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PROGRAMA DE ENFERMAGEM DE REABILITAÇÃO NA CAPACITAÇÃO FUNCIONAL DE IDOSOS EM RECLUSÃO: SÉRIE DE CASOS

REHABILITATION NURSING PROGRAM TO IMPROVE FUNCTIONAL CAPACITY IN INCARCERATED OLDER ADULTS: A CASE SERIES

PROGRAMA DE ENFERMERÍA DE REHABILITACIÓN PARA LA MEJORA DE LA CAPACIDAD FUNCIONAL EN ADULTOS MAYORES PRIVADOS DE LIBERTAD: SERIE DE CASOS

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RESUMO

Introdução: O envelhecimento em contexto prisional associa-se a um declínio acelerado da saúde muscular e da capacidade funcional, exigindo intervenções de Enfermagem de Reabilitação adequadas e precoces.
Objetivo: Avaliar os efeitos de um programa de Enfermagem de Reabilitação na Saúde Muscular e Capacidade Funcional de pessoas idosas em reclusão.
Métodos: Estudo descritivo, do tipo série de casos, com nove idosos. Implementou-se um programa de Enfermagem de Reabilitação, baseado nos princípios da prescrição do exercício físico; frequência, intensidade, tempo, tipo, volume e progressão, complementados por critérios de recuperação, efeitos, segurança, eficiência, gestão de risco/controlo de eventos adversos, princípios biológicos, monitorização de respostas e testes de avaliação sistemática, com três sessões semanais durante cinco semanas. A avaliação pré e pós-intervenção, incluiu níveis de atividade física e laboral, condições ambientais, testes de desempenho funcional (*Sit-to-Stand, Timed Up and Go, Single Leg Stance)*, força de preensão manual, potência muscular (absoluta, relativa e alométrica), tolerância e perceção de esforço (global e para o autocuidado), questionário *SARC-F,* circunferência dos quadríceps e monitorização de dor incluindo a dor muscular tardia (*DOMS*).
Resultados: Observaram-se melhorias significativas na potência muscular (+25,7% a +34,7%), com força de preensão manual (+3% a +19%), mobilidade funcional (+11%), equilíbrio (+16%), desempenho e pereformance (+33%), redução da perceção de esforço (-21% a -35%) e diminuição do risco de sarcopenia (-21%).
Conclusão: O programa PER, revelou-se exequível e seguro, demonstrando potencial para melhorar a saúde muscular e a capacidade funcional de idosos em reclusão.

Palavras-chave: enfermagem de reabilitação; idoso; prisões; força muscular; capacidade funcional

ABSTRACT

Introduction: Aging in prison settings is associated with an accelerated decline in muscle health and functional capacity, requiring timely and appropriate Rehabilitation Nursing interventions.
Objective: To evaluate the effects of a Rehabilitation Nursing program on muscle health and functional capacity in older adults living in prison.
Methods: A descriptive case-series study was conducted with nine older adults. A Rehabilitation Nursing program was implemented based on the principles of exercise prescription, including frequency, intensity, time, type, volume and progression, complemented by recovery criteria, safety, effectiveness, risk management/adverse event control, biological principles, response monitoring and systematic assessment procedures. Participants completed three weekly sessions over five weeks.
Pre- and post-intervention assessments included physical activity and occupational activity levels, environmental conditions, functional performance tests (Sit-to-Stand, Timed Up and Go, Single Leg Stance), handgrip strength, muscle power (absolute, relative and allometric), effort tolerance and perceived exertion (global and self-care related), SARC-F questionnaire, quadriceps circumference, and pain monitoring, including delayed onset muscle soreness (DOMS).
Results: Significant improvements were observed in muscle power (+25.7% to +34.7%), handgrip strength (+3% to +19%), functional mobility (+11%), balance (+16%), Sit-to-Stand performance (+33%), reduction in perceived exertion (-21% to -35%) and reduction in sarcopenia risk (-21%).
Conclusion: The Rehabilitation Nursing Program proved to be feasible and safe, demonstrating potential to improve muscle health and functional capacity among older adults in prison settings.

Keywords: rehabilitation nursing; older adults; prisons; muscle strength; functional status

RESUMEN

Introducción: El envejecimiento en el contexto penitenciario se asocia con un deterioro acelerado de la salud muscular y de la capacidad funcional, lo que exige intervenciones de Enfermería de Rehabilitación oportunas y adecuadas.
Objetivo: Evaluar los efectos de un programa de Enfermería de Rehabilitación sobre la salud muscular y la capacidad funcional de personas mayores privadas de libertad.
Métodos: Se realizó un estudio descriptivo de serie de casos con nueve personas mayores. Se implementó un programa de Enfermería de Rehabilitación basado en los principios de prescripción del ejercicio físico, incluyendo frecuencia, intensidad, tiempo, tipo, volumen y progresión, complementados con criterios de recuperación, seguridad, eficacia, gestión del riesgo/control de eventos adversos, principios biológicos, monitorización de respuestas y procedimientos sistemáticos de evaluación. Los participantes realizaron tres sesiones semanales durante cinco semanas. Las evaluaciones pre y postintervención incluyeron niveles de actividad física y laboral, condiciones ambientales, pruebas de desempeño funcional (Sit-to-Stand, Timed Up and Go, Single Leg Stance), fuerza de prensión manual, potencia muscular (absoluta, relativa y alométrica), tolerancia y percepción del esfuerzo (global y relacionada con el autocuidado), cuestionario SARC-F, circunferencia del cuádriceps y monitorización del dolor, incluida la aparición tardía de dolor muscular (DOMS).
Resultados: Se observaron mejoras significativas en la potencia muscular (+25,7% a +34,7%), fuerza de prensión manual (+3% a +19%), movilidad funcional (+11%), equilibrio (+16%), rendimiento en el Sit-to-Stand (+33%), reducción de la percepción del esfuerzo (-21% a -35%) y disminución del riesgo de sarcopenia (-21%).
Conclusión: El programa de Enfermería de Rehabilitación demostró ser factible y seguro, mostrando potencial para mejorar la salud muscular y la capacidad funcional de personas mayores en contexto penitenciario.

