**CRITICALLY APPRAISED TOPIC**

**FOCUSED CLINICAL QUESTION**

For 65-year-old and older patients with skeletal muscle deficits, is high-intensity resistance training as effective as aerobic exercise for improving functional outcomes, as indicated by the Timed Up and Go Test.

**AUTHOR**


| | | | |
|---|---|---|---|
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**CLINICAL SCENARIO**

During my inpatient rehab and acute rehab rotation I treated multiple older adults with general deconditioning, resulting in significant functional deficits. My CI and I would often prescribe targeted strengthening exercises, which were often underloaded and limited to a low intensity due to limited resources/equipment, especially in the acute care setting. However, underloading patients is not limited to the inpatient setting, as I observed similar issues while attempting to load my older adult patients in the outpatient orthopedic setting. Without a way to truly overload muscle and perform high-intensity resistance training, treatment sessions in the acute care setting often emphasized aerobic and balance training to improve function. However, I am curious of the impact of high-intensity resistance training on a functional outcome measure, such as the Time Up and GO Test, for older adults with deficits in skeletal muscle.

**SUMMARY OF SEARCH**

[Best evidence appraised and key findings]

Eight studies met the stated inclusion and exclusion criteria, which included five RCTs, 2 systematic reviews, and 1 umbrella review of systematic reviews.

- Moderate-to-high intensity resistance circuit training resulted in significant improvements in anthropometric data, strength measurements, and functional tests when compared to a physically inactive control.
- High intensity resistance impact training resulted in significant improvements in strength, function, neuromuscular control, and bone mineral density when compared to a low-intensity intervention, for postmenopausal women with low BMD.
- No serious, adverse effects were reported for either moderate-to-high and high intensity resistance training groups.

**CLINICAL BOTTOM LINE**

Older adults with musculoskeletal or orthopedic conditions can benefit from moderate-to-high intensity resistance training and show significant improvements in strength, bone quality, and functional outcomes when compared to programs of lower intensity. Furthermore, with proper supervision and progression from a trained professional, exercise at this intensity has no significant increased risk of serious, adverse effect.

***This critically appraised topic has been individually prepared as part of a course requirement and has been peer-reviewed by one other independent course instructor***

*The above information should fit onto the first page of your CAT*

**SEARCH STRATEGY**

| **Terms used to guide the search strategy** | | | |
|---|---|---|---|
| **P**atient/Client Group | **I**ntervention (or Assessment) | **C**omparison | **O**utcome(s) |
| (65+ years old,<br>Older adults; potentially included via filters)<br>Muscle weakness<br>Deconditioning<br>Frailty | High Intensity Resistance training<br>Resistance Training<br>Strength Training | Aerobic exercise<br>Cardiovascular, Endurance Training<br>Walking, Biking, Running | Timed up and go<br>Functional Outcome Measure<br>Functional Mobility<br>Gait Speed |

**Final search strategy (history):**

Muscle Weakness AND High-Intensity Resistance Training AND Aerobic Exercise AND Functional Outcome Measures

13 results, the majority of which included neurologic conditions, including stroke, CP

(Muscle Weakness OR Deconditioning OR Frailty) AND (High-Intensity Resistance Training OR Resistance Training OR Strength Training) AND (Aerobic Exercise OR Cardiovascular Training OR Walking) AND (Time up and Go OR Functional Outcome Measure OR Functional Mobility OR Gait Speed)

This search strategy provided 524 results. The first result was an article with a stroke population.

(Muscle Weakness OR Deconditioning OR Frailty) AND (High-Intensity Resistance Training OR Resistance Training OR Strength Training) AND (Aerobic Exercise OR Cardiovascular Training OR Walking) AND (Time up and Go OR Functional Outcome Measure OR Functional Mobility OR Gait Speed) NOT (stroke OR neurologic condition)

This yielded 354 results

**(Muscle Weakness OR Deconditioning OR Frailty) AND (High-Intensity Resistance Training OR Resistance Training OR Strength Training) AND (Aerobic Exercise OR Cardiovascular Training OR Walking) AND (Time up and Go OR Functional Outcome Measure OR Functional Mobility OR Gait Speed) NOT (stroke OR neurologic condition OR progressive disorder OR cachexia)**

