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Effects of an 8-Week Supplemental Resistance Training Program on Functional Strength and Mobility in Older Women: A Quasi-Experimental Study

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Abstract

This study investigated the effects of an 8-week exercise program supplemented with resistance training on lower body muscular endurance and functionality, and gait balance in active older women. A quasi-experimental design was employed, involving 26 participants (mean age =66.8±4.8 years). Participants were purposively assigned to either a control group (n=11), continuing their regular group exercise program, or an experimental group (n=15), which supplemented their program with 40-50 minutes of resistance training twice weekly. Assessments included body composition, the 30-second chair stand test, and the timed up and go test. The results showed that body composition remained unchanged in both groups, while statistically significant improvements ($p<0.05$) were observed in the 30-second chair stand test (control group: 17.9±3.5 to 23.7±4.5 repetitions; experimental group: 18.3±4.0 to 26.6±4.8 repetitions) and the timed up and go test (control group: 5.6±0.9 to 4.8±0.8 s; experimental group: 5.6±0.8 to 5.0±0.5 s). Despite non-significant between-group differences, improvements in the 30s chair stand test in the experimental as compared to the control group showed a moderate effect size. No significant differences were observed in timed up and go performance between groups. These findings support the benefits of exercise and resistance training for older women in enhancing lower body strength and functionality without altering body composition. This study highlights the feasibility and safety of implementing resistance training in this population. Practical applications include designing progressive resistance programs to promote healthy aging.

Keywords: *functional strength, mobility, sarcopenia, aging, lower body functionality*

Introduction

Ageing is a natural process characterized by the gradual deterioration of physiological function over time (Fabian & Flatt, 2011; Schmauck-Medina et al., 2022). A key hallmark of ageing is the decline in physical function, where the loss of skeletal muscle mass, strength and power can negatively impact mobility and overall health outcomes (Alcazar et al., 2023; Haynes et al., 2020). Over 50 years of age, skeletal muscle mass, strength, and functionality begin age-related declines (Dopsaj et al., 2020; Haynes et al., 2020; Trombetti et al., 2016). Moreover, declines in muscle mass, strength, power, and physical performance independently contribute to an increased fear of falling, whereby losses of muscle mass and physical performance are associated with a deterioration in quality of life (Hayflick, 2000; Trombetti et al., 2016). Therefore, efforts to slow this deterioration or even restore disrupted physiological function are logical and valuable pursuits.

Clark and Manini (2008) introduced the term “dynapenia” to more accurately describe the loss of muscle function related to the muscle's contractile properties. Additionally, Freitas et al. (2024) proposed "powerpenia," or the loss of muscle power, as a biomarker of healthy ageing. A 10-year longitudinal study on muscle power, force, and velocity found that the early decline in maximal power is primarily related to reduced strength, while later more pronounced declines are caused by reductions in contractile force and velocity (Alcazar et al., 2023). These findings highlight that multiple aspects of muscular fitness are essential for maintaining functional abilities, such as standing up, walking independently, and carrying out daily tasks. In return, maintaining good functionality is critical for healthy ageing (Abud et al., 2022). Exercise offers a promising approach to enhance physical, physiological and mental health, optimizing these functions for one's age. This strategy can improve the capacity (e.g., improve metabolism, release of exerkines, tissue regeneration) to maintain health and resist disease (McGee & Hargreaves, 2020).

