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Bone density, balance and quality of life of postmenopausal women taking alendronate participating in different physical activity programs

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***Abstract*:**
Background: The objective of this study was to determine the effects of different physical activity (PA) programs on bone density, balance and quality of life of postmenopausal women taking concomitant alendronate. A quasi-experimental study was conducted with 35 volunteers divided into four groups: practitioners of resistance training (RTG, $n = 9$, 49.8 ± 4.2 years), judo (JUG, $n = 11$, 52.2 ± 5.3 years), water aerobics (WAG, $n = 8$, 57.1 ± 7.4 years) and the control group (CG, $n = 7$, 53.8 ± 4.4 years).
Methods: The following assessment tools were used: bone mineral density (BMD) measured by dual X-ray absorptiometry of the spine and proximal femur, the 'Osteoporosis Assessment Questionnaire' (OPAQ) and the 'Static Balance Test with Visual Control'. The physical activities were planned for 12 months in cycles with different intensities. A two-way analysis of variance (ANOVA) was used for analysis between groups, and a Scheffé post-hoc test was used for multiple comparisons.
Results: The multiple comparisons results showed that the RTG and JUG groups were significantly more efficient in the variables studied, including: lumbar BMD ($\Delta\% = 6.8\%$, $p = 0.001$), balance ($\Delta\% = 21.4\%$, $p = 0.01$), OPAQ ($\Delta\% = 9.1\%$, $p = 0.005$) and lumbar BMD ($\Delta\% = 6.4\%$, $p = 0.003$), balance ($\Delta\% = 14\%$, $p = 0.02$) and OPAQ ($\Delta\% = 16.8\%$, $p = 0.000$) compared with the CG. Furthermore, the RTG ($\Delta\% = 4.8\%$, $p = 0.02$) was significantly better than the WAG for the neck of femur BMD, and the JUG ($\Delta\% = 16.8$, $p = 0.0003$) also demonstrated superiority to the WAG in the OPAQ.
Conclusions: The physical activities studied appear to improve BMD, balance and quality of life of postmenopausal women taking a bisphosphonate. In this small sample, the RTG and the JUG groups were superior to the other groups.

***Keywords*:** bisphosphonate, bone density, exercise, menopause, postural balance, quality of life

Introduction

Osteoporosis is a bone disease that causes bone fragility with increased risk of fracture and negative consequences on mobility [Drinkwater *et al.* 1995]. With advancing age, this skeletal fragility in conjunction with impaired balance [Jessup *et al.* 2003] and the risk and frequency of falls become determining factors for the risk of fracture [Sambrook *et al.* 2007], which compromises the quality of life (QoL) [Bener *et al.* 2007] because skeletal fragility affects the ability to perform daily activities [Navega and Oishi, 2007; Chan *et al.* 2003].

Women are more prone to this disease because of the decrease of the endogenous release of sex hormones and the absorption of calcium; estrogen influences the reduction of calcium absorption in bone tissue during menopause [Costa-Paiva *et al.* 2003]. In addition to gender, other factors are associated with osteoporosis,

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including genetic factors, European descent, age, body mass index (BMI <20), poor consumption of calcium (Ca^{2+}), physical inactivity and other factors related to bone mineral density (BMD) [Kanis *et al.* 2005].

In this study, special attention was given to physical activity (PA) because it has been considered a potential factor that aggravates this problem. The regular practice of PA has been widely recommended by the literature due to its beneficial effects related to BMD [Park *et al.* 2007]. Pharmacological treatment, with the use of alendronate (bisphosphonate), also efficiently controls the bone loss, acting as an inhibitor of the bone resorption caused by the osteoclastic action, contributing to the reduction of fractures [Delmas *et al.* 2005].

Given the different types of PA, resistance training (RT) has been cited as an effective activity for the treatment of osteoporosis due to the increase in muscular strength and consequently BMD [Aveiro *et al.* 2006; Cusller *et al.* 2005]. However, the participation in this form of PA is still low in older women who generally prefer PA such as water aerobics, which does not appear to enable significant osteogenic stimuli [Ay and Yurtkuran, 2005], even though it can contribute to an improvement of other risk factor variables, such as balance and QoL [Arnold *et al.* 2008; Kohrt *et al.* 2004]. Although judo has not been considered in the literature as a method of improving BMD in postmenopausal women, studies developed with children, youths and high-performance athletes have demonstrated a positive contribution of judo for the protection of the skeletal structure [Bréban *et al.* 2008; Nanyan *et al.* 2005; Andreoli *et al.* 2001].

Considering the above, this study aimed to verify the effects of different types of PA including judo, RT and water aerobics on BMD, body balance and QoL of postmenopausal women taking alendronate.

Methods

Subjects

The study sample comprised a total of 35 women volunteers with low BMD, residing in Tucuruí (Pará-Brazil), and recruited via local radio and television programs. Participants were distributed into three experimental groups according to proximity of their residence to the location of the class, namely: judo group (JUG, $n = 11$); resistance-training group (RTG, $n = 9$); water aerobics group (WAG, $n = 8$); and the control group (CG, $n = 7$). The control group was drawn from the same sample of volunteer women and was made up of women who were encouraged not to practice regular PA during the period of the study. Therefore, the study was designed as quasi-experimental.