318 results

*In the table below, show how many results you got from your search from each database you searched.*

| Databases and Sites Searched | Number of results | Limits applied, revised number of results (if applicable) |
|---|---|---|
| **PubMed** | **318** | **RCT, Systematic Review, in the last 10 years, Aged 65+ (77 results)** |
| **CINAHL** | **15 results** | **Published Date 2011-2021, aged: 65+ years (9 results)** |
| **PEDro** | **60 results** | **Therapy: strength training, Problem: muscle weakness, Subdiscipline: gerontology,** |

| | | |
|---|---|---|
| | | **Method: systematic review, Published Since: 2015 (this strategy yielded 60 results)** |

**INCLUSION and EXCLUSION CRITERIA**

| **Inclusion Criteria** |
|---|
| • musculoskeletal condition<br>• orthopaedic condition<br>• general deconditioning |
| • **Exclusion Criteria** |
| • progressive disorders, neurological disorders<br>• cachexia<br>• pediatrics<br>• adults 55 and younger<br>• traumatic injury |

**RESULTS OF SEARCH**

**Summary of articles retrieved that met inclusion and exclusion criteria**

*For each article being considered for inclusion in the CAT, score for methodological quality on an appropriate scale, categorize the level of evidence, indicate whether the relevance of the study PICO to your PICO is high/mod/low, and note the study design (e.g., RCT, systematic review, case study).*

| Author (Year) | Risk of bias (quality score)* | Level of Evidence** | Relevance | Study design |
|---|---|---|---|---|
| **Lai**[1] **(2021)** | **PEDro Scale: 8/10** | **2** | **low** | **RCT** |
| **Aas**[2] **(2020)** | **PEDro Scale: 5/10** | **3 – Less Rigorous Study Design** | **moderate** | **RCT** |
| **Yu**[3] **(2020)** | **PEDro Scale: 8/10** | **2** | **low** | **RCT** |
| **Vlietstra**[4] **(2018)** | **AMSTAR: 9/11** | **1** | **low** | **Systematic Review and Meta-Analysis** |
| **Jadczak**[5] **(2018)** | **AMSTAR: 10/11** | **1** | **low** | **Umbrella Review of Systematic Reviews** |
| **Escriche-Escuder**[6] **(2021)** | **AMSTAR: 10/11** | **1** | **low** | **Systematic Review and Meta-Analysis** |
| **Marcos-Pardo**[7] **(2019)** | **PEDro Scale: 4/10** | **3 – Less Rigorous Study Design** | **high** | **RCT** |
| **Watson**[8] **(2018)** | **PEDro Scale: 7/10** | **2** | **moderate** | **RCT** |

**BEST EVIDENCE**

The following 2 studies were identified as the 'best' evidence and selected for critical appraisal. Rationale for selecting these studies were:

- **Marcos-Pardo (2019) - Despite having a score of 4/10 on the PEDro scale, this study has higher relevance to the PICO question, and assesses the impact of resistance training of 60-80% max on function in the desired population.**
- **Watson (2018) – Similarly, this RCT had moderate relevance to the PICO question, with a high-intensity resistance training intervention, which targets the older-adult population. However, the population is limited to postmenopausal women with low bone mineral density. Additionally, this RCT had an acceptable quality score, with a 7/10 on the PEDro scale.**

**SUMMARY OF BEST EVIDENCE**

**(1)** Description and appraisal of **(Effects of a moderate-to-high intensity resistance circuit training on fat mass, functional capacity, muscular strength, and quality of life in elderly: A randomized controlled trial)** by **(Pablo Jorge Marcos-Pardo, Francisco Javier Orquin-Castrillon, Gemma Maria Gea-Garcia, Ruperto Menayo-Antunez, Noelia Gonzalez-Galvez, Rodrigo Gomes de Souza Vale, Alejandro Martinez-Rodriguez, 2019)**

| **Aim/Objective of the Study/Systematic Review:** |
|---|

Marcos-Pardo et al emphasize the importance of physical activity that promotes muscle strength gains and endurance. Similarly, this study identifies common processes of aging, including various negative adaptations to muscle quality and characteristics, including size, strength, and flexibility. Moreover, it is essential to use physical activity to promote independence, function, and disease prevention for this population. The main objective of this RCT was to determine the impact of a 12 week, moderate to high intensity resistance circuit training on these key outcomes for an elderly population.

**Study Design**

This randomized controlled trial by Marcos-Pardo et al included 66 participants, which were then randomly allocated to the experimental or control group. After allocation, an additional 21 subjects were excluded from the study, with a final participation of 24 subjects who completed the moderate-to-high intensity intervention and 21 subjects who served as the control. The outcomes were measured immediately before and after the 12-week program.

**Setting**

All subjects were from Murcia, Spain. The study does not report where the intervention was performed. However, based on the evidence and outcome measures discussed, this study appears most appropriate in t a community or outpatient setting.