In 2019, the National Strength and Conditioning Association released a position statement endorsing the benefits of resistance training for older adults (Fragala et al., 2019). Resistance training has been shown to promote beneficial adaptations at both the muscular level (e.g., muscle growth and metabolism) and neuromechanical level (e.g., intra- and inter-muscular coordination, strength, and power) (Fragala et al., 2019; Garber et al., 2011). These improvements play a crucial role in enhancing functionality, ultimately leading to a better quality of life. However, the frequency, intensity, and volume of resistance training must be carefully planned to promote adaptation while minimizing the risk of injury (Fragala et al., 2019). General recommendations for older adults include 2-3 resistance training sessions per week (Fragala et al., 2019; Garber et al., 2011). Despite clear statements on the importance of implementing resistance training with older adults (Fragala et al., 2019), the scarcity of research is evident, especially in women. The aim of this quasi-experimental study was to investigate the effects of two exercise programs, one supplemented with additional 40-50 min of resistance training and one without this supplement on strength and lower body functionality of older women. Both programs lasted for 8 weeks. Two hypotheses were tested: 1) both exercise programs will result in significant improvements in lower body functional strength and mobility; and 2) the exercise program supplemented with resistance training will improve both lower body functional strength and mobility measures more than the control group.

Materials and methods

Participants

For this study, we aimed to include apparently healthy 30 women who were part of the group exercise program for older adults conducted at the Faculty of Physical Education and Sports, University of Banja Luka. The inclusion criteria were that they were healthy for a minimum of three months, were not beginners to exercise programs, were able to perform the physical fitness assessment, and had no history of neurological conditions. The exclusion criteria were not attending baseline or post-treatment assessment and missing more than 20% of training sessions. The program was explained and offered to women who had exercised twice a week in an existing group exercise program for minimum of 3 months. In consultation with the group, the group leader (i.e., their coach) chose 30 participants who would attend the first testing session (i.e., baseline measurement), and after the assessment, who would be allocated to the Control and Experimental groups. Since not all participants were willing to join the experimental treatment, purposive assignment was used to maximize attendance. Also, rather than statistically deciding on the sample size, we used a convenience sample due to difficulty in finding a sample of older women who had some training history yet were not involved in resistance training. The participant flow is shown in Figure 1. Of 30 participants who attended the first meeting, 26 completed the baseline assessment; 11 were allocated to the control group (age =66.9±5.5 yrs, height =161.7±5.4 cm, body mass =82.3±15.9 kg), and 15 to the experimental group (mean: age =66.7±4.1 yrs, height =160.7±5.2 cm, body mass =71.7±7.6 kg). In the control group, all participants had a body mass index over 25 kg/m2 and four participants over 30 kg/m2. In the experimental group, three participants had a body mass index below 25 kg/m2 and four over 30 kg/m2. After 8-weeks of resistance training, 17 participants completed posttest assessments (7 control and 10 experimental). Prior to baseline assessment, all participants signed an informed consent form. This study was approved by the Ethical Review Board of the Faculty of Physical Education and Sports, University of Banja Luka (no: 11/1.74-1/25).

