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MARCELO AUGUSTO DA SILVA CARNEIRO

ENVELHECIMENTO, CAPACIDADE DE RESILIÊNCIA E TREINAMENTO RESISTIDO: EFEITO DO EXERCÍCIO EM DIFERENTES CONDIÇÕES DE DESUSO SOBRE INDICADORES DE SAÚDE E FUNÇÃO MUSCULAR

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Tese apresentada ao Programa de Pós-Graduação Associado em Educação Física - UEM/UEL, como requisito parcial para obtenção do título de Doutor.

Orientador: Prof. Dr. Edilson Serpeloni Cyrino

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CARNEIRO, Marcelo Augusto da Silva. **Envelhecimento, capacidade de resiliência e treinamento resistido: efeito do exercício em diferentes condições de desuso sobre indicadores de saúde e função muscular.** 2024. 134 p. Tese (Doutorado em Educação Física) – Universidade Estadual de Londrina, Londrina, 2024.

RESUMO

O desenvolvimento de estratégias que possam atenuar e/ou reverter os efeitos deletérios associados ao envelhecimento tem sido um grande desafio para profissionais e pesquisadores nas áreas de saúde. Assim, a presente tese foi estruturada a partir de três estudos. No primeiro estudo, nós analisamos os efeitos de intervenções pautadas em exercícios resistidos sobre a força muscular, potência muscular e aptidão funcional em idosos hospitalizados de maneira aguda, por meio de uma revisão sistemática com metanálise. Para tanto, nós selecionamos estudos clínicos aleatorizados que adotaram medidas de força muscular (preensão manual no *handgrip* e teste de uma repetição máxima no exercício *leg press*), potência muscular (potência máxima de saída no exercício *leg press*) e aptidão funcional (*timed-up-and-go* e *short physical performance battery*). No que tange aos nossos achados, esta meta-análise endossa o aumento de força e potência muscular e melhoria da aptidão funcional em favor da intervenção com exercícios resistidos em idosos hospitalizados de maneira aguda. No segundo estudo, novamente, uma revisão sistemática com metanálise foi empregada para comparar as possíveis alterações provocadas por intervenções baseadas em exercícios físicos, imediatamente após a alta hospitalar, com aquelas resultantes do cuidado usual, em idosos pós-hospitalizados. O comportamento da força de preensão manual, *short physical performance battery*, teste de caminhada de seis minutos e velocidade da marcha foram analisados por meio de estudos clínicos que ofereceram exercício resistido somente no período após a alta hospitalar. Os resultados revelaram que a intervenção com exercícios resistidos após a alta hospitalar promove melhores respostas adaptativas em comparação aos cuidados habituais, incluindo orientação para realização de atividade física. Por fim, no terceiro estudo analisamos o impacto de dois anos de interrupção do treinamento resistido sobre a composição corporal, força muscular, perfil metabólico e desempenho físico em mulheres idosas fisicamente independentes. Adicionalmente, para investigar a capacidade de resiliência, comparamos as mudanças provocadas por 12 semanas de retreinamento com as mudanças alcançadas após as primeiras 12 semanas de treinamento. Nesse sentido, 67 idosas foram submetidas a um programa de treinamento resistido de corpo inteiro durante 24 semanas (8–12 repetições, oito exercícios, três séries), em três sessões semanais em dias não consecutivos. A partir daí, um período de interrupção de dois anos foi estabelecido em virtude da pandemia de COVID-19. Na sequência, as participantes idosas foram submetidas a 12 semanas de retreinamento. Indicadores de composição corporal (absortometria radiológica de dupla energia), força muscular (testes de 1RM), perfil metabólico (concentrações de lipídeos sanguíneos) e aptidão funcional (testes motores) foram analisados nas diferentes etapas do estudo. Nosso resultados sugerem que dois anos de destreinamento causam prejuízos nos biomarcadores de saúde e função muscular que podem não ser recuperados totalmente após um período curto de retreinamento, indicando baixa capacidade de resiliência devido a menores mudanças provocadas por 12 semanas de retreinamento comparado as primeiras 12 semanas de intervenção sobre a massa muscular esquelética, massa isenta de gordura e osso apendicular, força muscular, perfil metabólico e aptidão funcional em mulheres idosas fisicamente independentes.

Palavras-chave: atrofia muscular, capacidade funcional, hospitalização, isolamento social, treinamento de força.

CARNEIRO, Marcelo Augusto da Silva. **Aging, resilience capacity, and resistance training: effect of exercise in different conditions of disuse on health indicators and muscle function.** 2024. 134 p. Thesis (Doctoral in Physical Education) – State University of Londrina, Londrina, 2024.

ABSTRACT

Developing strategies that can attenuate and/or reverse the harmful effects associated with aging has been a primary challenge for health professionals and researchers. Thus, the present thesis was structured based on three studies. In the first study, we analyzed the effects of resistance exercise interventions on muscular strength, muscle power, and functional fitness in acutely hospitalized older adults through a systematic review with meta-analysis. To this end, we selected randomized clinical studies that adopted measures of muscular strength (handgrip and one-repetition maximal test in the leg press exercise), muscle power (maximum output power in the leg press exercise), and functional fitness (timed-up-and-go and short physical performance battery). Concerning our findings, this meta-analysis endorses increased muscular strength and power and improved functional fitness in favor of resistance exercise intervention in acutely hospitalized older adults. In the second study, again, a systematic review with meta-analysis was used to compare the possible changes caused by exercise-based interventions immediately after hospital discharge with those resulting from usual care in post-hospitalized older adults. The behavior of handgrip strength, short physical performance battery, six-minute walk, and walking speed tests were analyzed through clinical studies that offered resistance exercise only after hospital discharge. The results revealed that the intervention with resistance exercises after hospital discharge promotes better adaptive responses compared to usual care, including guidance on physical activity. Finally, in the third study, we analyzed the impact of two years of interruption of resistance training on body composition, muscular strength, metabolic biomarkers, and physical performance in physically independent older women. In addition, to investigate resilience capacity, we compared the changes provoked by 12 weeks of retraining with the changes achieved by the first 12 weeks of training. In this sense, 67 older women were submitted to a whole-body resistance training program for 24 weeks (8–12 repetitions, eight exercises, three sets) in three weekly sessions on non-consecutive days. Following a two-year interruption period was established due to the COVID-19 pandemic. Subsequently, the participants underwent 12 weeks of retraining. Indicators of body composition (dual-energy X-ray absorptiometry), muscular strength (1RM tests), metabolic biomarkers (blood lipid concentrations), and functional fitness (motor tests) were analyzed in the different stages of the study. Our results suggest that two years of training cessation causes impairments in health biomarkers and muscle function that are not recovered after a short retraining period. This indicates low resilience capacity due to lower responses provoked by 12 weeks of retraining compared to the first 12 weeks of training in physically independent older women.

Key words: muscle atrophy, functional capacity, hospitalization, social isolation, strength training.

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LISTA DE ABREVIATURAS E SIGLAS

1-RM test – One-repetition maximum test
6MWT – Six minutes walking test
6MWD – 6-minute walk distance
ALST – Appendicular lean soft tissue
ANOVA – Analysis of variance
BMI – Body mass index
CI – Confidence interval
EX – Exercise intervention
GEE – Generalized Estimating Equations
HDL-c – High-density lipoprotein cholesterol
HGS – Isometric handgrip strength
HIV – Human immunodeficiency virus
ICC – Intraclass correlation coefficient
LDL-c – Low-density lipoprotein cholesterol
LSD – Low significance difference
ORCID – Open Researcher and Contributor ID
PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QIC – Model fit quality
RE – Resistance exercise
RE – Retraining
RCT – Randomized clinical trials
RoB1 – Risk of bias
RT – Resistance training
SD – Standard deviation
SEM – Standard error of measurement
SMM – Skeletal muscle mass
SPPB – Short-Physical Performance Battery
STS – Sit-to-stand test
TTV –Total training volume
TUG – Timed up and go test
UC – Usual care
WK – Week

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1 REFERENCIAL TEÓRICO

1.1. Aspectos epidemiológicos do envelhecimento

Uma matéria publicada na década de 1960 em um jornal brasileiro destacava a seguinte mensagem: “onibus entrou na casa humilde e foi apanhar a velhinha de 42 anos”. Para além da atualização da língua portuguesa na palavra ônibus e do fato trágico da mulher falecer após esse acidente, a vítima foi chamada de velha por ter 42 anos. Uma possível explicação para este fato é que nessa época a expectativa de vida era de apenas 54 anos de idade (CRIMMINS, 2015; SEALS et al., 2016). No século XX, de fato as pessoas viviam menos tempo do que atualmente (CRIMMINS, 2015; SEALS et al., 2016), uma vez que as doenças infectocontagiosas faziam parte da realidade mundial, em virtude, principalmente, das limitadas condições de tratamento disponíveis para tais enfermidades (CRIMMINS, 2015; SEALS et al., 2016). Portanto, naquela época era bastante comum adultos de meia idade serem considerados velhos.

Esse fenômeno foi sendo gradativamente alterado, de modo que a expectativa de vida da população cresceu para aproximadamente 74 anos de idade (CRIMMINS, 2015; SEALS et al., 2016), sendo que as mulheres tendem a viver mais do que os homens (RUDNICKA et al., 2020). Esse fato se deve, particularmente, pelo avanço da ciência e tecnologia, no que tange a diagnósticos precoces e formas de prevenção e tratamento mais eficazes contra diversas doenças (CRIMMINS, 2015; SEALS et al., 2016). Desse modo, a população idosa global tem crescido rapidamente (WORLD HEALTH ORGANIZATION, 2015), representando atualmente aproximadamente 20% da população mundial (RUDNICKA et al., 2020; SANDER et al., 2015), com previsão de que até 2050 esse número supere a taxa de dois bilhões (RUDNICKA et al., 2020; SANDER et al., 2015).

No Brasil, de acordo com o levantamento epidemiológico de 2022 realizado pelo Instituto Brasileiro de Geografia e Estatística, estima-se o seguinte cenário: 2022 (15,8% da população brasileira era composta por idosos, representando aproximadamente 32,5 milhões de pessoas) vs. 2060 (32,2% da população brasileira será composta por idosos, o que representará aproximadamente 68,7 milhões de pessoas). Em outras palavras, existe a previsão de uma taxa de crescimento na ordem de 16,4%.

Por outro lado, o cenário epidemiológico foi mudado sensivelmente, com redução expressiva nas taxas de morbidade e mortalidade por doenças infectocontagiosas e aumento expressivo de doenças crônicas não-transmissíveis, em especial, nas mulheres no período pós-menopausa (CRIMMINS, 2015; SEALS et al., 2016). De fato, o envelhecimento guarda estreita relação com aumento do risco para desenvolvimento de hipertensão arterial, diabetes mellitus tipo 2, dislipidemias, doença arterial coronariana, alguns tipos de câncer, entre outras doenças que contribuem para a redução da qualidade de vida, declínio da aptidão funcional e mortalidade precoce(WORLD HEALTH ORGANIZATION, 2015). Portanto, as doenças crônicas não-transmissíveis são um dos principais problemas de saúde pública sendo responsáveis por aproximadamente 42% do total das mortes ocorridas prematuramente no Brasil e de cerca de 70% das mortes ocorridas globalmente (WORLD HEALTH ORGANIZATION, 2015).

Assim, se faz necessário a compreensão das alterações decorrentes do processo de envelhecimento com objetivo de atenuar a morbidade e mortalidade precoce, associada as doenças crônicas não-transmissíveis, principalmente na mulher idosa.

1.2 Envelhecimento e capacidade de resiliência

Um conceito na área de geriatria foi proposto recentemente pelo Instituto Nacional de Envelhecimento dos Estados Unidos da América (capacidade de resiliência) com o objetivo de combater os prejuízos na saúde e função associados ao processo de envelhecimento (HADLEY; KUCHEL; NEWMAN, 2017). A capacidade de resiliência pode ser definida como a capacidade de um sistema fisiológico recuperar um determinado nível 'normal' de saúde e/ou função após experimentar um estressor clínico e/ou social, tal como a hospitalização aguda e/ou desastre ambiental pandêmico (RESNICK; GWYTHER; ROBERTO, 2011; WHITSON et al., 2016). Notadamente, o afastamento físico (agente estressor) e os níveis reduzidos de atividade física provocados pela pandemia de COVID-19 contribuiram para uma condição clínica de maior vulnerabilidade, sobretudo, no que diz respeito a biomarcadores de saúde e função muscular (por exemplo, mudanças na composição corporal, força muscular, perfil metabólico e aptidão funcional) em muitos idosos (CHEN et al., 2021; MACHADO et al., 2020; NUNES et al., 2022), inclusive naqueles que estavam engajados em alguma prática de atividade física. De acordo com esta abordagem, o tempo necessário para recuperação dos prejuízos à saúde e a função muscular acarretados pela pandemia de COVID-19 pode ser utilizado para análise da capacidade de resiliência (baixa ou alta) (WALSTON et al., 2023). No entanto, vale mencionar que alguns contribuintes de base podem influenciar essa capacidade de resiliência, tais como idade, índice de massa corporal (IMC), características psicossociais e consumo de medicamentos (WALSTON et al., 2023).

Adicionalmente, a aptidão funcional está estreitamente relacionada ao processo de envelhecimento biológico do indivíduo (LOPEZ-ORTIZ et al. 2022). Nesse sentido, a capacidade de resiliência parece se associar mais com o envelhecimento biológico (modificações nos indicadores de saúde e função muscular) do que com o envelhecimento cronológico (aumento dos anos de vida). De acordo com essa premissa, os aspectos que influenciam na capacidade de se locomover em um percurso de três metros, como a força e a potência muscular, explicam a aptidão funcional do idoso em realizar tarefas de curtas distâncias, pelo menos em partes. Assim, idosos com uma alta capacidade de produção de força máxima e rápida têm melhor função muscular nesses tipos de tarefas, e consequentemente, uma alta aptidão funcional pois se locomovem com mais velocidade.

Por outro lado, existem idosos com excesso de gordura corporal mas com força e/ou potência muscular alta que demonstram um declínio na aptidão funcional, uma vez que a gordura corporal exerce um impacto negativo na mecânica da marcha (LAROCHE; KRALIAN; MILLETT, 2011; MOORE et al., 2020), afetando diretamente sobre a capacidade de locomoção, principalmente em maiores distâncias (≥ 400 metros). Além disso, os idosos que apresentam excesso de gordura corporal associado a baixa força e/ou potência muscular experenciam um declínio significante da capacidade de se locomover em curtas e grandes distâncias (baixa aptidão funcional) (LOPEZ-ORTIZ et al. 2022; LAROCHE; KRALIAN; MILLETT, 2011; MOORE et al., 2020), especialmente pelo prejuízo provocado no sistema biológico que afeta diretamente os indicadores de saúde e função muscular. Portanto, estratégias de intervenção para reverter os prejuízos sobre a saúde e função muscular se mostram necessárias (HVID et al., 2014; WALSTON et al., 2023) e devem ser discutidas amplamente (MERCHANT et al., 2022).

1.3 Relevância da composição corporal, força muscular, perfil metabólico e aptidão funcional para a população idosa

Louis Sullivan, um arquiteto renomado, em uma de suas obras de construção civil reportou que a forma/composição de uma estrutura sempre segue a função para qual foi idealizada (WANG; YOULE, 2016). Transferindo este conceito para a área da saúde, é possível inferir que a forma/composição de uma estrutura dentro do organismo está relacionada a sua função (MARÍN PARRA; GLEESON, 2011). Assim, a forma/composição do músculo esquelético e/ou gordura corporal são considerados determinantes da aptidão funcional(HEYMSFIELD; PRADO; GONZALEZ, 2023; LAROCHE; KRALIAN; MILLETT, 2011; MOORE et al., 2020; MUMUSOGLU; YILDIZ, 2019), principalmente em idosos (JANSSEN et al., 2000). Portanto, é razoável aceitar que a aptidão funcional é influenciada, pelo menos em parte, pela produção de força e potência do músculo esquelético, ao passo que a gordura corporal exerce uma sobrecarga mecânica que pode comprometer a função.

O músculo esquelético é considerado um órgão endócrino-metabólico extremamente flexível no que tange a capacidade de adaptação às diferentes condições (hipertrofia, hipotrofia ou atrofia). Além disso, o músculo esquelético desempenha um papel fundamental na captação de ácidos graxos da circulação sanguínea (ARGILÉS et al., 2016; MOUGIOS, 2019), sugerindo um papel relevante sobre as concentrações séricas de lipídeos. Do ponto de vista funcional, o músculo esquelético está associado à geração de força e potência, fatores-chave para realização das atividades da vida diária, tais como levantar-se de uma posição sentada, caminhar pequenas distâncias, subir e descer escadas (FRONTERA; OCHALA, 2015). Assim, o músculo esquelético tem sido associado positivamente à saúde, independência funcional e qualidade de vida, principalmente em idosos (CRUZ-JENTOFT et al., 2019).

Por outro lado, o declínio da função musculoesquelética, oriunda da redução da força, potência muscular e aptidão funcional (FRONTERA; OCHALA, 2015), decorrente do envelhecimento, está associado ao aumento do risco de quedas, lesões, fraturas, infecções e outras complicações (CRUZ-JENTOFT et al., 2019; SKELTON; KENNEDY; RUTHERFORD, 2002) e, consequentemente, aumento nas taxas de internamento hospitalar em idosos (GILL et al., 2015). Assim, a hospitalização é um desfecho que, em muitos casos, tem como precedente/gatilho a baixa força e/ou potência muscular (função), sobretudo, na população idosa

(HEYMSFIELD; PRADO; GONZALEZ, 2023).

Embora a hospitalização possa ser uma estratégia valiosa para preservar vidas, o período de internação no qual um paciente fica acamado pode aumentar o risco de infecções (CRUZ-JENTOFT et al., 2019; MARTÍNEZ-VELILLA et al., 2013) e de hipotrofia induzida por desuso do musculoesquelético (NUNES et al., 2022). De fato, o período de internação hospitalar provoca uma redução acentuada dos níveis de atividade física (BROWN et al., 2009; TASHEVA et al., 2020) e muitas vezes causa desnutrição, devido a baixa ingestão energética e proteica (SULLIVAN; SUN; WALLS, 1999; WEIJZEN et al., 2020). Portanto, o quadro de internação hospitalar potencializa os efeitos deletérios do envelhecimento sobre a força e potência muscular (FORTINSKY et al., 1999; MUDGE; O'ROURKE; DENARO, 2010), prejudicando a realização das atividades básicas da vida diária (COVINSKY et al., 2003; COVINSKY; PIERLUISSI; JOHNSTON, 2011; LOYD et al., 2020).

Assim, a combinação de um agente estressor (hospitalização) e o envelhecimento pode prejudicar a capacidade de resiliência do idoso no momento da alta, fazendo com que o indivíduo não consiga recuperar efetivamente os prejuízos gerados pelo período de hospitalização, principalmente, no que tange a função muscular (BELL et al., 2015; WANG et al., 2019). Logo, o desenvolvimento de estratégias eficazes para atenuar e/ou reverter esse quadro deve ser uma das prioridades no campo da saúde (COVINSKY et al., 2003; COVINSKY; PIERLUISSI; JOHNSTON, 2011).

Por outro lado, o acúmulo de gordura corporal, especialmente na região abdominal (por exemplo, circunferência da cintura elevada e/ou alta quantidade de gordura androide) é um fenômeno recorrente associado com o envelhecimento (MUMUSOGLU; YILDIZ, 2019; ZHANG et al., 2016), sendo considerado um dos fatores-chave de risco cardiometabólico (MUMUSOGLU; YILDIZ, 2019; ZHANG et al., 2016), bem como para o aumento das taxas de prevalência e incidência de dislipidemias (ZHANG et al., 2016). Além disso, o declínio da força muscular em idosos tem sido associado negativamente ao acúmulo de gordura corporal (LAROCHE; KRALIAN; MILLETT, 2011; MOORE et al., 2020), sugerindo que esse componente da composição corporal possa prejudicar a aptidão funcional. Por exemplo, o acúmulo de gordura corporal oriunda do processo de envelhecimento da mulher é capaz de exercer uma sobrecarga adicional no corpo, afetando diretamente nas realizações das atividades básicas da vida diária (LAROCHE; KRALIAN;

MILLETT, 2011; MOORE et al., 2020).

De fato, do ponto de vista mecânico, para se locomover e/ou levantar-se de uma cadeira é necessário vencer uma resistência exercida pela sua massa corporal (LAROCHE; KRALIAN; MILLETT, 2011; MOORE et al., 2020). Assim, quanto maior a quantidade de gordura corporal presente no corpo (principalmente na região abdominal), maior terá que ser a força para caminhar e/ou subir um degrau de escada.

Nesse sentido, o excesso de gordura na região abdominal (central) está associado a uma maior incidência de quedas quando comparado ao excesso de gordura total (corpo inteiro) em mulheres idosas (NERI et al., 2020). Além disso, o desequilíbrio metabólico provocado pelo excesso de gordura corporal, em especial na região central, pode contribuir para prejuízos na força muscular e dislipidemias(LAROCHE; KRALIAN; MILLETT, 2011; MOORE et al., 2020; MUMUSOGLU; YILDIZ, 2019; ZHANG et al., 2016). Portanto, é razoável assumir que o excesso de gordura corporal, principalmente na região abdominal, possa afetar negativamente a força muscular, o perfil metabólico e a aptidão funcional de mulheres idosas (LAROCHE; KRALIAN; MILLETT, 2011; MOORE et al., 2020; MUMUSOGLU; YILDIZ, 2019; MUMUSOGLU; YILDIZ, 2019; ZHANG et al., 2016).

1.4 Efeito de intervenções não-farmacológicas sobre a composição corporal, força muscular, perfil metabólico e aptidão funcional em idosos

O impacto de intervenções não-farmacológicas, incluindo a prática de exercícios físicos sobre a composição corporal, força muscular, perfil metabólico e aptidão funcional tem atraído o interesse da comunidade científica (MERCHANT et al., 2022; WORLD HEALTH ORGANIZATION, 2017). Em idosos, particularmente, o exercício resistido tem sido amplamente recomendado pelos inúmeros benefícios associados à sua prática, com destaque para a melhoria da composição corporal, força e potência muscular, perfil metabólico e aptidão funcional (CARNEIRO et al., 2020a, 2020b, 2021a, 2022b, 2023; CAVALCANTE et al., 2023). Além disso, o exercício resistido tem demonstrado ser uma modalidade segura do ponto de vista cardiovascular, que permite que a prescrição seja realizada de forma individualizada, com base nas limitações e necessidades do praticante; possibilita a execução dos movimentos em diferentes velocidades; não exige grandes deslocamentos; pode ser executado de maneira confortável (sentado, deitado ou reclinado); e que possibiilta uma progressão gradual do volume e da intensidade de carga, de acordo com as mudanças na função muscular (FRAGALA et al., 2019; IZQUIERDO et al., 2021).

Nesse sentido, as diretrizes mais recentes sugerem que para a prevenção da saúde e promoção de um envelhecimento saudável a prática do exercício resistido deve ocorrer com uma frequência de duas a três sessões semanais, utilizando em torno de oito a 10 exercícios para o corpo inteiro com um volume de uma a três séries por exercício, com uma intensidade de carga suficiente para realização de 8 a 12 ou 10 a 15 repetições (FRAGALA et al., 2019; IZQUIERDO et al., 2021). Tais recomendações têm se mostrado efetivas, especialmente, em idosos fisicamente independentes, contudo, resta saber se os benefícios associados a prática do exercício resistido são estendidos ou não a indivíduos com diferentes condições de desuso, tais como hospitalização e/ou interrupção do treinamento devido a diferentes causas. De acordo com o nosso conhecimento, poucas investigações tem sido conduzidas com idosos durante a hospitalização aguda (VALENZUELA et al., 2020), após a alta hospitalar (VALENZUELA et al., 2020) ou, ainda, com aqueles que passaram por um longo período de afastamento físico devido a pandemia de COVID-19 (ARAGÃO-SANTOS et al., 2023), situações nas quais a saúde e a função muscular podem sofrer comprometimentos significativos (NUNES et al., 2022), afetando a capacidade de resiliência (CHHETRI et al., 2021; MERCHANT et al., 2022; RESNICK; GWYTHER; ROBERTO, 2011; WHITSON et al., 2016).

1.5 Exercício resistido aplicado em diferentes condições de desuso músculo esquelético em idosos

Para as situações de desuso abordadas anteriormente, se faz necessário o desenvolvimento de estratégias de intervenção que auxiliem idosos a se recuperarem dos efeitos adversos causados pela hospitalização ou pela interrupção do treinamento, tais como a causada pela pandemia de COVID-19 (NUNES et al., 2022). Fato é que após os idosos serem expostos a essas condições estressoras, é possível que a capacidade de resiliência seja comprometida, dificultando a recuperação da força e potência muscular, massa muscular esquelética, massa isenta de gordura e osso, concentrações séricas de lipídeos e aptidão funcional (HVID et al., 2014; MACHADO et al., 2020; WALSTON et al., 2023).