**Participants**

Out of the 75 participants originally selected via recruitment from elderly social groups for this study, 45 participants met the inclusion criteria. Participants were included if they were older than 65 years of age and had never participated in any formal fitness or physical activity training or education and had no strength-training experience. Subjects were excluded based on any history of neuromuscular, metabolic, hormonal, or cardiovascular diseases. Similarly, and medication that could impact hormonal and/or neuromuscular metabolism resulted in exclusion. 4 participants did not finish the program due to health issues determined by the medical team. All subjects were from Murcia, Spain. Of the participants who completed the 12-week program, 27 were women and 18 were men.

At baseline, there were no significant differences in weight, BMI, fat mass, and lean body mass between experimental and control groups for both men and women. However, significant differences existed between the female experimental and control group for the SSP test of the GDLAM, the 1RM chest press, and the 3$^{rd}$ and 6$^{th}$ categories of the QoL assessment. Additionally, significant differences existed between the male experimental and control group for the SSP test of the GDLAM, the 1RM chest press, and the 6$^{th}$ category of the QoL assessment.

**Intervention Investigated**

*Control*

The control group received did not perform the MHRCT intervention. No additional treatment or form of exercise was provided to the control group. This group reported for 12 week follow up after the baseline measurements were taken.

*Experimental*

The participants in the MHRCT group performed the exercises that would be used during the moderate-to-high intensity circuit training sessions during two sessions per week for two weeks, for education regarding proper technique. Following this period, participants performed resistance exercise training of six major muscle regions (which are not specified), 3 times per week for the remainder of the 12 weeks. These exercises were initially performed at a moderate intensity, determined by 60% of their 1RM, and progressed to high intensity, 80% of their 1RM. Furthermore, a physical education professional increased the load when the participant was able to complete more than 12 repetitions of the exercise. Finally, participants were given 1-2 minutes of rest between each set.

**Outcome Measures**

Two investigators measured all outcomes using a standardized protocol over two days for both data collection before and after the 12-week training period. Biological tests and quality of life measures were taken on the first day and the strength tests were performed on the second day.

Total body weight and lean body mass were calculated using a Tanita BC-418 MA bio-impedance machine. Additionally, height was calculated, and BMI was determined using the formula weight/height^2.

Functional outcome assessment included a 10-meter walk test, standing up from a seated position, standing up from a prone position, standing up from a chair and moving about the room, and putting on and taking off a shirt. A GDLAM index score is calculated from the results of these tests.

Muscular strength as assessed using submaximal strength testing, which provided predicted values for each participant's 1RM. Participants performed a chest press and military press to assess muscular strength of the upper extremity and leg extension and hip extension to assess muscular strength of the lower extremity.

Perceived exertion as determined by the OMNI-RES scale, which is an 11-point scale, ranging from 0-10; A score of 0 represents an extremely easy perceived exertion and a score of 10 represents an extremely hard perceived exertion.

Quality of Life was assessed via the WHOQOL-OLD, which is contains 24 self-reported items across 6 categories, including sensory abilities, autonomy, past present and future activities, social participation, death and dying, and intimacy. Scores can range from 4-20, with a score of 20 indicated the highest self-reported QoL.

**Main Findings**

| **Parameter** | **Control** | **Experimental** | |
|---|---|---|---|
| **Body Composition** | **X +/- SD** | **X +/- SD** | **P Value** |
| Weight (kg) | 1.27 +/- 0.55 | -0.01 +/- 1.50 | 0.074 |
| BMI (kg/m^2) | 0.47 +/- 0.21 | 0.00 +/- 0.59 | 0.074 |
| Fat mass (%) | 0.42 +/- 0.69 | -2.14 +/- 1.88 | 0.127 |
| LBM (kg) | 0.46 +/- 1.18 | 1.72 +/- 0.79 | **0.014** |
| **GDLAM** | | | |
| 10m Walk | 0.20 +/- 0.13 | -0.49 +/- 0.41 | **0.002** |
| SSP | 0.13 +/- 0.21 | -0.82 +/- 1.49 | **0.024** |
| SPP | 0.12 +/- 0.36 | 0.06 +/- 1.69 | **0.032** |
| SCMA | 0.23 +/- 0.64 | -2.45 +/- 3.05 | **0.002** |
| PTS | 0.12 +/- 0.17 | -1.44 +/- 2.97 | 0.079 |
| GI | 0.20 +/- 0.27 | -1.95 +/- 2.43 | **0.005** |
| **Strength Conditioning** | | | |
| 1RM CHP (kg) | -0.11 +/- 0.70 | 11.11 +/- 7.02 | 0.260 |
| 1RM MP (kg) | -0.11 +/- 0.45 | 12.70 +/- 5.98 | **<0.001** |
| 1RM LE (kg) | -0.19 +/- 0.28 | 16.26 +/- 7.54 | **<0.001** |
| 1RM HE (kg) | -0.41 +/- 0.39 | 17.54 +/- 14.14 | **<0.001** |
| **Quality of Life** | | | |