Palabras clave: enfermería de rehabilitación; personas mayores; prisiones; fuerza muscular; capacidad funcional; estado funcional

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INTRODUCTION

Population aging represents one of the main challenges for health care systems, and is particularly critical in highly vulnerable settings, such as prisons (DGS, 2021; WHO, 2015). The prison population often exhibits high levels of vulnerability, physical inactivity, multimorbidity, frailty, and a marked decline in neuromuscular and functional health, with direct and significant effects on independence and autonomy in self-care and activities of daily living, participation in institutional routines, and quality of life and life expectancy. These effects are particularly exacerbated and accelerated in individuals in a prison setting (Chan et al., 2025; Rocha, 2025; Shin, H., & You, 2026).

In Portugal, the prison population has been gradually aging, with an increase in the number of inmates over the age of 65, placing the country among the most aging prison systems in Europe (DGRSP, 2025; Aebi & Cocco, 2024). This reality calls for a restructuring of health care in the prison setting, with a particular focus on preventing dependence, functional decline and frailty, sarcopenia, dynapenia, and powerpenia, as well as on promoting and maintaining neuromuscular health (DGRSP, 2024; DGS, 2021) The global pattern suggests a greater clinical burden; a higher prevalence of multimorbidity; and a greater need for long-term care and functional rehabilitation.

Rehabilitation Nursing (RN) plays a central role in these contexts and settings by integrating systematic functional assessment, individualized prescribing of interventions and training, continuous monitoring, and empowerment for self-care and physical activities, with a focus on optimizing and maximizing functional capacity and preventing dependence, neuromuscular decline, and frailty (Ordem dos Enfermeiros, 2019; Vieira, 2023).

It is important to evaluate and implement structured interventions, tailored to the prison context, that promote not only active, functional, and dynamic aging, but also focus on fostering healthy transitions through familiarization and ongoing support, the implementation of strategies to build self-regulation and tolerance for exertion, promoting progressive autonomy in activities of daily living by strengthening the individual's abilities, as well as setting realistic goals and ensuring gradual progress in a safe therapeutic environment with positive reinforcement to increase self-efficacy and motivation to adopt a lifestyle conducive to improving health, including physical exercise (Meleis et al., 2000; Meleis et al., 2010; Orem 2001; Pender et al., 2025)

Rehabilitation Nursing Programs (RNP), based on integrative physical exercise and using multicomponent and multimodal methodologies, promote this integrity of neuromuscular health (NH) and functional capacity (FC), including positive effects on mobility, balance, and exercise tolerance, in individuals with alterations in movement kinetics and kinematics, which impair functional performance and increase the risk of falls and dependence, particularly among older women (Mazzarin et al., 2026; Pagan et al., 2026; Patel et al., 2025; Van Der Kruk et al., 2021, 2022).

Despite growing evidence regarding the benefits of RNP in community and non-prison institutional settings, there remains a knowledge gap regarding its implementation in prison settings, particularly when led by Specialist Nurses in Rehabilitation Nursing (SNRN) (Faria et al., 2022; Santos et al., 2025).

The overall objective of this study was to evaluate the effects of a RNP on motor skills and functional capacity in older adults in a residential care setting, with the specific objectives of analyzing the effects of the multimodal, multicomponent integrative method on motor skills and functional capacity, comparing pre-intervention (W1) and post-intervention (W5) indicators, and describing the participants' progress.

1. METHODS

A descriptive case series study was conducted at a Portuguese prison facility, which was deemed appropriate given the logistical and organizational limitations of this setting (Bright et al., 2023). The sample is described in Figure 1 and consists of nine men aged 65 or older who are independent in terms of mobility and functional ability. Inmates with major clinical contraindications for exercise or who were dependent on assistance for walking were excluded.

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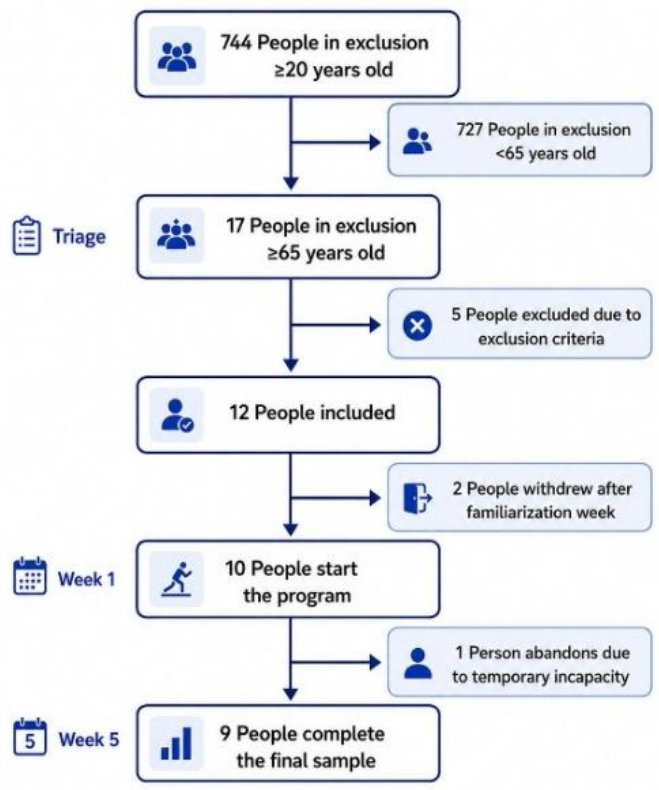

Figure 1- Participant Selection Flowchart

1.1 Rehabilitation Nursing Assessment (RNA)

The RNA was conducted at two time points (pre-W1 and post-intervention—W5), and allowed for the assessment, collection, and monitoring of care progress on an individualized basis. It enabled the interpretation of data on variables, indices, and functional dimensions, the identification of limitations and potential indicators of health status and functional capacity, and contributed to decision-making, the selection and organization of interventions, continuous improvement of practice, and indicators of quality of RN care.

Among the various dimensions of NH and FC, we focus on variables and performance indices related to physical and motor qualities, movement and mobility, functional abilities and skills, functional decline and frailty, with effects on the dynamics of activities of daily living, self-care, and physical activity, increased progressive risks of disability and falls, kinetic and kinematic changes in movement, and consequent sarcopenia, powerpenia, and dynapenia (Freitas et al 2024).

