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EFFECT OF 12-MONTH RESISTANCE TRAINING ON PHYSICAL FUNCTION IN POSTMENOPAUSAL WOMEN WITH OSTEOPENIA OR OSTEOPOROSIS: A PILOT STUDY

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ABSTRACT. ***Objective.*** The present study aimed to evaluate the effects of 12-month resistance training (6 reps x 70% of 1RM + 6 reps x 50% of 1RM) in physical performance in women with postmenopausal osteoporosis or osteopenia. ***Methods:*** Ten women with postmenopausal osteopenia/osteoporosis were divided into a exercise group (EX, n = 5) and control group (C, n = 5). The training program included exercises for upper and lower limb muscles with intensities of 50 – 70% of 1RM over a period of 12 months (twice weekly, 50 minutes training session). Physical performance was evaluated before and at the end of the study using the 30-second sit to stand test 30-second arm-curl test. ***Results:*** At the end of the study, the results of 10 patients were analyzed. A significant improvement was noted in physical performance for exercise group compared to control group: arm curl test (22.2±0.8 vs. 20.2±0.8, p = .014, r = -0.78) and chair stand test (19.8±0.8 vs. 17.6±1.7, p = .023, r = -0.72). ***Conclusion:*** Resistance training program improves physical performance among women with postmenopausal osteopenia/osteoporosis.

Keywords: *osteoporosis, osteopenia, resistance training, postmenopausal, physical performance.*

REZUMAT. ***Efectele programului de antrenament cu rezistență pe o perioadă de 12 luni asupra performanțelor fizice la femeile cu osteopenie/osteoporoză postmenopauză: studiu pilot. Obiectiv.*** Studiul de față a urmărit să evalueze efectele antrenamentului de rezistență de 12 luni (6 repetări x 70% din 1RM + 6 repetări x 50% din 1RM) asupra performanțelor fizice la femeile cu osteoporoză sau osteopenie postmenopauză. ***Material și metode:*** Zece femei cu osteopenie / osteoporoză postmenopauză au fost împărțite într-o grupă experimentală (EX, n = 5) și grupă de control (C, n = 5). Programul de antrenament a inclus exerciții pentru mușchii membrelor superioare și inferioare, cu intensități de

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50 - 70% din 1RM pe o perioadă de 12 luni (de două ori pe săptămână, 50 minute sesiunea de antrenament). Performanța fizică a fost evaluată înainte și la sfârșitul studiului, folosind testul de flexie a antebrațului pe brat în 30 de secunde cu o ganteră de 2 kg în mână (*arm curl test*) și testul de ridicare din așezat în stând în 30 de secunde (*chair stand test*). ***Rezultate:*** La sfârșitul studiului, au fost analizate rezultatele a 10 subiecți. S-a observat o îmbunătățire semnificativă a performanței fizice în cadrul grupei experimentale, în comparație cu grupa de control: testul de flexie a antebrațului pe braț (22.2 ± 0.8 vs. 20.2 ± 0.8, p = 0.014, r = -0.78) și testul de ridicare din așezat în stând (19.8 ± 0.8 vs. 17.6 ± 1.7, p = 0.023, r = -0.72). ***Concluzie:*** Programul de exerciții cu rezistență îmbunătățește performanța fizică în rândul femeilor cu osteopenie / osteoporoză postmenopauză.

Cuvinte cheie: *osteoporoză, osteopenie, antrenament de forță, postmenopauză, performanță fizică.*

Introduction

Osteoporosis is a skeletal disorder characterized by low bone mass and micro architectural deterioration of bone tissue, leading to an increase in bone fragility and susceptibility to fracture (Al-Tubaikh, 2010). An operational definition of osteoporosis has also been defined, based on a value for bone mineral density (BMD) 2.5 standard deviations or more below the young adult mean (World Health Organization, 1994). Bones reach their peak density in the third decade of life and then decrease gradually at the rate of 0.25– 1% per year. This percentage is higher in women at the menopause, which may reach up to 8% per year.