| | | | |
|---|---|---|---|
| Category 1 | 0.14 +/- 0.22 | 1.56 +/- 14.70 | 0.584 |
| Category 2 | 0.20 +/- 0.17 | 1.56 +/- 10.08 | 0.598 |
| Category 3 | -0.11 +/- 0.21 | -0.39 +/- 11.29 | 0.357 |
| Category 4 | 0.18 +/- 0.34 | -2.60 +/- 14.58 | 0.205 |
| Category 5 | -0.23 +/- 0.13 | -3.78 +/- 19.99 | 0.305 |
| Category 6 | 0.37 +/- 0.24 | -1.56 +/- 6.65 | 0.455 |
| Global QoL | 0.21 +/- 0,19 | -0.77 +/- 0.78 | 0.071 |

For women, participants who completed the MHRCT intervention demonstrated a significant improvement lean body mass, military press strength, leg extension strength, and hip extension strength. Moreover, significant improvements were seen in 5 of the 6 functional tests, including the 10-meter walk, standing from a seated position, standing from a prone position, standing up from a chair and moving about the room, and the GDLAM index. No significant difference was observed for putting on and taking off a shirt. Finally, no significant improvements in quality of life were reported

| **Parameter** | **Control** | **Experimental** | |
|---|---|---|---|
| **Body Composition** | **X +/- SD** | **X +/- SD** | **P Value** |
| Weight (kg) | 0.95 +/- 0.57 | -0.09 +/- 0.87 | **0.041** |
| BMI (kg/m^2) | 0.31 +/- 0.19 | -0.02 +/- 0.28 | **0.042** |
| Fat mass (%) | 0.39 +/- 1.06 | -2.32 +/- 0.88 | **0.018** |
| LBM (kg) | 0.04 +/- 1.34 | 2.02 +/- 0.75 | **0.003** |
| **GDLAM** | | | |
| 10m Walk | 0.16 +/- 0.20 | -0.43 +/- 0.63 | **0.002** |
| SSP | -0.13 +/- 0.16 | -0.79 +/- 1.18 | 0.500 |
| SPP | 0.20 +/- 0.19 | -1.13 +/- 1.54 | **0.018** |
| SCMA | 0.19 +/- 0.75 | -3.58 +/- 2.37 | **0.014** |
| PTS | 0.21 +/- 0.16 | -3.26 +/- 1.93 | **0.022** |
| GI | 0.21 +/- 0.19 | -3.11 +/- 1.50 | **0.000** |
| **Strength Conditioning** | | | |
| 1RM CHP (kg) | 0.04 +/- 0.88 | 18.06 +/- 9.48 | 0.066 |
| 1RM MP (kg) | -0.36 +/- 0.40 | 16.57 +/- 7.92 | **0.020** |
| 1RM LE (kg) | -0.31 +/- 0.34 | 19.07 +/- 19.24 | **0.003** |
| 1RM HE (kg) | -0.30 +/- 0.47 | 12.15 +/- 7.63 | 0.139 |
| **Quality of Life** | | | |
| Category 1 | 0.18 +/- 0.20 | 0.93 +/- 10.42 | 0.063 |
| Category 2 | 0.11 +/- 0.15 | 0.69 +/- 14.80 | 0.886 |

| | | | |
|---|---|---|---|
| Category 3 | 0.13 +/- 0.30 | -2.08 +/- 15.31 | 0.664 |
| Category 4 | -0.20 +/- 0.19 | -0.69 +/- 14.13 | 0.603 |
| Category 5 | -0.22 +/- 0.23 | -2.78 +/- 15.02 | 0.969 |
| Category 6 | 0.15 +/- 0.14 | 0.46 +/- 6.14 | 0.266 |
| Global QoL | 0.15 +/- 0.17 | -0.48 +/- 9.79 | 0.883 |

For men, participants who completed the MHRCT intervention demonstrated significant improvements in weight, BMI, fat mass, and lean body mass, when compared to the control. Moreover, significant improvements were seen for military press strength, leg extension strength, and 5 out of 6 functional tests, including 10-meter walk, standing from a prone position, standing up from a chair and moving about the room, putting on and taking off a shirt, and the GDLAM index. No significant differences in quality of life were reported.

