Adapted combat sports on bone related variables and functional independence of postmenopausal women in pharmacological treatment: a clinical trial study

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Abstract

Background & study Aim: Osteoporosis is a chronic disease that leads to bone fragility and is associated with fracture risks and serious consequences for mobility. The aim of study was effects of adapted judo and karate programs of on bone mineral density (BMD), functional autonomy (FA), muscular strength and quality-of-life (QoL) of postmenopausal women in pharmacological treatment and low socioeconomic level.

Material & Methods: To the clinical trial study, 50 volunteers distributed into three groups: adapted judo training (AJT, n = 17); adapted karate training (AKT, n = 17) and control group (CG, n = 16). The following assessment were used: bone mineral density by dual X-ray absorptiometry, 'Latin America Group for maturity' protocol for FA, 10RM test for strength and 'Osteoporosis Assessment Questionnaire' (OPAQ) for QoL. The adapted combat sports training were planned for 13 months with different intensities. *ANOVA* with *Bonferroni* post-hoc test were used.

Results: Intra-groups ($p<0.05$) were observed in all BMD variables only AJT, besides of FA, leg strength and QoL for AJT and AKT. The AJT was significantly more efficient ($p<0.05$) compared with AKT, including: L_2-L_4 BMD ($\Delta\% = 0.039\%$), total BMD ($\Delta\% = 0.05\%$) and OPAQ ($\Delta\% = 40.8\%$). In addition, both AJT and AKT were more efficient ($p<0.05$) compared with CG, including: FA ($\Delta\% = 5.9\%$) and ($\Delta\% = 4.7$); Leg press at 45° ($\Delta\% = 63.7\%$) and ($\Delta\%=53.7\%$); Knee extension ($\Delta\% = 15.3\%$) and ($\Delta\% = 14.5\%$), respectively. For OPAQ total only AJT presented better results ($\Delta\% = 35.4\%$) compared with CG.

Conclusions: The AJT presented favourable results for BMD and QoL, besides AJT and AKT showed better results for strength, FA and QoL compared to CG after 13 months. Therefore combat sport based on throws and grips of immobilisation of opponent's body (judo, sambo, wrestling etc.) they are likely to be optimal in achieving training effects measured in this work.

Keywords: bone density • functional autonomy • muscle strength • physical function • quality of life

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Combat sport – *noun* a sport in which one person fights another, e.g. wrestling, boxing and the martial arts [46].

Martial arts – *plural noun* any of various systems of combat and self-defence, e.g. judo or karate, developed especially in Japan and Korea and now usually practised as a sport [46].

Division of the combat sports under forms of the direct confrontation – workings of weapons; hits (strokes); throws and grips of immobilisation of opponent's body [47].

Main relationship between combat sport and martial arts – every combat sport is martial arts but not vice versa [47].

Adapted combat sports – are combat sports with methodological adaptations practiced by older adults and without previous knowledge of the modality [48].

Bone mineral density (BMD) – is the amount measured in (g/cm²) of mineral for bone area [3].

Functional autonomy (FA) – The principle of functional autonomy is particularized enough in its operation to account for the uniqueness of personal conduct [49].

Quality-of-life (QoL) – it is a multifactorial variable that measures the physical and mental health.

Muscular strength – it is the possibility of a muscle or muscular group overcome a resistance [21].

Muscle endurance – *noun* the capacity of muscles to sustain prolonged aerobic activity [46].

Training load – "A simple mathematical model of training load can be defined as the product of qualitative and quantitative factor. This reasoning may became unclear whenever the quantitative factor is called 'workload volume' or 'training volume' interchangeably with 'volume of physical activity'.

Introduction

The National Osteoporosis Foundation (NOF) considers osteoporosis a chronic disease of the skeletal system that leads to bone fragility and is associated with fracture risks and serious consequences for mobility [1, 2]. In the older women, the bone fragility, sarcopenia, the risk of falls and the frequency of falls are the decisive factors that considerably affect the morbidity and quality of life (QoL) [2, 3]. Moreover, these factors also affect the ability of the elderly and older women to participate in activities of daily living, which consequently affects their functional autonomy (FA) [2-4].