Bone remodeling, essential for bone strength, is mediated by osteoclast and osteoblasts. Osteoclasts resorb mineralized bone (resorption of old bone), which is then replenished by osteoblasts (formation of new bone matrix). Osteoporosis in caused by an imbalance of the two biological processes (uncoupling of osteoblasts and osteoclasts), with an increase in osteoclast activity, leading to overall bone loss (Shanks, Sharma, & Mishra, 2019).

The process of ageing in women is associated with an increase in the rate of bone remodeling in both cancellous and cortical bone, combined with a negative remodeling balance, resulting in bone loss and disruption of bone microarchitecture. Trabecular thinning and loss of trabeculae can be observed in cancellous bone (Parfitt, Mathews, Villanueva, Kleerekoper, Frame, & Rao, 1983), whereas in cortical bone, endocortical and intracortical bone loss lead to reduced cortical thickness and increased cortical porosity (Zebaze, et al., 2010).

From the age of 50 in women, bone loss accelerates through bone cortex thinning, increased cortical porosity and trabeculae destruction by thinning and perforation (Seeman, 2013). Bone loss does not attenuate with age, but continues throughout the whole life, at least in peripheral skeletal sites. Various factors contribute to age-related bone mass decrease and microstructural alterations (Rizzoli, 2018).

Osteoporosis constitutes a major public health problem, through its association with age-related fractures, particularly of the hip, vertebrae, distal forearm and humerus, with serious consequences in terms of morbidity and mortality (Johnell & Kanis, 2006).

Osteoporosis and poor bone health effects approximately 200 million people worldwide, with numbers expected to increase as the population ages. Increases in osteoporosis and poor bone health are associated with increased fragility fracture rates, increased morbidity and mortality, and a huge economic burden (Goode, Wright, & Lynch, 2020). More than half of all individuals older than the age of 50 are affected by poor bone health, osteopenia and/or osteoporosis, and the prevalence is expected to rise for many years. Fragility fracture rates along with their inherent morbidity and mortality are likewise predicted to rise (Miller, Lake, & Emory, 2015; Wright, Looker, & Saag, 2014; Friedman & Mendelson, 2014).

The number of new fractures in 2010 in the EU was estimated at 3.5 million, comprising approximately 610,000 hip fractures, 520,000 vertebral fractures, 560,000 forearm fractures and 1,800,000 other fractures such as pelvis, rib, humerus, tibia, fibula, clavicle, scapula, sternum, and other femoral fractures (Hernlund, et al., 2013)

Hip fractures create a huge economic burden as well. More than $20 billion in health care is spent on osteoporosis-related hip fractures annually (Weaver, Bischoff-Ferrari, & Shanahan, 2019).

Objectives

The present study aimed to evaluate the effects of 12-month resistance training (6 reps x 70% of 1RM + 6 reps x 50% of 1RM) in physical performance in women with postmenopausal osteoporosis or osteopenia.

Methods

Participants in the study: sedentary women (who perform less than 60 minutes of light intensity exercise - moderate per week), non-smoker, suffering from osteopenia / osteoporosis and who have no contraindications for practicing physical exercises. Women who reported problems with high blood pressure and / or orthopedic conditions that could prevent them from carrying out the proposed exercise program were excluded. Inclusion criteria: a) patients age 50 or older; their history does not include hormone therapy in the last 5 years; b) patients to present a total T score on the spine between -1.5 and -3. Exclusion criteria: a) patients who have suffered a fracture in any segment; b) hormone therapy for the last 5 years; c) women smokers or with a history of more than 5 years of smoking; d) patients who have been diagnosed with metabolic bone disease; e) patients whose body mass index exceeds 35; f) long-term treatment with corticosteroids or patients with thyroid disease; g) women already participating in an intense exercise program (once or twice a week); h) patients who have contraindications for intense physical exertion - high blood pressure, recent history of cardiac arrhythmias; i) patients with musculoskeletal problems that limit physical activity. The volunteers were divided into 2 groups (control group – sedentary group and exercise group – volunteers who wanted to participate in a resistance training program twice a week). Both groups were on alfacalcidol 0.5 μg daily. The flowchart of patient enrollment is given in Figure 1. The training program was conducted over a period of 12 months, twice a week and includes exercises for the development of the strength of the main muscle groups at the lower and upper limbs. The strength exercises were divided into two programs. In the first program, the exercises performed were the following: seated hip abduction, seated machine dip, seated back extension, seated hip flexion, seated hip extension and seated hip adduction. In the second program, the exercises performed were the following: horizontal leg press, prone hamstring curls, seated knee extension, bodyweight squats, Scott Bench biceps curls.