**Original Authors' Conclusions**

The author's concluded that a moderate to high resistance circuit training program serves as an effective and appropriate intervention strategy for older adults through improvements in physical and functional performance. Therefore, patients who perform this program have the potential for greater function and independence throughout the normal aging process along with quality-of-life improvements with continued compliance with this program. Additionally, the authors conclude that this program is also applicable to older adults who are frail.

**Critical Appraisal**

**Validity**

There are multiple strengths to this level 2 randomized controlled trial. Firstly, the recruited participants that were included in the study were randomly allocated into the control and an experimental group. Additionally, follow up occurred 12 weeks after baseline data was collected, which is an appropriate time to expect changes in strength and functional outcome. Moreover, the groups had similar baseline characteristics as discussed in the participant selection section.

However, there are numerous weaknesses of this study that impact its validity. For example, after initiation of the program, 21 additional participants were excluded due to health issues or discontinuation of the treatment; It appears that no intention-to-treat analysis was used as it was not discussed, and the 45 participants were included in the analysis despite the allocation of 66 participants. Additionally, there is no mention of the subjects or researchers being blinded to the group assignments. Finally, the findings of this study were not confirmed with a new set of subjects. These weaknesses are further supported by this trials score of 4/10 on the PEDro scale, which indicates fair reliability and clinical application.

**Interpretation of Results**

Both men and women that participated in the intervention group experienced statistically significant changes in lean body mass, with p values of 0.014 and 0.003 respectively. However, the statistically significant changes in strength and functional testing is of greater clinical relevance. Specifically, for women, a p value of <0.001 was reported for military press, hip extension, and leg extension when compared to the control group. Moreover, the p values for key functional assessment, such as walking 10 meters, and standing from a chair and moving about a room, were 0.002 and 0.002. Similarly, for men who completed the experimental intervention, p values of 0.020 and 0.003 were reported for military press strength and leg extension strength respectively. Moreover, a p value of 0.002 was reported for the 10-meter walk. Therefore, it appears that moderate-to-high resistance training can make significant improvements in strength and function. However, the control group did not perform any form of physical activity or resistance training. Therefore, these results can only suggest that these previously suggested significant improvements can only be called significant when compared to doing nothing. I believe these results would be more meaningful if compared to an additional form of physical activity. Moreover, no significant improvements in quality of life

were observed. Therefore, although we cannot be certain that these improvements in strength and function impact the subjective experience of this population and target the patient holistically.

**Applicability of Study Results**

Unfortunately, this study does not provide a specific exercise protocol and simply notes targets muscle regions. This clearly limits the applicability of this moderate-to-high intensity program. Moreover, as previously discussed, this study does not necessarily guide selection of this exercise program over another exercise program for older adults, but simply shows that this program will provide significant benefits in measurable outcomes. However, it is still beneficial to understand that higher levels of intensity are appropriate for older adults. Additionally, I believe implementing a resistance training program of this intensity, that targets all major muscle groups, 3 times per week, for 12 weeks is certainly feasible for the physical therapy setting, especially outpatient orthopedics. This frequency is certainly appropriate for a plan of care in this setting but can be further modified for completion of exercise at home with effective patient education and guidance from a professional.

**(2)** Description and appraisal of **(High-Intensity Resistance Training and Impact Training Improves Bone Mineral Density and Physical Function in Postmenopausal Women with Osteopenia and Osteoporosis: The LIFTMOR Randomized Controlled Trial)** by **(Steven L Watson, Benjamin K Weeks. Lisa J Weis, Amy T Harding, Sean A Horan, Belinda R Beck, 2018)**

**Aim/Objective of the Study/Systematic Review:**

The main objective of the Lifting Intervention for Training Muscle and Osteoporosis Rehabilitation Trial was to assess the impact of a high resistance impact training program on function and bone property and quality in postmenopausal women, without significant adverse effects, when compared to a low-intensity program.

**Study Design**

This trial was single-blinded, randomized, and controlled. Stratified randomization was used based on the use of medication for osteoporosis. After being provided sequentially numbered, opaque envelopes, an external investigator determined the randomization via a random number generator. Furthermore, random group allocation was performed by an internal researcher. Once allocated to the experimental or control group, participants performed either the 8-month HiRIT or low-intensity home-based exercise program. All outcome measures were collected during a testing session at baseline and follow-up by a single, unblinded investigator. Additionally, bone mineral density measures were verified by a blinded investigator.