Among many risk factors, the endogenous release of sex hormones and the absorption of the mineral calcium (Ca) make of the women a potential risk factor for the low bone mineral density (BMD) [1, 5]. In addition, the older age, calcium deficiency, diseases and medications related to low BMD and physical inactivity are serious risk factors [1-3, 5, 6]. Considering all risk factors, special attention should be observed to physical inactivity, alimentary behaviour and socioeconomic level, because are determinant for a healthy lifestyle [7, 8]. Pharmacological treatment, with the use of alendronate (bisphosphonate) and vitamin D, also efficiently controls the bone health [3, 6].

The relationship between BMD and PA can been explained because the effect of exercise on bone is thought to be due to a net increase in bone formation [9, 10]. In this study, special attention was observed to PA, because it has been considered a potential factor to both treatments: pharmacological associated and not associated with PA in this specific problem [9]. According to Sikorski and Błach [11], the judo can be a combat sport used for development of health variables. However, the adapted combat sports, as the judo and karate has not been cited as a treatment for osteoporosis and sarcopenia in older women. Thus, are few studies showing the adapted combat sports for older and elderly women to improve BMD, muscular strength, FA, QoL and related-variables of risk of falls [12-14]. The most research existing indicate that judo and karate practices in children and young athletes of high-performance has positive implications for playing a role in the protection of skeletal structure [15-17].

Therefore, the aim of study was effects of adapted judo and karate programs of on bone mineral density (BMD), functional autonomy (FA), muscular strength and quality-of-life (QoL) of postmenopausal women in pharmacological treatment and low socioeconomic level.

Our major hypothesis is that adapted judo results in more pronounced stimuli than adapted karate and should be more effective in maintaining or increasing BMD, FA, muscular strength and QoL in postmenopausal women in pharmacological treatment and low socioeconomic level compared to controls with pharmacological treatment without exercise.

Material and methods

Participants

The volunteers residing in Tucuruí (Brazil) were recruited via local radio and television programs. Registrations of volunteers were performed in campus XIII of State Pará University in the municipality of Tucuruí. The participants performed diagnostic assessments through interview and blood pressure check in time period 8 a.m. to 10 a.m. from Monday to Friday during January 2012. The following Inclusion and exclusion criteria have to be completed.

Inclusion criteria: **(a)** – female volunteers, **(b)** – aged over 50 years, **(c)** – with low BMD: T – score <–1SD (low bone density), **(d)** – different ethnic population (descendants of Europeans, Blacks and Indians), **(e)** – patients being treated with sodium alendronate [70mg] and/or vitamin D_3 [5600 IU], **(f)** – postmenopausal individuals (self-declared), **(g)** – no previous history of fractures (self-declared), **(h)** – no history for at least 1 year of regular practice of physical activity, **(i)** – with low socioeconomic level, **(j)** – with indication/medical clearance for physical exercises practices.

Exclusion criteria: **(a)** – who made some sort of surgery in the last six months, **(b)** – who had early menopause by ovary removal, **(c)** – with uncontrolled hypertension, **(d)** – that use additional bone active medications or hormone replacement therapy, **(e)** – individuals who were being treated with drugs that induces low BMD, as glucocorticoids.

It was used a mathematical calculation to verifier the sample size [18] after previous observations [12]. We expected a change of 0.5-4% in the bone formation by DXA assessment, as an indicator of osteogenic response from training and 5% or more for others variables of the study. With a power of 80% and significance level of 5%, 20 participants in each group were required to detect such a significant difference, considering a possible sample loss of 20% during the study. Thus, the minimum number of participants established for each group was of 16 subjects.

The selection process of this study is presented in Figure 1.

