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Effects of Moderate Intensity Resistance Training on Bone Mineral Density and Muscle Strength of Elderly Women

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ABSTRACT

Bacelar SNA, Almeida FJF, Sauaia BA, Novais TMG, Furtado AEA, Quintanilha LM, Pulcherio JOB, Filho JF, Gambassi BB Effects of Moderate Intensity Resistance Training on Bone Mineral Density and Muscle Strength of Elderly Women. **JEPonline** 2015;18(6):94-103. The purpose of this study was to investigate the effects of moderate intensity resistance training on bone mineral density and muscle strength in 18 elderly women with ages between 61 and 67 yrs old. The women had gone through anthropometric evaluation, bone mineral density evaluation, and muscular strength evaluation before and after a resistance training program, which consisted of 3 sets of 10 repetitions (maximum) for 10 wks. The data were statistically analyzed using the Stata / SE 11.1. Quantitative variables were expressed as mean ± standard deviation and checked for differences, using ANOVA and Student's *t* test ($P<0.05$). While the findings indicate that there was no significant difference in the changes of bone mineral density in the lumbar spine and femoral neck, the 10-wk moderate intensity resistance exercise resulted in a significant increase in muscle strength in the upper and the lower limbs of elderly women.

Key Words: Resistance training, Bone mineral density, Muscle strength, Elderly women

INTRODUCTION

The growing contingent of the elderly population, and its relation with decreased physical strength capacity and loss of bone mineral density have awakened the global scientific community to prophylactic measures of alternative experimentations (including resistance training).

Silva and colleagues (18) claim that due to the aging process there are structural and functional changes in the neuromuscular system that significantly impairs autonomy. In particular, the aging progress is linked to a significant decrease in strength in both women and men (4) that begins at 40 yrs of age in women (13).

During menopause, bone mass decreases in women. With each remodeling cycle the smaller amount of bone reabsorbed makes the bone fragile and susceptible to fractures (7,8). The incidence of osteoporosis has increased in the Brazilian population in recent years. There is an estimate that by mid-2020 osteoporosis will affect about 32 million people, and will account for more than 1.5 million fractures each year (17,20).

Exercise plays an important role in both preventing and/or treating osteoporotic problems. Yet, although Kemmler and colleagues (9) investigated the exercise effects on fitness and bone mineral density in early post-menopausal women, there are relatively few studies that seek to verify in this population the effect of moderate intensity resistance training.

We hypothesized that an increase in muscle strength and preservation of bone mineral density in elderly women occurs with 10 wks of resistance training of moderate intensity. Thus, the purpose of this study was to investigate the effects of moderate intensity resistance training on bone mineral density and muscle strength in elderly women.

METHODS

Subjects

The subjects consisted of elderly women with the ability to perform moderate intensity resistance exercises without any issues with their skeletal muscle system. Any subject who missed more than three exercise sessions, did not undergo evaluations, and/or asked for any reason to exit the program was excluded. The final sample consisted of 18 sedentary elderly women with a mean age of 64 ± 3 yrs. The subjects' body mass index (BMI) was 27.1 ± 2 $kg \cdot m^{-2}$ before and 27.4 ± 2 $kg \cdot m^{-2}$ after the exercise program.

The elderly were part of a project called UNICEUMA Without Borders where they were engaged in a computer class to stimulate memory. A total of 126 elderly participated in this project, including; active, sedentary, with and without skeletal muscle problems with and without chronic degenerative diseases.

Procedures

The evaluations were performed before and after 10 wks by students of physical education from the University Ceuma. Before starting the evaluations, the students were trained by a Professor of Physical Education at the University.

Data from the anthropometry and muscle strength evaluations were interpreted by a physical education teacher with experience in the field. The bone mineral density data were analyzed by a doctor.

Anthropometry

The following measurements were taken: (a) total body mass (kg); and (b) height (cm), using an anthropometric balance Filizola® for subsequent calculation of body mass index.

Evaluation of Bone Mineral Density

The Bone Mineral Density of the lumbar spine and femoral neck were performed in Maranhense Radiology Clinic, through absorptiometry by dual energy X-ray absorptiometry (DXA) of the LUNAR brand, DPX-Alpha model. The examination was performed by a medical specialist. The subject was prone on the equipment table with the legs supported at an angle of 30°.

Evaluation of Muscle Strength

The test of 10 maximum repetitions was used to assess muscle strength in the upright supine and leg press of 45°. Each subject performed the maximum possible force in isotonic form, according to the assessor's signal for 10 repetitions to concentric failure of the muscles. The exercises were performed in a maximum of 5 attempts with 3 min rest intervals between each series. The noted record was the result from the average of the 2 best attempts.

Resistance Training Program

An informal and detailed lecture described and clarified the program of multi-joint resistance exercises that were performed by the subjects. As recommended by the American College of Sports Medicine (2), the program consisted of running leg press 45°, seated row, leg curl, and bench press.