**Setting**

The intervention group performed their training program at Griffith University in the Gold Coast, Australia or the Bone Clinic in Brisbane, Australia.

The control group performed their training program at home.

**Participants**

[N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]

Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article.

Post-menopausal women greater than 58 years of age with a T-score of less than -1.0 at the hip or spine, were recruited through posters, radio, TV, newspapers, and word of mouth. Following this recruitment, 568 participants expressed interest, but only 468 agreed to participate. 305 participants were excluded;

Participants were excluded with lower limb joint injury or surgery, a fracture within the past year, localized back pain, less than 5 years postmenopause, malignancy, uncontrolled CVD, cognitive impairment, recent X-ray or radiation treatment, contraindications for participating in heavy physical activity, conditions or pharmaceuticals known to impact bone mineral density or quality. The remaining 101 participants were randomly allocated to the experimental or control group, resulting in 52 participants in the control group, and 49 participants in the experimental group.

At baseline, the control and experimental groups were comparable for age, weight, BMI, lumbar spine bone mineral density and T-score, femoral neck bone mineral density and T score, broadband ultrasound attenuation, speed of sound, stiffness index, back extensor strength, leg extensor strength, five times sit-to-stand, functional reach test, current bone-specificity physical activity questionnaire score, total bone-specific physical activity questionnaire score, and dietary calcium. The only between-group difference for the control and intervention groups at baseline was mean Time Up and Go score; The TUGT score for the control group was 5.9 seconds +/- 0.6 seconds compared to 6.3 seconds +/- 0.7 seconds for the experimental group, with a significant p Value of 0.008.

A total of 6 experimental group participants were lost to follow-up due to relocation, unrelated medical reasons, or an inability to attend sessions, while a total of 9 control group participants were lost to follow-up due to relocation, unrelated medical reasons, or participation withdrawal.

**Intervention Investigated**

*Control*

The control group performed a low-intensity exercise program for 30-minute sessions, twice per week, for 8 months. Low intensity was defined as 10 to 15 repetitions at an intensity <60% of the participant's 1RM, which was determined to be insufficient to stimulate bone adaptation. Instead, this control program emphasized balance and mobility improvement and included lunges, calf-raises, standing forward raises, shrugs, and neck, calf, shoulder, and lumbar spine stretching. The exercises were performed at body weight and were progressed to 3kg dumbbells. Additionally, a 10-minute warm-up and 5-minunte cool-down were included.

*Experimental*

The intervention group performed high intensity resistance training and impact loading exercises during 30-minute sessions, twice per week, for 8 months under the instruction of an exercise scientist and physical therapist. To allow for safe progression and adaptation to high-intensity loading, participants first underwent a period of load and bodyweight exercise, which included education of the correct movement patterns of the high-intensity exercises. This acclimation period was completed within the first two months of the program. Once completed, participants began performing the 3 resistance training exercises, which included deadlift, overhead press, and back squat for 5 sets of 5 repetitions at an intensity of 80-85% of their 1RM. A 2-set deadlift warmup at an intensity of 70% of their 1RM was performed before the completion of these exercises. In addition to the 3 resistance training exercises, an impact loading exercise was performed; Participants performed jumping chin-ups with drop landings by jumping as high as possible while pulling themselves as high possible with an overhead bar. Following the jump, participants let go of the bar and were instructed to land as heavily and comfortably as possible.

**Outcome Measures**

All outcome measures were collected during a testing session at baseline and follow-up, at the Griffith University in Gold Coast, Australia by a single, unblinded investigator. Additionally, bone mineral density measures were verified by a blinded investigator.

Height and body mass were collected, and BMI was calculated with this data using the formula BMI = weight/height^2. Participants provided data regarding the amount of physical activity they've performed throughout their lifetime and all physical activity performed throughout the past year to determine tBPAQ and cBPAQ scores. Additionally, the Australian calcium-specific questionnaire, with patient reported frequency and serving size of calcium intake, to determine daily calcium intake.

Bone Mineral Density of each participant's femoral neck and lumbar spine were measured on the same DXA device at baseline and follow-up.

All physical performance measures were performed in the same order at baseline and follow-up with the same investigator and instructions. An isometric dynamometer was used to determined lower limb extensor strength while a manual muscle testing system dynamometer was used to determine back extensor strength.