De acordo com essas premissas, a utilização do exercício resistido parece ser uma estratégia coadjuvante bastante interessante quando comparada aos cuidados habituais que são fornecidos no ambiente hospitalar (DE ASTEASU et al., 2019a; DE MORTON et al., 2007; MARTÍNEZ-VELILLA et al., 2021; MCCULLAGH et al., 2020; ORTIZ-ALONSO et al., 2020; RAYMOND et al., 2017; SAEZ DE ASTEASU et al., 2020). Por exemplo, a intervenção de exercício resistido individualizada realizada durante um curto período (5-7 dias consecutivos) promoveu mudanças significativas na aptidão funcional ao mitigar o declínio da força e potência muscular em comparação aos cuidados hospitalares habituais em pacientes idosos (DE ASTEASU et al., 2019a; MARTÍNEZ-VELILLA et al., 2021; MCCULLAGH et al., 2020; ORTIZ-ALONSO et al., 2020; SAEZ DE ASTEASU et al., 2020). Entretanto, as possíveis mudanças provocadas por uma intervenção com exercício resistido quando comparadas aos cuidados habituais hospitalares, sobretudo, em idosos hospitalizados de maneira aguda (VALENZUELA et al., 2020), merecem ser analisadas de maneira mais consistente pela literatura, visto que pacientes que não recebem intervenção com exercício físico durante o período de hospitalização aguda tendem a apresentar maiores prejuízos na capacidade de realizar atividades de vida diária, de forma independente, após a alta hospitalar (MARTÍNEZ-VELILLA et al., 2022; VALENZUELA et al., 2020).

Além disso, existem indicativos de que um programa de exercícios físicos individualizado possa promover mudanças significativas na força muscular e na aptidão funcional mais do que os cuidados habituais após a alta hospitalar, mesmo quando não realizados durante a internação (CAMPO et al., 2020; ECKERT et al., 2021; LI et al., 2015; SUNDE et al., 2020; TIMONEN et al., 2002). Embora o efeito do exercício resistido seja bastante promissor no combate ao risco de mortalidade em idosos hospitalizados de maneira aguda e após a alta hospitalar (VALENZUELA et al., 2020), até o momento, o número de investigações ainda é insuficiente para sustentar a adoção de tal conduta. Portanto, é necessário contrastar os achados produzidos até o presente momento sobre os efeitos de intervenções com e sem a presença de exercícios físicos em idosos, durante o período agudo de hospitalização aguda e em situações após a alta hospitalar (VALENZUELA et al., 2020).

Por outro lado, considerando que o exercício resistido tem sido amplamente recomendado para mulheres idosas como uma estratégia segura, não farmacológica e bem aceita para mitigar os efeitos prejudiciais do envelhecimento na composição corporal, força muscular, perfil metabólico e aptidão funcional (CHODZKO-ZAJKO et al., 2009; FRAGALA et al., 2019; NUNES et al., 2023; RATAMESS et al., 2009), mesmo mulheres idosas engajadas com essa prática experimentaram uma interrupção no programa de treinamento devido à pandemia de COVID-19 (ARAGÃO-SANTOS et al., 2023; MACHADO et al., 2020; NUNES et al., 2022). A interrupção do treinamento é caracterizada pelo abandono completo de um programa de exercícios que pode gerar uma reversão parcial ou total das respostas adaptativas que foram alcançadas durante o período de treino (MUJIKA; PADILLA, 2000, 2001). Além disso, concomitantemente, a ausência de sobrecarga mecânica corporal oriunda da interrupção do treinamento associada ao fenômeno denominado de resistência anabólica (redução da síntese proteica muscular), induzida pelo envelhecimento (BREEN; PHILLIPS, 2011; DE SOUZA TEIXEIRA et al., 2023; GRGIC, 2022; HVID et al., 2014; MACHADO et al., 2020; NUNES et al., 2022; PREOBRAZENSKI et al., 2023; TANNER et al., 2015; WALL; DIRKS; VAN LOON, 2013). Portanto, é razoável aceitar que os efeitos provocados pela interrupção do treinamento em biomarcadores de saúde e função muscular em mulheres idosas podem trazer prejuízos, pelo menos em parte, irreversíveis (GRGIC, 2022; WALSTON et al., 2023).

Embora os programas de treinamento resistido sejam recomendados para mulheres idosas como uma estratégia de intervenção eficaz para combater os efeitos deletérios do envelhecimento (CHODZKO-ZAJKO et al., 2009; FRAGALA et al., 2019; NUNES et al., 2023; RATAMESS et al., 2009), há poucas pesquisas publicadas sobre os efeitos do retreinamento de curto prazo sobre a capacidade de resiliência após longos períodos de interrupção do treinamento (ENCARNAÇÃO et al., 2022; GRGIC, 2022). Além disso, poucos estudos envolvendo mulheres idosas engajadas em um programa de treinamento resistido avaliaram o impacto da interrupção do treino imposto pela pandemia de COVID-19.

2 OBJETIVOS

Considerando que a presente tese foi estruturada de acordo com o modelo escandinavo, no qual a contextualização do problema dá origem ao estabelecimento de diferentes objetivos que, por sua vez, são analisados a partir da redação de artigos científicos, os propósitos desta investigação foram:

a) Analisar as mudanças provocadas por intervenções estruturadas envolvendo exercício resistido sobre a força e potência muscular, massa muscular e aptidão funcional comparado ao cuidado usual em idosos hospitalizados de maneira aguda, por meio de uma revisão sistemática com meta-análise (Artigo 1);

b) Comparar as mudanças causadas por intervenções aplicadas imediatamente após a alta hospitalar, envolvendo exercício físico ou cuidado usual, sobre a força e potência muscular, massa muscular e aptidão funcional em idosos por meio de uma revisão sistemática com meta-análise (Artigo 2);

c) Analisar os efeitos de dois anos de interrupção do treinamento sobre a composição corporal, força muscular, perfil metabólico e aptidão funcional de mulheres idosas engajadas em um programa de treinamento resistido. Adicionalmente, para investigar a capacidade de resiliência, comparamos as mudanças provocadas por 12 semanas de retreinamento com as mudanças alcançadas após as primeiras 12 semanas de treinamento (Artigo 3).

3 HIPÓTESES

As principais hipóteses testadas nesta investigação foram:

a) Intervenções estruturadas envolvendo exercício resistido (estudos clínicos aleatorizados) acarretarão maiores ganhos de massa muscular, força e potência muscular e melhoria da aptidão funcional em comparação aos cuidados usuais em idosos hospitalizados de maneira aguda (Artigo 1);

b) Intervenções estruturadas envolvendo exercício físico em idosos, aplicadas imediatamente após a alta hospitalar (que não receberam essa intervenção durante a internação), promoverão melhorias superiores de força e potência muscular, massa muscular e aptidão funcional comparado ao grupo controle (Artigo 2);

c) Dois anos de interrupção ao treinamento resistido irão resultar em declínio da função muscular e piora do quadro metabólico em mulheres idosas. As mudanças induzidas por 12 semanas de retreinamento serão menores do que as mudanças alcançadas com as primeiras 12 semanas de treinamento devido a falta de sobrecarga mecânica gerada por dois anos de destreinamento e pela resistência anabólica associada ao processo de envelhecimento (Artigo 3).

4 RESULTADOS

4.1 ARTIGO 1

Resistance Exercise Intervention on Muscular Strength and Power, and Functional Capacity in Acute Hospitalized Older Adults: A Systematic Review and Meta-Analysis of 2498 Patients in 7 Randomized Clinical Trials

Short Title Resistance Exercise Intervention in Acute Hospitalized Older Adults

CARNEIRO, Marcelo AS et al. Resistance exercise intervention on muscular strength and power, and functional capacity in acute hospitalized older adults: a systematic review and meta-analysis of 2498 patients in 7 randomized clinical trials. **Geroscience**, v. 43, n. 6, p. 2693-2705, 2021.

Resumo. Até o presente momento, nenhum estudo meta-analítico avaliando os benefícios de uma intervenção com exercício resistido sobre a força muscular, potência muscular e capacidade funcional em idosos hospitalizados de maneira aguda foi conduzido. Assim, o objetivo do presente estudo foi sintetizar as evidências emergentes sobre os efeitos da uma intervenção com exercício resistido sobre a força muscular, potência muscular e capacidade funcional em idosos hospitalizados de maneira aguda. Dois autores independentes realizaram uma busca sistemática (PubMed, Scopus, Web of Science e SciELO) até Janeiro de 2021. Estudos clínicos aleatorizados foram incluídos acerca dos efeitos de exercício resistido e cuidado usual. Para avaliação do risco de viés, utilizou-se a ferramenta da Colaboração Cochrane (RoB1). Foram incluídas comparações par força muscular (preensão manual no *handgrip* e teste de uma repetição máxima no exercício *leg press*), potência muscular (potência máxima de saída no exercício *leg press*), e capacidade funcional (*timed-up-and-go*, e *short physical performance battery*). O exercício resistido aumentou a força muscular (preensão manual no *handgrip*: diferença média = 2,50 kg, intervalo de confiança de 95% = 1,33 até 3,67; e teste de uma repetição máxima no exercício *leg press*: diferença média = 19,28 kg, intervalo de confiança de 95% = 14,70 até 23,86) e potência muscular (diferença média = 29,52 W, intervalo de confiança de 95% = 28,84 até 30,21), e aptidão funcional (*timed-up-and-go*: diferença média = 3,40 s, intervalo de confiança de 95% = 0,47 até 6,36; e *short physical performance battery*: diferença média = 1,29 pontos, intervalo de confiança de 95% = 0,10 até 2,48) na alta hospitalar comparado com o cuidado usual. Em conclusão, essa meta-análise suporta o aumento da força muscular, potência muscular e melhoria da capacidade funcional a favor do exercício resistido em idosos hospitalizados de maneira aguda.

Registro clínico

https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020203658

Palavras-chave: Envelhecimento, Inflamação, Idosos, Desempenho Físico, Treinamento de Força.

4.1.1 Introduction

One in four adults will be aged over 65 years by 2050 (SHAW et al., 2010). Considering that cumulative effects during the aging process are associated with decreases in muscular strength and power, functional capacity, and lean soft tissue (CRUZ-JENTOFT et al., 2019), older people become more vulnerable to the risk of injuries, falls, fractures, infections, and numerous complications related to chronic diseases (GUADALUPE-GRAU et al., 2015; SKELTON; KENNEDY; RUTHERFORD, 2002), leading to an increase in hospitalization (GILL et al., 2015). Although hospitalization may be a crucial life-saving strategy, the length of time a patient is bedridden can increase the risk of infection (CRUZ-JENTOFT et al., 2019; MARTÍNEZ-VELILLA et al., 2013) and muscle disuse-induced atrophy (COVINSKY; PIERLUISSI; JOHNSTON, 2011).

Many acute hospitalized older adults present lower physical activity levels (MARTÍNEZ-VELILLA et al., 2013; PAVON et al., 2020), rapid muscular strength and power declines (FORTINSKY et al., 1999; MUDGE; O'ROURKE; DENARO, 2010), which are key elements to perform basic activities of daily living such as walking, balance, and standing from a seated position (COVINSKY et al., 2003; COVINSKY; PIERLUISSI; JOHNSTON, 2011; LOYD et al., 2020). According to this approach, the development of strategies aiming to prevent muscular strength and power decreases, hospitalized-associated disability in older adults should be primary focus in the field of health care (COVINSKY; PIERLUISSI; JOHNSTON, 2011; FORTINSKY et al., 1999). Among strategies to provoke changes in the muscular strength and power, and functional capacity in acute hospitalized older adults, resistance exercise (RE) appears to be an attractive alternative when compared to hospital usual care (DE ASTEASU et al., 2019a; ORTIZ-ALONSO et al., 2020; VALENZUELA et al., 2020).

In this regard, recent studies have supported the effectiveness of RE intervention as a safe alternative strategy to change functional capacity during hospitalization in older adults (DE ASTEASU et al., 2019a; MARTÍNEZ-VELILLA et al., 2021; MCCULLAGH et al., 2020; ORTIZ-ALONSO et al., 2020; SAEZ DE ASTEASU et al., 2020). For instance, individualized and multicomponent (structured) RE intervention performed during short-time (5-7 days consecutively) promotes significant changes in functional capacity by mitigate the muscular strength and power decline over hospital usual care in older patients (DE ASTEASU et al., 2019a; MARTÍNEZ-VELILLA et al., 2021; MCCULLAGH et al., 2020; ORTIZ-ALONSO et al., 2020; SAEZ DE ASTEASU et al., 2020).Although qualitative synthesis has demonstrated benefits in favor of RE intervention compared with hospital usual care, to date, no meta-analytical study evaluating the changes of RE intervention over hospital usual care on muscular strength and power (stronger predictors of functional limitations), as well functional capacity (e.g., walking, balance, and standing from a seated position) in acute hospitalized older adults was conducted (VALENZUELA et al., 2020). Therefore, this systematic review and meta-analysis aimed to evaluate the changes provoked by structured RE intervention (randomized clinical trials) on muscular strength and power and functional capacity (including direct measurements to assess balance, walking, and agility) when compared to usual care in acute hospitalized older adults.

4.1.2 Methods

Data sources and searches approach

This systematic review was performed following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (PAGE et al., 2021) registered on the International Prospective Register of Systematic Reviews (PROSPERO 2020 CRD42020203658). English language articles by title and abstract were retrieved from the earliest record up to January 2021 on PubMed/MEDLINE, Scopus, Web of Science, and SciELO by two independent authors (MASC and ALS). The search strategy combined the following terms: ("Aged" OR "Older people" OR "Older adults" OR "Older hospitalized") AND ("Hospitalization" OR "Hospital-based" OR "Hospital admission") AND ("Exercise therapy" OR "Physical exercise" OR "Exercise program" OR "Exercise" OR "Physical activity" OR “Training”) AND ("Muscle mass" OR "Muscular strength" OR "Muscle strength" OR "Muscle power" OR "Physical function" OR "Functional capacity" OR "Functional performance" OR "Physical performance" OR “Balance” OR “Mobility” OR “Gait speed”). However, we did not find randomized clinical trials involving muscle mass assessment using direct measurements (e.g., magnetic resonance imaging, ultrasound, dual-energy X-ray absorptiometry), RE intervention, and acute hospitalized older adults. In addition, gray literature (e.g., abstracts, conference papers, and editorials) was excluded. In case of disagreements, a third reviewer evaluated the article (CSP).

Study selection

Two independent authors (MASC and ALS) performed the systematic search and completed the study selection. The eligibility criteria were determined according to PICOS (Population, Intervention, Comparators, Outcome, and Study design). Randomized clinical trials (RCT) in hospitalized older people (defined as age ≥ 65 years) (WORLD HEALTH ORGANIZATION, 2017) were examined, comparing RE intervention with hospital usual care and reporting muscular strength and/or power and functional capacity (balance, mobility, or gait speed). Hospital usual care was characterized by daily medical assessment, standard medical and pharmacological care therapy (including antibiotic, systemic steroids, inhaled bronchodilators, and oxygen), and full-time nursing assistance (DE MORTON et al., 2007; RAYMOND et al., 2017). Noteworthy, the geriatricians may orient to the patient to perform standard physical rehabilitation (mainly focused on walking exercises) for mitigate functional capacity declines (DE ASTEASU et al., 2019a; MARTÍNEZ-VELILLA et al., 2021; MCCULLAGH et al., 2020; ORTIZ-ALONSO et al., 2020; SAEZ DE ASTEASU et al., 2020). However, hospitalized older with usual care spend most time in bed, even the individual can walk without the help of a nurse (walk approximately 600 steps per day (only 12 min daily walking)] (FISHER et al., 2011; MCCULLAGH et al., 2020). Initially, the publications were first retrieved and preliminary screened by title and abstract. After exclusion of duplicate publications, the identified articles were included in the review if they matched the following criteria: (a) RCT study; (b) hospitalized older adults undergoing acute medical illness; (c) structured RE intervention (exercises performed against resistance) performed in the hospital compared to hospital usual care; (d) measurements of isometric handgrip strength (HGS) and/or one-repetition maximum test (1-RM test), timed up and go test (TUG), Short-Physical Performance Battery (SPPB), including sit-to-stand test (muscular power), balance and gait speed. Then, studies were excluded following exclusion criteria: (1) patients with chronic respiratory, circulatory, infectious, renal, urological, neurological, gastrointestinal, and musculoskeletal disorders - also cancer and HIV patients undergoing treatment; (2) intervention using the vibrating platform, Tai Chi Chuan, dance, exergames, and physical activities as exercise; (3) use of nutritional supplementation during hospitalization; (4) absence of information on the evaluations of the studied outcomes. The agreement between MASC and ALS was kappa = 0.89, $P < 0.001$. In eventual disagreements were discussed with a third author (CMCF).

Data extraction and quality assessments

The quality of included studies was performed using the ‘risk of bias’ assessment tool of the Cochrane Collaboration. The quality of selection bias, performance bias, detection bias, attrition bias, reporting bias, and other bias were classified as high (‘+’), low (‘-’), or unclear (‘?’) risk of bias (HIGGINS et al., 2011). Quality assessments of both reviewers were compared, and disagreements in the scores were resolved by discussion. Two authors (MASC, ALS) independently extracted the following data from each study for analysis: author/year, number of participants within each group, baseline participants’ characteristics, intervention details, pre- and post-data from all outcomes. In circumstances when standard deviations were not available, these values were calculated using traditional statistical methods, assuming a correlation of 0.50 between the baseline and post-intervention scores within each subject (FOLLMANN et al., 1992). Similarly, when studies reported standard error, the values were converted to standard deviation (SD). Hozo’s equations (HOZO; DJULBEGOVIC; HOZO, 2005) were used to estimate mean and SD in the investigations with non-parametric data reporting median and range.

Data syntheses and analyses

Meta-analysis was conducted using Review Manager Software (RevMan software package version 5.4). RevMan was used to calculate the effect size of RE intervention on isometric HGS, 1-RM leg press, and SPPB in hospitalized older people. The variation (pre-minus post-intervention) from all included studies was used to calculate the mean difference and 95% confidence interval (CI) and were conducted using the DerSimonian-Laird random-effects inverse variance model all outcomes (HEDGES; OLKIN, 1985; HIGGINS et al., 2021). Weighted percentages were based on the sample sizes of respective studies. Statistical significance was assumed as $P < 0.05$ in a Z test analysis to examine whether effect size was significantly different from zero. Study heterogeneity was evaluated using the I^2 statistic, and Cochrane’s Q. Values of I^2 higher than 50 and 75% were considered moderate and high heterogeneity. For Cochrane’s Q, significant heterogeneity exists when the Q value exceeds the degrees of freedom (df) of the estimate. Moreover, publication bias was tested visually using a funnel plot. Effect sizes were calculated, and values of 0.00 – 0.19 were considered trivial, 0.20 – 0.49 as small, 0.50 – 0.79 as moderate, and > 0.80 as large. Sensitivity analyses were performed by excluding one trial at a time according to the risk of bias to test the robustness of the pooled results. Forest plots were generated to illustrate the between study-level effect sizes along with a 95% CI (HIGGINS et al., 2003).

4.1.3 Results

The selection processes retrieved 3,090 full-text as documented in the PRISMA flow diagram **(Figure 1)**. After excluding abstracts, conference papers, editorials, and duplicated reviews and meta-analysis studies, 1,483 studies were then assessed according to PICOS eligibility criteria. Afterward, 1,476 studies were excluded for not presenting the inclusion criteria (e.g., no structured RE intervention, use of protein supplementation during hospitalization, absence of dependent variables of interest). Therefore, a total of 7 RCT's were included in the qualitative synthesis for meta-analysis [i.e., muscular strength measure by HGS and (or) 1-RM leg press, muscular power measure by leg-peak power, and functional capacity measure by TUG] whereas a total of 4 studies were included in the quantitative synthesis (i.e., functional capacity measure by SPPB scale). Moreover, all studies included in both qualitative and quantitative synthesis present a low risk of bias **(Figure 2)**.

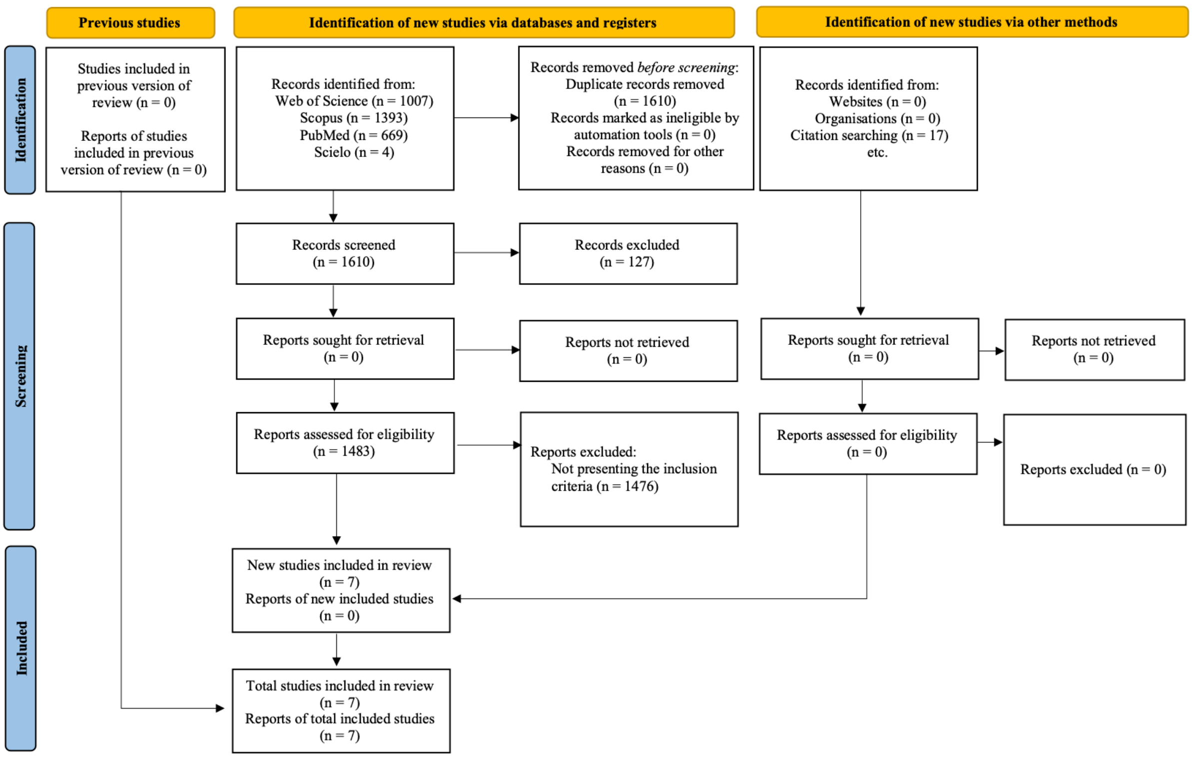

Fig. 1. PRISMA flow diagram of the study selection process.

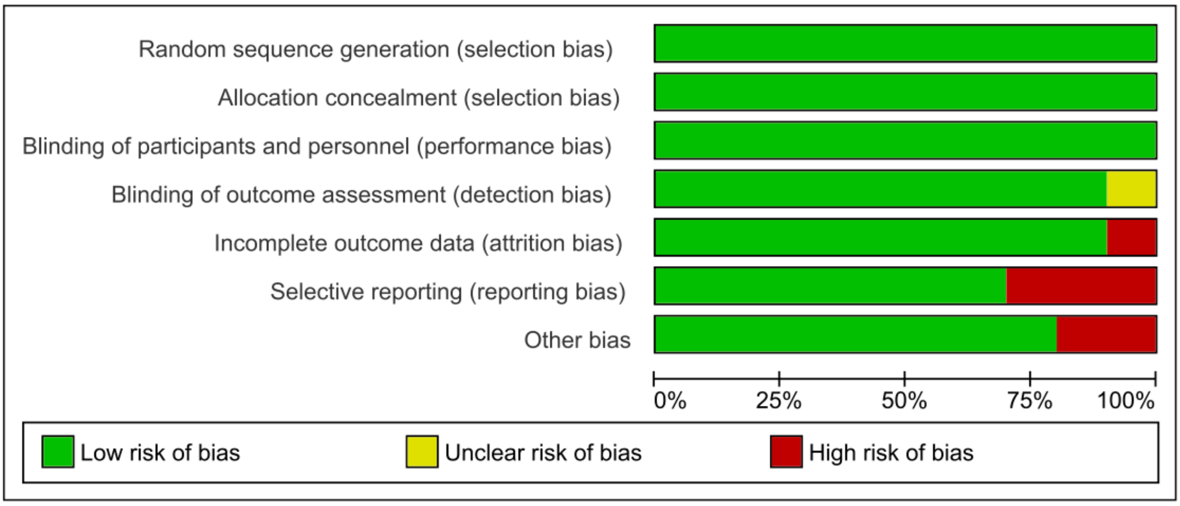

Fig. 2. Risk of bias summary.

Participants' characteristics

The participants' characteristics included in the systematic review and meta-analysis are presented in **Table 1**. Two thousand two hundred forty-three patients with a range between 65 to 88 years (male and female) were hospitalized for acute medical illness. Most studies included acute hospitalized older adults for different medical conditions (e.g., fall, respiratory, circulatory, infectious, renal, urological, neurological, gastrointestinal, and musculoskeletal conditions). Moreover, all participants presented low functional capacity [according to score obtained by SPPB scale and (or) Barthel Index scores, and another physical performance tests]. However, there were no adverse effects (i.e., signs or symptoms) reported by participants during the trials, and no patient had to interrupt the intervention. Finally, the average length of stay was between 5 and 12 days (median = 8).

Intervention characteristics

Three-RCTs were performed with RE progressive intervention using specific equipment (i.e., machine, external load, or cycle ergometer) and four-RCTs were composed by body weight RE intervention **(Table 1)**. On average, RE intervention were performed during 20-40 min per session and 5-7 days consecutively per week. Additionally, in five-RCTs the RE intervention were performed more than once per day (up to two times per day).

Table 1 Study characteristics included in the systematic review and meta-analysis.