The clinical trial study comprised a total of 50 analysed women volunteers with low BMD [20 Caucasian, 21 of Afro-Brazilian and 9 of Indian-Brazilian descent]. Participants were distributed into two experimental groups and control group according to randomly parallel form: adapted judo training (AJT, n = 17) and adapted karate training (AKT, n = 17), both 3 times-per-week and the control group (CG, n = 16). The CG 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 study period (Figure 1). The drop-outs was characterized by the not frequency in the experimental intervention training period (AJT, n = 3; AKT, n = 3) and evaluation tests (CG, n = 4) of dependent variables (Figure 1).

The study was approved by the Ethics Committee of the Federal State Rio de Janeiro University, Brazil, protocol number 0050/2011 FR 478507 CAAE:0061.0.313.412-11, according to the standards mandated by the Declaration of Helsinki [19].

Assessment Protocols

Assessment of bone mass by Dual X-ray absorptiometry

BMD was determined by scans Lunar® model DPX-L (USA). Variables obtained by DXA were:

Various units have been adopted as measures i.e. the number of repetitions, kilometres, tons, kilocalories, etc. as well as various units of time (seconds, minutes, hours) (...) As in the real world nothing happens beyond the time, the basic procedure of improvement of workload measurement should logically start with separation of the time factor from the set of phenomena so far classified together as '*workload volume*'. (...) Due to the fact that the heart rate (HR) is commonly accepted as the universal measure of workload intensity, the product of effort duration and HR seems to be the general indicator of *training load* defined as the amount of workload. It is useful in analyses with a high level of generality. (...) In current research and training practice the product of effort duration and HR was referred to as conventional units' or further calculations have been made to convert it into points." [40, p. 238].

Microcycle – shortest training cycle is characterising by the dynamic of loads occurring in 5 to 9 days (usually a week).

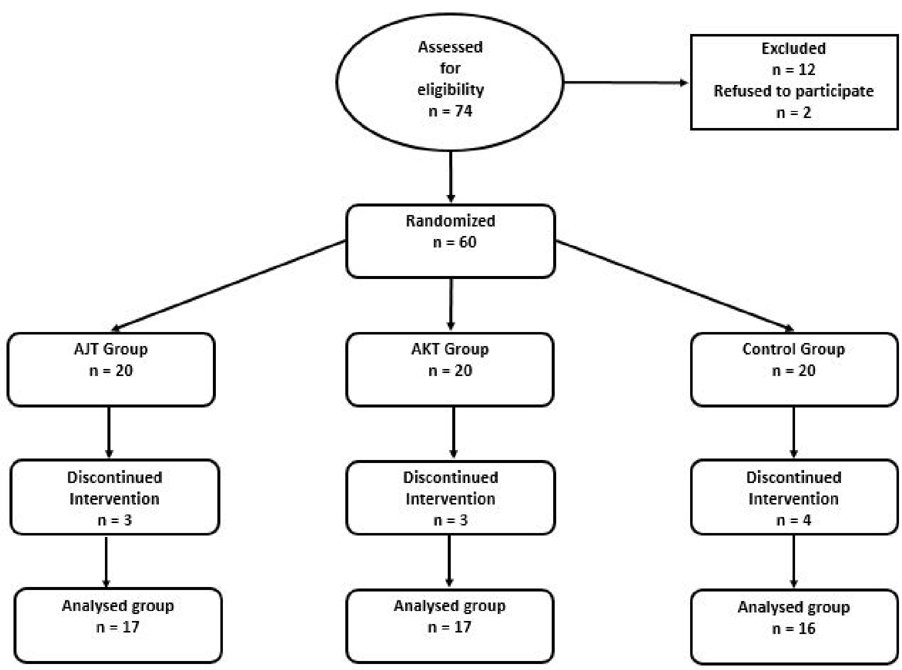

Figure 1. Diagram of the sample selection process for this study.

measures of BMD [g/cm^2] values in the lumbar spine L_2–L_4 region and the right total femur. Collected data analyses were performed using the following software version: DPXL 4.7e. DXPL uses an x-ray source at 78 kVp and a K-edge filter to produce stable beams of x-rays at energies of 38 and 70 keV. The radiation dose for a total body scan set on standard thickness using DPXL is 0.002 mSv. 4% above of the radiation dose received in a chest x-ray. All scans were performed by a particular laboratory that did not know the purpose of the study in order to not have any influence on study. To determine osteoporosis levels, was observed [*T scores*] as a condition in which BMD measures lower than –2.5 times the standard deviation [SD] and osteopenia with values between –1 and –2.5 SD compared with mean of young people [1, 3].