For both strength tests, the highest generated force across 3 trials was used. Similarly, the functional outcome measures, including the timed up-and-go test, the 5 times-sit-to-stand test, and functional reach test were performed three times, and the highest score was used. Finally, the maximal vertical jump test was performed on a force plate to capture ground reaction forces and determine the participant's neuromuscular performance.

**Main Findings**

| | **Control** | **Experimental** | |
|---|---|---|---|
| **Parameter** | **% Change** | **% Change** | **p Value** |
| Leg Extensor Strength (kg) | 5.1 +/- 23.1 | 37.1 +/- 20.3 | <0.001 |
| Back Extensor Strength (kg) | 10.9 +/- 25.1 | 36.3 +/- 24.1 | <0.001 |
| Timed up-and-go (sec) | -2.2 +/- 6.3 | 4.3 +/- 6.0 | <0.001 |
| Five times sit-to-stand (sec) | 1.7 +/- 8.1 | 11.6 +/- 7.9 | <0.001 |
| Functional Reach Test (cm) | 0.1 +/- 8.0 | 5.5 +/- 7.6 | <0.001 |
| Vertical Jump ((N x s)/kg)) | 3.6 +/- 16.0 | 5.1 +/- 16.0 | <0.001 |

Participants who completed the LIFTMOR intervention demonstrated significant between-group differences based on adjusted percent change for all strength measurements, functional outcomes, and neuromuscular control tests.

| | **Control** | **Experimental** | |
|---|---|---|---|
| **Parameter** | **% Change** | **% Change** | **p Value** |
| LS BMD (g/cm^2) | -1.2 +/- 3.1 | 2.9 +/- 3.1 | **<0.001** |
| FN BMD (g/cm^2) | -2.0 +/- 3.0 | 0.3 +/- 3.0 | **0.025** |
| BUA (dB/MHz) | 0.8 +/- 7.6 | 1.0 +/- 7.6 | 0.534 |
| SI | 2.0 +/- 6.8 | 2.7 +/- 6.8 | 0.200 |
| SOS (m/s) | 0.2 +/- 1.1 | 0.3 +/- 1.1 | **0.006** |

Participants who completed the LIFTMOR intervention demonstrated significant between-group differences based on adjusted percent change for lumbar spine bone mineral density, femoral neck bone mineral density, and speed of sound measurement.

| | **Control** | **Experimental** | |
|---|---|---|---|
| **Parameter** | **% Change** | **% Change** | **p Value** |

| | | | |
|---|---|---|---|
| FN trabecular volume (cm^3) | -0.8 +/- 11.9 | -2.9 +/- 12.0 | 0.963 |
| FN cortical volume (cm^3) | 5.1 +/- 16.7 | 9.8 +/- 16.7 | 0.492 |
| FN total volume (cm^3) | -0.2 +/- 10.8 | -1.4 +/- 10.7 | 0.987 |
| FN trabecular BMC (g) | -2.9 +/- 29.5 | -0.3 +/- 29.6 | 0.159 |
| FN cortical BMC (g) | 6.2 +/- 21.3 | 7.7 +/- 21.3 | **0.028** |
| FN total BMC (g) | -0.2 +/- 23.6 | 1.7 +/- 23.7 | 0.077 |
| FN trabecular vBMD (g/cm^3) | -2.5 +/- 28.8 | 2.4 +/- 28.9 | 0.798 |
| FN cortical vBMD (g/cm^3) | 0.8 +/- 15.0 | -1.9 +/- 15.1 | 0.310 |
| FN total vBMD (g/cm^3) | -0.3 +/- 24.3 | 3.7 +/- 24.3 | 0.830 |
| FN cortical thickness (mm) | 6.3 +/- 16.6 | 13.6 +/- 16.6 | **0.027** |

Participants who completed the LIFTMOR intervention demonstrated significant between-group differences based on adjusted percent change for femoral neck bone mineral content and cortical thickness.

Additionally, only one adverse event occurred in the HiRIT group, which was reported as a mild low-back muscle sprain.

**Original Authors' Conclusions**

The author's concluded that for elderly, postmenopausal women with low BMD, this high intensity resistance and impact training interventions is the best available program for improving bone quality at frequently fractured locations, along with significant improvements in strength and functional measures, which indicates increased functional performance and decreased risk of falls. Additionally, this intervention is safe and feasible under the guidance of a professional, as no serious adverse events occurred during this trial.