Study (country)	Sample	Protocol intervention	Endpoints	Main outcomes
Martínez-Velilla et al. 2020 (Spain)	UC: n = 49 patients (28 female) RE: n = 54 patients (25 female) Mean age: ~86 y (≥ 75 y) Diseases: type II diabetic patients, respiratory, cardiovascular, neurological, musculoskeletal, urinary, and other Patients with low physical function	UC: Occasionally, the patients performed a standard physiotherapy focused on walking exercises as recommended by the geriatricians. RE: Twice-day supervised sessions performed whole-body exercises (at 30-60% of 1-RM) during 20 min per session	Functional capacity assessment: SPPB scale Muscular strength assessment: isometric HGS	UC: ↔ SPPB scale, ↔ isometric HGS; RE: ↑ SPPB scale, ↑ isometric HGS
McCullagh et al. 2019 (Ireland)	UC: n = 95 patients (39 female) RE: n = 95 patients (41 female) Mean age: ~80 y (≥ 65 y)	UC: Composed by breathing and stretching exercises. RE: Once-day session performed whole-body exercises using body weight as external resistance during 20-40 min per session	Functional capacity assessment: SPPB scale	UC: ↑ SPPB scale, RE: ↑↑ SPPB scale

	Diseases: lower impairment in several systems, according to Cumulative Illness Rating Scale-Geriatrics Patients with low physical function			
Morton et al. 2007 (Australia)	UC: 126 patients (68 female) RE: 110 patients (61 female) Mean age: ~79 y (≥ 65 y) Diseases: respiratory, circulatory, digestive, genitourinary, and other Patients with low physical function	UC: Daily medical assessment, 24-hour nursing assistance, and allied health service on referral from medical, nursing or other allied health staff RE: Twice-day supervised sessions performed whole-body exercises using body weight as external resistance during 20-30 min	Functional capacity assessment: TUG	UC: ↔ TUG RE: ↔ TUG
Ortiz-Alonso et al. 2019 (Spain)	UC: 125 patients (67 female) RE: 143 patients (86 female) Mean age: ~88 y (75-102 y)	UC: Occasionally, the patients performed a standard physiotherapy focused on walking exercises as recommended by the geriatricians.	Functional capacity assessment: SPPB scale	UC: ↔ SPPB scale, RE: ↑ SPPB scale

continue	Diseases: respiratory, circulatory, renal, neurological, digestive, and falls Patients with low physical function	RE: Twice-day sessions performed whole-body exercises using body weight as external resistance during ~20 min		
Raymond et al. 2017 (Australia)	UC: 232 patients (134 female) RE: 236 patients (149 female) Mean age: ~84 y (≥ 65 y) Diseases: respiratory, renal, circulatory, neurological, dementia, musculoskeletal, and other (e.g., fall) Patients with low physical function	UC: Comprised individual physiotherapy sessions (gait retraining, aerobic, balance and strength exercises, range of movement, transfers and stairs practice). RE: Once-day supervised sessions performed whole-body exercises using body weight as external resistance (two sets of 8-12 repetition maximum)	Functional capacity assessment: TUG	UC: ↔ TUG; RE: ↔ TUG
Sáez de Asteasu et al. 2019	UC: 65 patients (32 female) RE: 65 patients (32 female) Mean age: ~87 y (≥ 75 y)	UC: Occasionally, the patients performed a standard physiotherapy focused on walking exercises as recommended by the geriatricians.	Functional capacity assessment: SPPB scale Muscular strength assessment:	UC: ↔ SPPB scale, ↔ sit-to-stand test, ↔ 1RM leg press exercise, ↔ muscle power;

(Spain)	Diseases: respiratory, circulatory, infectious, gastrointestinal, neurologic, and other Patients with moderate dependence	RE: Twice-day supervised sessions performed whole-body exercises using specific equipment (at 30-60% of 1-RM) during 20 min per session	1RM leg press exercise Muscular power assessments: Muscle power leg press exercise at 50% of 1RM	RE: ↑ SPPB scale, ↑ sit-to-stand test, ↑ 1RM leg press exercise, ↑ muscle power leg press exercise at 50% of 1RM
Sáez de Asteasu et al. 2020 (Spain)	UC: 185 patients (109 female) RE: 185 patients (100 female) Mean age: ~87 y (75-101 y) Diseases: respiratory, circulatory, infectious, gastrointestinal, neurologic, and other Patients with low physical function	UC: Occasionally, the patients performed a standard physiotherapy focused on walking exercises as recommended by the geriatricians. RE: Twice-day supervised sessions performed whole-body exercises using specific equipment (at 30-60% of 1-RM) during 20 min per session	Muscular strength assessment: 1RM leg press exercise Muscular power assessment: Muscle power leg press exercise at 45% of 1RM	UC: ↔ 1RM leg press exercise, ↔ muscle power leg press exercise at 45% of 1RM; RE: ↑ 1RM leg press exercise, ↑ muscle power leg press exercise at 45% of 1RM

Notes: UC = hospital usual care, RE = resistance exercise, SPPB: short physical performance battery, HGS: handgrip strength, TUG: timed-up-and-go test, 1RM = one repetition maximum test.

Muscular strength and power

Three-RCTs assessed endpoints related muscular strength using HGS or 1-RM test **(Table 2)**. Regarding muscular strength, RE intervention increased HGS [mean difference = 2.50 kg, 95% CI (1.33, 3.67), heterogeneity: not applicable, I^2 = 78%, *P* = 0.029] and 1-RM test [mean difference = 19.28 kg (14.70, 23.86), heterogeneity: *P* = 0.005, I^2 = 87%, *P* < 0.001)]. Two-RCTs assessed endpoints related muscular power by output during leg press exercise at lower-load intensity **(Table 2)**. Hence, RE intervention increased muscular power [mean difference = 29.52 W (28.84, 30.21), heterogeneity: *P* = 0.54, I^2 = 0%, *P* < 0.001)].

Table 2 Meta-analysis performed on the effects of resistance exercise intervention compared to hospital usual care on muscular strength and power, and functional capacity in acute hospitalized older adults.

Outcomes	k	SMD (95% CI)	I^2	*P*
Isometric HGS (kg)	1	2.50 (1.33, 3.67)	78%	0.029*
1RM leg press (kg)	2	19.28 (14.70, 23.86)	87%	<0.0001*
Leg-peak of power (W)	2	29.52 (28.84, 30.21)	0%	<0.0001*
Time-Up-and-Go (s)	2	3.40 (0.47, 6.36)	93%	0.020*
Test for overall effect	7	14.31 (6.44, 22.18)	99%	0.0008*

Notes: Calculation based on random effects model. Results are expressed as standard mean difference and 95% confidence intervals (95% CI). k = number of studies included in effect; SMD = standard mean difference; I^2 = heterogeneity; Kg = kilogram; W = watts; s = second; HGS = handgrip strength; 1RM = one-repetition maximum test. * (*P* < 0.05 in favor RE intervention vs. favor hospital usual care treatment).

Functional capacity

Six-RCTs assessed endpoints related functional capacity by TUG **(Table 2)** and SPPB scale **(Figure 3)**. Overall, the RE intervention improves TUG [mean difference = 3.40 s (0.47, 6.36), heterogeneity: *P* < 0.001, I^2 = 93%, *P* = 0.0200] **(Table 2)** and SPPB scale [mean difference = 1.29 points (0.10, 2.48), heterogeneity: *P* < 0.0001, I^2 = 94%, *P* < 0.001] **(Figure 3)**.

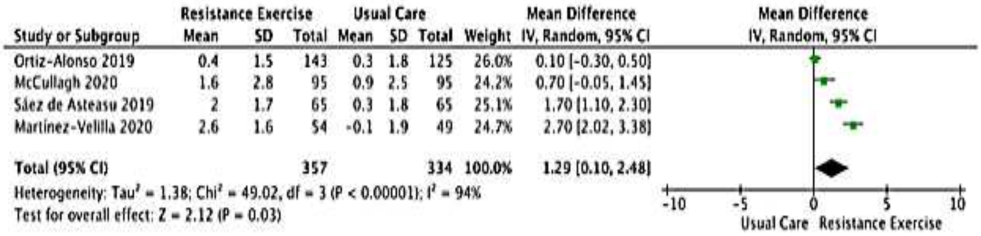

Fig. 3. Meta-analysis performed on the effects of resistance exercise compared to hospital usual care on short physical performance battery in acute hospitalized older adults. Notes: Calculation based on a random-effects model. Results are expressed as mean difference and 95% confidence intervals (95% CI). k = kappa coefficient, I^2 = heterogeneity.

4.1.4 Discussion

To date, and the best of our knowledge, this study is the first summarized meta-analytical evidence supporting the effectiveness of RE intervention on muscular strength and power, and functional capacity in acute hospitalized older adults. Overall, these findings may be explained, at least in part, by the daily frequency of RE intervention. Most studies (5/7 RCTs) reported that hospitalized patients had exercised twice a day (morning and evening) since the RE frequency of the stimulus appears to provide cumulative benefits in acute hospitalized older people. On the other hand, none participants related signs or symptoms of adverse effects during the intervention. In addition, no patient dropout the intervention, indicating high compliance. Therefore, this meta-analysis highlights the importance of including RE intervention for acute hospitalized older adults as primary focus in the field of health care to improve muscular strength and power and functional capacity **(Figure 4)**.

The decline in muscular strength with advancing age is widely recognized as an essential factor contributing to a longer length of stay in hospital and earlier death (REID; FIELDING, 2012; SKELTON; KENNEDY; RUTHERFORD, 2002). Thus, intervention strategies to improve the muscular strength of acute hospitalized older people are required (VALENZUELA et al., 2020).In the current study, RE intervention shows HGS and 1-RM increases over hospital usual care in acute hospitalized older adults. In this regard, our result is important because hospitalization condition in older adults is associated with functional decline (COVINSKY et al., 2003; FORTINSKY et al., 1999). Also, hospitalization-associated disability is related to impairments on general health in older adults (COVINSKY; PIERLUISSI; JOHNSTON, 2011; MARTÍNEZ-VELILLA et al., 2013). Therefore, our findings indicate that RE might be an effective intervention strategy to obtain improvements in muscular strength (at upper and lower limbs), and consequently attenuating and (or) preventing the loss of muscular strength in acute hospitalized older adults **(Figure 4)** (ATTAIX et al., 2005; BODINE; BAEHR, 2014; MAHMASSANI et al., 2019).

The muscular power has been demonstrated to be a fundamental element to perform basic activities of daily living such as walking, balance, and standing from a seated position (COVINSKY et al., 2003; COVINSKY; PIERLUISSI; JOHNSTON, 2011; LOYD et al., 2020). Hence, a structured exercise program applied during acute hospitalization might prevent muscular power declines in older adults. Our study demonstrated that RE intervention appears to be effective and safe compared to hospital usual care in improving muscular power by output during leg press exercise at the lower-load intensity in acute hospitalized older adults. Our findings have important clinical implications because muscular power declines at an earlier and faster rate during aging than muscular strength (REID et al., 2014; REID; FIELDING, 2012). Indeed, muscular power has been more strongly associated with a decline in functional capacity than muscular strength in older adults (FOLDVARI et al., 2000; MD et al., 2002). Moreover, the muscular power output plays an important mediator role on functional capacity endpoints in acute hospitalized older adults (DE ASTEASU et al., 2019b). Thus, the RE intervention presents potential therapeutic and functionally effects on improvement muscular power in acute hospitalized older adults **(Figure 4)**.

Effective strategies which improve functional capacity or delay further declines in acute hospitalized older adults by healthy lifestyle practices featuring regular exercise are needed (SEALS et al., 2016). In the current meta-analysis, only RE improving SPPB scale and TUG (strong predictors of functional capacity and fragility) in acute hospitalization older adults. According to this approach, RE intervention is the most robust overall evidence regarding functional capacity-preserving effects with aging, especially in acute hospitalization in older adults (VALENZUELA et al., 2020). Our findings support that decline in functional capacity may be mitigated by RE in this population. Therefore, evidence endorses the RE prescription to promote health span extension and should be considered a frontline intervention to prevent harmful effects on hospitalization (e.g., infection and mortality) in older adults **(Figure 4)**.

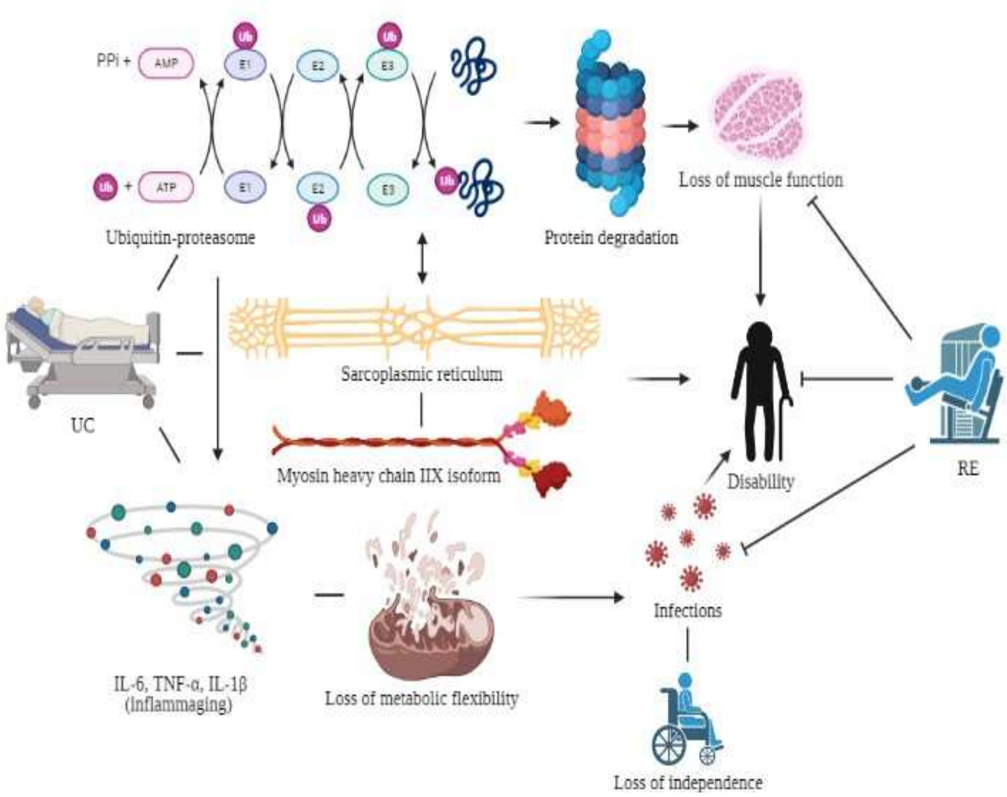

Fig. 4. Potential mechanisms involved in mitigating deleterious effect induced by resistance exercise intervention over usual care treatment during the acute hospitalization in older adults.

Limitations and strengths

While we are confident that RE intervention is a promising strategy to improve muscular strength and power and functional capacity during acute hospitalization, some limitations of this meta-analysis must be presented. The aspect that should not be overlooked is the small number of studies included in the analysis (7 RCTs). Although RE intervention has emerged as a strategy to improve muscle function outcomes, fewer studies investigated the effect of RE intervention in acute hospitalized older adults. In contrast, most studies included in this meta-analysis presented a low risk of bias due to a robust methodological approach and individualized orientation by health and fitness professionals. However, needs to be cautious with general interpretation due to studies heterogeneity (moderate to high).

The strong point in this meta-analysis is pioneering on evaluating the effects of RE intervention which most patients completed the intervention with high compliance. In summary, our findings suggest that RE intervention is an effective and safe intervention in acute hospitalized older adults (RAMIREZ-VELEZ et al., 2021; VALENZUELA et al., 2020).

Future perspectives

Muscular strength is considered a global measure of overall health status. Furthermore, a causal relationship between muscular strength and functional decline can be argued, even when the mechanisms involved are unclear. Noteworthy, as vital signs, when sure functional signs display abnormalities, clinicians should be encouraged to search for subjacent mechanisms related to the cross-talk axis muscle-adipose-brain. Future studies should consider investigating the role of RE intervention on muscle mass (pleiotropic effects), adiposity (potent regulator of inflammatory response), and fast walking speed (a strong predictor of death risk-related) in acute hospitalized older adults.

4.1.5 Conclusion

This meta-analysis suggests that RE intervention can increase muscular strength and power and improving functional capacity in acute hospitalized older adults. Moreover, acute hospitalized older patients undergoing RE intervention have strong protection against harmful effects.

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Declarations

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public, commercial, or not-for-profit sectors.

Conflicts of interest MASC, CMCF, ALS, PCS, GK, MI, ESC and CSP declare that they have no conflicts of interest relevant to the research, content, authorship and/or publication of this review.

Availability of data and materials The data and materials analyzed during the present study are available from corresponding author on reasonable request.

Code availability Not applicable.

Authors' contributions MASC and CSP contributed in planning. MASC, CMCF, ALS, PCS and GK conduct, data analysis, synthesis and reporting of the work. MASC, CMCF, ALS, PCS, GK and CSP contributed in data synthesis and revising of the work. MASC, CMCF and CSP contributed in data extraction. MI, ESC and CSP contributed in revising the work.

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Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

Open access Not applicable.

4.2 ARTIGO 2

Impact of Exercise Intervention-Based Changes on Physical Function Biomarkers in Older Adults After Hospital Discharge: A Systematic Review with Meta-Analysis of Randomized Clinical Trials

CARNEIRO, Marcelo AS et al. Impact of exercise intervention-based changes on physical function biomarkers in older adults after hospital discharge: A systematic review with meta-analysis of randomized clinical trials. **Ageing Research Reviews**, v. 80, p. 101673, 2022.

Resumo

Introdução: Essa revisão sistemática com meta-análise objetivou comparar as alterações causadas pelas intervenções com exercício com as provocadas pelo cuidado usual sobre biomarcadores de função física em idosos imediatamente após a alta hospitalar.

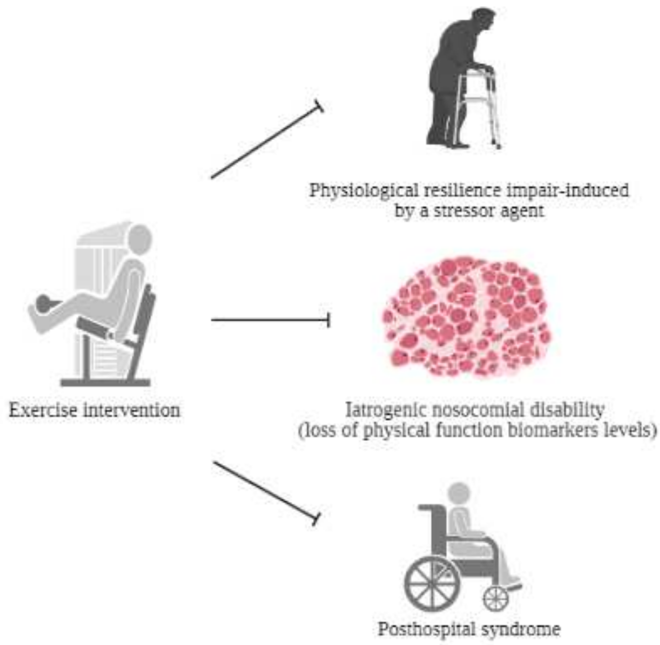
Métodos: Dois autores independentes realizaram uma busca sistemática (PubMed, Scopus, Web of Science e SciELO) dos estudos publicados nas bases de dados até Agosto de 2021. Estudos clínicos aleatorizados investigando os efeitos de intervenções com exercício comparadas com cuidado usual foram incluídos. Para avaliação do risco de viés, utilizou-se a ferramenta da Colaboração Cochrane (RoB1). Incluiu-se comparações de força de preensão manual de handgrip, *short physical performance battery*, teste de seis minutos e teste de 10-m de velocidade da marcha.

Resultados: De um modo geral, a intervenção com exercício leva a maiores mudanças significativas comparadas ao cuidado usual sobre os biomarcadores de função física (diferença média padronizada = 0,89; intervalo de confiança de 95% = 0,39 até 1,42; P = 0,001). Porém, considerando que poucos estudos investigaram cada variável separadamente, nossas sub-análises não revelaram efeitos estatisticamente significantes da intervenção com exercício sobre a força de preensão manual de handgrip, *short physical performance battery*, teste de seis minutos e teste de 10-m de velocidade da marcha.

Conclusões: Essa revisão sistemática com meta-análise de estudos clínicos aleatorizados sugere que intervenções com exercício após a alta hospitalar induzem maiores alterações sobre os biomarcadores de função física em idosos após a hospitalização do que o cuidado usual com orientação de atividade física. Futuros ensaios clínicos aleatorizados comparando os efeitos desses grupos de intervenções sobre os biomarcadores de função física nesta população são necessárias para confirmar nossos resultados.

Registro clínico: PROSPERO 2021 CRD42021275545

Palavras-chave: Envelhecimento, Hospitalização, Treinamento Resistido, Cuidado Usual, Desempenho Físico.



Graphical abstract. Potential mechanism involved in mitigating impairments in physiological resilience and declines in physical function biomarkers induced by exercise interventions in older adults after hospital discharge.

4.2.1 Introduction

Physiological resilience is a dynamic process in which the individual shows an ability to recover from an adverse effect caused by a stressor agent (RESNICK; GWYTHER; ROBERTO, 2011; WHITSON et al., 2016). With advanced age, many older adults demonstrate increasing exposure to different health conditions, such as respiratory, circulatory, neurological, and musculoskeletal diseases (CRUZ-JENTOFT et al., 2019; SHAW et al., 2010). Moreover, the adverse effects of these conditions on physiological resilience in older adults have dramatic and permanent impacts on physical function biomarkers (e.g., declines in muscle mass, muscular strength and power, and gait speed; impairments in balance and the capacity to stand from a seated position) (AARDEN et al., 2019; ANDREW et al., 2021; BODILSEN et al., 2016), independence (BOYD et al., 2005a, 2005b, 2008), and quality of life (HELVIK; ENGEDAL; SELBÆK, 2013a, 2013b, 2013c). In this regard, this vulnerability conferred by a stressor agent on physical function biomarkers has been associated with hospitalization and premature mortality in older adults (HADLEY; KUCHEL; NEWMAN, 2017; PAVASINI et al., 2016; STUDENSKI et al., 2011; YAZDANYAR et al., 2014).
During hospital-based care, hospitalization may be a friend or foe, since spending the majority of time in bed induces unloading and muscle disuse (e.g., atrophy), leading to hospitalization-associated disability (i.e., iatrogenic nosocomial disability) (COVINSKY; PIERLUISSI; JOHNSTON, 2011; LOYD et al., 2020). This process occurs because, during the hospital stay, older patients demonstrate lower levels of physical activity (BROWN et al., 2009; TASHEVA et al., 2020) and are often malnourished (e.g., low energy and protein intake) (SULLIVAN; SUN; WALLS, 1999; WEIJZEN et al., 2020).The combination of these stressor events can impair physiological resilience the time of discharge, whereby the individual cannot effectively mitigate the effects provoked by a stressor agent (BELL et al., 2015; WANG et al., 2019). This phenomenon is characterized as post-hospital syndrome (FRANKE, 2021), and indicates a period of increased vulnerability and a high risk of adverse events in older adults (KRUMHOLZ, 2013; QIAN et al., 2022). For instance, the hospitalization-induced catabolic state provokes severe loss of muscle mass, muscular strength, and power, mainly in older adults (BODINE et al., 2001).In addition, post-hospital syndrome impairs muscle mass, muscular strength and power, gait speed, and the capacity to stand from a seated position in older patients (BELL et al., 2015; KRUMHOLZ, 2013;

WANG et al., 2019). Indeed, the inability to recover muscle mass, muscular strength and power, and functional fitness following hospital discharge is an important predictor of hospital readmission (GREYSEN et al., 2015) and mortality in older patients (ÅHLUND et al., 2019). In this regard, combatting the deleterious effects caused by a hospitalization-induced catabolic state and post-hospital syndrome on physical function biomarkers has become a crucial issue in aging societies to prevent earlier death post-discharge (CRUZ-JENTOFT et al., 2019; SPILLMAN; LUBITZ, 2000). Therefore, we highlight the need for strategies to help older adults recover from the adverse effects caused by hospitalization so that they can regain physical function biomarkers during acute hospitalization and after hospital discharge.

Recent evidence supports the effectiveness of exercise interventions (5-7 days consecutively until discharge) as a safe alternative strategy to combat iatrogenic nosocomial disability in acutely hospitalized older adults (CARNEIRO et al., 2021; VALENZUELA et al., 2020), as well as inducing a lower risk of mortality (VALENZUELA et al., 2020), and functional improvements (VALENZUELA et al., 2020) three months post-discharge, compared to usual care. Nevertheless, it is reasonable to expect that older patients who do not receive an exercise intervention during the acute hospitalization period will present impairments in the ability to independently perform activities of daily living after hospital discharge (MARTÍNEZ-VELILLA et al., 2022; VALENZUELA et al., 2020).

In older patients who do not receive an exercise intervention during the acute hospitalization period, a continuous, individualized exercise plan can promote significant changes in muscular strength and functional fitness by mitigating the decreases in physiological resilience more than usual care after hospital discharge (CAMPO et al., 2020; ECKERT et al., 2021; LI et al., 2015; SUNDE et al., 2020; TIMONEN et al., 2002). Although the promising effect of an exercise intervention in combating the risk of mortality in acutely hospitalized older adults post-discharge has been suggested (VALENZUELA et al., 2020), to date, no meta-analytical studies have been conducted to evaluate the changes induced by exercise intervention versus usual care (control group) on physical function biomarkers in older adults after hospitalization. In addition, to the best of our knowledge, no meta-analytical study has aimed to summarize evidence on the effects of exercise interventions in older adults after hospitalization who do not receive this intervention during the acute hospitalization period. Therefore, this systematic review with meta-analysis aimed to compare the changes caused by exercise interventions with those provoked by usual care [randomized clinical trials (RCT)] on physical function biomarkers (i.e., muscle mass, muscular strength and power, and functional fitness) in older adults immediately after hospital discharge.

