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Whole Body Resistance Training and Physical Function Among Older Women

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Abstract

Aging is associated with a decline in physical function. This study aimed to assess the effects of whole-body resistance training (RT) on physical function among aged mature women. Fifteen women (age: 69 ± 7.45 years) were referred by physicians as apparently healthy. RT program was performed, 2 days/week for 8 weeks, 60 minutes per session. Upper muscle strength[One repetition maximum (1RM) for biceps curl, low row, and pull down], lower muscle strength (1RM for leg curl, leg abduction, and leg adduction), physical function [six-minute walk test (6MW)], and functional mobility [timed up-and-go (TUG)] were evaluated. The 1RM for upper and lower muscle strength and the 6MW test increased significantly ($p < 0.05$); while the TUG decreased significantly($p < 0.05$). RT is capable of increasing muscle strength and physical function. Interestingly, the exercise training program was able to reduce the risk for loss of functional mobility (i.e., decreased TUG time) among the participants.

Keywords: *Aging, Exercise, Muscle Strength, Functional Capacity.*

Introduction

In 2014, 46 million people age 65 and over lived in the United States, accounting for 15 percent of the total population (1). The older population in 2030 is projected to be more than twice as large as in 2000, growing from 35 million to 74 million and representing 21 percent of the total U.S. population (1). Between ages 30 and 75, lean body mass decreases, this is primarily due to loss of skeletal muscle mass (2). The loss of muscle mass and strength leads to a substantial decline in functional capacity, an increased risk of falls and fractures, and an increased risk of developing chronic metabolic diseases (2, 3). The relative loss of muscle mass and strength with age has been reported to be similar for men and women (4). However, the loss of muscle mass and strength may represent a greater health concern in women, as older women tend to suffer more from physical disabilities than older men (5).

Falls and mobility disorders are two of the most common and serious problems facing mature adults over the age of 60 and adult women have been less involved in preventive programs than men (6). Falls and instability can lead to reduction in function, especially skills related to activities of daily living (ADL). Maintaining the ability for living independently and having a satisfying quality of life involves a long time commitment to a healthy life style. Interestingly, measures of physical function and/or physical exercise capacity can predict major health related outcomes in older individuals, such as disability, institutionalization and death (7). For instance, the ability to walk for a distance on the six-minute walk test is a quick and inexpensive measure of physical exercise capacity, that not only reflects the capacity to undertake day to day ADL but also accurately predicts onset of disability in the elderly (8). Effective interventions are required to prevent or treat the detrimental consequences of muscle mass and strength loss in both elderly women and men.

The American College of Sports Medicine (ACSM) and the American Heart Association (AHA) published guidelines for physical activity in older adults and included the importance of resistance training (RT) related to public health issues (9). Indeed, RT training has been well established as an effective treatment strategy to counteract the loss of muscle mass and strength in the elderly population (10, 11). RT prevents decline in skeletal muscle mass and function when the mechanical stimuli provided by ADL are not sufficient to offset these declines with aging (12). Even in the very old population, substantial improvements in muscle mass, strength, and functional capacity have been observed following prolonged RT programs (13). Thus, this study aimed to assess the effects of an 8-week whole-body RT on physical function among aged mature women.

Methods

Study Participants

Fifteen women (age: 69 ± 7.45 years), from the East Texas area, were recruited and referred by physicians as apparently healthy. The inclusion criteria for the study were (a) females age 60 or older, (b) ability to maintain an upright posture for at least one minute voluntarily; (c) ability to walk at least 100 yards independently; and (d) willingness to participate in the study. Individuals were excluded from participation if there was (a) a history or evidence of central nervous system dysfunction; (b) musculoskeletal deformity which could influence gait and balance; (c) a history or evidence of vestibular dysfunction; (d) a history of angina, and (e) unstable disease (e.g., uncontrolled diabetes mellitus, arthritis, coronary artery disease, etc.). All participants were living independently and had no history of participating in any structured exercise training program over the previous 3 years before the study. All participants were informed on the nature and possible risks of the experimental procedures, before their written informed consent was obtained. Following explanation of all the details of the study, each participant signed an informed consent approved by the Institutional Review Board of the host institution.

Experimental Design

The study was a prospective, controlled design consisting of 8 weeks of whole-body RT, and was performed twice per week. The Health and Physical Activity Questionnaire (14) was used to determine the level of physical activity behavior, and the medical history of each participant before the study started. Participants were asked to avoid changing physical activity behavior during the study. The experimental testing procedures consisted of two separate visits performed before and after RT training.