The analysis took a multidimensional approach to NH and CF, including muscle power (MP)—in its various forms: absolute muscle power (AMP), relative muscle power (RMP), and allometric muscle power (AlMP)—muscle strength (MS), balance, exercise tolerance, and functional mobility. In addition to these domains, functional risk was also assessed, reinforcing the clinical relevance of the evaluation by integrating not only physical performance but also the participants' functional vulnerability, as shown in Figure 2 and Table 3.

MP is defined as the ability to produce maximum force in the shortest possible time; it is the result of the interaction between force and velocity and is considered a key determinant of functional mobility, as well as a more sensitive predictor of performance in activities of daily living than maximum force alone. It is the functional marker that is particularly more sensitive and relevant to independence, functional performance, and fall prevention. MP (force × velocity), conceptualized as "powerpenia," declines more rapidly with age than maximum strength. Indeed, its decline and loss occur early, even before that of strength alone and muscle mass, partly due to the atrophy of type II muscle fibers. (Freitas et al., 2024; Smith et al., 2020; Steinbrink et al., 2024)

MS is defined as the ability to generate sufficient force to overcome a maximum resistance; it is modulated by the recruitment of motor units, which corresponds to an increase in the number of activated muscle fibers. It is recognized as a "new vital sign" due to its clinical utility in identifying risk and monitoring health in older adults. The decline and loss of MS, characterized as dynapenia, tends to occur more slowly and constitutes one of the main biomarkers of sarcopenia, a predictor of mortality and unfavorable clinical outcomes. (Freitas et al., 2024; Furrer & Handschin, 2025; Vaishya et al., 2024).

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Balance—defined as the integrated ability of the central nervous, visual, proprioceptive, and vestibular systems to maintain postural stability—poses a significant challenge in its assessment, both in clinical practice and in research. Although various instruments are available, they have limitations in terms of diagnostic accuracy and in identifying the risk of falls in older adults. In this context, the ability to support body weight on a single lower limb—in a single-leg stance—proves to be an important indicator, as individuals unable to maintain this position for ≥5 seconds are at increased risk of falls, while durations approaching 10 seconds represent a relevant clinical milestone in the progression of movement disorders. (Chomiak, Pereira & Hu, 2015; Omaña et al., 2021; Springer et al., 2007)

Exercise tolerance refers to an individual's ability to sustain or perform self-care, physical activities, and/or functional tasks for a given period of time and at a given intensity without experiencing excessive fatigue, dyspnea, or other limiting symptoms. It reflects the interaction between the cardiovascular, respiratory, neuromuscular, and metabolic systems, and serves as an important indicator of functional capacity and the ability to perform activities of daily living (ACSM, 2022).

Several validated assessment tools were used, such as: Sit to Stand (STS) for calculating AMP (which reflects total and absolute power output, favoring taller/heavier individuals), RMP (W/kg) (power adjusted for body weight, indicating functional efficiency and the ability to move one's own body), and AlMP ($W \cdot kg^{-0.67}$) (body-size-adjusted power, providing a more accurate comparison between individuals with different body compositions) (Alcazar et al., 2018); Timed Up and Go (TUG); Single Leg Stance (SLS); MS assessed via handgrip strength (HGS) on a dynamometer; number of wall push-ups; modified Borg scale for perception of exertion during exercise, functional performance, and self-care; SARC F questionnaire for identifying risk of sarcopenia; anthropometry, body composition, and muscle morphology, such as the waist-to-height ratio (WHR), as a biomarker of cardiometabolic risk; quadriceps circumference (QC) as a marker of muscle mass and strength; maximum heart rate (HRmax) and training heart rate (HRtraining) during exercise; and pain monitoring, including post-exercise delayed onset muscle soreness (DOMS) (Cruz Jentoft et al., 2019; Malmstrom & Morley, 2013).

1.2 Rehabilitation Nursing Diagnoses

The RN diagnoses were established by the SNRN by the RNA, incorporating information from the interview, clinical observation, functional physical examination, and performance on the assessment tools used. The formulation of the diagnoses followed the conceptual framework of RN, allowing for the identification of functional limitations, movement abnormalities, performance deficits, and risk factors with a potential impact on functionality. The diagnoses were established prior to the implementation of the RNP, serving as the basis for defining therapeutic goals, planning interventions, and monitoring the participants' functional progress.

The distribution of RN diagnoses is presented in Table 1. A predominance of sedentary lifestyles and inactivity was observed, with a high prevalence of impaired self-care (88.9%) and exercise intolerance (77.8%), followed by the risk of joint stiffness (44.4%) and intolerance to light and moderate exertion (33.3%). Diagnoses of impaired gait, reduced muscle movement, and impaired ventilation were identified in 22.2% of the participants. In contrast, preserved functional status was observed in only 11.1% of the sample, indicating an overall profile of high functional vulnerability.

Table 1 – RN diagnoses with their respective prevalence distributions

RN Diagnosis	n	%
Impaired Self-Care	8	88.9%
Activity Intolerance	7	77.8%
Risk of Joint Stiffness	4	44.4%
Intolerance to Low and Moderate Physical Exertion	3	33.3%
Impaired Gait	2	22.2%
Decreased Muscle Movement	2	22.2%
Impaired Ventilation	2	22.2%
Preserved Functional Status	1	11.1%

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1.3 Design of the Rehabilitation Nursing Program (RNP)

The RNP took place over five weeks, with three sessions per week, based on an integrative, multicomponent, and multimodal training model that incorporated various stimuli, including strength, endurance, and motor skills, balance, and exercise tolerance (Granacher et al., 2011; Sherrington et al., 2017).

The exercise prescription followed the FITT VP framework (principles, frequency, intensity, time, type, and volume) (Delgado et al., 2022; Furtado et al., 2023), supplemented by criteria such as recovery, effects, safety, efficiency, risk management/adverse event control, biological principles, response monitoring, and systematic assessment tests (RESET PRT), with gradual progression and monitoring of intensity and exercise tolerance, ensuring exercise is performed with clinical safety.