4.2.2 Methods

Data source and search strategy

This systematic review was performed following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (PAGE et al., 2021) registered on the International Prospective Register of Systematic Reviews (PROSPERO 2021 CRD42021275545). English language articles were retrieved by title and abstract from the earliest record up to August 2021 on PubMed/MEDLINE, Scopus, Web of Science, and SciELO by two independent authors (MASC and GOJ). The search strategy combined the following terms: ("Aged" OR "Older people" OR "Older adults") AND (“Post-hospitalization” OR “Post-hospitalized” OR "Post-hospital" OR "Post-hospitalization" OR "Post-hospitalized" OR “Post-hospital” OR “After hospitalization” OR “Hospital discharge” OR “Post-hospital discharge” OR “Post-hospital discharge” OR “Post-acute care” OR “Discharge from hospital”) AND (“Home-based rehabilitation” OR “Exercise rehabilitation” OR "Exercise therapy" OR “Physical rehabilitation” OR "Physical exercise" OR "Physical activity" OR "Exercise program" OR “Exercise training” OR "Exercise" OR “Training” OR “Aerobic exercise” OR “Resistance exercise” OR “Elastic band exercise” OR “Elastic band training” OR “Multicomponent exercise” OR “Nutrition therapy” OR “Nutritional status” OR “Nutrition support” OR “Nutritional supplementation” OR “Dietary supplements” OR “Protein enrichment” OR “Protein intake” OR “Creatine”) AND ("Muscle mass" OR “Fat-free mass” OR “Lean body mass” OR “Lean mass” OR “Fat and bone-free mass” OR “Fat and bone-free lean mass” OR “Lean soft mass” OR "Muscular strength" OR "Muscle strength" OR “Muscular power” OR "Muscle power" OR "Physical function" OR "Physical performance" OR “Physical fitness” OR "Functional capacity" OR "Functional performance" OR “Functional fitness” OR “Functionality” OR “Gait speed” OR “Walking speed” OR “Balance” OR “Mobility”). However, we found only one RCT involving protein supplementation without exercise (e.g., isolated nutrition intervention) compared to placebo on muscular strength in older adults after hospitalization, and no RCTs involving muscular power assessments according to the purpose of the present study. Hence, these studies were not included in the current systematic review and meta-analysis. In addition, the grey literature (e.g., abstracts, conference papers, and editorials) was excluded. A third reviewer evaluated the article (PCS) in case of disagreements.

Study selection

Two independent authors (MASC and GOJ) performed the systematic search and completed the study selection. The eligibility criteria were determined according to PICOS (Population, Intervention, Comparators, Outcome, and Study design). RCTs in older adults (defined as age ≥ 65 years) (WORLD HEALTH ORGANIZATION, 2017) were examined, comparing exercise, without a nutritional intervention, with a control group (usual care) who did not receive the intervention during the acute hospitalization period, after hospital discharge, which reported muscular strength and power, muscle mass, and functional fitness assessments. In this case, the usual care was composed of physical activity guidance (e.g., walking, stretching, or health education) to mitigate iatrogenic nosocomial disability (CAMPO et al., 2020; ECKERT et al., 2021; LI et al., 2015; SUNDE et al., 2020; TIMONEN et al., 2002). Initially, the publications were retrieved and screened by title and abstract. After exclusion of duplicate publications, the identified articles were included in the review if they met the following criteria: (a) RCT study; (b) older adults, after hospitalization, undergoing acute medical illness; (c) exercise without nutritional intervention performed immediately after hospital discharge compared to usual care; (d) measurements of handgrip strength, one-repetition maximum test (1-RM test), isokinetic dynamometer strength, timed up and go test (TUG), Short-Physical Performance Battery (SPPB), and other physical performance batteries (e.g., senior fitness test), gait speed [10 m gait speed and six minutes walking test (6MWT)], Katz index, Barthel index, and Lawton index. Studies were excluded according to the following exclusion criteria: (a) intervention using structured and not structured exercise during hospitalization; (b) use of nutritional supplementation during hospitalization; (c) absence of information on the type of intervention used during the study; (d) absence of information on the evaluations of the studied outcomes; (e) usual care using structured exercise after hospital discharge. The agreement between MASC and GOJ presented a kappa result = 0.81, $P < 0.001$. Any disagreements were discussed with a third author (PCS).

Data extraction and quality assessments

The quality of the included studies was performed using the 'risk of bias' assessment tool of the Cochrane Collaboration. The quality was assessed according through evaluation of selection bias, performance bias, detection bias, attrition bias, reporting bias, and other biases, classified as high (red color), low (green color), or unclear (yellow color) risk of bias (HIGGINS et al., 2011). Quality assessments of both reviewers were compared, and disagreements in the scores were resolved by discussion. Two authors (MASC, GOJ) independently extracted the following data from each study for analysis: author/year, the number of participants within each group, baseline participants' characteristics, intervention details, and pre-and post-data from all outcomes. When standard deviations were not available, these values were calculated using traditional statistical methods, assuming a correlation of 0.50 between the baseline and post-intervention scores within each subject (FOLLMANN et al., 1992).

Data syntheses and analyses

A meta-analysis was conducted using Review Manager Software (RevMan software package version 5.4). RevMan was used to calculate the effect size of the exercise intervention on handgrip strength, SPPB scale, 6MWT, and 10 m gait speed in older adults following hospitalization. The variation (post-intervention minus pre-moment) from all included studies was used to calculate the standard mean difference **(Table 2)** or mean difference **(Fig. 3)** and 95% confidence interval (CI), and consequently, the DerSimonian-Laird random-effects inverse variance model was conducted for all outcomes (HEDGES; OLKIN, 1985; HIGGINS et al., 2021). Weighted percentages were based on the sample sizes of the respective studies. Statistical significance was assumed as $P < 0.05$ in a Z test analysis to examine whether the effect size differed significantly from zero. Study heterogeneity was evaluated using the I^2 statistic and Cochrane's Q. Values of I^2 higher than 50 and 75% were considered moderate and high heterogeneity. For Cochrane's Q, significant heterogeneity exists when the Q value exceeds the degrees of freedom of the estimate. Moreover, publication bias was tested visually using a funnel plot. Effect sizes were calculated, with values of 0.00 – 0.19 considered trivial, 0.20 – 0.49 small, 0.50 – 0.79 moderate, and > 0.80 large. Sensitivity analyses were performed by excluding one trial at a time according to the risk of bias to test the robustness of the pooled results. Forest plots were generated to illustrate the between study-level effect sizes and 95% CI (HIGGINS et al., 2003).

4.2.3 Results

Selection and quality assessment of the studies

The selection processes retrieved 1,694 full texts, as documented in the PRISMA flow diagram **(Fig. 1)**. After excluding abstracts, conference papers, editorials, duplicated reviews, and meta-analyses, 1,113 studies were assessed according to the PICOS eligibility criteria. Subsequently, 1,108 studies were excluded for not meeting the inclusion criteria. Therefore, five RCTs were included in the qualitative and quantitative synthesis; two investigations with handgrip strength data, two studies with SPPB scale data, two studies with 6MWT, and two studies with 10 m gait speed data. Moreover, all studies included in both the qualitative and quantitative synthesis present a low risk of bias **(Fig. 2)**.

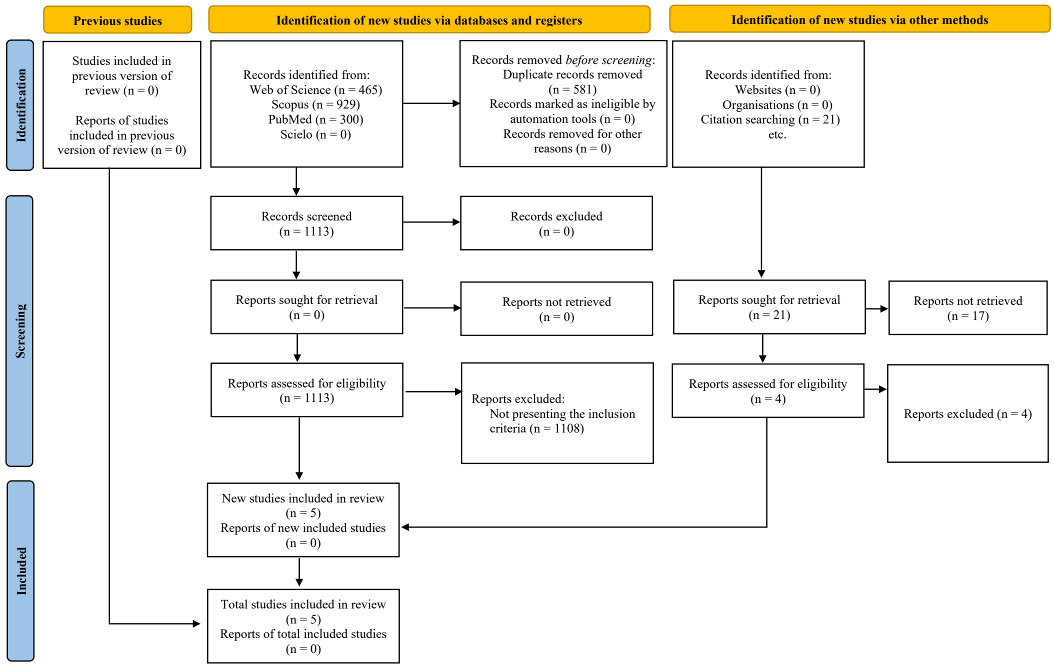


Fig. 1. PRISMA flow diagram of the study selection process.

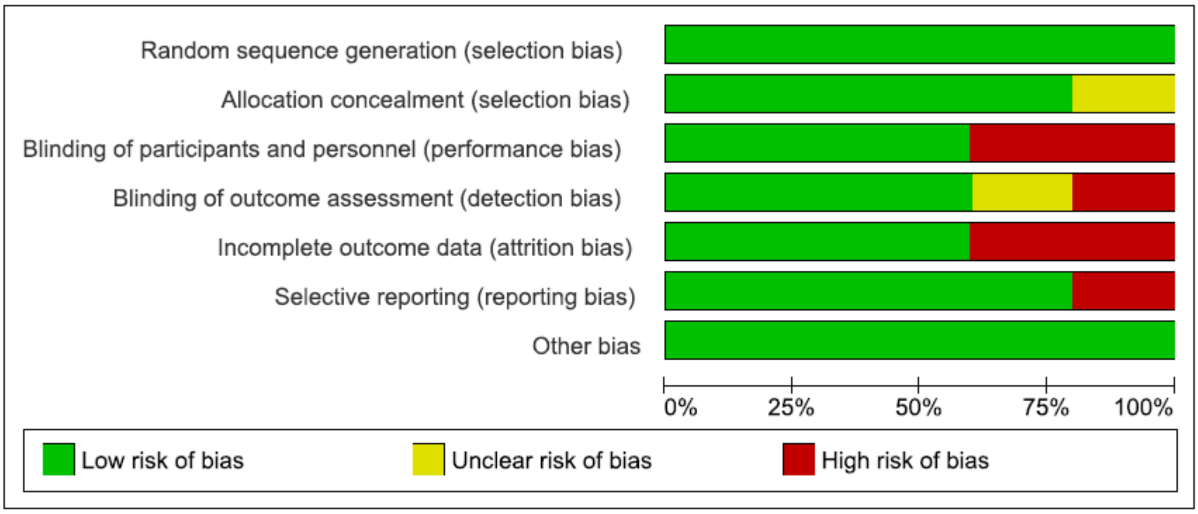


Fig. 2. Risk of bias summary.

Characteristics of the participants

The characteristics of the study participants included in the systematic review with meta-analysis are presented in **Table 1**. A total of 981 male and female patients aged 65 to 90 years, with different medical conditions (e.g., respiratory, circulatory, neurological, genitourinary, mental, behavioral, and musculoskeletal conditions) were included in the analysis. However, one study (TIMONEN et al., 2002) did not report the disease condition in the patients. The participants of four RCTs presented low physical function (according to scores obtained by the functional fitness assessment) (CAMPO et al., 2020; ECKERT et al., 2021; LI et al., 2015; TIMONEN et al., 2002), while the patients of one RCT did not demonstrate low physical function (SUNDE et al., 2020). Regarding adverse effects (i.e., signs or symptoms and death), one trial reported the deaths of participants during the study (i.e., cardiac problems or all-cause death) (CAMPO et al., 2020), and four trials reported that no patients had to interrupt the intervention (ECKERT et al., 2021; LI et al., 2015; SUNDE et al., 2020; TIMONEN et al., 2002).

Characteristics of the interventions

Two RCTs provided guidance to practice aerobic exercise (CAMPO et al., 2020; LI et al., 2015), in accordance with the recommendations for physical activity in older people (WORLD HEALTH ORGANIZATION, 2017),one RCT provided guidance on practicing unspecific flexibility training (ECKERT et al., 2021), and two RCTs provided guidance on practicing functional exercises using body weight as resistance (home-based exercise) (SUNDE et al., 2020; TIMONEN et al., 2002).

In the exercise intervention group, two RCTs were performed with supervision of the training (SUNDE et al., 2020; TIMONEN et al., 2002), whereas three RCTs had no supervision (CAMPO et al., 2020; ECKERT et al., 2021; LI et al., 2015).In addition, two RCTs were performed with progressive resistance exercise interventions involving the use of specific equipment (i.e., machine or external load) (CAMPO et al., 2020; TIMONEN et al., 2002), and three RCTs were composed of home-based exercises using body weight as external resistance (ECKERT et al., 2021; LI et al., 2015; SUNDE et al., 2020) **(Table 1)**. The intervention with exercises was performed 2-7 days per week (once per day) for 10 to 20 weeks.

Table 1. Study characteristics included in the systematic review and meta-analysis.

Study (country)	Sample	Protocol intervention	Physical function biomarkers	Main outcomes
Campo et al. 2020 (Italy)	UC: n = 118 patients (28 female) EX: n = 117 patients (26 female) Mean age: ~76 y (≥ 70 y) Diseases: neurological, cardiovascular, metabolic, and pulmonary diseases Patients with low physical function	UC: An investigator explained the importance of perform aerobic physical activity (30–60 min daily, moderate intensity, e.g., brisk gait, for at least 3 days per week during 20 weeks) EX: 20 weeks of unsupervised lower-limbs progressive and individualized strength and balance exercises (with weights on the ankles) performed during ~20 min, three days per week. In addition, patients received a gait program to perform at home	**Muscular strength assessment:** Handgrip strength **Functional fitness assessment:** 10m gait speed	UC: ↔ Handgrip strength, ↔ 10m gait speed EX: ↑ Handgrip strength, ↑ 10m gait speed
Eckert et al.	UC: 55 patients (42 female) EX: 63 patients (48 female)	UC: Unspecific flexibility training in a sitting position and were also supervised by the study staff within five home visits and weekly phone	**Functional fitness assessment:** SPPB scale	UC: ↔ SPPB scale EX: ↑ SPPB scale

2021 (Germany)	Mean age: ~82 y (≥ 65 y) Diseases: multi-morbidity in terms of the number of diseases Patients with low physical function	calls but did not receive motivational support and individually tailored training EX: 12 weeks of unsupervised daily home-based individually tailored physical training, including balance, strength, and gait. However, five home visits and weekly phone calls were administered by graduated sport scientists (master's degree or equivalent) to provide ongoing support during intervention		
Li et al. 2015 (China)	UC: 29 patients (9 female) EX: 32 patients (5 female) Mean age: ~81 y (≥ 75 y) Diseases: cardiovascular Patients with low physical function	UC: Standard health education (orientation) regarding physical activity normally provided to all patients hospitalized before discharge EX: 12 weeks of unsupervised home-based exercise rehabilitation program performed 5 days per week. The protocol is composed of	**Functional fitness assessment:** 6MWT, 30 s STS	UC: ↔ 6MWT, ↔ 30 s STS EX: ↑ 6MWT, ↑ 30 s STS

		14-type joint exercises performed 2-4 sets with 8 repetitions. These exercises took 10 minutes to complete and were made into a video as an aid for home practice. In addition, the participants performed 20-30 min of gait		
Sunde et al. 2020 (Norway)	UC: 44 patients (26 female) EX: 44 patients (17 female) Mean age: ~78 y (≥ 65 y) Diseases: mental, behavioral, neurological, circulatory, pulmonary, musculoskeletal, genitourinary, and other diseases Patients without low physical function	UC: Unsupervised home-based exercise program (using body weight as resistance), and participants were encouraged to perform exercise according to World Health Organization recommendations for physical activity in older people EX: Supervised home-based exercise program using 2 sets of 8-12 repetition maximum of two strength exercises (using body weight as resistance) for the lower-limbs with self-paced intensity	**Muscular strength assessment:** Handgrip strength **Functional fitness assessment:** SPPB scale, 6MWT	UC: ↔ Handgrip strength, ↔ SPPB scale, ↔ 6MWT EX: ↔ Handgrip strength, ↔ SPPB scale, ↑ 6MWT

		(however, the participants were encouraged to exercise progressively), and six balance exercises and to trunk rotation (performed near the limits of maintaining postural stability), at least 3 days per week during 16 weeks.		
Timonen et al. 2002 (Finland)	UC: 34 patients (34 female) EX: 34 patients (34 female) Mean age: ~83 y (≥ 75 y) Diseases: did not report Patients with low physical function	UC: Unsupervised a home exercise program performed 2 to 3 times per week with 2 sets of 15 repetitions of ~5 functional exercises. No further encouragement to exercise was given to the control subjects. EX: Supervised resistance exercise for knee extension, knee flexion, and hip abduction was performed. The loads were gradually increased to the point where the participant could accomplish only 8–10 repetitions in 2 sets. To maintain the relative	**Functional fitness assessment:** 10m gait speed	UC: ↓ 10m gait speed EX: ↑ 10m gait speed

intensity of the stimulus, weight loads were further increased as muscular strength increased. In addition, 2 sets of 15 repetitions of ~5 functional exercises were performed during 10 weeks.

Notes: UC = usual care, EX = exercise intervention, SPPB: short physical performance battery, 6MWT: six minutes walking test.

Physical function biomarkers

Overall, the exercise intervention demonstrated a more significant effect compared to usual care for muscular strength and functional abilities included in the meta-analysis [standard mean difference = 0.89 (0.39, 1.42), heterogeneity: *P* < 0.0001, I^2 = 93%, overall effect: *P* = 0.001] **(Table 2)**.

Table 2. Meta-analysis performed on the effects of exercise intervention compared to usual care including physical activity advise on muscular strength and functional abilities in post hospitalized older adults.

Physical function biomarkers	k	SMD (95% CI)	I^2	*P*
Handgrip strength (kg)	2	0.44 (-0.24, 1.12)	87%	0.200
SSPB scale (points)	2	0.53 (-0.16, 1.22)	83%	0.140
6MWT (m)	2	0.20 (-0.12; 0.53)	0%	0.210
10 m gait speed (s)	2	2.79 (-0.45, 6.03)	98%	0.090
Test for overall effect	8	0.89 (0.36, 1.42)	93%	0.001*

Note: Calculation based on random effects model. Results are expressed as standard mean difference (SMD) and 95% confidence intervals (95% CI). k = number of studies included in effect; I^2 = heterogeneity; SPPB = short physical performance battery; 6MWT = six minutes walking test; kg = kilogram; m = meters; s = seconds. * (*P* < 0.05 in favor to exercise intervention compared to usual care including physical activity advise).

When considering the outcomes separately, two RCTs (CAMPO et al., 2020; SUNDE et al., 2020) assessed endpoints related to muscular strength using handgrip strength **(Fig. 3A)**. The exercise intervention did not promote superior changes compared to usual care in handgrip strength [mean difference = 2.45 kg, 95% CI (-0.95 to 5.86 kg), heterogeneity: *P* = 0.02, I^2 = 81%, overall effect: *P* = 0.16]. In addition, two RCTs (ECKERT et al., 2021; SUNDE et al., 2020) assessed endpoints related to the SPPB scale **(Fig. 3B)**, two RCTs (LI et al., 2015; SUNDE et al., 2020) assessed the 6MWT **(Fig. 3C)**, and two RCTs (CAMPO et al., 2020; TIMONEN et al., 2002) assessed the 10 m gait speed **(Fig. 3D)**. Overall, the exercise intervention did not lead to improvements in the SPPB scale [mean difference = 0.87 points (-0.20, 1.95 points), heterogeneity: *P* = 0.02, I^2 = 81%, overall effect: *P* = 0.11], 6MWT [mean difference = 11.30 m (-9.28, 31.87 m), heterogeneity: *P* = 0.41, I^2 = 0%, overall effect: *P* = 0.28], and 10 m gait speed [mean difference = 0.58 s (-0.15, 1.30 s), heterogeneity: *P* < 0.001, I^2 = 99%, overall effect: *P* = 0.12] compared to usual care.

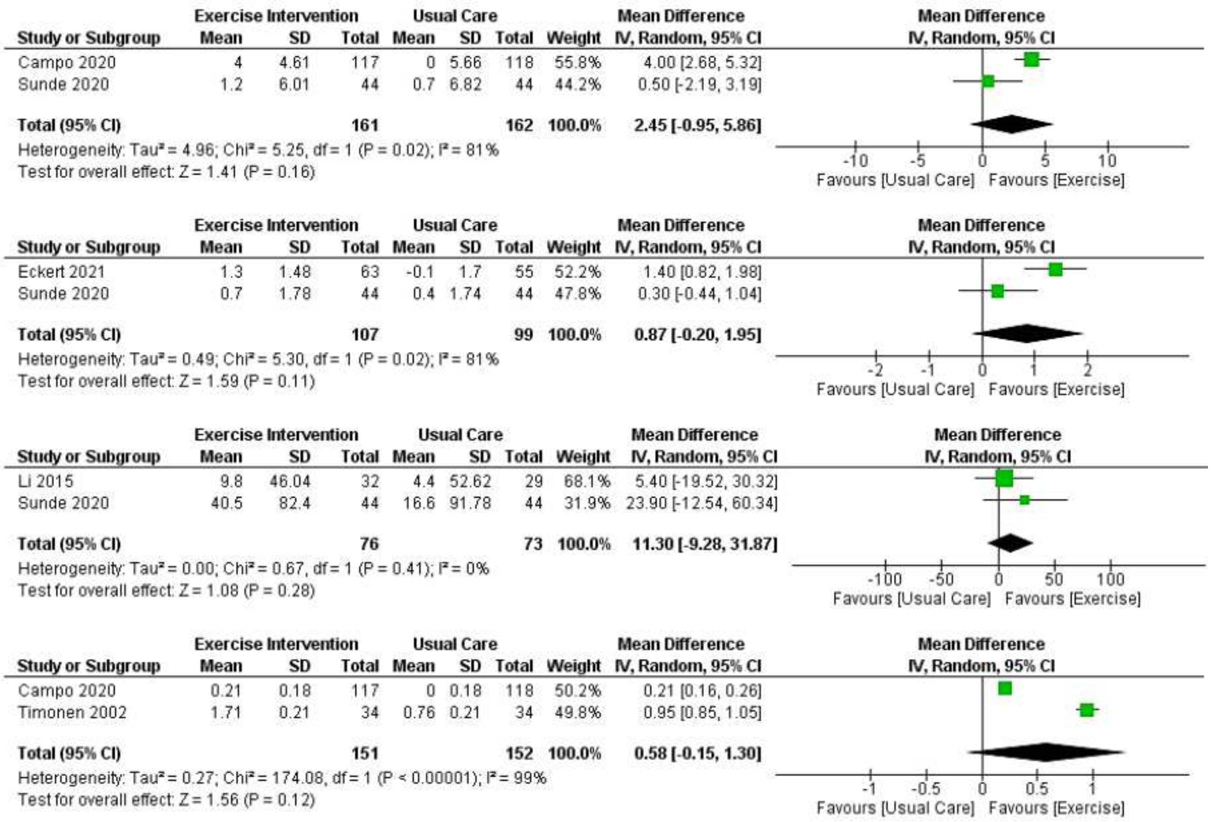


Fig. 3. Meta-analysis performed on the effects of exercise interventions compared usual care including physical activity guidance on handgrip strength (Fig. 3A), short physical performance battery (Fig. 3B), six minutes walking test (Fig. 3C), and 10 m gait test (Fig. 3D) in older adults after hospitalization. Notes: Calculation based on a random-effects model. Results are expressed as mean difference and 95% confidence intervals (95% CI). I^2 = heterogeneity.

4.2.4 Discussion

Main findings

To the best of our knowledge, this study is the first to summarize the evidence comparing exercise interventions to usual care as they relate to physical function biomarkers in older adults after hospitalization, who did not receive this intervention during the acute hospitalization period. The main finding of this study was that the exercise intervention improves muscular strength and functional abilities compared to usual care, including physical activity guidance (using aerobic, flexibility, or home-based exercises). However, considering the very few studies investigating each variable separately, our sub-analyses did not reveal a significant effect of the exercise intervention on handgrip strength, the SPPB scale, 6MWT, and 10m gait speed compared to usual care in older adults immediately after hospital discharge. In addition, the participants in both the intervention and control groups reported few signs or symptoms of adverse effects and had low dropout rates during the study. Thus, collectively, despite the positive adaptations induced by both treatments in the variables analyzed in this meta-analysis of randomized clinical trials, our results suggest that the exercise intervention improves muscular strength and functional abilities compared to usual care in older adults after hospital discharge.

