frailty represents a growing public health concern with profound implications for the health, independence, and quality of life of older adults. Characterized by physical weakness, impaired balance, and reduced physiological reserves, frailty increases vulnerability to adverse outcomes such as falls, disability, hospitalization, and premature mortality. As the global population ages, there is an urgent need for effective, scalable interventions to prevent, manage, and potentially reverse the trajectory of frailty.

Resistance training and balance exercises have emerged as foundational strategies in frailty rehabilitation. Grounded in robust physiological principles and supported by a growing body of clinical evidence, these interventions directly target the muscular, neuromuscular, and sensory deficits that underpin frailty. Resistance training enhances strength, mobility, and functional independence, while balance training improves postural control, confidence, and fall resistance. When delivered together in tailored, progressive programs, they produce synergistic benefits that extend beyond physical health, influencing psychological well-being and social participation.

However, to fully realize the potential of exercise-based interventions, implementation must be individualized, accessible, and embedded within a broader framework of interdisciplinary geriatric care. Programs must account for comorbidities, cognitive function, environmental barriers, and motivational factors. Innovations in technology, home-based delivery, and community engagement offer promising pathways to expand reach and sustainability.

Future efforts should focus on early intervention, long-term adherence, and integration of personalized exercise into routine health services for older adults. Additionally, public health policies must support the inclusion of exercise as a standard of care in aging populations, ensuring equitable access across socioeconomic and geographic boundaries.

In conclusion, resistance and balance training are not merely rehabilitative tools—they are transformative approaches that empower older adults to maintain autonomy, delay disability, and age with strength and dignity. Their role in frailty management is essential, and their integration into global aging strategies is both timely and imperative.

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