Assessment of functional autonomy

The protocol of the Latin American Development Group for Maturity (GDLAM) aims to standardize the assessment of FA [4]. GDLAM protocol has the following tests to assess FA: **(a) – 10meter walk** (10MW): walk the distance of 10 m rapidly to evaluate the displacement speed; **(b) – rising from sitting position (RSP)**: the individuals should get up and sit down of an chair five times consecutively to evaluate the strength of lower limbs; **(c) – rising from ventral decubitus position (RVDP):** the individuals must stand up as fast as possible after the command to assess the ability to the rise quickly from the ground; **(d) – rising from a chair and walking around the house (RCWH):** the test assess agility and dynamic balance; **(e) – putting on and taking off a shirt (PRTS):** the individuals must put on and take off the shirt (G t-shirt Hering®, Brazil) as fast as possible to assess flexibility. The GDLAM autonomy index (AI) was calculated using the following formula:

$$AI = \frac{[(10MW + RSP + RVDP + PRTS)\cdot 2] + RCWH}{4}$$

For the performance of the tests, the following equipment was used: a tape measure (Sanny®, Brazil); a stopwatch (Casio®, Brazil); a chair 50 cm above the ground; and a 20-mm-thick exercise mat.

Assessment of socioeconomic level

To evaluate the socioeconomic level of the investigated groups, the Economic Criterion Classification Brazil (ECCB) was used according with Research Companies Brazilian Association protocol [20]. The ECCB classifies individuals into one of five classes: A, B, C, D or E, where class A is the highest and class E is the lowest, establishing the following points for the classification with projection for the average family income: (a) – Class A1: 42-46 points with $2.587.00; (b) – Class A2: 35-41 points with $2.587.00; (c) – Class B1: 29-34 points with $1.463.96; (d) – Class B2: 23-28 points with $741.34; (e) – Class C1: 18-22 points with $470.67; (f) – Class C2: 14-17 points with $320.39; (g) – Class D: 8-13 points with $216.75; (h) – Class E: 0-7 points with $216.75.

Assessment of muscular strength

To assess muscle strength, the 10 maximum repetitions test (10MR) was used, in which the procedures adopted for the implementation were the following: **(a)** Performance of static stretching to prepare the large muscle groups. Two to three series of exercises were performed with light loads for familiarization of the movements; **(b)** Each individual had from three to four attempts to perform the test with a 10MR load according to the recommendations of the American College of Sports Medicine (ACSM) [21]. The breaks and the intervals—three to five minutes—between attempts were restoring. It is worth mentioning that the participants were not aware of the number of repetitions of the test, i.e., 10MR. The equipment used was from Physicus® (Brazil) and the following exercises: leg press 45° and knee extension.

Assessment 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 Brazilian-Portuguese OPAQ [22] that checks 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, humour, body image, independence and total OPAQ count from zero to 100 points. Where the zero point = lower QoL and 100 points = highest QoL.

Pharmacological treatment

The medication bisphosphonate sodium alendronate [70mg] once weekly and Vitamin D_3 [5600IU] once daily was used by volunteers that showed *T – Score* <–2.5 SD [osteoporosis]. In addition the volunteers that showed *T – score* among –1 and –2.5 SD [osteopenia] used only vitamin D_3 [5600IU/day] to aid in treatment for reduced bone mass [3, 6] in agreement with their prescriptions. Thus, in the AJT 11 volunteers used only vitamin D_3, and 6 volunteers used alendronate + vitamin D_3. In the AKT 11 volunteers used only vitamin D_3, and 6 volunteers used alendronate + vitamin D_3. And, in the CG 10 volunteers used only vitamin D_3, and 6 volunteers used alendronate + vitamin D_3. In addition, the medicines were used by two years, before the study, for the volunteers with osteopenia and at least four years, before the study, for the volunteers with osteoporosis. The medicine was consumed by the volunteers from both groups during the study period. The volunteers had the treatment according with their needs, prescribed by a medical doctor.