Muscular strength biomarkers

Loss of muscular strength is a critical consequence of the hospitalization-induced catabolic state, independent of age (BODINE et al., 2001a). Moreover, depending on the catabolic severity induced by hospitalization, this condition may lead to the development of infectious diseases (CONWAY et al., 2020; WESCH; KIRKIN; ROGOV, 2020).Hence, combatting the deleterious effects caused by the hospitalization-induced catabolic state, including loss of muscular strength, has become a crucial issue in aging societies (SPILLMAN; LUBITZ, 2000). In the present study, our overall results indicate higher changes induced by exercise interventions compared to usual care on muscular strength in older adults after hospitalization (Table 2). In this regard, classical evidence on resistance exercise interventions in older people with physical frailty (high risk of falling, and consequently, acute hospitalization) advocates in favor of progressive resistance training as an effective method to improve muscular strength when compared to a control group (FIATARONE et al., 1994). In the current study, three RCTs (60% of studies) were performed with progressive load intensity during resistance exercise interventions. Indeed, the load intensity must be progressively increased to induce additional gains in muscular strength after resistance exercise interventions in older adults (GARBER et al., 2011). Our results corroborated the classical evidence (FIATARONE et al., 1994) regarding the role of progressive load intensity during resistance exercise interventions in improving muscular strength and functional fitness in older adults. Thus, our findings suggest that the decline in muscular strength and consequent hospitalization-related changes in physiological resilience might be reversed by an exercise intervention compared to usual care that includes physical activity guidance in older adults immediately after hospital discharge. Notwithstanding, it should be mentioned that, although no statistical difference was observed between exercise interventions and usual care in our sub-analysis (as very few studies investigated this variable separately) **(Fig. 3A)**, the mean difference was 2.4 kg, which is more than double the value considered as a clinically relevant change (i.e., 1 kg).

SPPB scale

Improved scores on the SPPB scale may blunt the negative consequences caused by the acute hospitalization period in older adults (CARNEIRO et al., 2021b; VALENZUELA et al., 2020). However, evidence reporting favorable effects on the SPPB scale after an exercise plan in older adults post-hospitalization is limited (VALENZUELA et al., 2020). Moreover, post-hospital syndrome impairs physiological resilience to recover physical function in older patients (BELL et al., 2015; KRUMHOLZ, 2013; WANG et al., 2019). Accordingly, the overall results of the current study showed superior changes induced by exercise interventions compared to usual care, when considering the SPPB scale, in older adults after hospitalization. Although substantial deficits in physical function biomarkers are related to adverse outcomes after hospital discharge (HADLEY; KUCHEL; NEWMAN, 2017),little is known regarding the physiological resilience needed to recover physical function in older adults after hospitalization, who did not receive this intervention during the acute hospitalization period. Meanwhile, a recent meta-analysis from our lab suggested that a resistance exercise intervention can improve results of the SPPB scale in older adults during the acute hospitalization period (CARNEIRO et al., 2021b). In addition, other exercise intervention models have been demonstrated to improve physical function biomarkers in acutely hospitalized older adults (VALENZUELA et al., 2020). Collectively, these findings might suggest that, in older adults who did not receive an exercise intervention during acute hospitalization, the exercise intervention also provoked favorable SPPB scale changes. Therefore, although no statistical difference was observed between the treatments in our sub-analysis (as very few studies investigated this biomarker separately), our findings suggest that exercise interventions might aid in avoiding functional fitness declines in older adults after hospitalization, compared to usual care, including physical activity guidance.

Gait speed biomarkers

Gait speed, an objective measure of whole-body function related to locomotion, declines with aging (CHUNG; DEMIRIS; THOMPSON, 2015; CRUZ-JENTOFT et al., 2019; SIMONSICK et al., 2008). In addition, the decline in gait speed in older adults is widely recognized as an essential factor contributing to a longer hospital stay and earlier death post-discharge (CRUZ-JENTOFT et al., 2019).Thus, intervention strategies to improve gait speed in older adults after hospitalization are required. In the overall analysis of the present study, the exercise intervention showed greater improvements in long and short gait speed tests (6MWT and 10 m gait speed, respectively) compared to usual care, including physical activity guidance in older adults after hospital discharge. In this regard, a study with a resistance exercise intervention in older women suggested that a greater volume (i.e., six sets per exercise per session of training) promotes superior improvements in gait speed compared to lower volume (i.e., three or fewer sets per exercise per session of training) (NUNES et al., 2017). Accordingly, two RCTs included in our study reported that 10-m gait speed (short test) was performed with lower resistance exercise volume during the intervention (CAMPO et al., 2020; TIMONEN et al., 2002), whereas the 6MWT (long test) was measured in two RCTs using an exercise intervention with lower volume (LI et al., 2015; SUNDE et al., 2020). These findings indicate that a low exercise volume may not be sufficient as an intervention strategy for improving gait speed in older women. Taken together, these findings indicate that a low exercise volume may not be sufficient as an intervention strategy for provoking improvements in gait speed in older women, whereas in older adults immediately after hospital discharge it seems to be sufficient to provoke favorable changes in gait speed. Thus, the present meta-analysis results suggest that the exercise intervention presents positive effects on gait speed compared to usual care in older adults after hospital discharge, independent of long or short gait speed tests. Moreover, as gait speed is a strong biomarker of severe sarcopenia (a muscle-skeletal disease that can lead to death) (CRUZ-JENTOFT et al., 2019), the change of ~0.6 m/s in this outcome can also mitigate the physical phenotype of frailty induced by an acute hospitalization period in older patients post-discharge (Kwon et al., 2009; Perera et al., 2006) **(Fig. 3D)**.

Limitations and strengths

Although some RCTs included in our study showed an improvement in physical function biomarkers in older adults after hospital discharge, who did not receive this intervention during the acute hospitalization period, when analyzed separately in the meta-analysis according to the dependent variable, they demonstrated no additional gains (i.e., maintenance) in muscular strength and functional abilities, independent of the exercise intervention or usual care, which included physical activity guidance (with aerobic, flexibility, or home-based exercises). On the other hand, the exercise intervention demonstrated superior changes compared to usual care when analyzed by combining all dependent variables in the model. However, some limitations must be recognized. One aspect that should not be overlooked is the small number of studies (two RCTs for each dependent variable) included in the analysis, which corroborated to the performance of the meta-analysis using all variables in the model **(Table 2)**. Moreover, 40% of the RCTs included in our study investigated the effect of an unsupervised exercise intervention in older adults immediately after hospital discharge. In addition, most studies in this meta-analysis presented a low risk of bias due to a robust methodological approach. However, caution should be taken with the general interpretation of the results because the included studies presented moderate to high heterogeneity. On the other hand, a strong point of this meta-analysis is its pioneering approach in comparing the effects of the exercise intervention to usual care on physical function biomarkers in older adults after the hospitalization period, and most patients completed the intervention with high adherence. Although this study is the first to summarize evidence comparing the exercise intervention to usual care as they relate to physical function biomarkers in older adults after hospital discharge, who did not receive this intervention during the acute hospitalization period, further RCTs are needed in this population, comparing the effects of these intervention groups on muscular strength, gait speed, balance, and capacity to stand from a seated position, in order to confirm our results.

Future perspectives

Older patients after hospital discharge undergoing exercise interventions, who did not receive this intervention during the acute hospitalization period, might gain significant protection against harmful effects associated with functional fitness declines and physical dependence. However, some perspectives should be suggested. For instance, RCTs involving resistance exercise in older adults after the hospitalization period on muscular strength and functional fitness changes (strong predictors of premature death) should prioritize the manipulation of training variables (i.e., load intensity, volume, movement velocity, type of exercise intervention) during the intervention to ensure optimized adaptive responses after the training period. Furthermore, supervision of the exercise intervention is an essential factor in promoting greater physical function biomarkers effects in older adults, independent of resistance, aerobic, or home-based exercise.

The acute hospitalization condition may be a friend or foe during hospital-based care because, during the hospital stay, older patients demonstrate lower levels of physical activity (BROWN et al., 2009; TASHEVA et al., 2020) and are often malnourished (SULLIVAN; SUN; WALLS, 1999; WEIJZEN et al., 2020). These factors provoked by acute hospitalization can lead to an iatrogenic nosocomial disability (COVINSKY; PIERLUISSI; JOHNSTON, 2011; LOYD et al., 2020). According to recent meta-analytical studies in acute hospitalized older adults (CARNEIRO et al., 2021b; VALENZUELA et al., 2020), the effects of the exercise intervention on muscular strength and functional abilities are superior when compared to usual care. On the other hand, impairments in physiological resilience caused by an acute hospitalization period can generate difficulty in recovering muscular strength and functional abilities immediately after hospital discharge (GREYSEN et al., 2015; KRUMHOLZ, 2013).

Therefore, the present systematic review with meta-analysis suggests that an exercise intervention immediately applied after the hospitalization period is paramount to enhancing physical function biomarkers in older adults who did not receive this type of intervention during the hospital stay.

4.2.5 Conclusions

This systematic review with meta-analysis of randomized clinical trials suggests that exercise interventions after hospital discharge induce greater improvements in physical function biomarkers in older adults than usual care, including physical activity guidance.

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Declarations of Competing Interest

None.

4.3 ARTIGO 3

Resilience capacity in older women engaged in resistance training: effects of two years of training cessation and short-term retraining on health biomarkers and muscle function

Resumo

Proposta: O impacto de dois anos de interrupção do treinamento resistido causado pela pandemia de COVID-19 não foram elucidados até o presente momento. Assim, estratégias para reverter os prejuízos acumulados nesse período para a saúde, autonomia e qualidade de vida de idosos são necessárias. **Objetivos:** Analisar o efeito de dois anos de interrupção do treinamento sobre a composição corporal, força muscular, perfil metabólico e desempenho físico em mulheres idosas engajadas em um programa de treinamento resistido. Adicionalmente, para investigar a capacidade de resiliência, comparamos as mudanças provocadas por 12 semanas de retreinamento com as mudanças alcançadas após as primeiras 12 semanas de treinamento. **Métodos:** Sessenta e sete idosas fisicamente independentes foram submetidas a um programa de treinamento resistido de corpo inteiro durante 24 semanas (8–12 repetições, oito exercícios, três séries), em três sessões semanais, em dias não consecutivos. Em virtude da pandemia de COVID-19 as participantes foram destreinadas por dois anos. Na sequência, 12 semanas de treinamento resistido foram executadas para a análise do impacto do retreinamento. A composição corporal (absortometria radiológica de dupla energia), força muscular (testes de 1RM), perfil metabólico (concentrações de lipídeos sanguíneos) e aptidão funcional (testes motores) foram medidas nas diferentes etapas do estudo. **Resultados:** Dois anos de destreinamento provocou declínio da massa muscular esquelética e da massa isenta de gordura e osso apendicular, redução da força muscular, piora do perfil metabólico e da aptidão funcional quando comparado a condição antes pré-pandemia de COVID-19 ($P < 0{,}05$). Além disso, um período curto de retreinamento após um longo período de destreino não foi suficiente para recuperar a condição alcançada nas primeiras 12 semanas de treinamento. **Conclusões:** Nosso estudo sugere que dois anos de destreinamento provoca prejuízos nos biomarcadores de saúde e função muscular que podem não ser recuperados totalmente após um período curto de retreinamento, indicando baixa capacidade de resiliência devido a menores mudanças provocadas por 12 semanas de retreinamento comparado as primeiras 12 semanas de intervenção sobre a massa muscular esquelética, massa isenta de gordura e osso apendicular, força muscular, perfil metabólico e aptidão funcional em mulheres idosas fisicamente independentes.

Palavras-chave: desempenho físico, força muscular, isolamento social, massa isenta de gordura e osso, treinamento de força.

4.3.1 Introduction

Resistance training (RT) has been widely recommended for older women as a safe, nonpharmacological, and well-accepted strategy to mitigate the detrimental effects of aging/menopause on body composition, muscular strength, metabolic biomarkers, and physical performance (CHODZKO-ZAJKO et al., 2009; FRAGALA et al., 2019; NUNES et al., 2023; RATAMESS et al., 2009). However, training cessation can induce a partial or total loss of acquired benefits (MUJIKA; PADILLA, 2000, 2001). The mechanical unloading caused by training cessation combined with muscle anabolic resistance induced by aging may lead to the impairment of health biomarkers and muscle function (BREEN; PHILLIPS, 2011; DE SOUZA TEIXEIRA et al., 2023; GRGIC, 2022; HVID et al., 2014; MACHADO et al., 2020; NUNES et al., 2022; PREOBRAZENSKI et al., 2023; TANNER et al., 2015; WALL; DIRKS; VAN LOON, 2013). Therefore, the effects of training cessation, especially in older adults, can be catastrophic, resulting in severe damage to health and quality of life (GRGIC, 2022; WALSTON et al., 2023).

In this regard, although the practice of RT is an effective intervention strategy to combat the deleterious effects of aging (CHODZKO-ZAJKO et al., 2009; FRAGALA et al., 2019; NUNES et al., 2023; RATAMESS et al., 2009), few studies have evaluated the impact of extended periods of training cessation such as the one imposed by the COVID-19 pandemic in older adults (ENCARNAÇÃO et al., 2022; GRGIC, 2022). Moreover, little is known about the effects of retraining in this population after two years of detraining (ARAGÃO-SANTOS et al., 2023).

To our knowledge, only one study investigated the effects of 28 months of training cessation imposed by the COVID-19 pandemic on older women. Aragão-Santos et al. (2023) reported that lean soft tissue was reduced, body adiposity increased, and impairments in physical performance after 28 months of detraining compared to the value post-16 weeks of training (ARAGÃO-SANTOS et al., 2023). However, this study did not investigate the role of short-term retraining in combating the deleterious effects of the 28 months of training cessation imposed by the COVID-19 pandemic. Therefore, little is known regarding the impact of two years of detraining and short-term retraining on metabolic health and muscle function.

Thus, this study analyzed the effects of two years of RT cessation caused by the COVID-19 pandemic on body composition, muscular strength, metabolic biomarkers, and physical performance in older women. In addition, to investigate resilience capacity, we compared the changes provoked by 12 weeks of retraining with the changes achieved by the first 12 weeks of training. We hypothesized that two years of training cessation would promote impairment of health biomarkers and muscle function and that the changes induced by 12 weeks of retraining are lower than those achieved with the first 12 weeks of training due to mechanical unloading caused by two years of detraining and muscle anabolic resistance induced by aging.

4.3.2 Methods

Study overview. The present study is part of the research project "Active Aging Longitudinal Study" initiated in 2012, whose purpose is to analyze the impact of supervised, structured, and progressive RT programs on neuromuscular, morphological, physiological, metabolic, cognitive, and behavioral outcomes in older women (CAVALCANTE et al., 2023; CUNHA et al., 2023; KASSIANO et al., 2022a). This study was conducted over 148 weeks. Body composition, muscular strength, physical performance, and metabolic biomarkers were analyzed in five moments (weeks 1-3, 16-18, 31-33, 131-133, and 146-148). A progressive RT program was performed over 24 weeks pre-COVID-19 pandemic (weeks 4-15 and 19-30), and two years of detraining imposed by the COVID-19 pandemic occurred between weeks 34-130. Finally, the participants performed 12 weeks of retraining (weeks 134 to 145). It is worth mentioning that participants were requested not to perform any physical exercise throughout the study, including during two years of detraining. During this period, the participants were contacted and encouraged to maintain their regular activities of daily living and not to change their nutritional habits. During the training and retraining, 16 fitness professionals supervised all training sessions (two fitness professionals per exercise). Moreover, all assessments and RT sessions were performed at the same time of the day to minimize the effects of daytime biological variation. In addition, all muscular strength, lean soft tissue, and functional tests were performed at least 72 h after the last training session. The experimental design is illustrated in Figure 1.

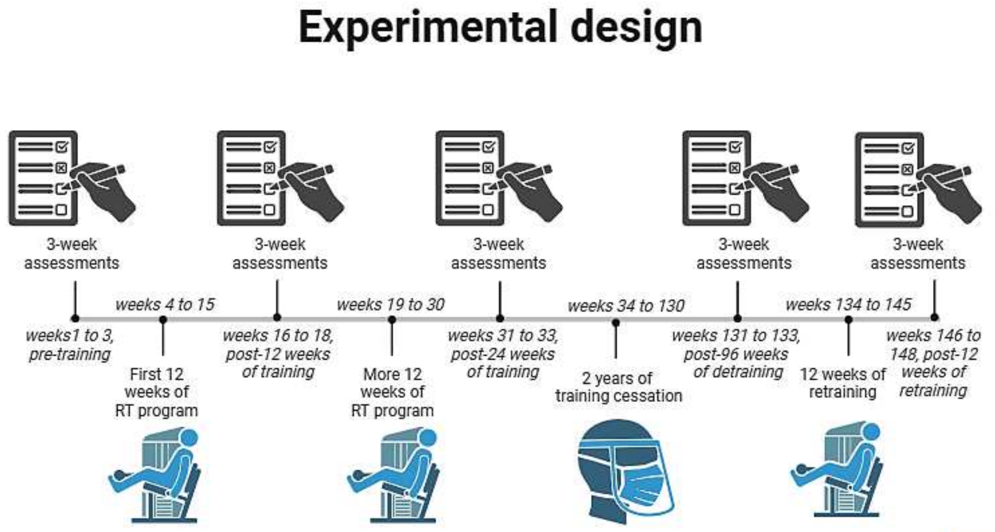

Figure 1. Study scheme.

Participants. All participants were recruited through social media and completed their health history using detailed anamnesis regarding age, labor situation, health indicators, history of past and present illnesses, therapeutic and physical activities, and met the following inclusion criteria: > 60 years; female; physically independent; had no cardiac, orthopedic, or musculoskeletal dysfunction that could impede physical exercise; not having uncontrolled diabetes mellitus or hypertension; not receiving hormonal replacement therapy; and not being involved in the practice of regular physical activity performed more than once a week over the three months before the start of the study. This study included participants only after passing a diagnostic graded exercise stress test with a 12-lead electrocardiogram reviewed by a cardiologist. After receiving a detailed description of the investigation procedures, the participants signed a written informed consent form. The local university Ethics Committee approved this study, which was conducted following the principles of the Declaration of Helsinki.

In addition, the levels of depressive and anxiety symptoms were assessed using two self-administered questionnaires: the 15-item Geriatric Depression Scale (YESAVAGE et al., 1982) and the Beck Anxiety Inventory, respectively (BECK et al., 1988). In addition, the levels of depressive and anxiety symptoms were assessed using two self-administered questionnaires: the 15-item Geriatric Depression Scale (YESAVAGE et al., 1982) and the Beck Anxiety Inventory, respectively (BECK et al., 1988). The Geriatric Depression Scale comprises 15 dichotomic items (yes or no) concerning different characteristics of geriatric depression, such as cognitive decline and somatic symptoms, with the final score ranging from 0 to 15. The Beck Anxiety Inventory comprises 21 items (statements) about different anxiety symptoms with a 4-point Likert scale, with the final score ranging from 0 to 63.

Anthropometry. Body mass was measured to the nearest 0.1 kg using a calibrated electronic scale (Balmak, model Class III, Labstore, Curitiba, PR, Brazil), and height was determined to the nearest 0.1 cm with a stadiometer attached to the scale. The participants used light workout clothing and no shoes for both measures. Body mass index (BMI) was calculated as body mass in kilograms divided by the square of the height in meters. Additionally, waist circumference was measured to indicate abdominal adiposity (BRAY; RYAN, 2000; ROSS; RISSANEN; HUDSON, 1996). It was assessed using inelastic tape, with three measurements taken for each participant, and the mean value was calculated. Waist circumference was measured midway between the lowest rib margin and the iliac crest in the anatomical position at the end of normal respiration. At the same time, participants stood erect, with arms hanging loosely at the sides and feet together.

Body composition. Lean soft tissue and android fat, an indicator of abdominal adiposity (NERI et al., 2020; TANNE; MEDALIE; GOLDBOURT, 2005; ZHANG et al., 2008), measurements were performed using dual-energy X-ray absorptiometry (DXA) scans in a Lunar Prodigy Advance device, model NRL 41990, (General Electric, Madison, WI, USA) to determine the appendicular lean soft tissue (ALST). Skeletal muscle mass (SMM) was estimated using the following equation: $SMM = (1.13 - ALST) - (0.02 - age) + 0.97$ (KIM et al., 2002). At the time of evaluation, the participants removed all metal objects, such as earrings, watches, chains, and bracelets, from their bodies before the exams started. Scans were performed with participants lying in a supine position. The feet were taped to the toes to immobilize the legs, and the hands were held in a prone position within the scanning region. Participants remained immobile throughout the scanning procedure. A qualified and experienced laboratory technician performed calibrations and analyses. The software generated standard lines that separated the head, trunk, and upper- and lower-limb segments. The same technician adjusted the lines using the anatomical points determined by the manufacturer. All analyses were performed by the same technician, who was blinded to the group identity of each participant. The standard error of measurement (SEM) and intraclass correlation coefficient (ICC) in our laboratory were calculated for upper limbs lean soft tissue (SEM = 0.1 kg; ICC = 0.99) and lower limbs lean soft tissue (SEM = 0.2 kg; ICC = 0.99).

Muscular strength. The maximal dynamic muscular strength was determined in three exercises using the 1RM test in the following order: chest press, leg extension, and preacher curl. All tests were standardized and supervised by experienced researchers to ensure proper technique, reliability, participant safety, and integrity. The participants performed a warm-up set (6–10 repetitions) with approximately 50% of the estimated weight used in the first attempt. The testing procedure was initiated 2 min after the warm-up. The participants attempted to perform two repetitions of the imposed weight. The weight was adjusted from 3% to 10% for the next attempt if the effort was successful (one or two repetitions were completed). In contrast, weight was removed in the same proportion if the effort was unsuccessful. The rest period between each attempt was 3–5 minutes. The 1RM was recorded in each testing session as the maximal lifted weight at which the participant could complete only one concentric and eccentric muscular action. Three 1RM sessions were performed, separated by 48 h, and the highest weight lifted in each exercise over the three sessions was used for analysis (DO NASCIMENTO et al., 2013). Verbal encouragement was provided in each test. The ICC from our laboratory for these tests was ≥ 0.96 with an SEM ≤ 2.0 kg.

Metabolic biomarkers. Venous blood samples were collected in tubes containing dipotassium ethylenediaminetetraacetic acid (12 mL, vacuum-sealed system; Vacutainer, England, UK) between 7:00 and 9:00 a.m. by a trained laboratory technician after an overnight fast of at least 12 h. The participants sat for 5 min before drawing 5 mL of blood from a prominent superficial vein in the antecubital space. All samples were centrifuged at 3,000 rpm for 15 min, and aliquots of plasma or serum were stored at −80°C until analysis. As determined in the human plasma, the variation between assay and within-assay coefficients was <10%. Serum levels of total cholesterol, high-density lipoprotein cholesterol (HDL-c), and triglycerides were determined using standard methods in a specialized laboratory at the University Hospital. Low-density lipoprotein cholesterol (LDL-c) was calculated using the following equation: LDLc = total cholesterol − (HDLc + triglycerides/5) (FRIEDEWALD; WT, 1972). Analyses were performed using a Dimension RxL Max biochemical autoanalyzer system (Siemens Dade Behring, Erlangen, Germany) according to methods established in the literature that were consistent with the manufacturer's protocol.

Functional tests. Two motor tests were performed to analyze the functional performance: timed-up-and-go (TUG) and 6-minute walk distance (6MWD). Both functional tests were performed on a flat floor around the sports court. For the TUG test, participants were seated on a chair (42 cm in height) supported by a wall, with their backs in contact with the backrest, feet fully supported on the floor, and hands resting on the thighs. The participants were asked to stand up, walk around a cone 3 m in front of the chair, return to the chair, and sit down. The participants were instructed to complete the path as quickly as possible without running. The time was recorded to the nearest 0.01 s with a stopwatch from the initial movement to rise from the chair until returning to sit down again. The participants completed two trials, with the best value recorded for analysis. Regarding the 6MWD, the walking course was 46 m (a rectangular path, 4.6 x 18.4 m) marked with cones on the floor. All participants were advised to walk as fast as possible with no interruptions and no running during the trial and stimulated (i.e., verbal stimulus, "you are doing great," "walk as fast as you can") during the walking tests. An evaluator timed the test time, counted the number of laps, and counted the total distance covered with an accuracy of 1 m. These functional tests have shown excellent test-retest reliability (BEAUDART et al., 2019).

Resistance training. The progressive RT program was performed three times a week (Mondays, Wednesdays, and Fridays) at the University fitness facility during the morning period. Sixteen fitness professionals personally supervised all participants throughout each training session to reduce deviations from the study protocol and to ensure proper technique and safety. The participants performed RT using a combination of free weights and machines. The RT protocol consisted of a whole-body program with eight exercises performed in the following order: chest press, horizontal leg press, seated row, leg extension, triceps pushdown, leg curl, preacher curl, and seated calf raise. The participants performed three sets of 8-12 repetitions during all training and retraining periods, including the first 12 weeks of intervention and short-term retraining. In addition, the participants were oriented to perform 12 repetitions (upper limit of repetitions) in all exercises during each set. They were instructed to inspire during the eccentric phase, exhale during the concentric phase, and maintain the movement velocity at a ratio of 1:2 (concentric and eccentric phases, respectively). The rest intervals were 1–2 minutes between sets and 2–3 minutes between exercises. The supervisors determined the weight of each exercise according to the participant's ability and improvement in exercise capacity throughout the study to ensure intensity maintenance. When participants completed the upper limit of repetitions in all sets for two consecutive sessions, the weight was increased by 2–5% for the upper limb exercises and 5–10% for the exercises of the lower limbs (RATAMESS et al., 2009). The total training volume (TTV) was calculated by multiplying the repetitions by the weight lifted in all sets in the eight exercises, including the three weekly sessions.