1.4 RNP Phases

The design and implementation of the RNP incorporated interventions based on high-intensity training, with training frequencies above 85% of maximum heart rate, including additional loads, performed at maximum speed and of short duration (approximately 20 minutes). This model demonstrates that these programs, with a primary focus on MP, promote significant improvements in NH and FC, metabolic health, exercise tolerance, and overall neuromuscular function in older adults. These approaches have proven to be effective and efficient strategies for optimizing independence and quality of life in this population, yielding results similar to those of longer-term programs, with the added advantage of greater time efficiency and the potential for increased adherence. Thus, the RNP design was structured based on scientific evidence from similar models (El Hadouchi et al., 2022; Liang et al., 2024; Morrison et al., 2023; Stern et al., 2023).

The RNP lasted approximately 35 minutes and was structured in three phases: the preparatory phase (6 minutes), the main phase (22 minutes), and the final phase (7 minutes).

In line with various biological principles of training, each week was individually designed to promote adaptation and continuity, progressive intensities, and variability. Participants were encouraged and instructed to perform the exercises at the fastest possible speed, completing as many repetitions as possible, regardless of the week.

The training load was gradually increased throughout the intervention. In Week 1 (W1), the exercises were performed using only body weight; in Weeks 2 and 3 (W2 and W3), an external load of 2 kg was added; and in Weeks 4 and 5 (W4 and W5), the external load was increased to 4 kg.

The preparatory phase included general activation exercises, movement preparation, and neuromuscular activation, specifically static walking with high knees and upper-body swinging (5 repetitions); the "good morning" exercise (30 seconds); bodyweight squats with the upper limbs raised above the head (10 repetitions), and breathing exercises (5 repetitions), supplemented with three repetitions of hypopressive exercises.

The fundamental phase consisted of four exercises: one-legged balance with timed count; wall push-ups with feet more than 60 cm from the wall and heels raised (30 seconds, recording the number of repetitions); squats with arms crossed over the chest, with or without additional weight (depending on the week), for 30 seconds (with the number of repetitions recorded); standing up from a chair, walking briskly for 3 meters, turning 180 degrees on one's own axis, and returning to the starting point to sit back down in the chair, with the time recorded.

The final phase included cool-down exercises, specifically abdominal-diaphragmatic breathing exercises (5 repetitions) and a cycle of box breathing (4/4).

1.5 Strategies, Recovery Interventions, and Performance Optimization

For performance optimization and recovery periods, recovery intervals of 30 to 45 seconds were designed; these were tailored to each participant based on their physiological response and subjective perception of exertion, and were monitored via heart rate and peripheral oxygen saturation measured by finger oximetry.

On non-training days, participants were encouraged and guided to increase their step count beyond their usual level, promoting low-intensity active recovery, in line with international recommendations that advocate for daily physical activity, a reduction in sedentary behavior, and the promotion of low-intensity activities, such as walking, as a safe and effective strategy for maintaining function and promoting health (Dablainville et al., 2025).

In addition, as a complementary self-care and recovery strategy—recommended on an individualized basis rather than as part of a standardized protocol—participants were instructed to use cold and/or hot water during the final phase of their shower for at least five minutes, directing the water flow toward the areas of the body where they experienced the greatest pain or muscle fatigue. This approach allowed each participant to try both temperature options, identifying the one that provided them with the greatest comfort and perceived benefit; based on their preferences and perceived benefits, they were encouraged to use this strategy at least while they were enrolled in the RNP (Wiecha et al., 2024).

Information was also provided on performance-optimization strategies frequently used in clinical practice, including increased fluid intake and the optional consumption of espresso before the session. This recommendation was not included in the intervention protocol nor was it subject to systematic monitoring. Caffeine, the main bioactive compound in coffee, appears to be associated with performance improvements during endurance and strength exercises due to its ergogenic effects (Filip-Stachnik et al., 2021;

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Xiao et al., 2025). Considering these potential benefits and the fact that coffee is one of the most widely consumed and accepted beverages in the prison setting (Freitas, 2024), it was suggested—on an individualized and non-mandatory basis— that participants drink an espresso approximately 30 to 45 minutes before RNP sessions, as a complementary strategy aimed at enhancing performance during the exercises, without interfering with the participants' usual routines.
Taking into account the context and available resources, participants were systematically monitored and asked about their subjective perception of pain and muscle fatigue using a numerical pain scale. It is recommended that delayed onset muscle soreness (DOMS) be monitored continuously, allowing for the management of muscle fatigue and the tailoring of recovery strategies and performance optimization. This approach should respect individual preferences and perceptions, while always remaining aligned with the best available scientific evidence and being adapted to the context, environment, population, and existing resources.

1.6 Safety Parameters

Safety parameters were established, stipulating that the session should be interrupted in the event of mild dyspnea with a Borg scale score between 2 and 4; peripheral oxygen saturation ≤90%; systolic blood pressure >180 mmHg or diastolic blood pressure >120 mmHg; excessive fatigue or chest pain; blood glucose ≥400 mg/dL; and/or other clinical signs of overtraining (Fiala e tal 2025; Kreher et al 2012; Weakley et al 2022).
Heart rates (HR), including maximum heart rate (HRmax), training heart rate (HRtraining), and resting heart rate, were calculated for each participant using the Tanaka formula—HRmax = 208 − (0.7 × age) (Tanaka et al., 2001)—corresponding, for those aged 65 to 74, to ~144–156 beats per minute (bpm); training HR (HRtraining) in the target zone of 85–95% ranged from 137 to 148 bpm, adjusted for individuals taking beta-blockers (an approximate reduction of 30 bpm), since this class of drugs lowers both resting and exercise HR by about 30–35 bpm; the use of the rate of perceived exertion (RPE) is recommended when HRmax is not attainable (Priel et al., 2021; Tesch, 1985). Although there are other formulas that allow for a more individualized prescription of intensity, the use of the Tanaka formula as an estimate of HRmax, supplemented by the Borg Scale and continuous clinical monitoring, proved to be a safe and appropriate approach for this population of institutionalized older adults (ACSM, 2024; Tanaka et al., 2001).

1.7 Data Analysis

The data were organized and analyzed using IBM SPSS Statistics for Windows, version 29.0.2.0 (IBM Corp., Armonk, NY, USA), employing descriptive statistics (means, standard deviations, medians, interquartile ranges, and percentage changes). To compare the pre-intervention (W1) and post-intervention (W5) time points, the Wilcoxon test for paired samples was used, with a significance level of 0.05. The use of the Wilcoxon test for paired samples was justified by the small sample size (n = 9) and the absence of assumptions of normality in the distribution of the differences between time points W1 and W5. This nonparametric test, based on the ordering of the signs and magnitudes of the differences, allows for a robust analysis of intra-individual changes.