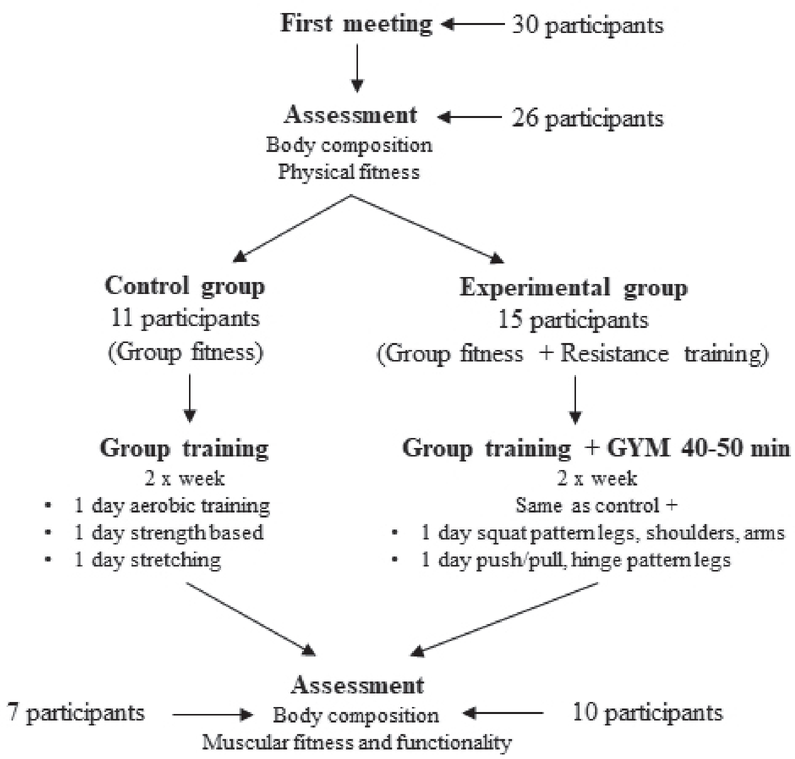

Figure 1. Participant flow

Procedures

Body composition

Participants' body height was measured using a Seca stadiometer (Germany) with 0.1 precision, while their backs and heels were against the wall and their heads were aligned in the Frankfurt plane. Body mass, body fat percentage, and fat free mass index were assessed using a segmental bioimpedance analyzer Tanita BC418 (Japan). Validity and reliability of this device is shown elsewhere (Kelly & Metcalfe, 2012).

Muscular fitness and functionality

The 30-s chair stand test was used to evaluate local muscular endurance and functionality of the lower limbs (Figueiredo et al., 2021). Participants were instructed to perform as many stands from the chair as possible in 30 seconds while holding their hands crossed over their chest. A chair stand was counted if the participant fully extended their legs at the top and sat back down to the chair, without removing their hands from their chest. This test has been shown to be valid and reliable (Figueiredo et al., 2021).

The timed up and go test was used to evaluate participants' gait balance as well as their risk of falls (Kojima et al., 2015). Starting from a seated position in the chair, participants were instructed to stand up, walk 3 meters, turn around the cone and get back to the starting position, as fast as possible. This test has been found to be valid and reliable (Christopher et al., 2021).

Training

The control group continued their regular group exercise program twice a week (Monday and Thursday, 1600-1700h). Participants did three types of training that were performed interchangeably, whereby every training session included different training type. These three types of training were performed in sequence, regardless of the specific day of the week.

The first type of training involved low-impact aerobic exercises that focused on improving cardiovascular fitness, endurance, and overall body coordination while minimizing the stress on joints. The second type of workout focused on bodyweight strength training emphasizing the engagement of major muscle groups. The third type of training included stretching and mobility including static and dynamic stretches and ending with relaxation and breathing exercises to promote mental and physical calmness, reduce stress, and enhance overall recovery.

The experimental group did the same training with the control group and then proceeded with an additional dose of 40-50 minutes of resistance training. The first resistance training addition in the week (Monday) focused on squat and push/pull pattern exercises for the chest and back, and core exercise. The second resistance training addition (Thursday) focused on hinge movements, leg extensions/flexions, overhead presses, front/lateral shoulder raises, and hand extensions/flexions.

Exercises and dosage used for the supplementary resistance training are shown in Table 1. The training sessions consisted of 3-4 two-exercise stations, with each station performed for 2-3 sets. Both sessions included a selection of one lower-body exercise and one for the upper body and core. Exercises were carefully chosen to ensure optimal activation of key large muscle groups. For instance, one 3-station training session would include two exercises 1a/1b, 2a/2b, and 3a/3b

(See Table 1). During the sixth to eighth week of training, a fourth station was introduced, featuring exercises with more complex mechanics, allowing for timely progressive increases in load and motor demands. All training sessions were planned and administered by the University Professors.