Dietary intake. The 24-hour dietary recall method was used to analyze food consumption. Two experienced dietitians conducted the assessments on three nonconsecutive days of the week in the RT's first and last two weeks, according to each moment of study. The dietitians provided specific instructions regarding recording portion sizes and quantities to estimate all food and fluid intake, including viewing food models to enhance portion estimation precision. Energy intake and carbohydrate, protein, and lipid dietary contents were calculated using the Virtual Nutri Plus software (Keeple®, Rio de Janeiro, RJ, Brazil). Food composition tables were used to add items not found in the program database. All participants were asked to maintain their eating habits throughout the study period.

Baseline contributors to resilience capacity. The Study of Physical Resilience of Aging was proposed to identify physiological and biological measures that affect the resilience capacity in older adults submitted to significant clinical and/or social stressors (WALSTON et al., 2023). According to Walston et al. (2023), physical resilience capacity may be affected by baseline characteristics. Thus, age, anxiety and depression symptoms (psychosocial aspects), BMI (an indicator of health), and medication intake (hypertension, diabetes, and/or dyslipidemia) may have an impact on health biomarkers and muscle function (WALSTON et al., 2023), which were controlled during the current study, including before and after the clinical stressor (the COVID-19 pandemic).

Statistical analyses. The one-way variance analysis (ANOVA) was used to compare the general characteristics of the variables at the baseline. On the other hand, the behavior of variables concerning time was analyzed by an intention-to-treat analysis using Generalized Estimating Equations (GEE), AR(1) working correlation matrix, and maximum likelihood estimation. The linear or gamma model was chosen based on model fit quality (QIC). When necessary, the low significance difference (LSD) post hoc was used. Moreover, baseline characteristics that may affect the resilience capacity (age, BMI, anxiety and depression symptoms, medication intake for hypertension, diabetes, and dyslipidemia) were categorized according to the median and inserted in the model as dummy variables. We used repeated measures of ANOVA to observe the effect of time on the TTV in weeks 1, 4, 8, 12, and 24 of training. Also, we performed repeated measures of ANOVA to analyze the effects of 1, 4, 8, and 12 of retraining on TTV. All values were described as means and Wald 95% confidence intervals (95% CI) or standard deviation. The significant level was set at $P < 0.05$.

4.3.3 Results

General characteristics and medication intake. Sixty-seven women participated in interview and completed initial screening through anamnesis (age = 68.7 ± 5.8 years; body mass = 68.6 ± 12.2 kg; height = 155.0 ± 6.4 cm; BMI = 28.5 ± 4.2 kg/m²; schooling = 7.5 ± 4.8 years; 58% of women used antihypertensive, 7% used antihyperglycemic, and 36% used cholesterol-lowering medication).

Total training volume. Figure 2 shows the changes in TTV between moments. When comparing week 1, week 4, and week 8 with week 12 or week 24 of training, the TTV increased (Δ% = +26.3, +11.9, and +4.5), respectively. After the retraining period, TTV was similar compared to the training period in the week-4 (Δ% = -2.4, $P > 0.05$), week-8 (Δ% = +1.1, $P > 0,05$), and week-12 (Δ% = +1.2, $P > 0.05$), except for week-1 (Δ% = -8.0, $P < 0.05$). In addition, the progression of TTV was similar between 12 weeks of retraining when compared to the first of 12 weeks of training, without difference between them ($P > 0.05$).

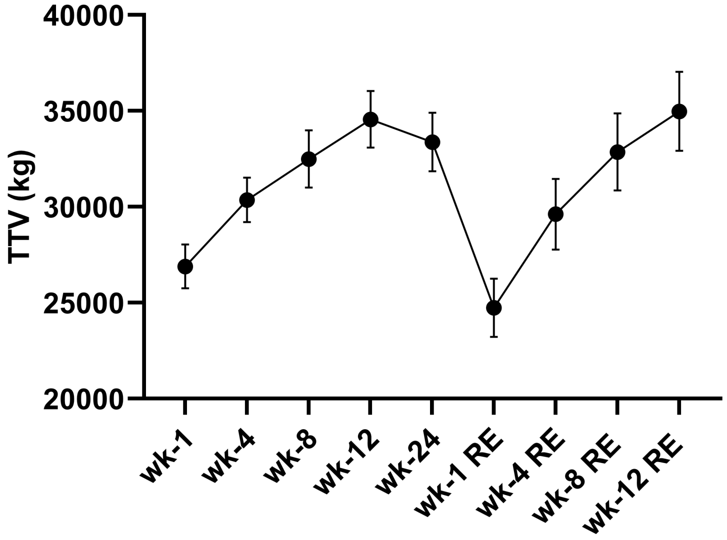

Figure 2. Total training volume between moments involving resistance training program. **Notes.** wk = week; RE = retraining.

Change Scores by two years of detraining compared to post-24 weeks of RT (before training cessation due to the COVID-19 pandemic)

Dietary intake. Table 1 shows the changes in energy total, carbohydrate, protein, and lipids between moments. When comparing the changes (Δ) provoked by two years of detraining with the changes (Δ) achieved by 24 weeks of training (before the COVID-19 pandemic), we observed lower carbohydrate intake [diff = -0.63 g/kg/d (95% CI: -0.99; -0.27), $P < 0.001$], indicating inferiority for the changes generated by detraining period (Table 1). Regarding energy total, protein, and lipid, we did not observe a difference between the changes provoked by two years of detraining compared to 24 weeks of training ($P > 0.05$).

Muscular strength. Table 2 shows the changes in chest press, leg extension, preacher curl, and total load lifted between moments. When comparing the changes (Δ) provoked by two years of detraining with the changes (Δ) achieved by 24 weeks of training, we observed lower muscular strength values at chest press [diff = -29.0 kg (95% CI: -31.4; -26.6, $P < 0.001$)], leg extension [diff = -15.3 kg (95% CI: -18.6; -12.0, $P < 0.001$)], preacher curl [diff = -5.7 kg (95% CI: -7.1; -4.3, $P < 0.001$)], and total lifted load [diff = -50.6 kg (95% CI: -55.6; -45.6, $P < 0.001$)], indicating inferiority for the changes provoked by detraining period (Table 2). Overall, two years of detraining demonstrated significantly reduce in muscular strength levels compared to 24 weeks of training (before COVID-19 pandemic), indicating impairment in chest press (post-two years of detraining = 34.3 kg vs. post-24 wk of training = 63.5 kg), leg extension (post- two years of detraining = 50.8 kg vs. post-24 wk of training = 66.1 kg), preacher curl (post- two years of detraining = 23.7 kg vs. post-24 wk of training = 29.5 kg), and total lifted load (post- two years of detraining = 108.9 kg vs. post-24 wk of training = 159.6 kg).

Body composition. Table 3 shows the changes in SMM, appendicular lean soft tissue, android fat, and waist circumference between moments. When comparing the changes (∆) provoked by two years of detraining with the changes (∆) achieved by 24 weeks of training, we observed lower SMM [diff = -0.87 kg (95% CI: -1.24; -0.51), $P < 0.001$] and ALST [diff = -0.74 kg (95% CI: -1.07; -0.42), $P < 0.001$], indicating inferiority for the changes provoked by detraining period (Table 3). Regarding android fat and waist circumference, we did not observe a difference between the changes achieved by 94 weeks of detraining compared to 24 weeks of training. Overall, two years of detraining demonstrated a significant reduction in muscle tissue compared to 24 weeks of training (before the COVID-19 pandemic), indicating impairment in SMM (post- two years of detraining = 19.14 kg vs. post-24 wk of training = 20.01 kg) and ALST (post-two years of detraining = 17.35 kg vs. post-24 wk of training = 18.09 kg).

Metabolic biomarkers. Table 4 shows the changes in total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and triglycerides between moments. When comparing the changes (∆) provoked by two years of detraining with the changes (∆) achieved by 24 weeks of training, we observed greater serum metabolic risk in total cholesterol concentrations [diff = +27.2 pg/mL (95% CI: 17.0; 37.5), $P < 0.001$], high-density lipoprotein cholesterol concentrations [diff = +4.3 pg/mL (95% CI: 0.3; 8.3), $P = 0.033$], and low-density lipoprotein cholesterol concentrations [diff = +22.6 pg/mL (95% CI: 14.2; 31.1), $P < 0.001$], indicating superiority for the changes achieved by detraining period (Table 4). Regarding triglycerides, we did not observe a difference between the changes provoked by two years of detraining compared to 24 weeks of training. Overall, two years of detraining demonstrated significantly reduce in serum lipid concentrations compared to 24 weeks of training (before the COVID-19 pandemic), indicating impairment in total cholesterol concentrations (post-two years of detraining = 198.5 pg/mL vs. post-24 wk of training = 171.3 pg/mL), high-density lipoprotein cholesterol concentrations (post- two years of detraining = 61.2 pg/mL vs. post-24 wk of training = 56.9 pg/mL), and low-density lipoprotein cholesterol concentrations (post- two years wk of detraining = 113.5 pg/mL vs. post-24 wk of training = 90.8).

Physical performance. Table 5 shows the changes in functional tests between moments. When comparing the changes (Δ) provoked by two years of detraining with the changes (Δ) achieved by 24 weeks of training, we observed worse physical performance at timed up and go test [diff = +1.76 s (95% CI: 1.46; 2.07), $P < 0.001$] and 6-minute walk distance [diff = -19.3 m (95% CI: -5.1; -33.5), $P = 0.008$], indicating superiority for the changes provoked by detraining period (Table 5). Overall, two years of detraining demonstrated significant changes in physical performance compared to 24 weeks of training (before the COVID-19 pandemic), indicating impairment in timed up and go (post- two years of detraining = 7.80 s vs. post-24 wk of training = 6.03 s) and 6-minute walk distance (post- two years of detraining = 484.0 m vs. post-24 wk of training = 503.3 m).

Change Scores by 12 weeks of retraining compared to the first 12 weeks of training

Dietary intake. When comparing the changes (Δ) provoked by 12 weeks of retraining with the changes (Δ) achieved by the first 12 weeks of training, we did not observe difference between these moments (according to 95% CI values) in energy total [diff = 4.3 kcal (95% CI: -243.7; 252.3) vs.15.4 kcal (95% CI: -53.2; 83.9), $P > 0.05$], carbohydrate [diff = 0.10 g/kg/d (95% CI: -0.27; 0.47) vs. 0.23 g/kg/d (95% CI: -0.02; -0.47), $P > 0.05$], protein [diff = -0.03 g/kg/d (95% CI: -0.30; 0.24) vs. -0.03 g/kg/d (95% CI: -0.10; 0.03), $P > 0.05$], and lipid [diff = -0.03 g/kg/d (95% CI: -0.29; 0.23) vs. -0.03 g/kg/d (95% CI: -0.09; 0.03), $P > 0.05$], indicating similarity for 12 weeks of retraining compared to the first 12 weeks of training (Table 1), without difference between them ($P > 0.05$).

Muscular strength. When comparing the changes (Δ) provoked by 12 weeks of retraining with the changes (Δ) generated by the first 12 weeks of training, we observed greater muscular strength values (according to 95% CI values) at leg extension [diff = 8.8 kg (95% CI: 5.3; 10.7) vs. -0.6 kg (95% CI: -3.3; 2.0), $P < 0.05$], preacher curl [diff = 8.3 kg (95% CI: 7.1; 9.3) vs. 2.4 kg (95% CI: 1.3; 3.4), $P < 0.05$], and total lifted load [diff = 23.3 kg (95% CI: 19.7; 27.0) vs. 5.1 kg (95% CI: 1.3; 8.9), *P*

< 0.05)], indicating superiority for the changes provoked by short-term retraining (Table 2), except for chest press [diff = 6.9 kg (95% CI: 5.7; 8.1 vs. 3.5 kg (95% CI: 0.9; 6.0), $P > 0.05$]. Overall, 12 weeks of retraining demonstrated greater muscular strength gains than the changes provoked by the first 12 weeks of training ($P < 0.05$).

Body composition. When comparing the changes (Δ) provoked by 12 weeks of retraining with the changes (Δ) achieved by the first 12 weeks of training, we did not observe skeletal muscle mass and appendicular lean soft tissue gains (according to 95% CI values) for 12 weeks of retraining [diff = 0.28 kg (95% CI: -0.04; 0.60 vs. 0.98 kg (95% CI: 0.70; 1.26), $P < 0.05$] and [diff = 0.26 kg (95% CI: -0.02; 0.55) vs. 0.87 kg (95% CI: 0.62; 1.11), $P < 0.05$], indicating that only the first 12 weeks of training was able to increase skeletal muscle mass and lean soft tissue (Table 3). Regarding android fat and waist circumference, we did not observe a difference between moments for android fat and waist circumference ($P > 0.05$). Overall, 12 weeks of retraining did not increase skeletal muscle mass and appendicular lean soft tissue compared to the changes provoked by the first 12 weeks of training ($P > 0.05$).

Metabolic biomarkers. When comparing the changes (Δ) provoked by 12 weeks of retraining with the changes (Δ) achieved by the first 12 weeks of training, we observed greater serum lipid concentrations (according to 95% CI) in total cholesterol concentrations [diff = -10.6 pg/mL (95% CI: -25.4; 4.2) vs. -10.9 pg/mL (95% CI: -15.8; -6.0), $P < 0.05$)] and low-density lipoprotein cholesterol concentrations [diff = -6.9 pg/mL (95% CI: -19.6; 5.9) vs. -11.6 (95% CI: -17.0; -6.3), $P < 0.05$)], indicating inferiority for the short-term retraining (Table 4). Regarding high-density lipoprotein cholesterol and triglycerides, we did not observe a difference between the changes achieved by 12 weeks of retraining compared to the first 12 weeks of training ($P > 0.05$). Overall, 12 weeks of retraining did not improve serum lipid concentrations compared to the first 12 weeks of training ($P > 0.05$).

Physical performance. When comparing the changes (Δ) provoked by 12 weeks of retraining with the changes (Δ) achieved by the first 12 weeks of training, we observed lower physical performance (according to 95% CI) in timed up and go test [diff = -10.6 pg/mL (95% CI: -25.4; 4.2) vs. -10.9 pg/mL (95% CI: -15.8; -6.0), $P < 0.05$)] and 6-minute walk distance [diff = -6.9 pg/mL (95% CI: -19.6; 5.9) vs. -11.6 (95% CI: -17.0; -6.3), $P < 0.05$)], indicating inferiority for the short-term retraining (Table 5).

Overall, 12 weeks of retraining was insufficient to improve physical performance compared to the first 12 weeks of training (*P* > 0.05).

Table 1. Dietary intake at baseline, after 12- and 24-wk training, long-term detraining, and 12-wk retraining with whole-body resistance training in older women.

Variables	Mean (IC 95%)	Δ	*P* Time
Energy total (kcal)			
Baseline	1715.2 (1652.4; 1780.4)	Δ¹ 15.4 (-53.2; 83.9)	0.001
12-wk training	1730.6 (1654.1; 1810.6)	Δ² -53.6 (-176.8; 69.5)	
24-wk training	1676.9 (1550.9; 1813.3)	Δ³ -268.2 (-539.2; 2.8)	
Long-term detraining	1408.8 (1196.8; 1658.3)*†	Δ⁴ 4.3 (-243.7; 252.3)	
12-wk retraining	1413.1 (1289.3; 1548.9)*†‡		
Carbohydrate (g/kg/d)			
Baseline	3.29 (3.09; 3.51)	Δ¹ 0.23 (-0.02; 0.47)	<0.001
12-wk training	3.52 (3.21; 3.86)	Δ² -0.24 (-0.57; 0.09)	
24-wk training	3.28 (3.02; 3.56)	Δ³ -0.63 (-0.99; -0.27)	
Long-term detraining	2.64 (2.37; 2.95)*†‡	Δ⁴ 0.10 (-0.27; 0.47)	
12-wk retraining	2.75 (2.45; 3.08)*†‡		
Protein (g/kg/d)			
Baseline	1.02 (0.95; 1.10)	Δ¹ -0.03 (-0.10; 0.03)	0.063
12-wk training	0.99 (0.91; 1.07)	Δ² 0.02 (-0.06; 0.09)	
24-wk training	0.97 (0.86; 1.09)	Δ³ -0.10 (-0.36; 0.16)	
Long-term detraining	0.87 (0.65; 1.15)	Δ⁴ -0.03 (-0.30; 0.24)	
12-wk retraining	0.84 (0.74; 0.96)		
Lipid (g/kg/d)			
Baseline	0.83 (0.76; 0.91)	Δ¹ -0.03 (-0.09; 0.03)	0.270
12-wk training	0.80 (0.72; 0.89)	Δ² -0.02 (-0.13; 0.10)	
24-wk training	0.79 (0.64; 0.97)	Δ³ -0.05 (-0.34; 0.24)	
Long-term detraining	0.74 (0.53; 1.03)	Δ⁴ -0.03 (-0.29; 0.23)	
12-wk retraining	0.71 (0.60; 0.84)		

Notes: Generalized estimating equation test adjusted for age, body mass index, anxiety and depression symptoms, hypertension, diabetes, and dyslipidemia (baseline contributors for resilience capacity) was used to compare the changes over time. Data are presented in means and confidence intervals of 95%. Δ^1 12-wk training vs. Pre. Δ^2 24-wk training vs. 12-wk training. Δ^3 long-term detraining vs. 24-wk training. Δ^4 12-wk retraining vs. long-term detraining. * $P < 0.05$ vs. Pre. † $P < 0.05$ vs. post 12-wk training. ‡ $P < 0.05$ vs. post 24-wk training. § $P < 0.05$ vs. long-term detraining.

Table 2. Muscular strength at baseline, after 12- and 24-wk training, long-term detraining, and 12-wk retraining with whole-body resistance training in older women.

Variables	Mean (IC 95%)	Δ	*P* Time
Chest press (kg)			
Baseline	56.2 (53.1; 59.6)	Δ^1 3.5 (0.9; 6.0)	
12-wk training	59.7 (56.3; 63.4)*	Δ^2 3.7 (2.7; 4.7)	
24-wk training	63.5 (59.9; 67.2)*†	Δ^3 -29.0 (-31.4; -26.6)	<0.001
Long-term detraining	34.3 (32.3; 36.7)*†‡	Δ^4 6.9 (5.7; 8.1)	
12-wk retraining	41.3 (38.7; 44.1)*†‡§		
Leg extension (kg)			
Baseline	57.4 (53.3; 61.8)	Δ^1 -0.6 (-3.3; 2.0)	
12-wk training	56.8 (52.7; 61.2)	Δ^2 9.3 (7.2; 11.5)	
24-wk training	66.1 (61.4; 71.2)*†	Δ^3 -15.3 (-18.6; -12.0)	<0.001
Long-term detraining	50.8 (46.7; 55.3)*†‡	Δ^4 8.8 (5.3; 10.7)	
12-wk retraining	58.9 (54.8; 63.2)‡§		
Preacher curl (kg)			
Baseline	28.2 (27.0; 29.4)	Δ^1 2.4 (1.3; 3.4)	
12-wk training	30.5 (29.1; 32.1)*	Δ^2 1.0 (-0.1; 2.1)	
24-wk training	29.5 (29.1; 32.1)*	Δ^3 -5.7 (-7.1; -4.3)	<0.001
Long-term detraining	23.7 (22.2; 25.2)*†‡	Δ^4 8.3 (7.1; 9.3)	
12-wk retraining	31.3 (29.4; 33.3)*‡§		
Total load lifted (kg)			
Baseline	142.2 (135.5; 149.1)	Δ^1 5.1 (1.3; 8.9)	
12-wk training	147.3 (140.6; 154.3)*	Δ^2 12.3 (9.8; 14.9)	<0.001
24-wk training	159.6 (152.3; 167.4)*†	Δ^3 -50.6 (-55.6; -45.6)	
Long-term detraining	108.9 (103.4; 114.9)*†‡	Δ^4 23.3 (19.7; 27.0)	

12-wk retraining	132.2 (125.6; 139.4)*†‡§

Notes: Generalized estimating equation test adjusted for age, body mass index, anxiety and depression symptoms, hypertension, diabetes, and dyslipidemia (baseline contributors for resilience capacity) was used to compare the changes over time. Data are presented in means and confidence intervals of 95%. Δ^1 12-wk training vs. Pre. Δ^2 24-wk training vs. 12-wk training. Δ^3 long-term detraining vs. 24-wk training. Δ^4 12-wk retraining vs. long-term detraining. * $P < 0.05$ vs. Pre. † $P < 0.05$ vs. post 12-wk training. ‡ $P < 0.05$ vs. post 24-wk training. § $P < 0.05$ vs. long-term detraining.

Table 3. Body composition at baseline, after 12- and 24-wk training, long-term detraining, and 12-wk retraining with whole-body resistance training in older women.

Variables	Mean (IC 95%)	Δ	*P* Time
Skeletal muscle mass (kg)			
Baseline	18.85 (17.79; 19.96)	Δ^1 0.98 (0.70; 1.26)	
12-wk training	19.83 (18.71; 21.02)*	Δ^2 0.18 (-0.36; 0.72)	
24-wk training	20.01 (18.95; 21.14)*	Δ^3 -0.87 (-1.24; -0.51)	<0.001
Long-term detraining	19.14 (18.13; 20.21)†‡	Δ^4 0.28 (-0.04; 0.60)	
12-wk retraining	19.42 (18.39; 20.51)*‡		
Appendicular lean soft tissue (kg)			
Baseline	16.04 (16.12; 18.02)	Δ^1 0.87 (0.62; 1.11)	
12-wk training	17.91 (16.93; 18.95)*	Δ^2 0.18 (-0.30; 0.66)	
24-wk training	18.09 (17.16; 19.08)*	Δ^3 -0.74 (-1.07; -0.42)	<0.001
Long-term detraining	17.35 (16.46; 18.29)†‡	Δ^4 0.26 (-0.02; 0.55)	
12-wk retraining	17.62 (16.71; 18.57)*‡		
Android fat (kg)			
Baseline	2.80 (2.61; 3.02)		
12-wk training	2.67 (2.46; 2.88)*	Δ^1 -0.13 (-0.21; -0.07)	
24-wk training	2.71 (2.50; 2.95)	Δ^2 0.05 (-0.09; 0.20)	
Long-term detraining	2.70 (2.48; 2.94)	Δ^3 -0.01 (-0.12; 0.09)	<0.001
12-wk retraining	2.59 (2.37; 2.82)	Δ^4 -0.11 (-0.23; 0.01)	
Waist circumference (cm)			
Baseline	99.16 (87.94; 92.44)		
12-wk training	91.35 (88.98; 93.77)*	Δ^1 -1.19 (-2.32; -0.05)	
24-wk training	92.21 (89.30; 95.22)	Δ^2 0.87 (-1.76; 3.50)	0.049
Long-term detraining	94.08 (91.17; 97.08)	Δ^3 1.86 (-0.91; 4.63)	
12-wk retraining	92.91 (90.14; 95.76)	Δ^4 -1.17 (-2.36; 0.03)	

Notes: Generalized estimating equation test adjusted for age, body mass index, anxiety and depression symptoms, hypertension, diabetes, and dyslipidemia (baseline contributors for resilience capacity) was used to compare the changes over time. Data are presented in means and confidence intervals of 95%. Δ^1 12-wk training vs. Pre. Δ^2 24-wk training vs. 12-wk training. Δ^3 long-term detraining vs. 24-wk training. Δ^4 12-wk retraining vs. long-term detraining. * $P < 0.05$ vs. Pre. † $P < 0.05$ vs. post 12-wk training. ‡ $P < 0.05$ vs. post 24-wk training. § $P < 0.05$ vs. long-term detraining.

Table 4. Metabolic biomarkers (serum lipid concentrations) at baseline, after 12- and 24-wk training, long-term detraining , and 12-wk retraining with whole-body resistance training in older women.

Variables	Mean (IC 95%)	Δ	*P* Time
Total cholesterol (pg/mL)			
Baseline	188.1 (177.3; 199.5)	Δ^1 -10.9 (-15.8; -6.0)	
12-wk training	177.2 (167.0; 187.9)*	Δ^2 5.9 (-0.22; 12.0)	<0.001
24-wk training	171.3 (162.1; 181.0)*	Δ^3 27.2 (17.0; 37.5)	
Long-term detraining	198.5 (186.3; 211.5)†‡	Δ^4 -10.6 (-25.4; 4.2)	
12-wk retraining	187.9 (174.6; 202.2)‡		
High-density lipoprotein cholesterol (pg/mL)			
Baseline	61.8 (56.6; 67.5)	Δ^1 -0.6 (-2.7; 1.4)	
12-wk training	61.2 (55.8; 67.1)	Δ^2 -4.3 (-6.7; -1.9)	0.014
24-wk training	56.9 (51.5; 62.8)*†	Δ^3 4.3 (0.3; 8.3)	
Long-term detraining	61.2 (54.7; 68.4)‡	Δ^4 -3.9 (-10.7; 2.9)	
12-wk retraining	57.3 (52.3; 62.6)		
Low-density lipoprotein cholesterol (pg/mL)			
Baseline	104.7 (96.7; 113.5)	Δ^1 -11.6 (-17.0; -6.3)	
12-wk training	93.1 (85.7; 101.1)*	Δ^2 -2.2 (-7.5; 3.0)	
24-wk training	90.8 (84.4; 97.8)*	Δ^3 22.6 (14.2; 31.1)	<0.001
Long-term detraining	113.5 (103.4; 124.4)†‡	Δ^4 -6.9 (-19.6; 5.9)	
12-wk retraining	106.6 (95.3; 119.2)†‡		
Triglycerides (pg/mL)			
Baseline	101.8 (86.4; 119.9)	Δ^1 11.0 (-3.9; 26.0)	
12-wk training	112.8 (100.3; 126.9)	Δ^2 2.2 (-8.7; 13.1)	0.658
24-wk training	115.0 (99.8; 132.6)	Δ^3 -7.7 (-26.7; 12.5)	
Long-term detraining	107.9 (90.0; 129.4)	Δ^4 1.0 (-17.4; 19.3)	

12-wk retraining	108.9 (94.0; 126.1)

Notes: Generalized estimating equation test adjusted for age, body mass index, anxiety and depression symptoms, hypertension, diabetes, and dyslipidemia (baseline contributors for resilience capacity) was used to compare the changes over time. Data are presented in means and confidence intervals of 95%. Δ^1 12-wk training vs. Pre. Δ^2 24-wk training vs. 12-wk training. Δ^3 long-term detraining vs. 24-wk training. Δ^4 12-wk retraining vs. long-term detraining. * $P < 0.05$ vs. Pre. † $P < 0.05$ vs. post 12-wk training. ‡ $P < 0.05$ vs. post 24-wk training. § $P < 0.05$ vs. long-term detraining.