The exercises were performed by isotonic contraction that lasted 3 sec for the concentric phase and 3 sec for the eccentric phase (1). To establish the training intensity, maximum repetition was used (i.e., the load which enabled the attainment of a specified number of repetitions per set to concentric fatigue).

Each subject underwent 20 sessions (i.e., 2 sessions$\cdot$wk^{-1} for 10 wks) with a 48-hr interval of rest between each session. During the first 2 wks, the subjects performed 3 sets of 15 repetitions maximum (low intensity) in order to adapt. Then, the subjects performed 3 sets of 10 repetitions maximum for 8 wks. Control of the training load was carried out in accordance with Baechle and Earle’s (3). A rest interval of 2-min between sets (13) was used.

Statistical Analyses

The stored data were analyzed using the Stata / SE 11.1 (Stata Corp, College Station, Dallas, USA). Quantitative variables were expressed as mean ± standard deviation checked for differences using ANOVA and Student's *t* test with the alpha set at P<0.05.

RESULTS

Based on the results shown in Table 1 (P = 0.8684), the mean difference in lumbar spine bone mass density in the elderly women before and after moderate intensity resistance training was not significant. The elderly women neither gained nor lost bone mineral density in the sample investigated.

Table 1. Bone Mineral Density (BMD) at the Lumbar Spine in Elderly Women Who Underwent Moderate Intensity Resistance Exercises.

Subjects	Bone Mineral Density at Lumbar Spine ($g \cdot cm^{-2}$)				
	BRE	Mean	**ARE**	Mean	(P value)
01	1.084		1.100		
02	0.975		0.959		
03	0.814		0.847		
04	0.953		0.943		
05	1.008		1.032		
06	1.043		0.986		
07	0.932		0.886		
08	0.923		0.959		
09	0.898		0.856		
10	0.885	0.940	0.893	0.935	0.8684
11	0.723		0.736		
12	0.855		0.870		
13	0.988		0.955		
14	0.965		0.990		
15	1.071		1.084		
16	0.755		0.819		
17	1.004		0.934		
18	1.049		0.982		

Legend: **BRE** = before resistance exercises; **ARE** = after resistance exercises

Based on the results shown in Table 2 (P = 0.8471), the mean difference in lumbar spine bone mass density (BMD) at the femoral neck in the elderly women before and after moderate intensity resistance training was not significant. The elderly women neither gained nor lost bone mineral density in the sample investigated.

Table 2. Bone Mineral Density (BMD) at the Femoral Neck in Elderly Women Who Underwent Moderate Intensity Resistance Exercises.

Subjects	Bone Mineral Density at Femoral Neck ($g \cdot cm^{-2}$)				
	BRE	Mean	**ARE**	Mean	(P value)
01	1.003		0.999		
02	0.836		0.829		
03	0.861		0.867		
04	0.943		0.928		
05	1.028		1.033		
06	1.091		1.083		
07	1.038		1.017		
08	1.006		1.000		
09	0.819		0.805		
10	0.754	0.916	0.763	0.909	0.8471
11	0.815		0.816		
12	0.742		0.738		
13	0.986		0.993		
14	0.821		0.814		
15	1.072		1.065		
16	0.817		0.765		
17	0.830		0.828		
18	1.023		1.012		

Legend: **BRE** = before resistance exercises; ARE = after resistance exercises

The strength of the lower extremities muscles in the elderly women subjects was evaluated by the 10 RM Test (Leg Press Exercise) in two stages: before and after the activity with test application for Students samples matched, considering the decision level alpha = 0.01.

The results in Table 3 show that the difference in strength levels observed with the practice of exercise is significantly increased ($P<0.0001$). Also, based on the (*t*) Negative (-8.4604), it follows that the level of muscle strength before the activity was well below that obtained after resistance training program. Therefore, we can say that the moderate intensity resistance training promoted a significant improvement in the strength of the muscles of the lower extremities in the elderly women subjects.

Table 3. Strength Levels of the Muscles of the Lower Limbs in Elderly Women Who Underwent Moderate Intensity Resistance Exercise (Evaluated by 10 RM Test – Leg Press Exercise).

Subjects	Strength Levels of the Muscles of the Lower Limbs (kg)						
	BRE	Mean	SD	**ARE**	Mean	SD	*t*
01	60			80			
02	50			76			
03	62			80			
04	66			80			
05	54			90			
06	60			80			
07	50			84			
08	50	52.56	6.92	60	74.78	10.22	-8.4604
09	60			70			
10	40			90			
11	50			60			
12	50			70			
13	50			60			
14	54			70			
15	50			86			
16	40			60			
17	50			70			
18	50			80			

P value (bilateral) <0.0001; Legend: **BRE** = before resistance exercises; **ARE** = after resistance exercises; SD = standard deviation.