Table 1. Training structure of training for the control group and structure of the resistance training supplementation for experimental group

	Control	Experimental	
	Weeks 1-8	Weeks 1-6	
		Monday	Thursday
First type: Aerobic	The session began with a 10-minute warm-up. The main workout consisted of 20-30 minutes of low-impact aerobic activities such as in place stepping, marching and side shuffles.	1a. Goblet squat or Dumbbell Split Squat 1b. Lat pulldown or Inverted row 2a. Step ups or Lunge 2b. Dumbbell bench press or Chest fly 3a. Seated cable row or Barbell row 3b. Crunches or Dad bag	1a. Dead lift/Hip thrust 1b. Dumbbell shoulder press/ Dumbbell shoulder lateral raise 2a. Seated leg extension/Glute bridge 2b. Biceps curls/Triceps extension 3a. Prone leg curls/standing calf raises 3b. Lying back extensions/High plank
Second type: Strength	The session began with a 10-minute warm-up. The main workout consisted of 20-30 minutes of body weight strength exercises for upper, lower, and core body muscles.	Weeks 6-8	
		Monday	Thursday
Third type: Stretching	The session consisted of a group of exercises for static and dynamic mobility, along with breathing and relaxation exercises. The total duration of the training was 45 minutes.	Same as Weeks 1-6 + 4a. Bulgarian squat 4b. Incline pushups	Same as Weeks 1-6 + 4a. Seated hip abductions/ adduction 4b. Dumbbell front shoulder raises

Statistics

Analyses were performed using JASP statistical software (version 0.18.3, Amsterdam). Descriptive statistics included mean and standard deviation. The normality of the distribution was tested using the Kolmogorov-Smirnov test and where the normality was violated, a non-parametric test was used. To test the effects of the applied exercise treatments in the two groups (between-within design), repeated measure ANOVA was used. For non-parametric data, Conover's post hoc test was used. Statistical significance was set at $p<0.05$. Effect sizes (Sullivan & Feinn, 2012) were calculated using Cohen's d to provide quantitative and qualitative representation of the treatment effect. The effects were qualified as follows: $d<0.2$ (trivial), $d=0.2$-0.5 (small), $d=0.5$-0.8 (moderate), $d=0.8$-1.2 (large), and $d>1.2$ (very large).

Results

Descriptive statistics for both groups of participants with complete data at baseline and post-treatment are shown in Table 2. The normality of distribution was violated for body mass and body fat percentage, so a non-parametric test was used to assess between-group differences at baseline. Compared to the experimental group, the control group had significantly higher body mass ($T=2.29$, $p=0.04$) and body fat percentage ($T=2.29$, $p=0.04$) at baseline. Age, height and indicators of muscular fitness and functionality did not significantly differ between the groups at baseline.

Table 2. Descriptive statistics for baseline and post-treatment measurements among older women

Variables	Control (n=7)		Experimental (n=10)	
	Baseline	Post-treatment	Baseline	Post-treatment
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Body mass (kg)	80.1±9.1	79.1±8.2	72.2±8.2	71.3±8.2
Body fat (%)	40.4±3.1	39.0±3.5	35.2±5.7	34.2±5.8
Fat free mass (kg)	47.6 ±4.1	48.1±4.3	46.4±3.3	46.7±4.8
30-s Chair stand (reps)	17.9±3.5	23.7±4.5	18.3±4.0	26.6±4.8
Timed up and go (s)	5.6±0.9	4.8±0.8	5.6±0.8	5.0±0.5

There was no treatment effect on body composition indicators in either group. However, both the control and experimental groups significantly improved their performance in 30-s chair stand test and timed up and go test (Table 3). Very large effects (d) were observed in the 30-s chair stand test for both groups. Both exercise treatments produced large positive effects in timed up and go (i.e., shorter time to complete) test.

Table 3. Between- and Within-Group comparison

Between-Within-group comparison		30-s Chair Stand (reps)		TUG (s)	
		Mean difference	*d*	Mean difference	*d*
Control group, Baseline	Experimental group, Baseline	-0.48	Trivial	-0.02	Trivial
	Control group, Post-treatment	-5.86	Very large**	0.76	Large
Experimental group, Baseline	Experimental group, Post-treatment	-8.22	Very large**	0.61	Large
Control group, Post-treatment	Experimental group, Post-treatment	-2.84	Moderate	-0.17	Small

Note. ** Significant at p<0.001; TUG= Timed up and go test

Considering the effect size analysis, it could be observed that the improvement in the 30-s chair stand test was somewhat greater in the experimental than in the control group (Figure 2). The improvement was 32.7% in control and 44.9% in experimental group. Although a small difference was observed in the effects of the treatment on timed up and go test between groups, it held no practical or statistical significance (Figure 2).