Inclusion criteria for the study included women with osteoporosis and/or osteopenia in at least one of the measurements of BMD *T*-score, patients being treated with sodium alendronate (70 mg), no previous history of fractures and no history for at least 1 year of regular practice of PA. In addition, they were required to be in good physical and mental health, in agreement with medical evaluation.

The participants gave informed consent and the study was approved by the Ethics Committee of the Castelo Branco University, Rio de Janeiro, Brazil/VREPGPE/COMEP/PROCIMH, protocol number 0171/2008, according to the standards mandated by the Declaration of Helsinki [World Medical Association, 2008].

Protocols

Bone mineral density measurement. In this study, the dual-energy X-ray absorptiometry (DXA) was performed using a Lunar DPX Medium class with a 750 μA current. The machine was calibrated daily. BMD was measured in the proximal femur and lumbar spine regions. The variables obtained from the DXA were BMD (g/cm^2) and *T*-score measurement of the lumbar spine (L_2–L_4 vertebrae), neck of the femur, greater trochanter and Ward's triangle.

Evaluation of body balance. Balance was evaluated by the 'Static Balance Test with Visual Control' [Rikli and Jones, 1999], which requires the person being assessed to remain in static balance, standing on one foot for no more than 30 s at a distance of 2 m from a mark made on the wall where the individual has to look for the duration of the assessment period. The test result was averaged from three measurements.

Evaluation of quality of life. The 'Osteoporosis Assessment Questionnaire' (OPAQ) is a tool used to measure the QoL of people with low BMD. This study used the OPAQ (Brazilian-Portuguese) [Cantarelli *et al.* 1999] that assesses issues related to general health, mobility, walking and leaning, back pain, flexibility, personal care, housework, movement, fear of falling, social activities, support from family and friends, pain associated with osteoporosis, sleep, fatigue, work, tension level, humor, body image, and independence. The analysis only used the total OPAQ count.

Pharmacological treatment. The drug, sodium alendronate, at a dosage of 70 mg/week, was used as an aid for the treatment of reduced bone density [Delmas *et al.* 2005], verified from prescriptions written by physicians who usually monitored the evolution of BMD change of the volunteer subjects. The subjects agreed not to use additional bone active medications or hormones during the study.

Experimental procedures. The PAs investigated were performed for 12 months in 6 bimonthly cycles [Dantas, 2003]. The classes for all experimental groups (JUG, RTG, WAG) were conducted three times a week on alternate days with each class lasting 60 minutes. The stimuli intensities varied every 2 months and are shown in Table 1, in agreement with the recommendations by Dantas [2003]. To determine the intensities of the JUG and WAG classes, the Borg scale of perceived exertion [Borg, 1982] was used. According to this scale, the intensities light, moderate, and high correspond to the values 12, 14, and 16 of the scale, respectively. For the RTG, the 10 maximum repetitions (10MR) test was used for each cycle, and the intensities varied between 70% and 90% of the values found in the test (Table 1). The equipment used for the RTG was from Pró-Physical® (Brazil), and the following exercises were performed: leg press at 45°; knee extension; plantar flexion; squats; hip adduction; gluts (machine for gluts); elbow flexion; elbow extension; and shoulder adduction.

For JUG, the traditional methodology for judo classes was used [Drigo *et al.* 2006], consisting of initial salutation to the inventor and instructor, stretches, fitness, breakfalls (Ukemi), repetition of techniques (Uchi-komi), training kimono grip changes, attack–defense (Kakari-geiko) and alternate projections (Yaku-soku-geiko), stretches and final salutations. Combat training (Handori) was excluded from the methodology due to the possible risk of fractures associated with this activity in older females. The classes for the JUG were conducted in a 103 m^2 room with a 40-mm-thick synthetic rubber tatami (2 m × 1 m).

The WAG classes were conducted in a 12-m section of a 25-m pool, 1.45 m deep, with the following exercises: dislocations (previous, posterior, and lateral); shoulder adduction/abduction; short jumps with knee extension; alternate elbow flexion; alternate knee flexion; alternate elbow extension; hip adduction/abduction; shoulder abduction/adduction; and squats (Table 1).

Statistical analysis

A significance level of $p \leq 0.05$ was adopted for the statistical analysis of all variables studied. The PASW® for Windows 17.0 program was used for the data analysis. Descriptive analysis of the groups studied was carried out with measures of central tendencies and dispersion. A Shapiro–Wilk test was performed to confirm proximity with a normal distribution. A two-way analysis of variance (ANOVA) was carried out for analysis between groups, and the Scheffé post-hoc test was performed to test for multiple differences of variables between groups. The equation $\Delta\% = [(\text{Posttest} - \text{test}) * 100/\text{test}]$ was used to determine the percentage difference.