Table 5. Functional tests (physical performance) at baseline, after 12- and 24-wk training, long-term detraining, and 12-wk retraining with whole-body resistance training in older women.

Variables	Mean (IC 95%)	Δ	*P* Time
Timed up and go test (s)			
Baseline	6.80 (6.57; 7.04)		
12-wk training	6.44 (6.24; 6.65)*	Δ^1 -0.36 (-0.59; -0.14)	
24-wk training	6.03 (5.85; 6.22)*†	Δ^2 -0.40 (-0.50; -0.31)	<0.001
Long-term detraining	7.80 (7.52; 8.09)*†‡	Δ^3 1.76 (1.46; 2.07)	
12-wk retraining	7.92 (7.56; 8.29)*†‡	Δ^4 0.12 (-0.45; 0.21)	
6-minute walk distance (m)			
Baseline	450.2 (434.7; 466.3)		
12-wk training	489.9 (472.1; 508.3)*	Δ^1 39.7 (23.0; 56.4)	
24-wk training	503.3 (484.9; 522.4)*†	Δ^2 13.4 (9.7; 17.2)	<0.001
Long-term detraining	484.0 (466.1; 502.6)*‡	Δ^3 -19.3 (-5.1; -33.5)	
12-wk retraining	474.9 (457.8; 496.8)*‡	Δ^4 -7.1 (-16.8; 2.7)	

Notes: Generalized estimating equation test adjusted for age, body mass index, anxiety and depression symptoms, hypertension, diabetes, and dyslipidemia (baseline contributors for resilience capacity) was used to compare the changes over time. Data are presented in means and confidence intervals of 95%. Δ^1 12-wk training vs. Pre. Δ^2 24-wk training vs. 12-wk training. Δ^3 long-term detraining vs. 24-wk training. Δ^4 12-wk retraining vs. long-term detraining. * $P < 0.05$ vs. Pre. † $P < 0.05$ vs. post 12-wk training. ‡ $P < 0.05$ vs. post 24-wk training. § $P < 0.05$ vs. long-term detraining.

4.3.4 Discussion

To the best of our knowledge, this study is the first to analyze the effects of two years of RT cessation due to the COVID-19 pandemic on body composition, muscular strength, metabolic biomarkers, and physical performance in older women. Moreover, this study is the first to verify whether the changes provoked by 12 weeks of retraining on these health biomarkers and muscle function would be sufficient to achieve the modifications obtained by 12 weeks of training. Our hypothesis was confirmed, indicating that two years of RT cessation demonstrate a significant impairment in health biomarkers and muscle function compared to the pre-COVID-19 pandemic (post-24 weeks of training). Moreover, short-term retraining seems insufficient to recover fully the condition achieved by the first 12 weeks of training on SMM, ALST, metabolic biomarkers, and physical performance (except for muscular strength), indicating a classical frame of low resilience capacity due to lower changes achieved after 12 weeks of retraining compared to the first 12 weeks of intervention. Therefore, our study suggests that two years of training cessation promoted impairments in health biomarkers and muscle function that are not fully recovered by short-term retraining in older women engaged in RT.

Change Scores by two years oftraining cessation compared to post-24 weeks of RT (before training cessation due to the COVID-19 pandemic)

The biological adaptation against determined stimuli is a phenomenon that may be influenced by nutrition intake–mainly protein, intervention length with RT, and/or training cessation (detraining period) in older individuals (CARNEIRO et al., 2021b, 2022a, 2023; CAVALCANTE et al., 2023; MUJIKA; PADILLA, 2000, 2001; NAHAS et al., 2019; NUNES et al., 2023; PADILHA et al., 2015). Training cessation is characterized by a complete abandonment of a systematic RT program, which induces a partial or total reversal of health biomarkers and muscle function (MUJIKA; PADILLA, 2000, 2001). In this regard, meta-analytical evidence suggests that more than 48 weeks may provoke significant impairments in health biomarkers and muscle function (ENCARNAÇÃO et al., 2022; GRGIC, 2022). In contrast, 12 weeks of training cessation has been related to muscular strength reduction in older women engaged in RT (PADILHA et al., 2015). Although this study only oriented the participants to maintain their daily activities during the detraining period, there was no control of dietary intake (PADILHA et al., 2015).

In this study, we did not observe a difference between the changes promoted by two years of detraining compared to 24 weeks of training (before training cessation) on energy total, protein, and lipid ($P > 0.05$), indicating that physical distance due to COVID-19 pandemic did not change nutritional habits of older women engaged in RT. Our results are according to Nascimento et al. (2020), who monitored participants' food consumption during 12 weeks of detraining, and no differences were observed between moments on dietary intake assessments (DO NASCIMENTO et al., 2022). Moreover, our findings corroborate with the results found by Padilha et al. (2015) and Nascimento et al. (2020) after 12 weeks of detraining (DO NASCIMENTO et al., 2022; PADILHA et al., 2015), indicating that two years oftraining cessation promote a significant reduction ($P < 0.05$) in muscular strength in the chest press, leg extension, preacher curl, and total lifted load compared to 24 weeks of RT.

Aragão Santos et al. (2023) found impairments in physical performance with long-term detraining imposed by the COVID-19 pandemic compared to the value post-16 weeks of training in older women (ARAGÃO-SANTOS et al., 2023). Our investigation revealed that two years of detraining promoted significant changes in physical performance compared to the value achieved before the COVID-19 pandemic, indicating impairment in timed up-and-go and 6-minute walk performance. Therefore, our findings suggest that two years oftraining cessation with orientation to maintaining regular daily activities during physical distance may impair muscular strength and physical performance, regardless of dietary intake.

Regarding body composition and metabolic biomarkers, available evidence regarding the effects of detraining seems limited. Aragão-Santos et al. (2023) demonstrated that lean soft tissue reduced, while body adiposity increased after 28 months of detraining. Our results revealed a significant reduction ($P < 0.05$) in SMM and ALST after two years of detraining compared to 24 weeks of training, while no changes were found for android fat and waist circumference.

Hence, our study is the pioneer in analyzing the effects of two years oftraining cessation on metabolic biomarkers in older women. Our results suggest that this detraining period promotes significant harm in serum lipid concentrations compared to 24 weeks of training. This indicates impairment after long-term training cessation in total cholesterol, HDL-c, and LDL-c concentrations. Previously, Nascimento et al. (2020) found an impairment in triglycerides and LDL-c concentrations after 12 weeks of detraining. Moreover, these biological adaptations related to training cessation may increase the risk of developing non-communicable diseases (FRANCESCHI et al., 2000; HERNANDEZ-ONO et al., 2002). Therefore, due to impairment in SMM, ALST, and metabolic biomarkers after training cessation revealed in our investigation, it is reasonable to assume that this frame appears harmful to health, favoring the prevalence of non-communicable diseases in older women.

Change Scores by 12 weeks of retraining compared to the first 12 weeks of training

We hypothesized that 12 weeks of retraining would promote lower responses on body composition, muscular strength, metabolic profile, and physical performance compared to the first 12 weeks of training. According to 95% CI, 12 weeks of retraining do not improve skeletal muscle mass and appendicular lean soft tissue [SMM: retraining = 0.28 g (95% CI: -0.04; 0.60) vs. training = 0.98 g (95% CI: 0.70; 1.26), ALST: retraining = 0.26 g (95% CI: -0.02; 0.55) vs. training = 0.87 g (95% CI: 0.62; 1.11)], serum lipid concentrations [total cholesterol: retraining = -10.6 pg/mL (95% CI: -25.4; 4.2) vs. training = -10.9 pg/mL (95% CI: -15.8; -6.0) and low-density lipoprotein cholesterol: retraining = -6.9 pg/mL (-19.6; 5.9) vs. training = -11.6 pg/mL (95% CI: -17.0; -6.3)], and physical performance [timed-up-and-go: retraining = +0.12 s (95% CI: -0.45; 0.21) vs. training = -0.36 s (95% CI: -0.59; -0.14) and 6MWD: retraining = -7.1 m (95% CI: -16.8; 2.7) vs. training = +39.7 (95% CI: 23.0; 56.4)] compared to the changes provoked by the first 12 weeks of training ($P > 0.05$). Regarding dietary intake, we observed similarity for 12 weeks of retraining compared to the first 12 weeks of training, without difference between them ($P > 0.05$), indicating no influence of energy total [diff = 4.3 kcal (95% CI: -243.7; 252.3) vs. 15.4 kcal (95% CI: -53.2; 83.9), $P > 0.05$], carbohydrate [diff = 0.10 g/kg/d (95% CI: -0.27; 0.47) vs. 0.23 g/kg/d (95% CI: -0.02; -0.47), $P > 0.05$], protein [diff = -0.03 g/kg/d (95% CI: -0.30; 0.24) vs. -0.03 g/kg/d (95% CI: -0.10; 0.03), $P > 0.05$], and lipid [diff = -0.03 g/kg/d (95% CI: -0.29; 0.23) vs. -0.03 g/kg/d (95% CI: -0.09; 0.03), $P > 0.05$] on biological adaptations. In addition, we did not observe a difference between moments for android fat and waist circumference ($P > 0.05$). Thus, our results suggest that the changes achieved by 12 weeks of retraining following two years of training are insufficient in improving skeletal muscle mass, appendicular lean soft tissue, metabolic profile, and physical performance compared to the changes provoked by the first 12 weeks of training. Although RT with higher load intensity may not be required to promote physical performance gains (RAYMOND et al., 2013), it has been demonstrated that power training (as fast and powerfully as possible of muscle actions) has a slight advantage compared to RT using higher load intensity for physical performance gains (TSCHOPP; SATTELMAYER; HILFIKER, 2011). Thus, power training may be considered to enhance physical performance due to a slight improvement compared to RT with higher load intensity in this biomarker of function, independent of load intensity (BALACHANDRAN et al., 2022; RAYMOND et al., 2013; TSCHOPP; SATTELMAYER; HILFIKER, 2011).

Muscle anabolic resistance is a physiological adaptation wherein older individuals demonstrate an attenuated muscle protein synthesis response to RT compared to their younger parts (BURD et al., 2010; BURD; GORISSEN; VAN LOON, 2013). In addition, the detraining period can lead to rapid muscle anabolic resistance (BREEN; PHILLIPS, 2011; TANNER et al., 2015). Thus, short-term retraining responses in older adults may be weakened after two years of training cessation on SMM and ALST. Indeed, after 12 weeks of retraining, we observed lower SMM [diff = -0.59 kg (95% CI: -1.01; -0.17), P = 0.006] and ALST [diff = -0.47 kg (95% CI: -0.85; -0.10), P = 0.013] compared to values achieved before training cessation, indicating minor changes after short-term retraining. Grgic et al. (2022) suggested that the impairment in muscle tissue may be related to detraining duration (GRGIC, 2022). Based on this meta-analytical evidence, assuming that the highest SMM loss may occur during long-term detraining, such as two years analyzed in our investigation (GRGIC, 2022), is acceptable.

Our results indicate that short-term retraining may not fully reverse the SMM loss induced by two years of training cessation. In addition, Grgic et al. (2020) demonstrated that a small effect size on SMM occurs (~1.5%) after the RT program in very older adults (i.e., > 75 years) (GRGIC et al., 2020). As the current study participants started the intervention at ~69 years, two years of training cessation due to social stressors promoted a biological aging of half a decade in older women. Our findings in older women corroborate with the findings of Grgic et al. (2020) and (2022) studies, suggesting a classical frame of muscle anabolic resistance due to aging and two years of training cessation (GRGIC, 2022; GRGIC et al., 2020). Therefore, future studies are needed to combat this classical frame by using a more extended retraining period (24 weeks) investigating skeletal muscle responses in older women after a long detraining period.

The rapid decline in muscular strength is a common characteristic in older women due to menopause transition (ASIKAINEN; KUKKONEN-HARJULA; MIILUNPALO, 2004; PÖLLÄNEN et al., 2011; SIROLA; RIKKONEN, 2005). Moreover, it has been suggested that this decline contributes to physical performance impairment, especially in the muscle function related to mobility and walking (BEAUDART et al., 2019). This condition is associated with increased healthcare costs for community-dwelling older adults because individuals with low muscular strength contribute to this twice as much compared to those with normal muscular strength (CAWTHON et al., 2017; PINEDO-VILLANUEVA et al., 2019). Contrary to our hypothesis, we observed greater responses of 12 weeks of retraining compared to the first 12 weeks of training on muscular strength [chest press: retraining = +6.9 kg (95% CI: 5.7; 8.1) vs. training +3.5 kg (95% CI: 0.9; 6.0), leg extension: retraining = +8.8 kg (95% CI: 5.3; 10.7) vs. -0.6 (95% CI: -3.3; 2.0), preacher curl: retraining = +8.3 kg (95% CI: 7.1; 9.3) vs. training = +2.4 kg (95% CI: 1.3; 3.4)], and total load lifted: retraining = +23.3 kg (95% CI: 19.7; 27.0) vs. training = +5.1 kg (95% CI 1.3; 8.9)], indicating a superiority for the changes achieved after short-term retraining. The proposed mechanisms for muscular strength changes have traditionally consisted of neural adaptations followed by contributions from muscle mass gain (FOLLAND; WILLIAMS, 2007; SALE, 1988). However, the present study observed muscular strength gains after 12 weeks of retraining without skeletal muscle mass and appendicular lean soft tissue improvements. Similar to our results, Kassiano et al. (2022) demonstrated higher muscular strength gains in older women after RT program, regardless of muscle mass gains (KASSIANO et al., 2022b). Although the mechanism by which 12 weeks of retraining induces superior increases in all 1RM assessments is not understood, stronger older women have increased neural drive (KASSIANO et al., 2021), increased intermuscular coordination, and higher preservation of high-threshold motor units (FRONTERA et al., 2000; HÄKKUKINEN; KOMI; ALEN, 1985; SALE, 1988). Further research is required to confirm our hypothesis regarding possible mechanisms associated with greater muscular strength gains after short-term retraining following two years of training cessation compared to neural adaptations achieved by the first 12 weeks of training in older individuals.

The link between women's aging and abdominal adiposity excess (elevated waist circumference and/or android fat) is a critical point in developing metabolic risk factors (MUMUSOGLU; YILDIZ, 2019; ZHANG et al., 2016), such as dyslipidemia (ZHANG et al., 2016). In addition, muscular strength (a key point related to physical performance in older individuals) is negatively associated with body adiposity excess (LAROCHE; KRALIAN; MILLETT, 2011; MOORE et al., 2020), suggesting that body adiposity excess has been related to low physical performance. Recently, a cohort study reported that abdominal adiposity excess is associated with a greater incidence of falls compared to whole-body fat mass in older women (NERI et al., 2020). Thus, it is reasonable to assume that body adiposity excess, mainly in the abdominal region, may negatively affect metabolic biomarkers, muscular strength, and physical performance in older women.

In addition, our study did not observe a difference between the changes achieved by 12 weeks of retraining compared to the changes provoked by the first 12 weeks of training on android fat and waist circumference. According to this approach, 12 weeks of retraining cannot improve serum lipid concentrations. This indicates a low resilience capacity to recover the ‘normal’ values of total cholesterol and low-density lipoprotein cholesterol. Collectively, the lack of abdominal adiposity changes may influence, at least partly, the changes in metabolic biomarkers, muscular strength, and physical performance after short-term retraining following two years of detraining. Thus, preventing impairments in metabolic biomarkers, muscular strength, and physical performance with advancing age through modulation in abdominal adiposity may blunt the prevalence of chronic diseases in older women. In this regard, a recent systematic review with meta-analyses showed that higher improvements in metabolic biomarkers are achieved after RT intervention using a higher volume (NUNES et al., 2023). Therefore, future studies using a higher volume during the retraining period after long-term detraining may be employed to improve body adiposity (including in the abdominal region) and metabolic biomarkers in older women.

Limitations and strengths

This present study has limitations that should be recognized. One aspect that must be considered is that the results observed were in older women engaged in RT (24 weeks of training) and should not be extrapolated to other populations with different physical and physiological characteristics. Moreover, we did not assess physical activity levels and sedentary behavior. The extent to which changes in these variables may have influenced the present findings is unknown. However, all participants were instructed not to engage in any other physical exercise program throughout the investigation, including during the COVID-19 pandemic (two years of detraining).

It is essential to highlight the strengths of the present study. First, we monitored the dietary intake in the first and the last two weeks of RT at each moment. Maintaining protein intake during the present study strengthens the adaptive responses, especially in lean soft tissue and muscle mass. Second, our lab presents low SEM and high ICC for DXA (SEM = 0.1 kg; ICC = 0.99 for upper limbs lean soft tissue, and SEM = 0.2 kg; ICC = 0.99 for lower limbs lean soft tissue) and 1RM assessments (SEM ≤ 2.0 kg; ICC = ≥ 0.96). In addition, the functional tests performed in the current study showed excellent test-retest reliability (BEAUDART et al., 2019). Third, sixteen fitness professionals (two per exercise) supervised all RT sessions, allowing adequate control of exercise execution, with individualized monitoring, attenuating the risk of injuries and favoring the progression of the RT program to optimize muscular strength gains and functional fitness improvements (LACROIX et al., 2017). Lastly, it used a approximately three years of longitudinal design, which compared the five moments to investigate resilience capacity on health biomarkers and muscle function in older women engaged in RT after a long-term detraining.

4.3.5 Conclusions

Our results indicate that two years of training cessation due to the COVID-19 pandemic (social stressor) in older women engaged in RT led to vulnerability in health biomarkers and muscle function, which do not fully recover after short-term retraining, indicating a classical frame of low resilience capacity due to lower responses provoked by 12 weeks of retraining compared to the first 12 weeks of training. These data provide valuable insights into the effects of detraining and retraining periods on the resilience capacity of older individuals. For future studies analyzing the impact of a retraining period on body composition, muscular strength, metabolic biomarkers, and physical performance in physically independent older women after long-term detraining, it is relevant to consider adjusting the intervention time.

5. CONSIDERAÇÕES FINAIS

Um em cada quatro adultos terá mais de 65 anos em 2050. Considerando que os efeitos cumulativos durante o processo de envelhecimento geram declínio da massa muscular, força, potência muscular e da aptidão funcional, concomitantemente como aumento da gordura corporal e piora do perfil metabólico (biomarcadores de saúde e função), muitos idosos se tornam mais vulneráveis a lesões, quedas, fraturas, isolamento social, infecções e inúmeras complicações relacionadas a doenças crônicas não-transmissíveis, resultando em aumento nas taxas de hospitalização.

Em contrapartida, o treinamento resistido tem sido amplamente recomendado como uma estratégia não medicamentosa segura e eficaz para combater diversos efeitos deletérios do envelhecimento. Entretanto, pouco se sabe em relação aos efeitos do treinamento resistido em pacientes hospitalizados e pós-hospitalizados. De acordo com o conhecimento produzido até o momento, a literatura carece de estudos meta-analíticos avaliando o impacto das respostas adaptativas acarretadas pelo treinamento resistido em comparação ao cuidado usual fornecido por profissionais de saúde em idosos durante os períodos de internação e após a alta hospitalar.

Além disso, pouco se sabe sobre os efeitos da interrupção do treinamento provocado pela pandemia de COVID-19 (destreinamento de longo prazo) mesmo em idosos engajados em programas de treinamento resistido sobre a composição corporal, força muscular, perfil metabólico e aptidão funcional. Finalmente, o papel do retreinamento de curto prazo sobre a capacidade de resiliência desses biomarcadores de saúde e função muscular, também, permanece desconhecido, principalmente em idosos.

Diante do cenário atual na área do treinamento resistido aplicado a população idosa, não encontramos estudos meta-analíticos na literatura que sumarizassem os achados dos estudos clínicos em pacientes hospitalizados e/ou pós-hospitalizados. Além disso, pouco se sabe sobre os efeitos do destreinamento de longo prazo induzido pela pandemia de COVID-19 seguido por um período curto de retreinamento. Tais informações são necessárias para uma maior compreensão da capacidade de recuperação de mulheres idosas engajadas em programas de treinamento resistido sobre a composição corporal, força muscular, perfil metabólico e aptidão funcional, após um estresse social de extrema complexidade.

Assim, no primeiro estudo da presente tese, analisamos as mudanças provocadas por intervenções estruturadas envolvendo exercício resistido (estudos clínicos aleatorizados) sobre a força e potência muscular, massa muscular e aptidão funcional (incluindo medidas diretas para medir o equilíbrio, a caminhada e a agilidade) comparado ao cuidado usual (grupo controle) em idosos hospitalizados de maneira aguda, por meio de uma revisão sistemática com meta-análise. No segundo estudo, comparamos as mudanças causadas por intervenções envolvendo exercício físico com o cuidado usual (grupo controle, ensaios clínicos aleatorizados) sobre a força e potência muscular, massa muscular e aptidão funcional em idosos imediatamente após a alta hospitalar, por meio de uma revisão sistemática com meta-análise. Por fim, no terceiro estudo, analisamos os efeitos de dois anos de interrupção do treinamento (destreinamento de longo prazo devido à pandemia de COVID-19) sobre a composição corporal, força muscular, perfil metabólico e desempenho físico de mulheres idosas recreacionalmente engajadas em um programa de treinamento resistido. Adicionalmente, investigamos se as mudanças provocadas por 12 semanas de retreinamento sobre esses biomarcadores de saúde e função muscular seriam suficientes para reverter os prejuízos acarretamos pela interrupção do treinamento devido à pandemia de COVID-19.

Nossos resultados indicaram que uma intervenção de exercício resistido realizada durante a internação é capaz de aumentar a força e potência muscular, bem como melhorar a aptidão funcional de idosos hospitalizados. Além disso, esse modelo de intervenção parece exercer um efeito protetor contra os prejuízos gerados pela hospitalização em pacientes idosos. Adicionalmente, nossos achados revelaram que idosos submetidos a intervenção com exercício resistido, realizada imediatamente após a alta hospitalar (que não receberam essa intervenção durante a internação), experimentam uma melhoria no quadro clínico superior ao cuidado usual. Por fim, nossos dados indicaram que dois anos de interrupção do treinamento resistido devido à pandemia de COVID-19 (fator estressor social) resultaram em prejuízos metabólicos e funcionais importantes em mulheres idosas. Tais efeitos deletérios foram parcialmente revertidos após 12 semanas de retreinamento, indicando baixa capacidade de resiliência. Vale destacar que esses achados fornecem caminhos importantes acerca dos efeitos da interrupção ao treinamento resistido, demostrando que a preservação das respostas adaptativas requerem continuidade. Para futuras investigações sobre o impacto do retreinamento sobre a composição corporal, força muscular, perfil metabólico e desempenho físico em mulheres idosas fisicamente independentes, sugere-se um acompanhamento de longo prazo, uma vez que períodos relativamente curtos, ou seja, de até 12 semanas, não parecem ser suficientes para reverter o impacto do destreino.

Com relação as possíveis aplicações clínicas, com base nos nossos resultados em idosos hospitalizados e pós-hospitalizados, intervenções com treinamento resistido são recomendadas para a melhoria da autonomia e independência física durante a internação e após a alta do hospital, em virtude da eficácia e segurança, devendo, portanto, fazer parte das condutas de atenção primária à saúde nesses pacientes.

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APÊNDICES

Apêndice A: Termo de consentimento livre e esclarecido do projeto de pesquisa pré-pandemia

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Título da pesquisa:
"Efeito de quatro ordens de execução dos exercícios em programa de treinamento resistido em mulheres idosas treinadas"

Prezada Senhora,

Gostaríamos de convidá-la a participar da pesquisa **"Efeito de quatro ordens de execução dos exercícios em programa de treinamento resistido em mulheres idosas treinadas"** a ser realizada no município de Londrina/PR. O objetivo desta pesquisa será analisar o efeito de um programa de treinamento com pesos sobre parâmetros morfológicos, metabólicos, cognitivos e de desempenho de mulheres idosas.