2. RESULTS

The sample (n=9) shows a consistent pattern of high disease burden, multiple comorbidities, and risks, with low levels of cardiovascular and respiratory health, NH, performance, and FC, and a high risk of decline and frailty, as shown in Tables 2 and 3 and Figure 2.
For Self-Care: 8 out of 9 (88.9%) participants showed impairment mainly in dressing and lower-body hygiene; 3 out of 9 (33.3%) had difficulties with transfers, particularly functional transfers (lying down–sitting–standing)
Tolerance and Perceived Effort for Self-Care and Activities of Daily Living: 3/9 (33.3%) reported difficulty and intolerance for very intense activities; 2/9 (22.2%) for moderately intense activities; 2/9 (22.2%) for mild activities; 2/9 (22.2%) for very mild activities; 1/9 (11.1%) very, very mild.
Regarding levels of physical activity, sedentary behaviors were predominant in 77.8% (7/9) of the participants. Only 33.3% (3/9) had moderate levels of physical activity, two of whom regularly attended the gym. With regard to employment, 44.4% (4/9) performed regular occupational duties and were considered physically active, while 66.7% (6/9) did not have any structured employment and exhibited a predominantly inactive profile.
For quadriceps circumference (QC), only 22.2% (2/9) of the participants had values within the normal range (≥50 cm in both lower limbs). A high prevalence of reduced values (<49 cm) was observed in 88.9% (8/9) of the sample, suggesting an increased risk of muscle frailty. Additionally, 44.4% (4/9) had a QC of less than 40 cm, an indicator consistent with severe frailty and greater functional vulnerability.
Regarding the duration of confinement, the participants were mostly in medium- and long-term situations (1–8 years). As for the onset of functional difficulties, 33.3% (3/9) reported that symptoms had appeared less than 12 months ago, another 33.3% (3/9) estimated their onset to be around 12 months ago, while 22.2% (2/9) reported limitations lasting longer than 24 months. Only one participant (11.1%) did not report significant functional limitations.

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Regarding living arrangements, 66.7% (6/9) of the participants lived on the ground floor, while 22.2% (2/9) lived on the first floor, climbing approximately 22 steps per day. Only one participant (11.1%) lived on the third floor, facing a greater daily physical demand, corresponding to about 44 steps per day.

Regarding bed type, 88.9% (8/9) of the participants used low beds. Only one participant (11.1%) used a high bed (bunk bed), requiring sequential transfers between the floor, an intermediate chair, and the bed, thereby increasing the complexity of the task and the potential risk of falling.

Regarding clinical profile, all participants (100%; 9/9) had cardiovascular disease and hypertension. There was also a high prevalence of multimorbidity, with 88.9% (8/9) of participants having two or more concurrent chronic conditions. Regarding the main clinical profiles identified, 44.4% (4/9) had cardiovascular disease associated with hypercholesterolemia and prostatic hyperplasia; 33.3% (3/9) had insulin-treated type 2 diabetes mellitus, dyslipidemia, and constipation; and 22.2% (2/9) had chronic obstructive pulmonary disease associated with vertigo syndrome. Additionally, 55.6% (5/9) had musculoskeletal disorders.

Table 2 - Functional Variables

Dimension	Variable	n (%)
Self-Care	Compromised lower body dressing/hygiene	8 (88.9)
	Difficulty with functional transfers	3 (33.3)
Effort Tolerance and Perceived Exertion	Very intense	3 (33.3)
	Slightly intense	2 (22.2)
	Light	2 (22.2)
	Very light	2 (22.2)
	Very, very light	1 (11.1)
Physical Activity Level	Sedentary	7 (77.8)
	Moderately active	3 (33.3)
	Regular gym users	2 (22.2)
Work Activity	Active	4 (44.4)
	Inactive	6 (66.7)
Quadriceps Circumference	≥50 cm (normal)	2 (22.2)
	<49 cm (reduced/risk of frailty)	8 (88.9)
	<40 cm (marked frailty)	4 (44.4)
Length of Incarceration	1–8 years (predominantly medium/long term)	–
Onset of Functional Difficulties	<12 months	3 (33.3)
	≈12 months	3 (33.3)
	>24 months	2 (22.2)
	No limitations	1 (11.1)
Environmental Conditions	Ground floor	6 (66.7)
	1st floor (≈22 stairs/day)	2 (22.2)
	3rd floor (≈44 stairs/day)	1 (11.1)
	Lower bunk bed	8 (88.9)
	Toilet (risk of falls)	1 (11.1)
Multimorbidity	Cardiovascular disease	9 (100)
	Arterial hypertension	9 (100)
	≥2 chronic diseases	8 (88.9)
	Musculoskeletal disorder	5 (55.6)

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The sample showed a high prevalence of impaired NH and FC, evidenced primarily by impaired self-care (88.9%) and activity intolerance (77.8%). Intolerance to light and moderate exertion was also observed in 33.3% of the participants, suggesting functional limitations that extend beyond the most physically demanding tasks.

Motor changes and reduced muscle movement were identified in 22.2% of the sample, while impaired ventilation was present in 22.2% of the participants. The risk of joint stiffness was observed in 44.4%, reinforcing the existence of significant musculoskeletal vulnerabilities.

Only 11.1% of the individuals had preserved functional status, confirming an overall profile of functional impairment and a high need for intervention. Taken together, these results support the implementation of rehabilitation programs aimed at promoting autonomy, improving exercise tolerance, preserving mobility, and preventing musculoskeletal decline.

Changes in the main indicators and indices for NH and FC were assessed at time points W1 and W5, as shown in Figure 2 and Table 3.