Each training session lasted approximately 50 minutes, and the sessions took place in the gymnasium of Ștefan cel Mare Suceava University – Faculty of Physical Education and Sport. The subjects had a period of two weeks of familiarization with the exercises and learning the correct technique of execution, and in this two weeks the intensity used was 40% of 1RM with a number of 12 – 15 repetitions for each set. Subsequently, in the third week the intensity increased to 50% of 1RM, followed by the fourth week to use the specific method (6 x 50% of 1RM + 6 x 70% of 1RM) and each exercise was performed in 2 sets and the break between sets was between 1'30'' – 2'. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, Inc., Chicago, IL, USA) version 20. The data were expressed as the mean and standard deviation (SD) for each variable. The Shapiro-Wilk test was used to test the normality of the data, Wilcoxon test was used for within-group comparisons. Between-group comparisons of difference scores and/or percent changes were performed using the Mann-Whitney U test. A *p* value < 0.05 was considered statistically significant. Effect size (*r*) was also calculated.

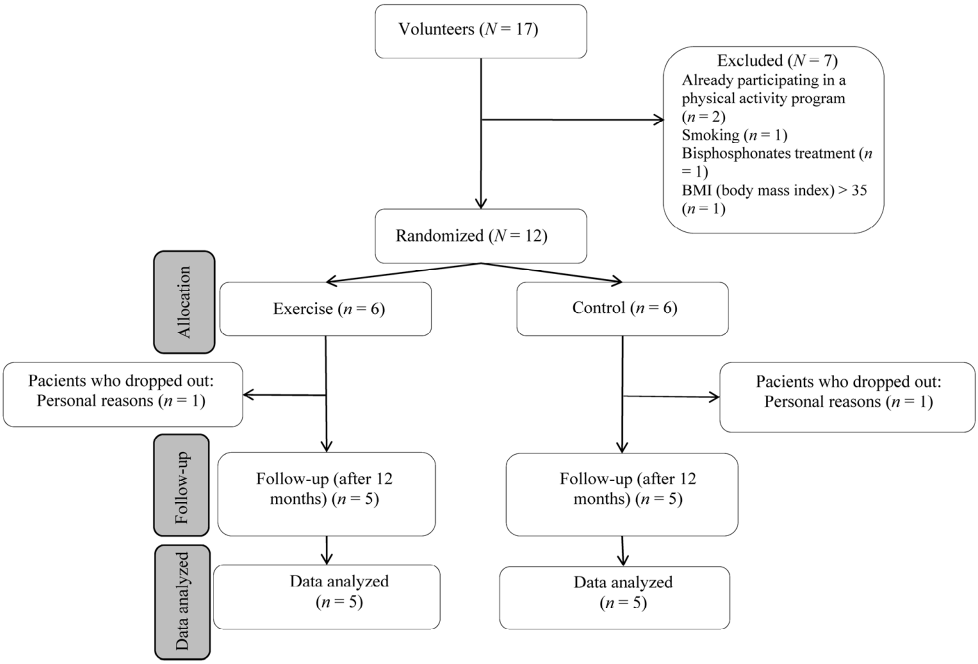

Fig. 1. Flow diagram of study participants

Results

One patient from the control group and one patient from the exercise group dropped out from the study. The patient from the exercise group dropped out because of personal reason (could not reach the exercise program) and the other patient in the control group dropped out due to family issues. The results of the remaining 10 patients were included in the analysis.