Interventions

The physical activity investigated was performed for 13 months in the linear periodization according to the recommendations of Borba-Pinheiro et al. [12]. The classes for experimental groups (AJT and AKT), were conducted three-times-week, on alternate days with each class lasting 60 minutes. The periodization were based in studies of Borba-Pinheiro et al. [13] for AJT and Borba-Pinheiro et al. [14] for AKT. The adapted training, were basically, composed of stretching before and after the training, strength training, agility, overall coordination and specific exercises of judo or karate. The training-intensity was measured by subjective effort scale [23]. It is should be noted, that the fight- training was excluded for this training-adaptation, besides experienced athletes also assisted the voluntaries for greater control of technical movements. The CG not realized no exercise program type in study period.

Table 1. Descriptive characteristics of the volunteers groups.

Variables	Groups						
	AJT n=17		AKT n=17		CG n=16		
	Mean	SD	Mean	SD	Mean	SD	p-value
Age (years)	56.60	3.30	60.50	6.60	55.30	6.80	0.055
Menopause of age (years)	45.05	2.50	45.06	3.10	45.70	3.40	0.342
Weight (kg)	63.06	9.30	59.08	4.90	62.70	7.50	0.340
Height (cm)	154.50	0.05	148.10	0.04	150.06	0.05	**0.050**
BMI (kg/m^2)	26.50	5.30	26.90	1.70	27.80	3.50	0.595
Frequency Session (class/week)	2.63	0.13	2.36	0.12	*	*	**0.001**
T-Score L_2-L_4 (SD)	−1.47	0.70	−1.43	0.62	−2.36	0.37	0.075
T-Score Neck Femur (SD)	−1.22	0.65	−1.33	0.68	−1.68	0.97	0.309
T-Score Trochanter (DS)	−1.19	0.74	−1.28	0.70	−1.02	0.77	0.185
T-Score Total Femur (SD)	−1.31	0.68	−1.21	0.65	−1.35	0.85	0.872
BMD L_2-L_4 (g/cm^2)	0.918	0.04	0.921	0.06	0.913	0.06	0.678
BMD Neck Femur (g/cm^2)	0.790	0.07	0.789	0.07	0.786	0.11	0.277
BMD Trochanter (g/cm^2)	0.694	0.07	0.679	0.05	0.696	0.08	0.550
BMD Total Femur (g/cm^2)	0.739	0.07	0.741	0.07	0.732	0.09	0.707
BMD Total (g/cm^2)	0.802	0.08	0.798	0.08	0.793	0.07	0.410
Functional Autonomy Index (Score)	28.64	2.55	28.16	2.98	28.17	2.18	0.953
Keen Extension Exercise (kg)	31.00	6.52	31.56	6.67	28.75	4.77	0.611
Leg Press at 45° Exercise (kg)	77.06	15.70	78.20	17.60	78.81	16.23	0.662
OPAQ Total (points)	291.82	56.24	273.50	35.48	312.31	35.94	0.090
Socioeconomic Level (points)	22.52	5.70	22.00	4.60	21.25	5.60	0.793

SD – Standard Deviation; AJT – Adapted Judo Training; AKT – Adapted Karate Training; CG – Control Group; BMD – Bone Mineral Density; OPAQ – Osteoporosis Assessment Questionnaire. Bold numbers indicate p<0.05. (*) – No exercise frequency for CG.