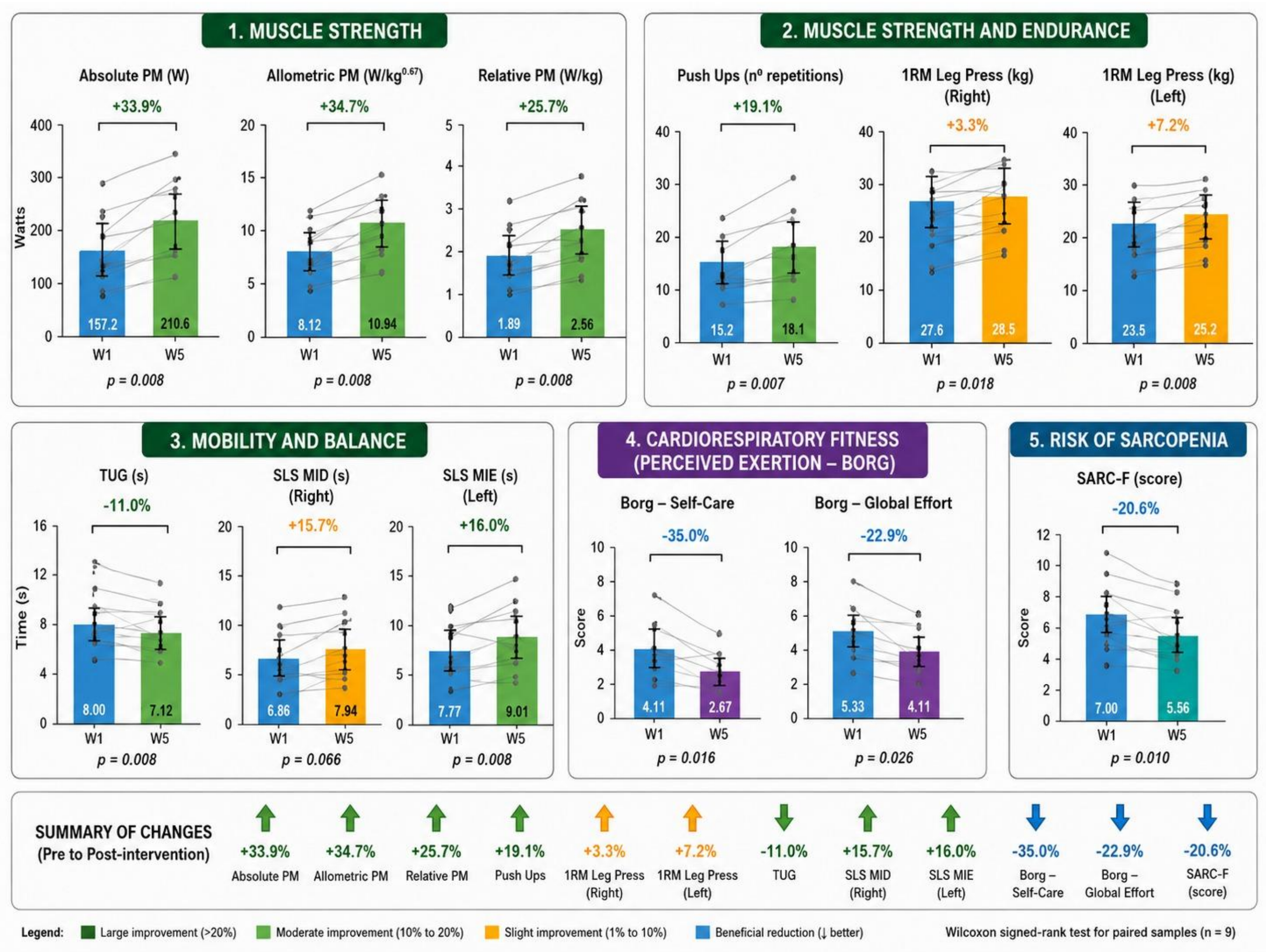

Figure 2 - NH and FC Indicators and Indices

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Table 3 - Evolution of Muscle and Functional Health Indicators

Variable	Pre-intervention (W1)		Post-intervention (W5)		*p* (Wilcoxon)
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	
Absolute PM (W)	157.2 (77.8)	154.3 (131.2)	210.6 (81.6)	210.5 (124.7)	**0.008**
Allometric PM	8.12 (3.80)	8.63 (6.62)	10.94 (4.06)	10.82 (6.89)	**0.008**
Relative PM (W/kg)	1.89 (0.87)	2.09 (1.54)	2.56 (0.95)	2.50 (1.71)	**0.008**
Push Ups (repetitions)	15.2 (7.5)	15.0 (12.5)	18.1 (9.1)	18.0 (16.0)	**0.007**
Borg – Self-Care	4.11 (2.80)	3.0 (5.0)	2.67 (2.18)	2.0 (4.0)	**0.016**
SARC-F (score)	7.0 (2.24)	6.0 (3.0)	5.56 (2.60)	5.0 (2.0)	**0.010**
1RM Leg Press (Right) (kg)	27.6 (6.05)	25.7 (6.0)	28.5 (6.44)	26.4 (6.4)	**0.018**
1RM Leg Press (Left) (kg)	23.5 (6.39)	22.6 (5.7)	25.2 (6.79)	24.1 (6.3)	**0.008**
TUG (s)	8.00 (1.89)	7.59 (1.86)	7.12 (1.63)	7.12 (2.03)	**0.008**
Borg – Global Effort	5.33 (2.12)	5.0 (4.0)	4.11 (1.54)	4.0 (2.0)	**0.026**
SLS MID (Right)	6.86 (3.68)	7.0 (6.39)	7.94 (3.98)	7.12 (5.11)	0.066
SLS MIE (Left)	7.77 (2.82)	7.34 (2.19)	9.01 (2.81)	9.46 (3.10)	**0.008**

The results showed statistically significant differences in most of the indicators analyzed. Although the nature of the study design does not allow for the establishment of causal relationships, the observed changes are consistent with a potential effect of the intervention implemented.

Significant improvements were observed in all measures of MP. AMP increased by 33.9%, from 157.2±77.8 W to 210.6±81.6 W (p=0.008). Similarly, RMP increased from 1.89±0.87 to 2.56±0.95 W/kg (p=0.008), while AlPM increased by 34.7%, rising from 8.12±3.80 to 10.94±4.06 (p=0.008). These gains, accompanied by a 33% improvement in Sit-to-Stand test performance, demonstrate a greater capacity to generate force per unit of time, suggesting favorable neuromuscular adaptations. From a functional perspective, these changes may translate into greater efficiency in performing tasks that require strength and speed of movement—such as standing up, transferring positions, regaining balance, and moving independently—thereby helping to mitigate age-related functional deficits and reduce the risk of powerpenia.