There were no significant differences at the baseline between the age, height, weight, BMI, T score, BMD spine, arm curl test or chair stand test between the exercise and control group (Table 1). Subjects in the experimental group recorded an statistically significant increase in performance (Δ% = 11%) at the end of the study (M = 22.2, SD = 0.8) compared to the baseline results (M = 20, SD = 0.7), Z = -2.12, p = .034, r = -0.95 (Table 2).

Table 1. The Descriptive Characteristics for Volunteers Groups in Baseline

	Exercise (*n* = 5)	Control (*n* = 5)	*U*	*p*	*r*
Age (years)	55.2±1.3	55.4±1.1	-0.32	.75	-0.10
Height (cm)	160.0±6.0	156.4±4.4	-1.27	.21	-0.40
Weight (kg)	67.2±3.7	65.2±6.5	-0.95	.34	-0.30
BMI (kg/m^2)	26.2±1.3	26.6±1.9	-0.42	.68	-0.13
T_{total} score (Spine)	-2.2±0.3	-2.1±0.3	-0.32	.75	-0.10
BMD_{Total} (Spine)	0.811±0.039	0.819±0.030	-1.36	.92	-0.43
Arm Curl test	20.0±0.7	20.6±1.1	-0.98	.32	-0.31
Chair Stand test	18.0±0.7	18.0±1.2	-0.34	.74	-0.11

Note. Results are represented as mean and standard deviation (±); BMI = Body Mass Index; BMD = bone mineral density (g/cm^2); *r* = effect size.

Within the control group, there was a decrease in performance (Δ% = -1.94%) after 12 months (*M* = 20.2, *SD* = 0.8) compared to the baseline (*M* = 20.6, *SD* = 1.1), but the decrease was not statistically significant, *Z* = -1.41, *p* = .16, *r* = -0.63. For the arm curl test, Mann-Whitney U test showed a significant difference between the two groups at the end of the study, *U* = -2.46, *p* = .014, *r* = -0.78 (Figure 2).

Table 2. Pre and Post-test Results for the Physical Performance Tests

	Exercise (*n* = 5)			Control (*n* = 5)			
	Pre	Post	p^a	Pre	Post	p^b	p^c
Arm Curl (30’)	20.0±0.7	22.2±0.8*‡	.034	20.6±1.1	20.2±0.8‡	.16	.014
Chair Stand (30’)	18.0±0.7	19.8±0.8*‡	.034	18.0±1.2	17.6±1.7‡	.16	.023

Note. Results are represented as mean and standard deviation (±); The symbol (*) indicates a significant difference p ≤ .05 intra-group; The symbol (‡) indicates a significant difference p < .05 inter-groups in the favor of exercise group; The p^a value measures the intra-group (pre vs post) difference at the exercise group level; The p^b value measures the intra-group (pre vs post) difference at the control group level; The p^c value measures the intergroup post-test difference.

For the 30 second chair stand test, the exercise group showed an increase in performance (Δ% = 10%) after 12 months (*M* = 19.8, *SD* = 0.8) compared to the baseline (*M* = 18, *SD* = 0.7), *Z* = -2.12, *p* = .034, *r* = -0.95. In contrast, control group showed a decrease in performance (Δ% = -2.22%) at the end of the study (M = 17.6, SD = 1.7) compared to the baseline results (M = 18, SD = 1.2), Z = -1.41, p = .16, r = -0.63. However, at the end of the study, the difference between the two groups was significant different, U = -2.27, p = .023, r = -0.72.