**Critical Appraisal**

**Validity**

This level 2 randomized controlled trial scored a 7/10 on the PEDro scale indicating good reliability and clinical application. As discussed, internal validity was improved through the randomization and allocation of experimental and control groups, with concealment via opaque envelopes, and external investigators who used a random number generator to determine experiment or control group. Another strength of this study was the length of the study protocol; The authors decided to use an 8-month protocol, despite previous record of bone mineral density improvements in 6 months, to maximize potential detection of treatment effects. Finally, the researchers performed an *a priori* sample size calculation, which determined, 100 participants were required to achieve appropriate statistical power in detecting differences between the group and control. Similarly, as previously mentioned, participants were lost to follow-up in both groups. However, the authors performed both an intention-to-treat analysis for the 101 initial participants and a per protocol analysis for the 86 participants that were not lost to follow up.

However, the authors did not randomly select the participants of this trial, which impacts the study's external validity, and therefore, generalizability beyond this study's population. Additionally, the researchers reported that the control group performed an unsupervised low intensity program. The lack of supervision could potentially impact compliance to the provided program, and therefore, result in differences between groups that may not have occurred with similar levels of supervision from a trained professional. Finally, the investigators did not confirm their findings with a new set of subjects.

**Interpretation of Results**

The p values of <0.001 across all measures of strength, function, and neuromuscular control are the strongest and most clinically applicable evidence, indicating the significance and exceptional value of using a higher intensity over a lower intensity in clinic for this population for improvements in these areas for elderly women. Additionally, resistance training and impact loading at this intensity is unlikely to result in serious, adverse effects for postmenopausal women with low bone mineral density.

**Applicability of Study Results**

The emphasis on osteoporosis in postmenopausal women, and impact of the intervention on bone quality and density limits the application of these results to men and older adults with other orthopedic or musculoskeletal conditions. However, this study utilized the appropriate exercise intensity with targeted resistance training exercises. Additionally, there are concerns with the feasibility of this intervention program, as it requires 8 months of supervision for continued progression and maintenance of appropriate intensity. Similarly, the need for equipment to achieve optimal, high intensity loading limits the feasibility and accessibility to all older adults. An 8-month program is likely not feasible due to insurance coverage, and older adults who do not have access to gym equipment or transportation may not be able to complete this program. However, despite the length of this program, the authors reported that adherence was high for both groups.

## SYNTHESIS AND CLINICAL IMPLICATIONS

In conclusion, both studies discussed in this CAT suggest moderate-to-high intensity resistance training is appropriate and beneficial for older adults with musculoskeletal/orthopedic deficits. The study by Marcos-Pardo et al has high applicability to the proposed clinical question. For both men and women that participated in a moderate-to-high resistance training program, significant improvements in anthropometric data, strength, and functional testing were observed when compared to the control. Specifically, for women, p values of <0.001 were reported for strength testing of military press, hip extension, and leg extension and p values for walking 10 meters and standing up from a chair and moving about the room were <0.002. Moreover, for men who completed the experimental intervention, p values of 0.020 and 0.003 were reported for military press strength and leg extension strength respectively. Moreover, a p value of 0.002 was reported for the 10-meter walk. Unfortunately, the quality and validity of this study was fair, as indicated by the PEDro score of 4/10. Similarly, a lack of blinding, lack of control intervention, lack of thorough experimental intervention description, limit the validity, quality, and applicability of this study.

The second study discussed, by Watson et al. has less applicability due to its population consisting of postmenopausal women over the age of 55 years of age with low mineral density. However, the p values of <0.001 across all measures of strength, function, and neuromuscular control provide strong evidence in favor of high intensity resistance training and impact loading. Furthermore, no serious adverse events occurred throughout this 8-month program and adherence was high. However, the applicability of this study to the PICO question is most limited by the narrow and limiting population, which limits generalizability to patients with other MSK conditions. Despite this limitation, this study was of higher quality and of less bias, as indicated by the PEDro score of 7/10.

It is critical that patients are loaded appropriately throughout their physical therapy treatment. Unfortunately, from personal experience, patients, especially older adults, receive significantly lower loads than they can tolerate or loads that do not provide optimal benefit. It is essential that future research continues to assess the effectiveness of specific, high-intensity resistance training programs for older adults with orthopedic/musculoskeletal conditions and/or weakness on functional outcome and independence. Moreover, due to the increased complexity of some older adult patients, future studies should consider additional comorbidities while implementing high-intensity programs. Additionally, the impact of long-term outcomes and quality of life should be assessed as the use of higher-intensity programs increase. Finally, the impact of high-intensity resistance training on functional outcome should be compared to other forms of physical activity, such as aerobic exercise, of similar intensity, with the goal of determining the most appropriate type and frequency of physical activity to promote independent living and healthy, normal aging for the older adult population.

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