Results

Table 2 shows the volunteers' baseline demographic details including *T*-score and time since menopause, which confirmed the low BMD in the groups studied. Although the RTG and JUG were somewhat younger than the WAG and controls, the subject's age, mass and height did not differ significantly between groups. However, significant differences ($p < 0.05$) were present for the following variables: *T*-score L_2–L_4 and Wards, BMD L_2–L_4 and Wards, as well as QoL between the four groups (Table 2).

Figure 1 shows that after the 12 months of intervention through the PA programs (RTG, JUG, WAG), there were statistically significant differences for the BMD sites between groups, namely: lumbar vertebrae L_2–L_4, neck of the femur and greater trochanter, but not with the Ward's triangle site. Therefore, $\Delta\%$ values are shown for each site in their respective groups: RTG (L_2–L_4 $\Delta\% = 6.8\%$; neck of the femur $\Delta\% = 4.8\%$; trochanter $\Delta\% = 0.76\%$; Ward's $\Delta\% = 0.4\%$), JUG (L_2–L_4 $\Delta\% = 6.4\%$; neck of the femur $\Delta\% = 2.6\%$; trochanter $\Delta\% = 2.3\%$; Ward's $\Delta\% = 1.6\%$), WAG (L_2–L_4 $\Delta\% = 2.0\%$; neck of the femur $\Delta\% = -0.7\%$; trochanter $\Delta\% = 2.6\%$; Ward's $\Delta\% = 0.8\%$) and CG (L_2–L_4 $\Delta\% = -0.3\%$; neck of the femur $\Delta\% = -6.6\%$; trochanter $\Delta\% = -3.3\%$; Ward's $\Delta\% = -1.9\%$).

When the groups were compared through the Scheffé post-hoc test, there were significant

Table 1. Periodization of physical activity [Dantas, 2003].

12 months					
Resistance training					
Cycle 1 Adaptation Learning of mechanics of movements Progressive increase Of load 10MR Test (70%) 3 series/10 repetitions/ 9 exercises	Cycle 2 10MR 80% 3 series 8–10 repetitions 9 Exercises Interval/series – 30" Interval/exercise – 40"	Cycle 3 10MR 90% 3 series 6–8 repetitions 9 Exercises Interval/series–50" Interval/exercise– 60"	Cycle 4 10MR 70% 3 series 20 repetitions 9 Exercises Interval/series–20" Interval/exercise– 30"	Cycle 5 10MR 85% 3 series 8–10 repetitions 9 Exercises Interval/series–30" Interval/exercise– 40"	Cycle 6 10MR 90% 3 series 6–8 repetitions 9 Exercises Interval/series – 50" Interval/exercise– 60"
VME – Moderate	VME – Maximum	VME – Slow	VME – Moderate	VME –Maximum	VME – Slow
Water aerobics					
Cycle 1 11 Exercises 3 Series 20 Repetitions Intensity (12) VME – Moderate	Cycle 2 8 Exercises 3 Series 10 Repetitions Intensity (16) VME – Slow	Cycle 3 11 Exercises 3 Series 20 Repetitions Intensity (14) VME – Moderate	Cycle 4 8 Exercises 3 Series 6–8 Repetitions Intensity (16) VME – Maximum	Cycle 5 8 Exercises 3 Series 10 Repetitions Intensity (14) VME – Slow	Cycle 6 8 Exercises 3 Series 6–8 Repetitions Intensity (16) VME – Maximum
Judo training					
Cycle 1 Race – 5 min	Cycle 2 Race – 8 min	Cycle 3 Race – 8 min	Cycle 4 Short race – 3 Sprints/12 m	Cycle 5 Race– 8 min	Cycle 6 Short race – 4 Sprints/12 m
12 Exercises 3 Series 12 Repetitions Intensity (12) VME – Slow	12 Exercises 3 Series 12 Repetitions Intensity (12) VME – Slow	10 Exercises 3 Series 8 Repetitions Intensity (14) VME – Moderate	10 Exercises 3 Series 6 Repetitions Intensity (16) VME – Maximum	10 Exercises 3 Series 10 Repetitions Intensity (14) VME – Moderate	10 Exercises 3 Series 6–8 Repetitions Intensity (16) VME – Maximum

VME, velocity of movement execution; 10MR, 10 maximum repetitions test.

differences in the variable BMD of the lumbar vertebrae L_2–L_4 (Table 3) between the CG and the RTG and JUG experimental groups. In the neck of the femur, it was possible to distinguish between the RTG from the WAG and CG. The latter also showed differences from the RTG for the trochanter.

According to Figure 2, the body balance showed significant differences between groups. In addition, the study presented Δ% values for RTG Δ% = 21.4%, JUG Δ% = 14%, WAG Δ% = 9.5% and CG Δ% = −5.3%.

The Scheffé post-hoc test showed significant differences between the CG and the RTG and JUG (Table 3). Therefore, the QoL between groups were also significant for the total count of OPAQ ($p < 0.0001$), which is shown in Figure 3, and the percentage differences are presented as follows: RTG Δ% = 9.1%, JUG Δ% = 16.8%, WAG Δ% = 3.4% and CG Δ% = −2.1%.