Statistical analysis

The software PASW® 20.0 was used and the significance level of $p \leq 0.05$ was adopted for the statistical analysis. Descriptive analysis was carried out with measures of central tendencies and dispersion. A *Shapiro-Wilk* and *Levene's* tests were performed to confirm proximity with a normal distribution and homoscedastic variance. One-Way *ANOVA* and *Kruskal Wallis* tests in the baseline analysis were used. The *ANOVA* with repeated measures was carried out in factors groups and time (pre- and post-test) for analysis intra and inter-groups, and the *Bonferroni post-hoc* test was performed for multiple differences of variables between groups. In addition, the effect size was present for all variables. *Kruskal Wallis* tests were carried for QoL analysis with *Dunn post hoc* test for multiple differences between groups. The equation Δ% [(Posttest_test) · 100/test] was used to determine the percentage difference.

Results

In baseline, there were no statistical differences in age, age at menopause and for *T score* related variables, BMD, FA, strength and QoL (Table 1). However, height, and frequency of weekly session showed differences ($p<0.05$).

The effect size of the experiment presented to L_2-L_4 = 99%, neck and total femur = 93%; besides, trochanter and total BMD = 99% showed strengthening the magnitude of results achieved in this analysis. The results show that AJT presented intra-group improvements ($p<0.05$) for bone variables, as follows: L_2-L_4 (Δ% = 0.073%; p=0.01); neck femur (Δ% = 0.083%; p=0.03), total femur (Δ% = 0.084%; p = 0.031), total BMD (Δ% = 0.086%, p<0.01). And again, the AJT showed better results ($p<0.05$) compared to CG for BMD variables: L_2-L_4 (Δ% = 0.076%, p=0.01); Neck femur (Δ% = 0.077%, p=0.007); total femur (Δ% = 0.074%, p=0.01), total BMD (Δ% = 0.082%, p=0.001). In addition, the AJT was statistically better compared with AKT in L_2-L_4 (Δ% = 0.039%, p=0.038) and total BMD (Δ% = 0.05%, p=0.01). And, the AKT and CG remained with not statistically increase (stable) BMD (Figure 2).

The effect size of the experiment presented to FA tests: RVDP = 95%, 10MW = 92%, and all of