In the area of general MS, consistent gains were observed in upper-body strength and endurance, as well as core stabilization. Specifically, performance on the wall push-up test increased by 19.1%, rising from 15.2±7.5 to 18.1±9.1 repetitions (p=0.007). Taken together, these results suggest improvements in upper-body muscle strength and endurance following the intervention, with a greater magnitude of change observed in the left upper limb, which may indicate a trend toward a reduction in functional asymmetries between the limbs. In the right upper limb, the mean values increased from 27.6±6.05 kg to 28.5±6.44 kg (p=0.018), corresponding to an increase of approximately 3%. In the left upper limb, there was an increase from 23.5 ± 6.39 kg to 25.2 ± 6.79 kg (p = 0.008), equivalent to an improvement of about 7%. HGS showed statistically significant improvements in both upper limbs, suggesting gains in muscle function and strength capacity. These results may help mitigate the decline in strength associated with aging, reducing the risk of dynapenia and its functional repercussions.

In terms of functional mobility, there was an approximately 11% reduction in TUG completion time, from 8.00±1.89 s to 7.12±1.63 s (p=0.008). This result suggests improvements in functional mobility, reflecting greater agility, efficiency, and safety during transfers, as well as better integration between muscle strength, dynamic balance, and walking ability

Static balance during single-leg standing improved by ~16%, with a significant increase in the time on the left lower limb during the SLS (7.77 ± 2.82 s to 9.01 ± 2.81 s; p=0.008) and a trend toward improvement in the right lower limb (6.86±3.68 s to 7.94±3.98 s; p=0.066), indicating improved postural control and stability, as well as joint stability—a key factor in fall prevention.

Improved exercise tolerance was associated with a clinically relevant reduction in perceived exertion, with a 35% decrease in perceived exertion for Self-Care + ADLs, representing one of the most significant improvements (4.11±2.80 to 2.67±2.18) (p=0.016), indicating greater efficiency, ease, and less energy expenditure in performing daily tasks with improved functional performance. For overall exertion (5.33±2.12 to 4.11±1.54; p=0.026), reflected in a 22.9% a difference between W1 and W5 of 5.33 and 4.11,

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respectively, indicating greater performance and functional efficiency, as well as lower subjective effort and reduced perceived fatigue.

The mean score on the SARC F questionnaire—used as a screening tool for sarcopenia—across its five functional domains of strength, need for assistance while walking, ability to stand up from a chair, ability to climb stairs, and incidence of falls, decreased by -20.6%, from 7.0 ± 2.24 to 5.56 ± 2.60 (p = 0.010), as shown in Graph 5 of Figure 2, suggesting a favorable reduction in the functional risks associated with sarcopenia.

3. DISCUSSION

This study demonstrated significant improvements in most indicators of NH and FC between time points W1 and W5. The gains observed in MP, MS, body fat, functional mobility, balance, perceived exertion, and risk of sarcopenia suggest that RNP is effective in promoting functionality in older adults in institutional care. The convergence of these results reinforces the consistency of the observed adaptations and is consistent with the literature, which identifies MP as one of the main determinants of functionality in older adults, showing a stronger association with autonomy, independence, mobility, and the performance of activities of daily living than muscle strength alone (Alcazar et al., 2018).

Taken together, the results suggest that the increase in MP may have been the primary adaptive mechanism underlying the observed improvements. These improvements, accompanied by an increase in performance on the Sit-to-Stand test, indicate a greater capacity to generate force per unit of time. This adaptation may translate into greater biomechanical efficiency of movement, lower metabolic cost of tasks, and a reduction in the subjective perception of effort, contributing to the mitigation of processes associated with powerpenia and age-related functional decline (Freitas et al., 2024; Ghorbanzadeh et al., 2025).

The results regarding upper-limb MS support this interpretation. The improvement in HGS in the right upper limb (+3%) and the left upper limb (+7%), accompanied by a 19% increase in wall push-up performance, suggests consistent gains in upper-limb muscle strength and endurance. Although HGS is frequently used as an indicator of overall health and functional capacity in older adults, the concomitant improvement in a functional task involving multiple muscle groups supports the hypothesis of neuromuscular adaptations induced by the program. The greater improvement observed in the left upper limb may also indicate a trend toward a reduction in functional asymmetries between the limbs. From a clinical perspective, these gains may translate into a greater ability to perform tasks that require support, transfer, lifting, or manipulation of objects, contributing to the maintenance of functional autonomy (van der Veen et al., 2026).

At the same time, significant improvements were observed in functional mobility, balance, and exercise tolerance. The approximately 11% reduction in Timed Up and Go test time and the increase in single-leg stance time suggest improvements in the integration of functional mobility, dynamic balance, motor coordination, and gait. At the same time, the reduction in the subjective perception of exertion—both overall and as it relates to self-care—suggests greater functional efficiency in performing activities of daily living. These results are consistent with evidence linking multicomponent exercise programs to improved functionality and a reduction in adverse outcomes among older adults (Sherrington et al., 2019).

The high prevalence of reduced quadriceps circumference (<49 cm) and the baseline SARC-F scores suggest the coexistence of structural and functional muscle deficits. The decrease in lower-limb muscle reserve, combined with the high risk of sarcopenia observed at baseline, reinforces this population's vulnerability profile. The improvement observed in the SARC-F score following the intervention suggests a reduction in the functional risk associated with sarcopenia, corroborating the gains observed in the other indicators of NH and FC (Cruz-Jentoft et al., 2019; Malmstrom & Morley, 2013).

The initial profile of the sample revealed high functional vulnerability, as evidenced by the high prevalence of impaired self-care, activity intolerance, physical inactivity, multimorbidity, and reduced muscle reserve. The presence of impaired ventilation and risk of joint stiffness in part of the sample further suggests the coexistence of cardiorespiratory and musculoskeletal limitations with a potential impact on overall functionality. Impaired ventilation may reflect reduced cardiorespiratory efficiency, limiting exercise tolerance and participation in physical and functional activities. In turn, the risk of joint stiffness indicates a greater vulnerability to the development of mobility restrictions, biomechanical changes, and functional deficits. These findings reinforce the importance of early implementation of rehabilitation nursing interventions aimed at maintaining range of motion, promoting functional mobility, and preventing neuromusculoskeletal dysfunctions (ACSM, 2022; Izquierdo et al., 2021)

The prison setting proved to be a key factor in understanding the results obtained. The high prevalence of a sedentary lifestyle, low participation in occupational activities, prolonged duration of incarceration, and limited exposure to functional environmental stimuli may have contributed to the observed process of physical deconditioning. Additionally, incarceration is often associated with restricted mobility, social isolation, sleep disturbances, and prolonged exposure to chronic stress. These conditions promote neuromuscular deconditioning, low-grade chronic inflammation, and progressive functional decline, compromising muscular, functional, and neurocognitive health (Bright et al., 2023). In this context, the implementation of structured Rehabilitation Nursing programs is particularly important as a strategy to mitigate the adverse effects associated with aging in incarceration.