For QoL, the CG was statistically different from RTG and JUG, and the latter was different from the WAG (Table 3).

Discussion

The literature has shown that PA can have a potential role in aiding or modifying the effects of osteoporosis [Sambrook *et al.* 2007; Jessup *et al.* 2003; Chan *et al.* 2003]. Given the range of different PAs available, RT is the activity that generally shows the best results in the stimulation of osteogenesis [Borba-Pinheiro *et al.* 2010; Cusller *et al.* 2005].

In a study that used RT in postmenopausal women, three times per week, two series of six to eight repetitions and an intensity of 70–80% of 10MR, a significant relationship was found between the percentage frequency of exercise in groups with an average consumption of calcium (1.635 ± 367 mg/day) and calcium supplementation (711 ± 174 mg/day) with gains of 1.9% BMD in the trochanter and 2.3% in the femoral neck ($p < 0.05$). In the group that were treated with hormone replacement therapy, gains of 1.5% in the trochanter, 1.2% in the femoral neck, and 1.2% in the lumbar column were observed ($p < 0.01$) [Cusller *et al.* 2005].

Table 2. Descriptive analysis of the sample.

Variables	Resistance training, *n* = 09		Judo, *n* = 11		Water aerobics, *n* = 08		Control, *n* = 07		*p*-value
	Mean ± SD	SE	Mean ± SD	SE	Mean ± SD	SE	Mean ± SD	SE	
Age (years)	49.8 ± 4.26	1.4	52.2 ± 5.3	1.6	57.1 ± 7.47	2.6	53.8 ± 4.41	1.6	0.064
Mass (kg)	57.2 ± 5.49	1.8	58.1 ± 12.88	3.8	61.5 ± 7.5	2.6	61.78 ± 12.17	4.5	0.720
Height (cm)	155.1 ± 4.37	1.4	155.6 ± 6.65	2.0	152.6 ± 2.38	0.84	153.1 ± 7.05	2.6	0.590
Time since menopause (age)	2.6 ± 1.4	0.48	2.7 ± 1.3	0.38	4.1 ± 1.3	0.45	3.2 ± 1.01	0.37	0.056
T-score L_2–L_4 (SD)	−1.56 ± 0.69	0.23	−2.61 ± 0.7	0.21	−2.64 ± 1.39	0.49	−1.44 ± 1.19	0.45	**0.024**
T-score neck femur (SD)	−1.53 ± 0.98	0.32	−1.79 ± 0.89	0.26	−1.68 ± 0.32	0.11	−0.97 ± 0.84	0.31	0.216
T-score Ward's (SD)	−1.35 ± 0.84	0.28	−1.93 ± 0.56	0.17	−1.62 ± 0.66	0.23	−0.98 ± 0.64	0.24	**0.044**
T-score trochanter (SD)	−0.74 ± 0.78	0.26	−1.20 ± 0.81	0.24	−1.04 ± 0.32	0.11	−0.18 ± 1.15	0.43	0.077
BMD, L_2–L_4 (g/cm^2)	1.006 ± 0.08	0.02	0.883 ± 0.07	0.02	0.883 ± 0.16	0.06	1.025 ± 0.14	0.05	**0.026**
BMD, neck femur (g/cm^2)	0.797 ± 0.11	0.04	0.766 ± 0.10	0.03	0.777 ± 0.03	0.01	0.870 ± 0.10	0.04	0.186
BMD, Ward's (g/cm^2)	0.733 ± 0.10	0.03	0.658 ± 0.07	0.02	0.698 ± 0.08	0.03	0.783 ± 0.08	0.03	**0.045**
BMD, trochanter (g/cm^2)	0.715 ± 0.09	0.03	0.672 ± 0.10	0.03	0.675 ± 0.03	0.01	0.778 ± 0.13	0.05	0.122
Body balance (time (s))	23 ± 3.4	1.13	23.8 ± 7.2	2.1	21.8 ± 8.8	3.1	21.1 ± 4.2	1.6	0.805
OPAQ total count (points)	346.4 ± 27.6	9.2	295.9 ± 60.32	18.2	249.7 ± 26.6	9.4	321.0 ± 40.41	15.2	**0.001**

BMD, bone mineral density; OPAQ, osteoporosis assessment questionnaire; SD, standard deviation; SE, standard error; Bold numbers indicate $p < 0.05$.

The literature shows that there is a positive relationship between the increase in muscular strength and BMD [Borba-Pinheiro *et al.* 2010; Rhodes *et al.* 2000]. Experiments such as those by Nickols-Richardson and colleagues are consistent with this proposition [Nickols-Richardson *et al.* 2007]. Their study found an increase in unilateral strength of arms and legs, BMD of the hip and lower arm and BMD of the lower arm ($p < 0.05$) of volunteers submitted to 5 months of concentric and eccentric RT, with the nondominant group being used as the experimental group and the dominant group as the control. As studies have suggested that periodized RT programs have a greater possibility for effective strength gains [Silva and Farinatti, 2007], a hypothesis can be formulated that this type of training would also be the most suitable to increase BMD.