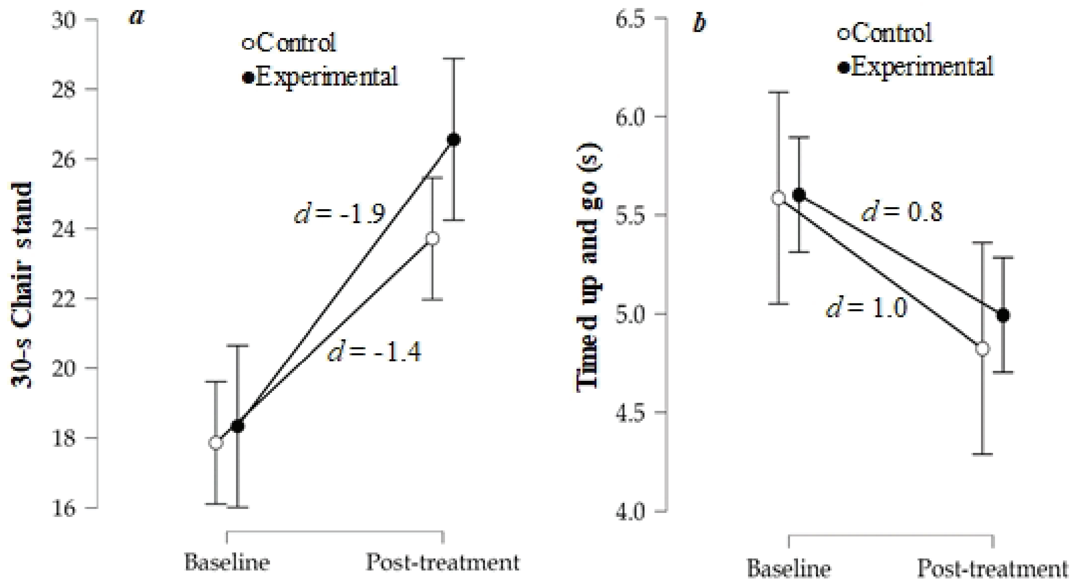

Figure 2. Descriptive plots and effect sizes of the applied programs on lower body functional strength and functionality

Discussion

This study investigated the effects that a group exercise program (control group) supplemented with a dose of resistance training (experimental group) had on lower body functional strength and mobility in older women. The main findings showed significant improvements in the lower body strength and functionality of both groups. Furthermore, improvements in the 30s chair stand test (i.e., lower body functional strength) in the experimental as compared to the control group showed a moderate effect size, although the differences were non-significant. Thus, the first hypothesis was true, while the second hypothesis was partially supported. The effects were equivocal between groups for the timed up and go test (i.e., lower body functional mobility).

Our results indicate that the women in the study were able to maintain, and even improve their physical function, thus helping delay age-related declines (Fabian & Flatt, 2011; Hayflick, 2000; Silva et al., 2023). Experiencing improvements in lower body strength and functionality may help reduce the fear of falling and help maintain quality of life (Silva et al., 2023; Tieland et al., 2018). The exercise programs used in this study were able to address multiple aspects of muscular fitness and function, which are critical for healthy aging (Ahtiainen, 2019; Ratamess et al., 2009; Tieland et al., 2018). Given that both groups performed the same training and that experimental group only supplemented it with additional resistance training, it seems logical that both groups improved. This finding strongly supports the utilization of thoughtfully organized and structured exercise programs.