Exercise tolerance is closely related to cardiorespiratory fitness, since both depend on the integrated capacity of the cardiovascular, respiratory, and muscular systems to sustain physical activity. However, exercise tolerance represents a broader functional

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construct, also influenced by body fat, muscle mass, mobility, balance, and psychosocial factors. Thus, although the reduction in subjective perception of exertion observed in this study suggests improvements in exercise tolerance, it does not allow for direct inferences regarding changes in cardiorespiratory fitness, since the latter was not assessed using specific methods (ACSM, 2022).

No episodes of clinically relevant DOMS were recorded that would have warranted interruption or modification of the program. The progressive reduction in muscle pain observed throughout the intervention suggests a favorable adaptation to training stimuli, consistent with the Repeated Bout Effect. This phenomenon has been associated with neural, structural, and inflammatory adaptations that provide greater protection against exercise-induced muscle damage, contributing to a reduced perception of pain during subsequent exposures. The absence of disabling symptoms throughout the intervention reinforces the safety of the program and the appropriateness of the progression of the implemented loads (Doma et al., 2023).

It was also observed that participants with a history of regular physical exercise, higher levels of physical activity, engagement in work-related activities, and greater quadriceps circumference showed better initial preservation of NH and FC, resulting in more significant gains following the intervention. In contrast, sedentary individuals with low functional activity and lower muscle reserve showed greater vulnerability to functional decline and frailty. In particular, quadriceps circumference measurements below 40 cm were associated with greater deficits in strength, power, mobility, and overall functionality, suggesting the potential value of this indicator as a complementary clinical marker of functional vulnerability (Cinarli et al., 2024; Ganbat et al., 2026).

The results obtained are consistent with previous studies reporting significant improvements in muscle strength, functional mobility, balance, and functionality following integrative, multicomponent, and multimodal physical exercise programs in older adults (Alcazar et al., 2018; Luo et al., 2024; Sherrington et al., 2019; Toosi et al., 2026). Similarly, the reduction in functional risk associated with sarcopenia observed in this study is supported by currently available evidence (Cruz-Jentoft et al., 2019; Malmstrom & Morley, 2013).

The findings underscore the importance of systematically integrating SNRN into prison health services, promoting interventions aimed at maintaining functionality, preventing functional decline, and promoting active aging among older adults in prison. In this context, the SNRN plays a central role in the functional assessment, prescription, implementation, monitoring, and adaptation of functional rehabilitation programs, integrating technical, scientific, and educational competencies aimed at functional empowerment, optimization, and maximization, as well as the promotion of autonomy and independence (Ordem dos Enfermeiros, 2019; Vieira, 2023).

This study has several limitations, including the small sample size, the case series design, the absence of a control group, and the short duration of the intervention—factors that limit the generalizability of the results and prevent robust causal inferences. Additionally, it was not possible to assess the sustainability of the observed effects in the medium and long term, nor the impact on relevant clinical indicators, such as falls, hospitalizations, or reintegration following incarceration.

Despite these limitations, the consistency of the improvements observed across multiple functional domains and their statistical significance in a particularly vulnerable and frail population suggest that RNPs have significant clinical potential in a prison setting. Future research should include larger samples, comparison groups regardless of age, longer follow-up periods, and cost-effectiveness analyses, while also incorporating nutritional and educational components that can enhance and sustain the functional gains achieved (Luo et al., 2024).

CONCLUSION

The implementation of a Rehabilitation Nursing Program—using a short-term, high-intensity, high-speed, multicomponent, and multimodal integrative training methodology—among elderly individuals in long-term care facilities proved to be feasible, safe, and associated with improvements in muscle health and functional capacity. These gains were more pronounced among participants who were more active and consistent in their participation in activities of daily living, physical activities and exercise, and work-related activities.

Despite the limitations inherent in the sample size and the absence of a control group, the results demonstrated that the combination of interventions focused on activities of daily living, work-related activities, and structured physical exercise—oriented toward muscle strength and power training, daily tasks, and mind-body approaches—may contribute to favorable neuromuscular adaptations that improve exercise tolerance, with measurable gains in these indicators, as well as in movement, mobility, and balance, which directly impact the perception of exertion and the ability to perform activities of daily living autonomously and independently in their various dimensions.

Without muscle power, there is no efficiency. Without efficiency, there is no reduction in effort. Without a reduction in effort, there is no sustainable autonomy.

The improvements observed across multiple indicators and indices allowed for an integrated analysis of the functional adaptations that occurred over a short period of time, demonstrating consistent overall gains in various physical and motor abilities and qualities, including physiological, neuromuscular, and functional adaptations. This reduces the risk associated with functional

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decline and frailty, sarcopenia, dynapenia, and powerpenia, reinforcing the potential of structured intervention as an efficient strategy for managing care time—particularly relevant in contexts of institutionalization, hospitalizations, or early discharges—and underscoring the potential of these interventions and methodologies in vulnerable, clinical, and special populations.

Statement from the Institutional Review Board

The study was conducted in accordance with the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of Escola Superior de Saúde Atlântica.

Informed Consent Form

All participants signed an informed consent form, in good conscience and of their own free will, in accordance with current ethical principles (World Medical Association, 2013).

AUTHORS´CONTRIBUTION

Conceptualization, D.S.; data curation, D.S.; formal analysis, D.S.; methodology, D.S.; project administration, D.S.; resources, D.S.; supervision, N.G.; validation, N.G. and L.S.; visualization, D.S.; writing – original draft, D.S.; writing – review & editing, D.S., N.G., J.M., S.S. and L.S.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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