Study Procedures and Assessments

Muscle Strength

One Repetition Maximum (1RM) was conducted on weight machines (i.e., Life Fitness). The assessments evaluated upper body (i.e., biceps curl, low row, and pull down) and lower body (i.e., leg curl, leg abduction, and leg adduction) muscle groups. The 1RM test is a reliable test of muscular strength (15). Participants were asked to lift the heaviest weight they were able to lift within their comfort level one time. In order to eliminate inter-observer variability, the same investigators performed these procedures before and after training. Prior to testing, the participants were familiarized with the procedures and instructed on the correct techniques.

Functional Exercise Capacity

A Six-Minute Walk (6MW) test was administered using a standardized protocol outlined by the American Thoracic Society (16). Briefly, participants were instructed to walk at their own pace trying to cover as much distance as possible in 6 minutes on an indoor track. In order to standardize the protocol, the participants were not coached during the test, but made aware of time remaining to completion. The distance covered was recorded to the nearest meter. Maximum walking distance traveled in 6 minutes, to the nearest meter, was recorded and used for analysis. The 6MW test is a valid measure of "functional exercise capacity" as it evaluates the integrated response of all systems involved during physical activity (16). It is therefore frequently used in both elderly and diseased populations, and was the rationale for using it in the current study.

Functional Mobility

A timed up-and-go (TUG) test was used to assess functional mobility using a previously established protocol (17). The TUG test is a useful and highly reliable test in detecting mobility impairment (18, 19). The TUG test requires standing up from a chair, walking 3 meters (m), and turning and walking back to the chair as quickly as possible. A firm chair with arm rests was placed in the middle of a well-lit, indoor hallway. In front of the chair, a distance of 3 m was marked on the floor and a large cone was placed on the opposite end from the chair. The test began with the participant seated with their back against the chair, arms in lap, and feet just behind the distance-marker on the floor. Instructions were to stand up using the arm rests if needed, walk safely to and around the cone, walk back to the chair, and sit all the way back in the chair as fast as possible. The timer was started on the word "go", and stopped when the participant's back touched the back of the chair. The average time to complete each of 2 separate trials was recorded and used for analysis.

Exercise Program

The whole-body RT program was performed in 1-hour sessions, 2 days/week for 8 weeks, consisting of 10-minute warm-up, 40-minute resistance training, and 10-minute cool-down. Each participant was encouraged to complete 1-2 sets on ten resistive weight machines, using 8-12 repetitions. Initial intensity was set at 40% of 1RM or as tolerated. After each routine, passive stretches were performed. Training load was increased roughly 2 to 2.5 kg for the next session when participants were able to perform 12 repetitions. Training load, number of repetitions, and ratings of perceived exertion (RPE, Borg scale) (20) were recorded to document the tolerance and progression of training. The exercise program included biceps curl, low row, pull down, chest press, back extension, leg curl, leg abduction, leg adduction, leg extension, and leg press.

Statistical Analysis

All values are means ± standard deviation (SD) or ± standard error (SE) when appropriate. Analyses was performed using Student *t*-test for paired samples with Wil coxon matched-pairs signed rank test. All statistical analyses were performed with Graph Pad Prism version 6.0a (Graph Pad Software, Inc. CA, USA). The level of significance was set at $p < 0.05$.

Results

Fifteen women (69 ± 7.45 years) participated in all aspects of this study. All individuals were free from symptoms indicative of chronic illness. None of the participants reported any problem during or after the exercise intervention. The baseline characteristics of these individuals are presented in Table 1.

All subjects completed a total of 16 training sessions. The average values for upper and lower muscle strength assessments are presented in Table 2 and Figures 1 and 2. Following an 8-week whole body RT exercise program, upper and lower muscle strength increased significantly.

Table 1. *Baseline Characteristics*

Variable	Mean (n=15)	SD
Age, (y)	69	7.45
Height (cm)	162	6.89
Body Weight (kg)	69.57	12.92
BMI ($kg{\cdot}m^{-2}$)	26.31	3.54
Resting SBP (mmHg)	130	11
Resting DBP (mmHg)	66	7
Resting HR (b pm)	74	9

All values represent means ± SD. y, years; m, meters; kg, kilograms; BMI, body mass index; SBP, systolic blood pressure; mmHg, DBP, diastolic blood pressure; HR, heart rate; bpm, beats per minute.