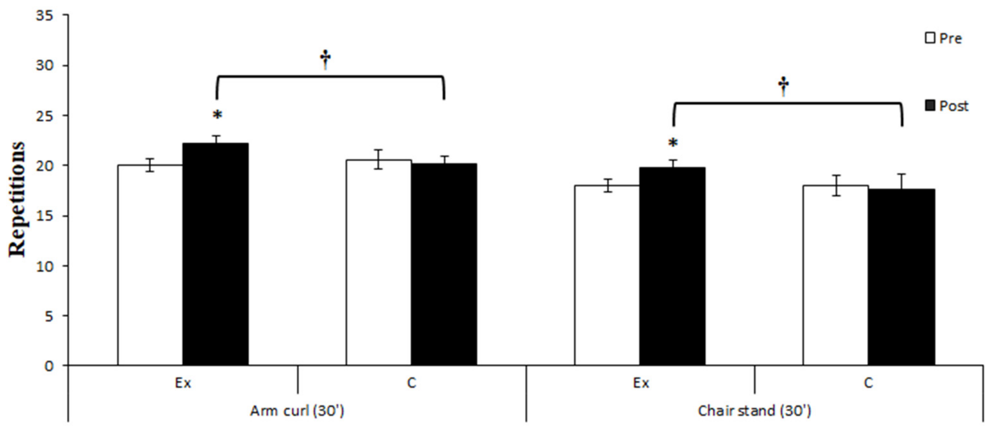

Fig.2. Pre and post-test results with 95% confidence interval for the arm curl and chair stand tests. The symbol (*) indicates intra-group difference (p < .05) and the symbol (†) indicates inter-group difference (p < .05)

Conclusions

Weight bearing exercise forms an integral component of osteoporosis management (Howe, et al., 2011). Many articles and meta-analyzes demonstrate the beneficial effect of strength training on the elderly and postmenopausal women (Arnold & Bautmans, 2014; Shaw, Gouveia, McIntyre, & Shaw, 2016; Fernandez-Lezaun, Schumann, Makinen, Kyrolainen, & Walker, 2017); Nunes, et al., 2017; Radaelli, et al., 2018). Increased muscle strength through resistance training contributes to reduce fracture risk by maintaining bone mass by stimulating bone formation and decreasing bone resorption (Girgis, 2015). Mixed loading exercise appears to be effective to reduce bone loss in postmenopausal women (Kelley, Kelley, & Kohrt, 2012; James & Carroll, 2009). Some prevention of hip fracture by physical activity has been consistently reported (Karlsson, Nordqvist, & Karlsson, 2008).

In the case of beginners, it is recommended that in the initial stage, when they are in the period of learning the technique execution, the intensities used will be between 50 – 60% of 1RM or even lower (American College of Sports Medicine, 2009). In the case of the elderly, the strength training performed with intensities of 85 – 95% of 1RM with a number of 4 series, improves the functional capacity and leads to the prevention of falls. Also, this type of training leads to the increase in size of type II muscles fibers, as well as to the increase in their number (Wang, et al., 2017).

For postmenopausal women, both strength training that used 3 sets and those that used 6 sets with an intensity of 70% of 1RM led to similar changes in muscle strength and hormonal responses (Nunes, et al., 2017). The use of multiple sets led to increases in muscle strength between 3.5 – 5.5% while the use of a single set led to decreases in strength by up to -1% and even -2% (Kemmeler, Lauber, Engelke, & Weineck, 2004).

For older women, high volume strength training (3 sets per exercise) leads to similar changes in strength and muscle mass, with lower volume strength training (1 series per exercise), both workouts being performed twice a week (Radaelli, et al., 2013; Cuhna, et al., 2018; Radaelli, et al., 2018).

This pilot study provides a brief presentation of the effects that resistance training has on physical performance in patients with postmenopausal osteopenia/osteoporosis. Thus, practising resistance exercises can help improve the upper and lower body strength in these patients and can be used as a preferential method.

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