In contrast, it is unclear why the experimental group did not experience significant improvements over those experienced by the control group. It may be that the eight weeks of training were too short to detect differences (Ahtiainen, 2019). It is of note, however, that a trend towards advanced improvements in lower body strength measures could be observed, Previous research has found no significant changes in muscle strength, although improvements in stair climb performance occurred (Lopez et al., 2020). The structure of the experimental group in the present study may also play the role as it included participants who wanted to do an extra 40-50 minutes of resistance training (purposely selected). This could introduce a healthy subject bias (i.e., reduced training effects due to training and physical activity behavior history) (Shrank et al., 2011). Like the statement by the National Strength and Conditioning Association (Fragala et al., 2019), the women in this study physically benefitted from the resistance training as well as from the body weight exercises.

Somewhat expectedly, neither group experienced any changes in body composition (i.e., body mass, body fat percentage, or fat free mass). However, this study did not control the nutrition of participants and the duration may not have been sufficient to induce changes in body composition (Bellicha et al., 2021; Sardeli et al., 2018). Furthermore, participants from this study were already active older women who had been participating in group exercise program. Thus, the effects that occurred were not sufficient to change participants' body composition (i.e., increase muscle mass and/or reduce body fat mass).

Key study considerations include the application of resistance training with the group of older women in a real-life scenario. The study showed that group resistance training can be safely used with this population, despite the challenges of accessing active older women as participants and being relatively short for more notable effects results do indicate an increasing trend. Therefore, while the duration of this study could be listed as limiting factor, it provides valuable information for practitioners who want to start a resistance program with this population. Considering the risk of injury due to age-related declines (Ambrose et al., 2013; Kojima et al., 2015;

Millor et al., 2013), no participants in our study reported experiencing any injuries. However, one participant did bruise her ribcage when her hand slipped while exiting the leg curl bench; she reported feeling pain for the next few days but continued the program.

The 35% attrition rate observed in this study provides critical insights for future research and practice. To determine if the drop-out rate introduced bias, we compared the baseline characteristics of participants who completed the study (n=17) with those who withdrew (n=9). No statistically significant differences were observed between the two groups in any parameter at baseline, suggesting that the attrition was not influenced by initial physical or demographic disparities. To improve retention in future studies, we recommend centralizing all training components within a single facility. By minimizing environmental shifts, practitioners can better ensure that the supplemental training dose is completed in its entirety.

Study limitations

Study limitations include the lack of a direct measure of lower body or upper body strength, that may have detected training effects with higher sensitivity than the functional measures we used. Another limitation was that there was a 35% drop-out rate among women who had already been participating in a group exercise program for at least 3 months. The facility design required the women in the experimental group to change buildings to complete the additional resistance training, and some women did not show up for the second part, but we did not get the information whether they attended the first part either.

Methodologically, non-random allocation of participants into groups could be another limitation. We partially mitigated this limitation with allowing their coach to assign them to groups as he knew them best. While this approach was chosen to maximize attendance and safety, it likely contributed to the significant baseline differences observed in body mass and body fat percentage between groups. These initial discrepancies act as potential confounders, and therefore, the 'supplemental' effects of the resistance training must be interpreted with caution.

Practical implications

This study provides findings supportive of National Strength and Conditioning Association and American College of Sports Medicine statements on resistance training for older adults. It shows that even program as short as 8 weeks start to show an increasing trend in lower limb strength of older women. Further, this study showed that resistance training can be applied safely with older women, providing a foundation for studying a longer-duration program. Conversely, it shows that in active older women, this duration of resistance training may not be sufficient to provide the significant advantage compared to group trainings that include aerobic training, body weight strengthening, and stretching with mobility. Framing the intervention as a supplemental training dose highlights key feasibility concerns. The addition of 80–100 minutes of resistance training per week requires careful consideration of time commitments, equipment accessibility, and the necessity for continuous professional supervision. Practitioners should focus on integrating these supplemental sessions into the existing lifestyles of older adults without creating logistical burdens, as program adherence is highly dependent on the ease of implementation. Future studies should focus on resistance training of longer duration. Also, the controlled nutrition (e.g., tracking nutrition or nutrition intervention) should be included.

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Conflicts of interest

The authors declare no conflicts of interest.

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