There was a 37% increase for biceps curl (pre = 9.02 ± 2.45; post = 12.36 ± 2.49 kg, $p < 0.05$), a 27% increase for low row (pre = 15.91 ± 3.44; post = 20.18 ± 3.09 kg, $p < 0.05$), a 25% increase for pull down (pre = 26.97 ± 4.62; post = 33.77 ± 4.74 kg, $p < 0.05$), a 25% increase for leg curl (pre = 36.00 ± 8.92; post = 45.12 ± 8.52 kg, $p < 0.05$), a 25% increase for leg abduction (pre = 32.73 ± 4.61; post = 41.03 ± 6.19 kg, $p < 0.05$), and a 16% increase for leg adduction (pre= 52.42 ± 10.43; post = 61.04 ± 9.53 kg, $p < 0.05$).

The average values for the physical exercise capacity are presented in Table 2 and Figure 3. The average baseline 6MW test was 564 ± 91 m. After 8-week RT program, the distance covered in the 6MW increased significantly. Interestingly, there was a 25% increase from baseline (564 ± 91 m to 653 ±51 m, $p < 0.05$). Finally, the average values for functional mobility are presented in Table 2 and Figure 4. The average baseline TUG was 6.6 ±1.3 sec.

Following the RT program, the TUG decreased significantly. Indeed, the participants experienced an18% decrease from baseline (6.6 ± 1.3 to 5.4 ± 0.9 sec, $p < 0.05$).

Table 2. *Muscle Strength and Functional Assessments*

Variable	Pre (n = 15)	Post (n = 15)
Biceps Curl (kg)	9.02 ± 2.45	12.36 ± 2.49*
Low Row (kg)	15.91 ± 3.44	20.18 ± 3.09*
Pull Down (kg)	26.97 ± 4.62	33.77 ± 4.74*
Leg Curl (kg)	36.00 ± 8.92	45.12 ± 8.52*
Leg Abduction (kg)	32.73 ± 4.61	41.03 ± 6.19*
Leg Adduction (kg)	52.42 ± 10.43	61.04 ± 9.53*
6MW (m)	564 ± 91	653 ± 51*
TUG (sec)	6.6 ± 1.3	5.4 ± 0.9*

All values represent means ± SD. kg, kilograms; 6MW, Six-Minute Walk test; m, meters; TUG, timed up-and-go; sec, seconds. *Significantly different from Pre ($p < 0.05$).