The strength of the muscles of the upper limbs in the elderly women subjects was evaluated by the 10 RM bench press exercise in two stages: before and after the activity with test application for Students samples matched, considering the decision level alpha = 0.01.

The results indicate in Table 4 that the difference in the elderly women subjects' strength after resistance training is significantly (P<0.0001) increased. Therefore, once again regarding strength improvement, it is clear that the moderate intensity resistance training resulted in a significant improvement in the strength levels of the upper limbs muscles in the elderly women.

Table 4. Strength Levels of the Muscles of the Anterior Chest in Elderly Women Who Underwent Moderate Intensity Resistance Exercise (Evaluated by 10 RM Test – Bench Press Exercise).

Subjects	Strength Levels of the Muscles of the Anterior Chest (Pectoral) (kg)						
	BRE	Mean	SD	**ARE**	Mean	SD	*t*
01	8			12			
02	8			12			
03	8			12			
04	6			10			
05	8			14			
06	6			10			
07	6			10			
08	6	6.67	0.97	8	10.78	1.69	-12.0230
09	6			8			
10	6			12			
11	6			8			
12	6			10			
13	6			10			
14	6			12			
15	8			12			
16	6			12			
17	6			12			
18	8			10			

P value (bilateral) <0.0001; Legend: **BRE** = before resistance exercises; **ARE** = after resistance exercises; **SD** = standard deviation.

DISCUSSION

The main finding of this study was that moderate intensity resistance training performed twice a week for 10 wks resulted in a significant increase in muscle strength of the pectoral and quadriceps muscles. Moreover, it is reasonable to conclude that maintenance of bone mineral density in the elderly women in this study was achieved, especially since there was no significant loss in both the subjects' femoral neck region and lumbar spine. The results indicate that moderate intensity resistance training in elderly females is a good non-pharmacological strategy to increase muscle strength and promote bone mass maintenance.

It is important to note that the findings are in agreement with Silva et al. (18) who reported an improvement in strength, muscle mass, and functional autonomy in elderly following a resistance training program. The findings also help to support most of the earlier work by Vale et al. (19) who observed an increase in maximum strength, flexibility, and functional autonomy in their elderly subjects following strength training 2 times·wk^{-1}. There are other studies, such as Buzzachera and colleagues (5), as well as the American College of Sports

Medicine (2) that emphasizes the importance of resistance training in the improvement of muscle strength and cardiorespiratory fitness in elderly subjects.

Interestingly, contrary to the results obtained in the present study, Pruitt et al. (15) observed an increase of 1.6% in bone mineral density in the lumbar region after low to moderate intensity resistance training. Kerr and colleagues (10) also reported an increase in bone mineral density in after 2 yrs of moderate intensity resistance training in postmenopausal women.

Recent study by Pinheiro et al. (14), with resistance training, where 16 volunteers were submitted for a period of 12 months to two distinct groups of physical exercise. The treatment group practiced resistance training that was divided into 6 cycles with intensity of 70 to 90% of the subjects' maximum load (RM 10). The second group was the control group. The results indicated significant differences in support of the treatment the group that trained the lumbar spine L2-L1 (6.8%, P=0.001), femoral neck (4.8%, P=0.005), and trochanter (0.76%, P=0.005). The authors stated that post-menopausal women with low mineral density should engage in resistance training.

The use of exercise, especially resistance training exercise, has been demonstrated to be a relevant means to promoting and maintaining bone mass and promoting mechanical stimulation that leads to the osteogenesis (9). The lumbar spine responds best to resistance exercises, as they have higher amounts of trabecular bone and are more metabolically active (11,12,15). The femoral neck is especially a susceptible bone to increase bone mineral density since the effect of physical activity on the bone mineral density occurs at sites that support stress (12).

Corroborating the results of this study, Meireles and Nunes (11) examined the effect of a resistance training program lasting 12 months, frequency of 3 sessions·wk^{-1} with loads ranging from 60 to 85% of 1 RM on the bone mineral density of postmenopausal women. The authors observed a 25% reduction in the column bone mineral density and 77% of bone mineral density of the femur. Thus, they concluded that there was a significant reduction in bone mineral density in postmenopausal women.

Although the practice of resistant exercise can positively influence muscle strength in relation to bone remodelling, the process responsible for this result is not entirely clear. Other factors such as genetic characteristics of the individual, nutritional status, and hormonal factors are also likely to influence the findings. Hence, there is the need for more studies designed to identify the influence of different intensities, duration, and frequency of specific resistance training exercises to realize the identified benefits.

CONCLUSIONS

While the findings indicate that there was no significant difference in the changes of bone mineral density in the lumbar spine and femoral neck, the 10-wk moderate intensity resistance exercise resulted in a significant increase in muscle strength in the upper and the lower limbs of elderly women. We suggest that further research is carried out to help ensure a better understanding of the physical mechanisms that influence strength development and bone mass in conjunction with resistance training.

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