Todas as avaliações serão realizadas por profissionais previamente treinados para tal finalidade. A assinatura deste termo permitirá que você participe das seguintes atividades:

(1) Programa de treinamento com pesos com duração de 50 semanas; (2) Preenchimento de questionários sobre prática de atividades físicas, hábitos alimentares e fumo; (3) Medidas de peso, estatura e pressão arterial/frequência cardíaca em repouso; (4) Avaliação da composição corporal pelos métodos de impedância bioelétrica (teste com duração de 30s: deitado em um colchonete, dois pequenos eletrodos serão colocados na mão e pé direito e transmitirão uma pequena corrente elétrica que indicará a quantidade de água [procedimento indolor e sem qualquer tipo de risco]), DEXA (teste com duração de aproximadamente sete minutos: deitado em uma mesa no próprio equipamento, sem portar qualquer tipo de objeto metálico, vestindo apenas roupas). O equipamento fará um escaneamento do corpo todo para determinação da massa livre de gordura (procedimento indolor e sem qualquer tipo de risco); (5) Coleta de sangue venoso em jejum de 12 h feito por um técnico capacitado e habilitado para a avaliação de indicadores metabólicos; (7) Avaliação da aptidão neuromuscular pelos testes isométrico e isocinético (no dinamômetro Biodex), e de uma repetição máxima (teste realizado em três exercícios para os segmentos de membros superiores, inferiores e tronco, que consiste na realização de três tentativas com o objetivo de levantar a maior quantidade de peso possível em apenas uma repetição para determinação da força muscular máxima); (8) Avaliação de funções cognitivas. (9) Avaliação biomecânica da marcha. (10) Eletroencefalografia.

Gostaríamos de esclarecer que a participação é totalmente **voluntária**. O participante pode recusar-se a participar/desistir a qualquer momento sem sofrer prejuízo algum. As informações serão utilizadas somente para fins de pesquisa e todos os documentos e amostras utilizados serão identificados por um código numérico sem identificação nominal para preservar a identidade do participante. Lembramos que não será cobrada taxa alguma por estas avaliações. Da mesma forma, não será paga quantia alguma aos participantes.

Ao final do estudo, comprometemo-nos a retornar com os resultados de todas as avaliações, que serão entregues aos participantes. Espera-se, com essa pesquisa, proporcionar informações que possam favorecer a melhoria da saúde e qualidade de vida de indivíduos adultos idosos por meio da prática de treinamento e associação com aspectos nutricionais, além de possibilitar a melhoria de parâmetros morfológicos, neuromusculares e metabólicos dos participantes. Apesar de considerados mínimos, os possíveis riscos são: desconfortos na coleta sanguínea e cansaço durante os testes físicos. É possível também que alguns grupamentos musculares exigidos nos testes de esforço fiquem doloridos entre 24 e 48 horas após a realização dos mesmos.

Caso você tenha dúvidas ou necessite de maiores esclarecimentos pode contatar o coordenador do grupo de pesquisa, Prof. Dr. Edilson Serpeloni Cyrino, no Laboratório de Metabolismo, Nutrição e Exercício, localizado no Centro de Educação Física e Esporte, da Universidade Estadual de Londrina, pelo telefone (43) 3371-4772 / 99139-4509 ou procurar o Comitê de Ética em Pesquisa Envolvendo Seres Humanos da Universidade Estadual de Londrina, na Rodovia Celso Garcia Cid, km 380 – Campus Universitário, telefone (43) 3371-4000. Este termo deverá ser preenchido em duas vias de igual teor, sendo uma delas, devidamente preenchida, assinada e entregue a você.

______________________ Londrina, __ de ________ de 2019.

Edilson Serpeloni Cyrino

Eu, ____ (**nome por extenso do sujeito de pesquisa**), portadora do RG: ________________________ tendo sido devidamente esclarecido sobre os procedimentos da pesquisa, concordo em participar **voluntariamente** da pesquisa descrita acima.

Assinatura (ou impressão dactiloscópica): ______________________ Data: __/__/2019

Apêndice B: Termo de consentimento livre e esclarecido do projeto de pesquisa pós-pandemia

“IMPACTO DE UM ANO DE INTERVENÇÃO COM TREINAMENTO RESISTIDO SOBRE A FORÇA MUSCULAR, COMPOSIÇÃO CORPORAL E BIOMARCADORES DE RISCO CARDIOMETABÓLICO EM MULHERES PÓS-MENOPAUSADAS: ESTUDO LONGITUDINAL ENVELHECIMENTO ATIVO”

Prezada Senhora:

Gostaríamos de convidá-la para participar da pesquisa “Impacto de um ano de intervenção com treinamento resistido sobre a força muscular, composição corporal e biomarcadores de risco cardiometabólico em mulheres pós-menopausadas: Estudo Longitudinal Envelhecimento Ativo”, a ser realizada no município de Londrina/PR. O objetivo desta pesquisa é analisar os efeitos de dois anos de prática regular e sistematizada de treinamento resistido sobre a força muscular, composição corporal e biomarcadores de risco cardiometabólico em mulheres pós-menopausadas.

Todas as avaliações serão realizadas por profissionais previamente treinados para tal finalidade. A assinatura deste termo permitirá que você participe das seguintes atividades: (1) Programa de treinamento com pesos nas suas diferentes fases acompanhado por profissionais e estudantes de Educação Física; (2) Entrevista afim de avaliar o histórico médico, sintomas de ansiedade e depressão, percepção de qualidade de vida, sono e cognição; (3) Medidas de peso, altura, pressão arterial, frequência cardíaca em repouso, atividade física habitual, comportamento sedentário e sono; (4) Avaliação da composição corporal pelos métodos de impedância bioelétrica e densitometria óssea; (5) Coleta de sangue venoso em jejum de 12 h feita por um técnico capacitado e habilitado para a avaliação de indicadores metabólicos; (6) Avaliação nutricional por meio da aplicação de registros alimentares de três dias; (7) Avaliação da aptidão neuromuscular por meio de testes de uma repetição máxima; (8) Avaliação da capacidade de realizar atividades de vida diária por meio de testes funcionais.

Gostaríamos de esclarecer que a participação é totalmente voluntária. A participante pode recusar-se a participar/desistir a qualquer momento sem sofrer prejuízo algum. As informações serão utilizadas somente para fins de pesquisa e todos os documentos e amostras utilizados serão identificados por um código numérico sem identificação nominal para preservar a identidade da participante. Lembramos que não será cobrada taxa alguma por estas avaliações. Da mesma forma, não será paga quantia alguma as participantes. Adicionalmente, comprometemo-nos a respeitar as determinações previstas na Lei 10.741 de 2003 – Estatuto do Idoso, que resguardam os direitos e a proteção às pessoas idosas, em especial ao respeito, dignidade e integridade física, emocional, social e afetiva.

Ao final do estudo, comprometemo-nos ainda a retornar com os resultados de todas as avaliações, que serão entregues as participantes. Espera-se com essa pesquisa, proporcionar informações que possam favorecer a melhoria da saúde e qualidade de vida de mulheres idosas por meio da prática de treinamento e associação com aspectos nutricionais, além de possibilitar a melhoria de parâmetros morfológicos, fisiológicos, neuromusculares e metabólicos das participantes. Apesar de considerados mínimos, os possíveis riscos são: desconfortos na coleta sanguínea e cansaço durante os testes físicos. É possível também que alguns grupamentos musculares exigidos nos testes de esforço fiquem doloridos entre 24 e 48 horas após a realização dos mesmos e durante as primeiras semanas de treino.

Caso você tenha dúvidas ou necessite de maiores esclarecimentos pode contactar o Prof. Dr. Edilson Serpeloni Cyrino, no Laboratório de Metabolismo, Nutrição e Exercício, localizado no Centro de Educação Física e Esporte, da Universidade Estadual de Londrina, pelo telefone (43) 3371-4772 / 9139-4509 ou procurar o Comitê de Ética em Pesquisa Envolvendo Seres Humanos da Universidade Estadual de Londrina, na Avenida Robert Kock, 60 ou no telefone (43) 3371- 2490. Este termo deverá ser preenchido em duas vias de igual teor, sendo uma delas, devidamente preenchida, assinada e entregue a você.

Londrina,_____de____________________de 2022.

Pesquisador Responsável: Prof. Dr. Edilson Serpeloni Cyrino

RG: ______________________________

Eu,____(nome por extenso do sujeito de pesquisa), tendo sido devidamente esclarecido sobre os procedimentos da pesquisa, concordo em participar voluntariamente da pesquisa descrita acima.

Assinatura (ou impressão dactiloscópica):

____

Londrina,_____de___________________de 2022.

Apêndice C: Recordatório alimentar

Nome:______________________________________ Data: ______/______/_________

Dia da semana do Recordatório: ___________________ Avaliador: _________________________

REFEIÇÃO E O HORARIO	Alimentos, bebidas e/ou preparações	Quantidades (gramas ou medida caseira)
Café da manhã **Horário:** ________		
Lanche manhã **Horário:** ________		
Almoço **Horário:** ________		
Lanche tarde **Horário:** ________		
Jantar **Horário:** ________		
Ceia **Horário:** ________		

ANEXOS

Anexo A: Comitê de ética do projeto de pesquisa pré-pandemia

Universidade Estadual de Londrina — Hospital Universitário — PARANÁ Governo do Estado

HOSPITAL UNIVERSITÁRIO
DIRETORIA SUPERINTENDENTE
PARECER Nº429
PROCESSO 9544.2019.84

Ao Pesquisador
João Pedro Alves Nunes

Considerando o Projeto de Pesquisa com o título: ***"EFEITO DE QUATRO ORDENS DE EXECUÇÃO DOS EXERCÍCIOS EM PROGRAMA DE TREINAMENTO RESISTIDO SOBRE A COMPOSIÇÃO CORPORAL, FORÇA MUSCULAR, CAPACIDADE FUNCIONAL, BIOMARCADORES SANGUÍNEOS E COGNIÇÃO EM MULHERES IDOSAS TREINADAS"*** apresentado a esse Hospital Universitário, estando vinculado ao Programa de Pós-graduação em Educação Física do Centro de Educação Física e Esporte da Universidade Estadual de Londrina;

Considerando o parecer favorável apresentado nas instâncias administrativas que envolvem a realização do estudo.

Informamos que o nosso **parecer é favorável** à realização do projeto acima nominado, resguardando-se o atendimento da legislação vigente.

Atendendo a Resolução 466/12 do Conselho Nacional de Saúde o projeto deverá ser analisado pelo Comitê de Ética em Pesquisa da UEL (CEP/UEL) para posterior operacionalização.

Conforme **Ofício Circular da Diretoria Superintendente do HU nº 214/2015**, a cópia do parecer de aprovação do CEP/UEL deverá ser apresentado à Chefia e/ou Gerente das unidades envolvidas antes do início da coleta de dados.

Solicitamos que, tão logo o Comitê de Ética emita parecer, essa Diretoria Superintendente seja notificada, para os procedimentos cabíveis relacionados à documentação da pesquisa.

Solicitamos também que, uma vez realizado o estudo, uma cópia seja apresentada a esta Diretoria, para ciência e divulgação.

Em 01/08/2019

Enfa. Ma. Vivian Biazon El Reda Feijó
Diretora Superintendente

Comissão de Avaliação de Projetos de Pesquisa Científica (CAPPC) do HU
Fone: (43)3371-2301

Anexo B: Relação cadastral do projeto de pesquisa pós-pandemia

Universidade Estadual de Londrina
PROPPG - Diretoria de Pesquisa
Divisão de Cadastro e Acompanhamento

Pág.1
25/05/2023

Relação de Pesquisas Cadastradas

Centro: CENTRO DE EDUCAÇÃO FÍSICA E ESPORTE - CEFE Tel.: (0xx43) 3371-4218
Depto: DEPARTAMENTO DE EDUCAÇÃO FÍSICA - CEFE-DEF Tel.: (0xx43) 3371-4238
Projeto: 13183 - IMPACTO DE UM ANO DE INTERVENÇÃO COM TREINAMENTO RESISTIDO SOBRE A FORÇA MUSCULAR, COMPOSIÇÃO CORPORAL E BIOMARCADORES DE RISCO CARDIOMETABÓLICO EM MULHERES PÓS-MENOPAUSADAS: ESTUDO LONGITUDINAL ENVELHECIMENTO ATIVO

Tipo de Cadastro: 17 - ÓRGÃOS EXTERNOS DE FOMENTO - RESOLUÇÃO 70/2012
Tipo de Pesquisa: TRABALHO CIENTÍFICO — Classificação: Aplicada
Processo: / — Relatório:
Tempo Pr. Inicial: 024 — Meses Prorrog.: — Término Previsto: 27/01/2024
Área do CNPQ: EDUCACAO FISICA

Desenvolvimento do Projeto

Data	Situação	Motivo
28/01/2022	EM EXECUÇÃO	

Aprovações do Projeto

Enviado para	Aprovado	Nº Referência	Especificação

Participantes do Projeto

Código	Categoria	Titulação	Sit	C.H.	Função	Data	Nome
202112970012	PÓS-GRAD.		AT		COLABORADOR	28/01/2022	ÁGATHA GRAÇA AMARANTE DO N..
0116485	DOCENTE	MESTRADO	AT		CONSULTOR	28/01/2022	ALESSANDRA MIYUKI OKINO
202012980010	PÓS-GRAD.		AT		COLABORADOR	28/01/2022	ALEXANDRE PICOLOTO
202312970001	PÓS-GRAD.		AT		COLABORADOR	25/05/2023	ALINE PRADO DOS SANTOS
201912980003	PÓS-GRAD.		AT		COLABORADOR	25/05/2023	ANA PAULA MICHELIN
201913060003	PÓS-GRAD.		AT		COLABORADOR	28/01/2022	BRUNA DANIELLA DE VASCONCE..
202000860059	GRADUAÇÃO		AT		COLABORADOR	28/01/2022	BRUNO BARLATI BARDACON
0407067	DOCENTE	DOUTORADO	AT		CONSULTOR	28/01/2022	DANIELLE VENTURINI
201900874029	GRADUAÇÃO		AT		COLABORADOR	28/01/2022	DANRLEI SOARES ANTUNES
201900864050	GRADUAÇÃO		AT		COLABORADOR	25/05/2023	DANRLEI SOARES ANTUNES
0402788	DOCENTE	DOUTORADO	AT		CONSULTOR	28/01/2022	DECIO SABBATINI BARBOSA
202012980003	PÓS-GRAD.		AT		COLABORADOR	28/01/2022	EDILAINE FUNGARI CAVALCANTE
0510870	DOCENTE	DOUTORADO	AT	6	COORDENADOR	28/01/2022	EDILSON SERPELONI CYRINO
201900870092	GRADUAÇÃO		AT		COLABORADOR	28/01/2022	FELIPE DE OLIVEIRA LISBOA
202100870348	GRADUAÇÃO		AT		COLABORADOR	25/05/2023	FELIPE GOMES CORREA DE PAULA
202113060001	PÓS-GRAD.		AT		COLABORADOR	28/01/2022	GABRIEL KUNEVALIKI DE MORAES
202000860140	GRADUAÇÃO		AT		COLABORADOR	28/01/2022	GABRIEL ZACARIAS DE LIMA
201800871013	GRADUAÇÃO		AT		COLABORADOR	28/01/2022	IAN ISIKAWA TRICOLI
202222970004	PÓS-GRAD.		AT		COLABORADOR	25/05/2023	IAN ISIKAWA TRICOLI
202100860131	GRADUAÇÃO		AT		COLABORADOR	28/01/2022	INGRID GABRIELE MANSKE ULIANA
202113060003	PÓS-GRAD.		AT		COLABORADOR	28/01/2022	JARLISSON FRANCSUEL MELO D..
2023470075	ESPECIAL		AT		COLABORADOR	25/05/2023	JHENEPHAN MACEDO DA SILVA
2023470082	ESPECIAL		AT		COLABORADOR	25/05/2023	JOAO PEDRO ALVES NUNES
2023470076	ESPECIAL		AT		COLABORADOR	25/05/2023	KAMILA PINTO QUINTILHANO
201900860227	GRADUAÇÃO		AT		COLABORADOR	28/01/2022	KAWANE CONSTANCIO
202212980004	PÓS-GRAD.		AT		COLABORADOR	25/05/2023	LAURA DE OLIVEIRA SEMEAO
2018470163	ESPECIAL		AT		COLABORADOR	25/05/2023	LEANDRO DOS SANTOS
201900870252	GRADUAÇÃO		AT		COLABORADOR	28/01/2022	LEONARDO CESAR BOLFER CORREIA
2023470083	ESPECIAL		AT		COLABORADOR	25/05/2023	LETICIA TRINDADE CYRINO
202100860222	GRADUAÇÃO		AT		COLABORADOR	28/01/2022	LUCAS YUDI TAKAKI

2023470077	ESPECIAL	AT	COLABORADOR	25/05/2023	LUIS ALBERTO GOBBO
202100871292	GRADUAÇÃO	AT	COLABORADOR	28/01/2022	LUIS ALVES DE LIMA
202013060003	PÓS-GRAD.	AT	COLABORADOR	28/01/2022	MARCELO AUGUSTO DA SILVA C..
202000861050	GRADUAÇÃO	AT	COLABORADOR	28/01/2022	MARIA FERNANDA MELITO RUGG..
202000860413	GRADUAÇÃO	AT	COLABORADOR	28/01/2022	MARIA VITORIA DE LIMA DE SA
2023470078	ESPECIAL	AT	COLABORADOR	25/05/2023	MATHEUS AMARANTE DO NASCIM..
201900870923	GRADUAÇÃO	AT	COLABORADOR	28/01/2022	MATHEUS FLAUZINO FERREIRA
201800870909	GRADUAÇÃO	AT	COLABORADOR	28/01/2022	MATHEUS HENRIQUE SPATTI
2023470079	ESPECIAL	AT	COLABORADOR	25/05/2023	MELISSA ANTUNES
2023470080	ESPECIAL	AT	COLABORADOR	25/05/2023	MICHELE CAROLINE DE COSTA ..
202112970008	PÓS-GRAD.	AT	COLABORADOR	28/01/2022	NATA GOMES DE LIMA STAVINSKI
202313060005	PÓS-GRAD.	AT	COLABORADOR	25/05/2023	NATÃ GOMES DE LIMA STAVINSKI
202013060004	PÓS-GRAD.	AT	COLABORADOR	28/01/2022	NELSON HILARIO CARNEIRO
202113060005	PÓS-GRAD.	AT	COLABORADOR	28/01/2022	PÂMELA DE CASTRO E SOUZA
2023470081	ESPECIAL	AT	COLABORADOR	25/05/2023	PAOLO MARCELLO DA CUNHA FABRO
201812980009	PÓS-GRAD.	AT	COLABORADOR	28/01/2022	PAULO SUGIHARA JUNIOR
201912980010	PÓS-GRAD.	AT	COLABORADOR	28/01/2022	RICARDO JOSE RODRIGUES
201812980012	PÓS-GRAD.	AT	COLABORADOR	28/01/2022	RODRIGO DOS REIS FERNANDES
202100861041	GRADUAÇÃO	AT	COLABORADOR	28/01/2022	SANDRO MARCELO DA ROCHA JU..
202113060007	PÓS-GRAD.	AT	COLABORADOR	28/01/2022	WITALO KASSIANO FERREIRA D..

Resumo do Projeto

INTRODUÇÃO: A PRÁTICA REGULAR SISTEMATIZADA DE TREINAMENTO RESISTIDO TEM SIDO AMPLAMENTE RECOMENDADA, SOBRETUDO PARA MULHERES IDOSAS, EM VIRTUDE DOS INÚMEROS BENEFÍCIOS QUE PODEM SER PROPORCIONADOS TANTO PARA À SAÚDE QUANTO PARA A QUALIDADE DE VIDA. ENTRETANTO, O EFEITO DESSE TIPO DE TREINAMENTO TEM SIDO INVESTIGADO NA MAIORIA DOS ESTUDOS POR PERÍODOS RELATIVAMENTE CURTOS DE TEMPO (OITO OU 12 SEMANAS), O QUE DIFICULTA A ANÁLISE DO IMPACTO DESSE TIPO DE INTERVENÇÃO AO LONGO DO PROCESSO DE ENVELHECIMENTO. OBJETIVO: ANALISAR OS EFEITOS DE UM ANO DE PRÁTICA REGULAR E SISTEMATIZADA DE TREINAMENTO RESISTIDO SOBRE A FORÇA MUSCULAR, COMPOSIÇÃO CORPORAL E BIOMARCADORES DE RISCO CARDIOMETABÓLICO EM MULHERES PÓS-MENOPAUSADAS. MÉTODOS: ENSAIO CLÍNICO ALEATORIZADO E CONTROLADO, COM A PARTICIPAÇÃO MULHERES FISICAMENTE INDEPENDENTES (> 60 ANOS). O PROTOCOLO DE TREINAMENTO RESISTIDO SERÁ COMPOSTO POR OITO EXERCÍCIOS PARA OS DIFERENTES SEGMENTOS CORPORAIS, A SABER: SUPINO VERTICAL, LEG PRESS HORIZONTAL, REMADA ARTICULADA, CADEIRA EXTENSORA, ROSCA SCOTT, MESA FLEXORA, TRÍCEPS NO PULLEY E PANTURRILHA SENTADA. A PROGRESSÃO AO LONGO DO TEMPO OCORRERÁ MEDIANTE DA MANIPULAÇÃO DE VARIÁVEIS QUE COMPÕEM ESTE TIPO DE TREINAMENTO (CARGAS, ORDEM DE EXECUÇÃO DOS EXERCÍCIOS, NÚMERO DE SÉRIES E REPETIÇÕES, FREQUÊNCIA SEMANAL, SISTEMAS DE TREINAMENTO, PERIODIZAÇÃO) PARA EVITAR UM POSSÍVEL PLATÔ ADAPTATIVO. ANTROPOMETRIA, TESTES DE UMA REPETIÇÃO MÁXIMA (1-RM), MEDIDAS DE COMPOSIÇÃO CORPORAL (ABSORTOMETRIA RADIOLÓGICA DE DUPLA ENERGIA, BIOIMPEDÂNCIA ESPECTRAL E ULTRASSONOGRAFIA) E COLETAS DE SANGUE PARA ANÁLISE DO COMPORTAMENTO DE BIOMARCADORES DE RISCO CARDIOMETABÓLICO (GLICOSE, TRIGLICÉRIDES, COLESTEROL TOTAL, HDL-C, LDL-C E PROTEÍNA C-REATIVA) SERÃO AS VARIÁVEIS A SEREM ANALISADAS NOS MOMENTOS PRÉ-TREINAMENTO E AO FINAL DE UM ANO DE INTERVENÇÃO. RESULTADOS ESPERADOS: ACREDITAMOS QUE A PRÁTICA DO TREINAMENTO RESISTIDO EM MULHERES PÓS-MENOPAUSADAS, POR UM PERÍODO DE TEMPO PROLONGADO (UM ANO), POSSA PROPORCIONAR RESPOSTAS ADAPTATIVAS POSITIVAS E DURADOURAS SOBRE A FORÇA MUSCULAR, COMPOSIÇÃO CORPORAL E INDICADORES CARDIOMETABÓLICOS. ADICIONALMENTE, VARIÁVEIS MENOS RESPONSIVAS A ESTE TIPO DE TREINAMENTO EM CURTOS PERÍODOS DE INTERVENÇÃO, COMO O CONTEÚDO E A DENSIDADE MINERAL ÓSSEA, BEM COMO INDICADORES DO PERFIL LIPÍDICO, PODERÃO SER ANALISADAS DE FORMA MAIS CONSISTENTE.

Anexo C: Escala de depressão geriátrica

ESCALA DE DEPRESSÃO GERIÁTRICA - GDS

1. Está satisfeito (a) com sua vida? (não =1) (sim = 0)
2. Diminuiu a maior parte de suas atividades e interesses? (sim = 1) (não = 0)
3. Sente que a vida está vazia? (sim=1) (não = 0)
4. Aborrece-se com freqüência? (sim=1) (não = 0)
5. Sente-se de bem com a vida na maior parte do tempo? (não=1) (sim = 0)
6. Teme que algo ruim possa lhe acontecer? (sim=1) (não = 0)
7. Sente-se feliz a maior parte do tempo? (não=1) (sim = 0)
8. Sente-se freqüentemente desamparado (a)? (sim=1) (não = 0)
9. Prefere ficar em casa a sair e fazer coisas novas? (sim=1) (não = 0)
10. Acha que tem mais problemas de memória que a maioria? (sim=1) (não = 0)
11. Acha que é maravilhoso estar vivo agora? (não=1) (sim = 0)
12. Vale a pena viver como vive agora? (não=1) (sim = 0)
13. Sente-se cheio(a) de energia? (não=1) (sim = 0)
14. Acha que sua situação tem solução? (não=1) (sim = 0)
15. Acha que tem muita gente em situação melhor? (sim=1) (não = 0)

Avaliação:

0 = Quando a resposta for diferente do exemplo entre parênteses.
1= Quando a resposta for igual ao exemplo entre parênteses.
Total > 5 = suspeita de depressão

Anexo D: Inventário de ansiedade de Beck

Nome:______________________________________ **Idade:**__________ **Data:** ____/____/____

Abaixo está uma lista de sintomas comuns de ansiedade. Por favor, leia cuidadosamente cada item da lista. Identifique o quanto você tem sido incomodado por cada sintoma durante a **última semana, incluindo hoje**, colocando um "x" no espaço correspondente, na mesma linha de cada sintoma.

	Absolutamente não	**Levemente** Não me incomodou muito	**Moderadamente** Foi muito desagradável mas pude suportar	**Gravemente** Dificilmente pude suportar
1. Dormência ou formigamento				
2. Sensação de calor				
3. Tremores nas pernas				
4. Incapaz de relaxar				
5. Medo que aconteça o pior				
6. Atordoado ou tonto				
7. Palpitação ou aceleração do coração				
8. Sem equilíbrio				
9. Aterrorizado				
10. Nervoso				
11. Sensação de sufocação				
12. Tremores nas mãos				
13. Trêmulo				
14. Medo de perder o controle				
15. Dificuldade de respirar				
16. Medo de morrer				
17. Assustado				
18. Indigestão ou desconforto no abdômen				
19. Sensação de desmaio				
20. Rosto afogueado				
21. Suor (não devido ao calor)				