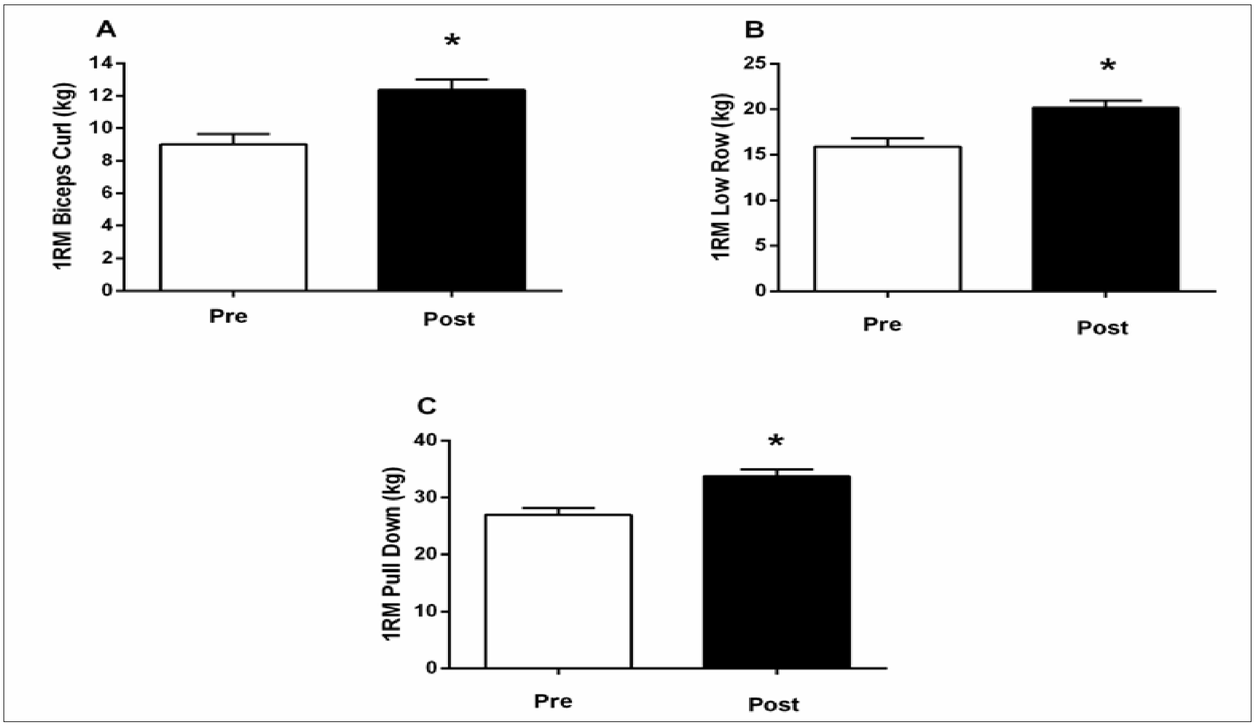

Figure 1. *One repetition maximum (1RM) for biceps curl **(A)**, low row **(B)**, and pull down **(C)**. Values are means ± S.E. *Significantly different from Pre (p < 0.05).*

Discussion

The present data indicated that in aged healthy women patients, an 8-week progressive whole body RT was capable of increasing not only muscle strength, but also increasing the distance covered during the 6MW test and decreasing the TUG time. This study underlies the importance of RT as an effective and safe exercise intervention suitable for older women.

Muscle Strength

Aging and disability are associated with a progressive decline in muscle strength, muscle mass, impaired physical function, and the ability to independently perform ADL. The decline in muscle mass, strength and physical function can contribute to mobility impairments, falls, fractures, and physical disability. RT has been well established as an effective treatment strategy to counteract the loss of muscle mass and strength by maintaining or even increasing muscle strength inolder populations (10-13, 21).