The results found in the present study are consistent with this literature; significant differences (Table 3) were found for BMD in the lumbar spine in favor of the RTG and JUG with greater percentage gains in relation to the WAG and CG. However, the RTG and JUG did not show significant differences in relation to the WAG or each other. For the femoral neck site, the RTG was statistically better than WAG and CG; however, the RTG did not show differences in relation to the JUG. In relation to the trochanteric site, the RTG was only better than the CG and did not differ from the other groups (Table 3).

Consequently, the methodology used for the RTG with the diversification of load intensity and bimonthly modification, with a test (10MR) for each cycle and over 12 months of planning (70%; 80%; 90% and 70%; 85%; 90%), may have contributed to different adaptations, which makes it a potential alternative for the control of BMD in postmenopausal women.

Studies have suggested that the regular practice of judo can also promote powerful osteogenic stimuli [Prouteau *et al.* 2006]. Young judo practitioners and high-performance athletes show an increased BMD when compared to practitioners of other sports, as demonstrated by [Andreoli *et al.* 2001] who compared the BMD of judo, karate and water polo athletes and verified that judo athletes possess significantly higher overall BMD and BMD of the arms, torso and legs when compared with the other sports and with the control. In a comparison of the BMD of student

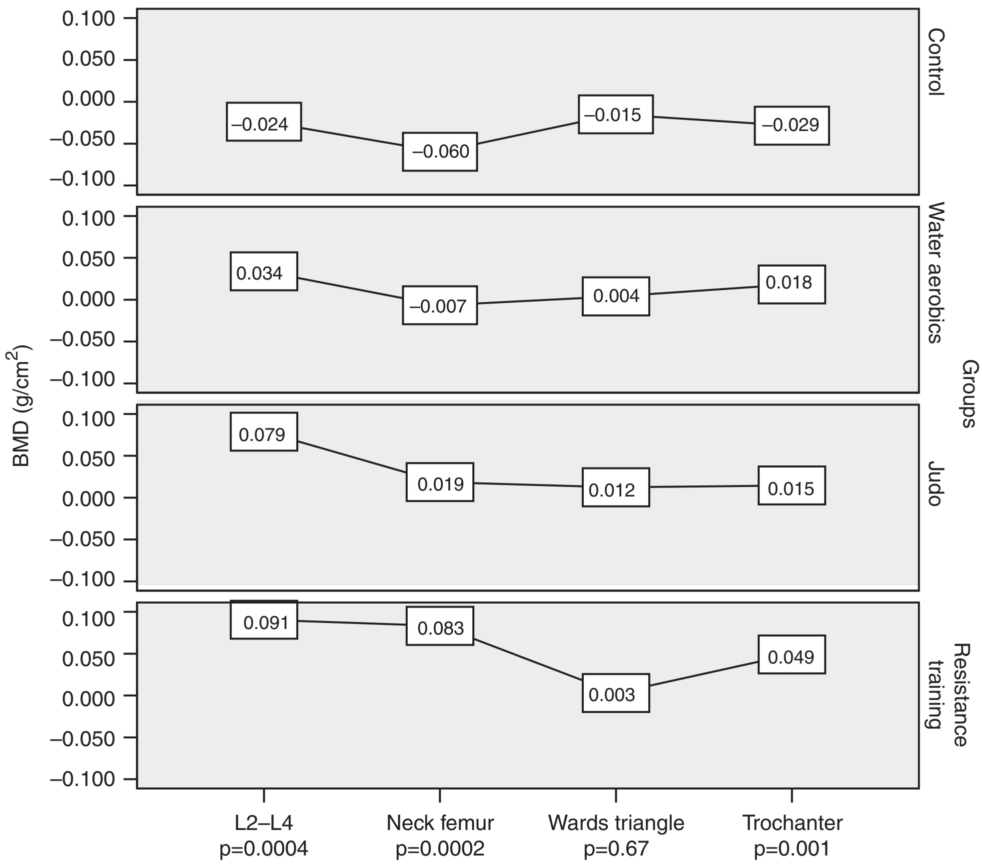

Figure 1. Analysis of bone mineral density (BMD) differences between groups.

Table 3. Analysis of multiple comparisons of variables between groups.

	Resistance training	Judo	Water aerobics	Control
Lumbar L_2–L_4	$M = 0.09056$	$M = 0.07882$	$M = 0.03387$	$M = -0.0237$
Resistance training		$p = 0.9672$	$p = 0.1842$	$\mathbf{p = 0.0016}$
Judo			$p = 0.3335$	$\mathbf{p = 0.0032}$
Water aerobics				$p = 0.2186$
Neck of femur	$M = 0.08322$	$M = 0.01855$	$M = -0.0066$	$M = -0.0597$
Resistance training		$p = 0.1006$	$\mathbf{p = 0.0211}$	$\mathbf{p = 0.0002}$
Judo			$p = 0.8102$	$p = 0.0525$
Water aerobics				$p = 0.3442$
Greater trochanter	$M = 0.04911$	$M = 0.01455$	$M = 0.01825$	$M = -0.0286$
Resistance training		$p = 0.2192$	$p = 0.3790$	$\mathbf{p = 0.0019}$
Judo			$p = 0.9970$	$p = 0.1210$
Water aerobics				$p = 0.1132$
Body balance	$M = 5.7444$	$M = 5.3000$	$M = 1.3000$	$M = -1.057$
Resistance training		$p = 0.9958$	$p = 0.1701$	$\mathbf{p = 0.0181}$
Judo			$p = 0.2133$	$\mathbf{p = 0.0221}$
Water aerobics				$p = 0.7239$
OPAQ	$M = 30.556$	$M = 53.091$	$M = 7.625$	$M = -7.286$
Resistance training		$p = 0.1017$	$p = 0.1349$	$\mathbf{p = 0.0058}$
Judo			$p = 0.0003$	$\mathbf{p = 0.0000}$
Water aerobics				$p = 0.5339$

OPAQ, Osteoporosis Assessment Questionnaire.
Bold numbers indicate $p < 0.05$.

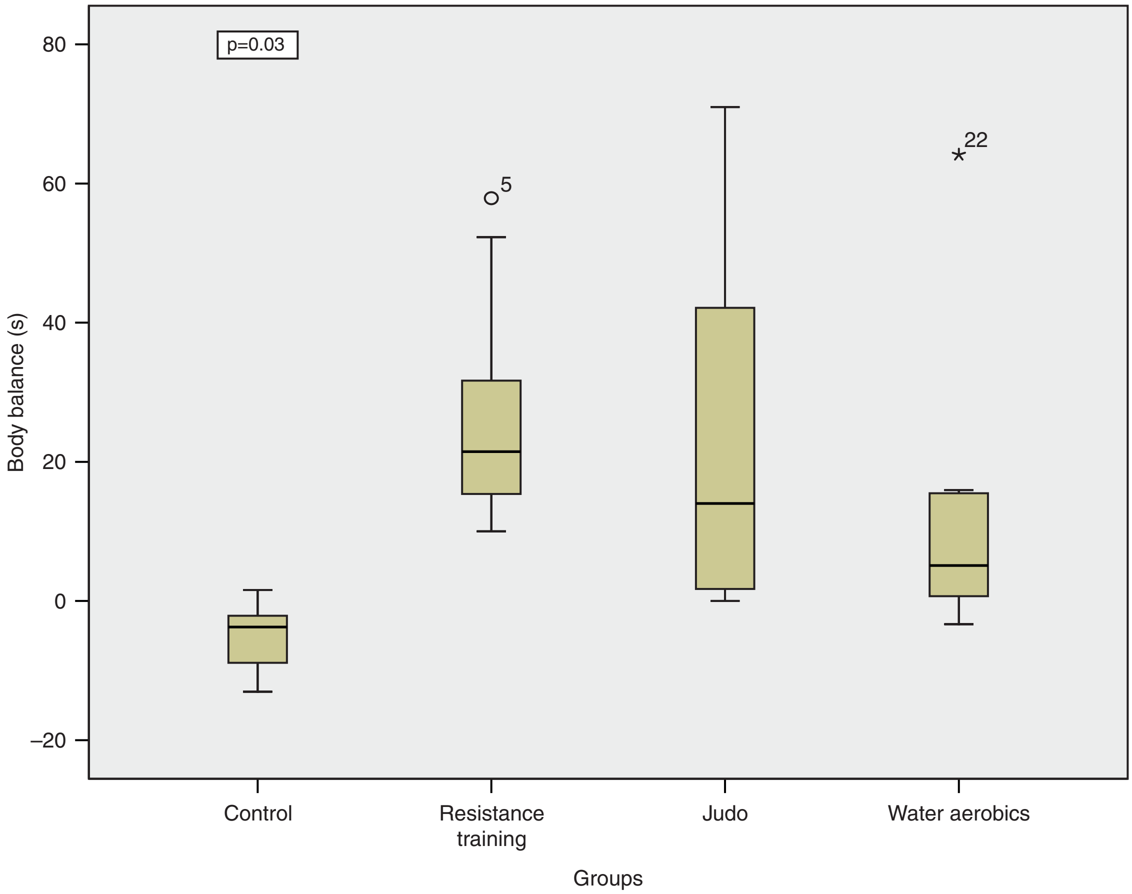

Figure 2. Body balance analysis between groups (° and * = outlines).

athletes of different sports (judo and other martial arts, runners, cyclists and team sports), in addition to the control group, Platen and colleagues showed significant differences in the lumbar and femoral BMD in the martial arts practitioners when compared with the control group [Platen *et al.* 2001]. They also found that lean body mass can be a strong differential for the BMD of these athletes because the specific biomechanics of judo, which has a particular mechanical load in the bone and muscular structure, can have positive effects on osteoblastic activity.