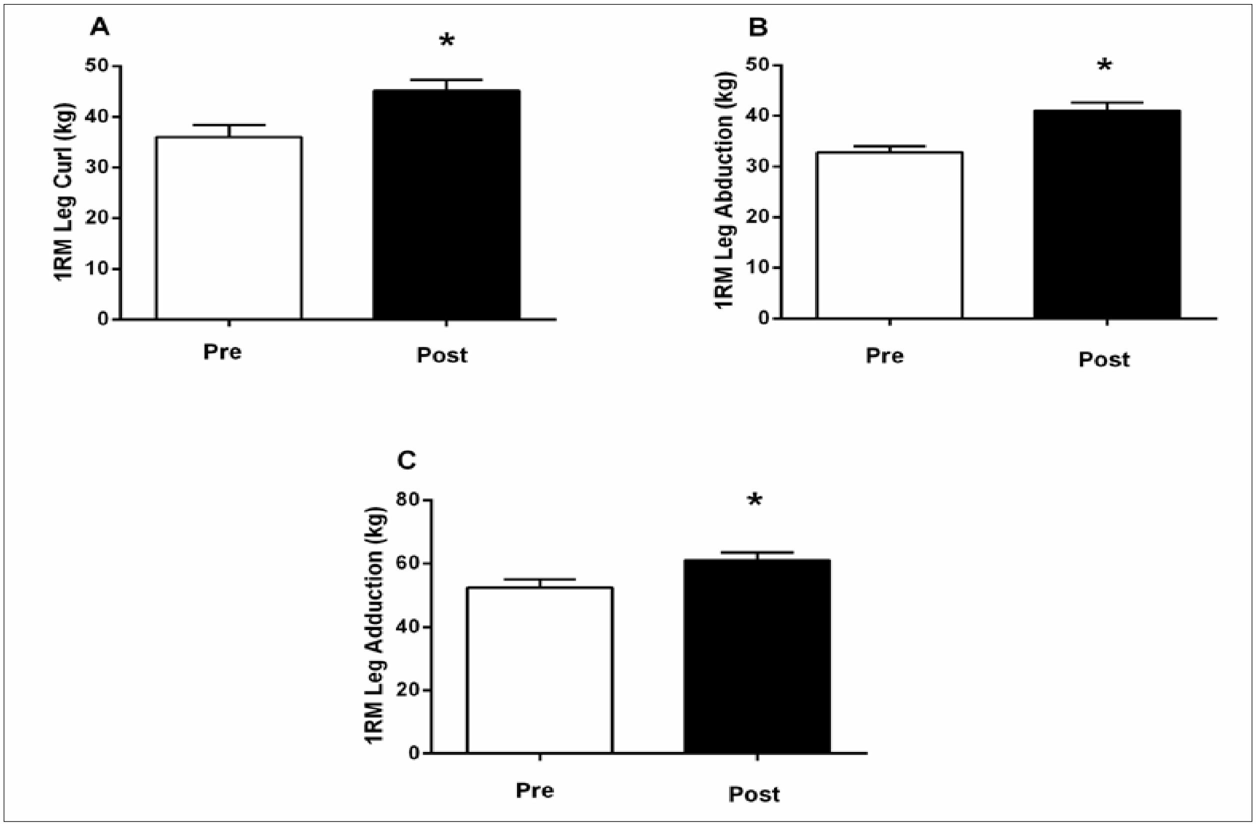

Figure 2. *One repetition maximum (1RM) for leg curl* ***(A)****, leg abduction* ***(B)****, and leg adduction* ***(C).*** *Values are means ± S.E. *Significantly different from Pre (p < 0.05).*

It has been reported that muscle strength declines by 15% per decade after age 50 and 30% per decade after age 70 (22). Our findings reported that whole body RT program was an effective therapeutic tool to counteract muscle strength decline among older woman. Indeed, upper and lower muscle strength increased significantly (37% for biceps curl, 27% for low row, 25% for pull down, leg curl, and leg abduction, and finally 16% for leg adduction (Table 2, Figures 1 and 2). The increase in strength, following RT program, has also shown a positive effect on several important functional limitations in older people (21). For instance, leg strength predicts functional gait in older adults and consequently, RT is commonly emphasized for this population (23). Furthermore, the increased strength can aid the elderly gain independence in ADL and overcome limitations. The improvements in strength reported in our study are consistent with previous studies. In fact, the 2009 ACSM (24) position statement for older adults reported that RT programs can increase muscle strength by 20% - 30% or more in older adults. The initial gains in strength are believed to be due to neural adaptations (24). These adaptations might include; improvements in muscle activation and coordination, enhanced muscle fiber recruitment, and improved muscle contraction synergism (24).

Physical Exercise Capacity

The 6MW test is an easily implemented test that determines the maximum distance a person can walk in 6-min. This test is a valid measure of "functional exercise capacity" as it evaluates the integrated response of all systems involved during physical activity. It is therefore frequently used in both elderly and diseased populations, and was therefore chosen for the current study. The 6MW distance in healthy adults has been reported to range from 400m to 700m (8). The baseline group a verage for the 6MW in this study (564m) (shown in Table 2 and Figure 3) appears to be fairly typical for those seen in community dwelling elderly people with independent function older than 60 years of age (538 m) (25). For healthy adults, the 6MW has also been used to detect changes following interventions to improve exercise tolerance (26), and it has also been used to predict hospitalization and mortality (26, 27).

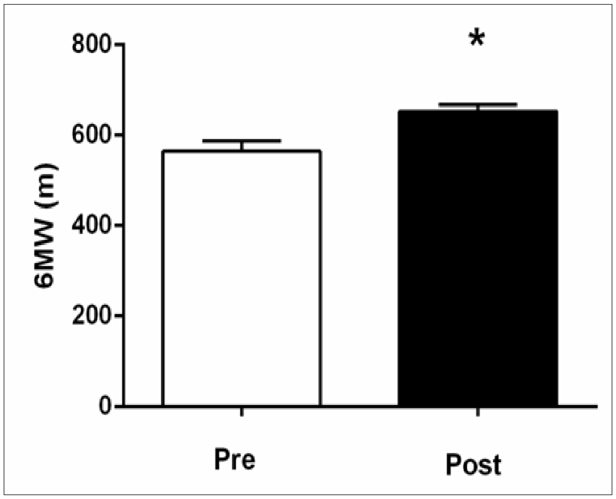

Figure 3. *Six-Minute Walk (6MW) test. Values are means ± S.E. *Significantly different from Pre (p < 0.05).*

Indeed, based on the literature indicating that a walking distance less than 400m is associated with higher prevalence of institutionalization, morbidity, mortality, and hospitalization (26, 27). Importantly, we reported here that following an 8-week progressive RT exercise program, the distance covered in the 6MW increased significantly by 89 m or 16% (564 ± 91 to 653 ± 51 m, $p < 0.05$) (Table 2, Figure 3). The improvement of 89 m following RT exercise program is quite interesting. It has been reported that an improvement of 54m is a clinically important difference (28) among people with chronic lung disease, which is similar to the recommended criteria of meaningful clinical change of 50m among community living older adults and individuals who have survived a stroke (29).