The current study displayed a positive differential related to the practice of judo. This study presented a methodology focused on older women with low BMD, and this has not been studied previously in the literature. The results of the JUG for the BMD of the lumbar spine were significantly better than the CG, although no other differences were found between the other PA groups (Table 3). These results partially corroborate the positive results concerning the BMD of the above studies [Silva and Farinatti, 2007; Andreoli *et al.* 2001; Platen *et al.* 2001] that were conducted with youths and high-performance athletes, suggesting that the practice of judo could aid the BMD of postmenopausal women, which was seen in this study. However, it is worth noting that the RTG had the best results, including in relation to the JUG.

The WAG and CG presented the lowest improvement in BMD, however, the WAG was better than the CG. The WAG had a better result for the trochanter, which did not occur with the CG. It is important to note that although all of the volunteers were being treated with sodium alendronate, somewhat surprisingly the CG, which did not participate in PA, demonstrated apparent loss in BMD at proximal femur sites (Table 3).

The results mentioned above are consistent with those presented in the literature; it has been shown that PA in water does not allow for large BMD gains [Ay and Yurtkuran, 2005]. These authors, in assessing 62 postmenopausal women, found favorable results in water exercise

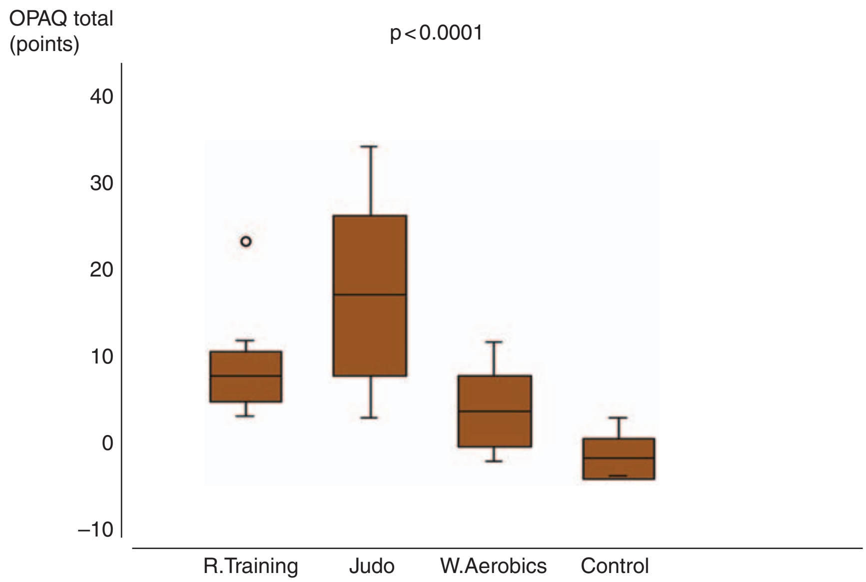

Figure 3. Analysis of quality of life between groups (° = outline). OPAQ, Osteoporosis Assessment Questionnaire.

for the BMD of the calcaneus 3.1% ($p < 0.05$). Nevertheless, the group that practiced exercises on land obtained better results 4.2% ($p < 0.05$), whereas the control observed a loss of 1.3% in BMD. A similar result was found by Andreoli and colleagues, who compared the BMD of judo, karate and water polo athletes and found that the PA in water athletes had total BMD, in addition, the BMD of the arms, torso and legs that was significantly lower when compared with other sports [Andreoli *et al.* 2001].

This study also utilized concomitant 70 mg sodium alendronate. Although the drug was not analyzed as an independent variable for correlation with the other variables, it was likely that the drug may have contributed to the increase or in the maintenance of the BMD of the volunteers because there is evidence in the literature that a combination of PA with alendronate shows positive effects on BMD. For example, a study of 164 menopausal women compared four groups: Group 1 (G1) subjects treated with 5 mg alendronate/day plus jumping exercises with progressive effort; Group 2 (G2) subjects treated only with 5 mg alendronate/day; Group 3 (G3) subjects treated with placebo plus progressive jumping exercise; and Group 4 (G4) subjects treated only with placebo. It was observed that G1 had a significant improvement in the BMD of the femur and lumbar spine compared with G3. However, the latter had a significant improvement (3.6%) in the distal tibia when compared with those that did not practice PA (G2 and G4) [Uusi-Rasi *et al.* 2003]. As expected there was a reduction in biochemical markers of bone turnover in G2 but no statistically significant change in any exercise group. Therefore, together, alendronate and PA may be more efficient in reducing the risk of fracture [Borba-Pinheiro *et al.* 2010; Uusi-Rasi *et al.* 2003].

Balance was another variable analyzed in this study. It is one of the most adversely affected systems with aging, which leads to the emergence of instability and the occurrence of falls in the elderly [Baloh *et al.* 2003]. The literature shows that PAs that improve balance, in addition to improving walking, significantly minimize the risk of falls and the consequent risk of fractures [Baloh *et al.* 2003]. In a study conducted with healthy judoists with previously induced mild trauma [Perrot *et al.* 2008], there was maintenance of the static and dynamic balance, indicating that judoists develop excellent adaptation in motor sensory and cognitive abilities to compensate for injury.