Functional Mobility

Functional mobility entails motor skills essential for independent living. The TUG test provides a measure of functional mobility in older adults (17, 30). The test assesses the time it takes a participant to stand up from a chair, walk around a cone 3 m away, walk back to the chair, and sit down. Data regarding norms and threshold scores for the TUG test are available but are somewhat conflicting. For example, Steffen et al., (25) reported average TUG test times on a group of 60 to 69 years old women around 8 sec. Bischoff et al., (18) recommended the need for early evaluation and intervention for community-dwelling elderly women between 65 - 85 years of age, who scored above 12 sec on the TUG test. Others have identified a cutoff point of 16 sec as a parameter that significantly predicted falls in community dwelling older adults (31).

The baseline group average for the TUG test in this study (6.6 sec) (shown in Table 2 and Figure 4) appears to be quite typical to those reported among a group of 60 to 69 years old women (8 sec) (25). Performance of the TUG test is a more complex interplay between physiological systems than the walk test. It is generally accepted that the TUG test does not focus on independent effects of organ impairments, such as low muscle strength, decreased balance and other impairments, but measures the interaction of these factors on the performance of ADL. The initiation and subsequent continuation of a movement pattern is very much dependent on the ability to immediately increase blood flow to the working muscle. Aging individuals have exhibited reduced vascular function and blood flow delivery (32); on the other hand exercise has been able to show improvement on vascular function (33). The time taken to complete the TUG test is strongly correlated to level of functional mobility (i.e., the more time taken, the less capability of performing ADL and a higher risk for falling). Interestingly, we reported here that following the 8-week RT exercise program, the TUG decreased significantly (i.e., "better time"); the participants experienced an 18% decrease from baseline (6.6 ± 1.3 to 5.4 ± 0.9 sec, $p < 0.05$) (Table 2, Figure 4).

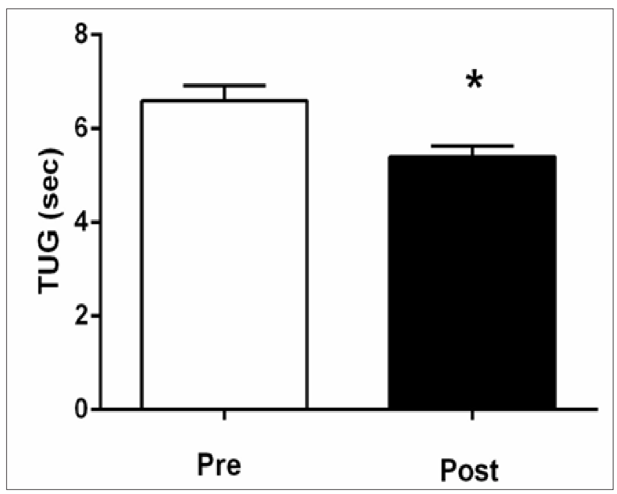

Figure 4. *Timed Up-and-Go (TUG). Values are means ± S.E. *Significantly different from Pre (p < 0.05).*

Regular exercise is an important therapeutic intervention for successful aging for persons to maintain strength, range of motion, and endurance. Without a doubt several daily tasks, such as rising from chair, climbing stairs, and walking are influenced not only by muscle strength but also by physical function, especially in older people. The implementation of interventions that can lessen the age-related decline in function and prevent early onset of physical disability are critical. The ability to maintain functional independence in this population would result in an increased life expectancy without a corresponding increase in health care costs. Thus, the clinical relevance of our findings, increased strength and functional capacity among older women following RT exercise program, is quite relevant to improved ADL.

Conclusion

These findings demonstrate that whole-body RT is capable of increasing upper and lower muscle strength and physical exercise capacity among older women. This study underlies the importance of whole-body RT as part of a healthy and active lifestyle in older women. Interestingly, the exercise training program was able to increase the distance covered during the 6MW test (i.e., physical exercise capacity), and to reduce the risk for loss of functional mobility (i.e., decreased TUG time) among the participants.

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