This study found significant differences between groups ($p < 0.05$) for body balance (Figure 2), where the JUG had an increase of $\Delta\% = 14\%$. This group was superior to the CG and was similar to the other groups. The RTG was also better than the CG and was also similar to the WAG and JUG. However, the WAG and the CG were not better in relation to any other group (Table 3).

Another study examined older women with low BMD who performed multiple exercises (RT, motor coordination and balance, increased consumption of calcium and vitamin D for a period of 12 months) and found a significant improvement in balance and strength in addition to a decrease in the risk of falls ($p < 0.05$) [Swanenburg *et al.* 2007]. Other programs with multiple exercises have also shown effectiveness for variables that relate to the risk of fractures [Cusller *et al.* 2003]. Similarly a study by Jessup and colleagues submitted elderly women to RT combined with a walk, going up and down steps, and balance exercises practiced for 60 min, three times a week, and showed a positive effect on BMD of the femoral neck and balance ($p < 0.05$) [Jessup *et al.* 2003]. In addition to reducing falls, exercises developed with balance training appear effective for the improvement of mobility, static and functional balance [Madureira *et al.* 2007].

In terms of effects on QoL, a study conducted in 68 elderly women with low BMD, divided into three groups (water exercises [WE], running exercises [RE] and no exercises [NE]), observed no significant differences for balance variables (except walking backwards, favorable for WE) and for functions using a QoL questionnaire (except for the total score function, favorable for RE) compared with NE [Arnold *et al.* 2008]. The QoL was also analyzed in this study and showed a significant difference between the groups ($p < 0.0001$) (Figure 3). QoL is impaired in women with low BMD, as shown in the study by Romagnoli and colleagues that compared the QoL of 361 women, either normal or with osteopenia or osteoporosis [Romagnoli *et al.* 2004]. In this study, the women with osteoporosis, with or without fractures, showed a significant reduction ($p < 0.05$) in the perception of general health, physical and social function and total count. Subjects with spinal fractures and low femoral BMD had impaired perception of QoL. These results were confirmed by Adachi and colleagues, who evaluated the QoL of women over 50 years with low BMD that suffered from spinal or nonspinal fractures or no fractures and found a worsening of QoL measures in the groups with spinal and nonspinal fractures [Adachi *et al.* 2002].

In the present study, the QoL showed significant improvements in the groups that practiced PA: RTG, JUG and WAG. However, the CG also suffered losses in overall QoL. The multivariate analysis showed that the JUG had increased QoL compared with the WAG and the CG; however, no differences in relation to the RTG were observed (Table 3). Yet, the RTG showed significant improvement in comparison to the CG, but it did not show improvements in relation to the JUG and WAG. The latter again did not show significant differences in relation to the other groups (Table 3).

Taken together, the types of PA examined in this study could be recommended alone or as adjunctive therapy to a bisphosphonate in postmenopausal women with low BMD, especially RT, which has also been recommended by the literature [Borba-Pinheiro *et al.* 2010; Nickols-Richardson *et al.* 2007; Rhodes *et al.* 2000], and potentially judo, although acceptance of the latter may be limited in this age group, because they demonstrated superior effects on BMD, balance and QoL in relation to water aerobics and the CG. However, periodized water aerobics could be recommended for women with low BMD and walking problems or chronic joint disease, because our results revealed that this activity showed some benefit compared with controls and such concomitant physical limitations would make the execution of activities with greater impact difficult.

This study has a number of strengths and weaknesses. Our study appears to be the first to examine judo as a form of PA in subjects with postmenopausal osteoporosis. However, our sample size was small, the subjects were not randomized, the generalizability of the findings about judo are unclear as might be its acceptance in postmenopausal women and the likelihood of adherence to such intensive PA programs outside the clinical trial setting is likely to be much lower. Compliance with alendronate was not assessed. In addition, the control group would not have experienced any placebo effect (e.g. attention from exercise instructors, etc.) that the other groups received, which may partially explain their poorer outcomes. Our groups also differed substantially with regards to baseline BMD. However, the differences in improvement in BMD are unlikely to be explained by larger percentage increases in those groups with lower BMD since, although the baseline BMD was lower in the JUG and WAG groups than RTG and controls, there was little difference between baseline BMD between RTG and controls or between JUG and WAG groups, respectively.

Nevertheless some of the improvements in BMD with PA were larger than might be expected and may be in part a result of the small sample size.

Further studies are recommended using the above methodologies applied to a range of PA with a larger number of subjects and using a bisphosphonate as an independent variable, in order to confirm the possible correlation between the effects of different PA and bisphosphonate treatment. Furthermore, the inclusion of more groups that practice PA including a placebo group is suggested, in addition to the combination of judo and RT training, to confirm these preliminary findings.

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Conflict of interest statement

This study did not have financial support of any institution, so there are no potential conflicts of interest.

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