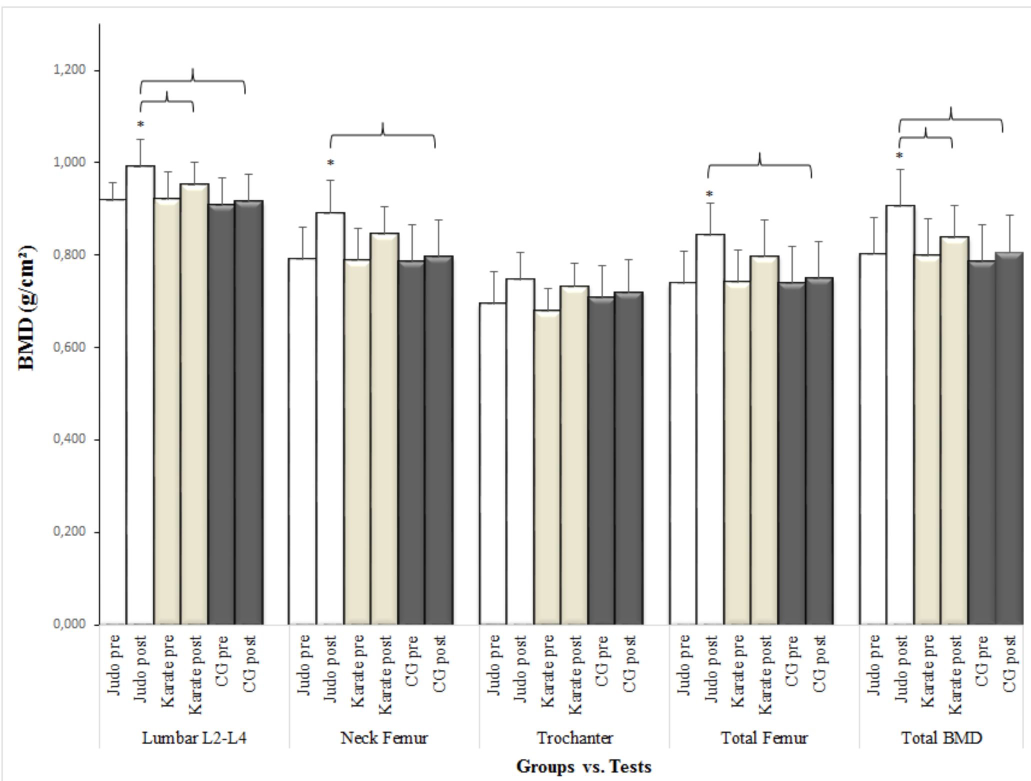

Figure 2. Present the pre and post-tests for BMD variables. The "tests" indicate pre and post evaluations. The symbol (*) indicate intra-groups differences (p<0.05) and the symbol () indicate inter-groups differences (p<0.05).

other tests: PRTS, RSP, RCWH, AI presented 99%, showed strengthening the magnitude of the analysis. The results show that AJT and AKT presented intra-group improvements ($p<0.05$) for FA tests-variables, as follows: RVDP (AJT Δ% = 1.13%; p=0.038), PRTS (AJT Δ% = 3.7%; p<0.001 and AKT Δ% = 3.5%; p<0.001), 10mw (AJT Δ% = 1.15%; p=0.036), RSP (AJT Δ% = 1.16%, p=0.032 and AKT Δ% = 1.5%, p=0.001), RCWH (AJT Δ% = 10.5%; p<0.001), AI (AJT Δ% = 6.2%; p<0.001 and AKT Δ% = 4.5%; p<0.001). Besides, AJT and AKT showed better results ($p<0.05$) compared to CG for FA tests-variables: RVDP (AJT Δ% = 1.13%; p=0.046), PRTS (AJT Δ% = 3.5%; p<0.001 and AKT Δ% = 3.3%; p<0.001), 10mw (AJT Δ% = 1.2%; p=0.035), RSP (AJT Δ% = 1.2%, p=0.026 and AKT Δ% = 1.5%, p=0.001), RCWH (AJT Δ% = 10.1%; p<0.001 and AKT Δ% = 5.7%; p=0.017), AI (AJT Δ% = 5.9%; p<0.001 and AKT Δ% = 4.7%; p<0.001). In addition, the AJT not statistically better results compared with AKT and CG remained with not statistically results (stable) FA tests (Figure 3).

The effect size of the experiment presented to leg press 45° and knee extension = 99% showed strengthening the magnitude of this analysis. Figure 4 shows the results for strength and also showed that both experimental groups were effective ($p<0.001$, intra-groups) for Leg Press 45°: AJT (Δ% = 63.8%) and AKT (Δ% = 52.5%). In addition, both experimental groups ($p<0.001$, inter-groups): AJT (Δ% = 63.7%) and AKT (Δ% = 53.7%) showed better results compared with CG (Figure 4).

The results for knee extension and again both experimental groups were effective ($p<0.001$, intra-groups): AJT (Δ% = 13.1%) and AKT (Δ% = 11.8%). Also, effective (p<0,001, inter-groups) the AJT (Δ% = 15.3%) and AKT (Δ% = 14.5%) were also better compared to the CG (Figure 4).

The results listed below are of OPAQ protocol showed statistical differences (H = 222.8, p=0.0005) presented in Table 2.

For total score OPAQ experimental groups showed improvement ($p<0.05$) intra-groups: AJT (Δ% = 55.06%, p<0.001) and AKT (Δ% = 32.5%, p=0.025). The AJT also showed better results (Δ% = 40.8%, p=0.005) compared to AKT. Moreover, experimental group AJT (Δ% = 35.4%, p=0.013) presented better results compared with CG. In the overall health, the intra-group result to the AJT (Δ% = 4.6%, p<0.001); also showed that AJT presented better results (Δ% = 4.2%) compared with AKT, in addition, the AJT showed better improvements (Δ% = 3.6%) compared with CG (Table 2). The AJT showed intra-group improvements for the mobility (Δ% = 2.6%, p=0.047). The AJT also presented better results (Δ% = 3.8%,

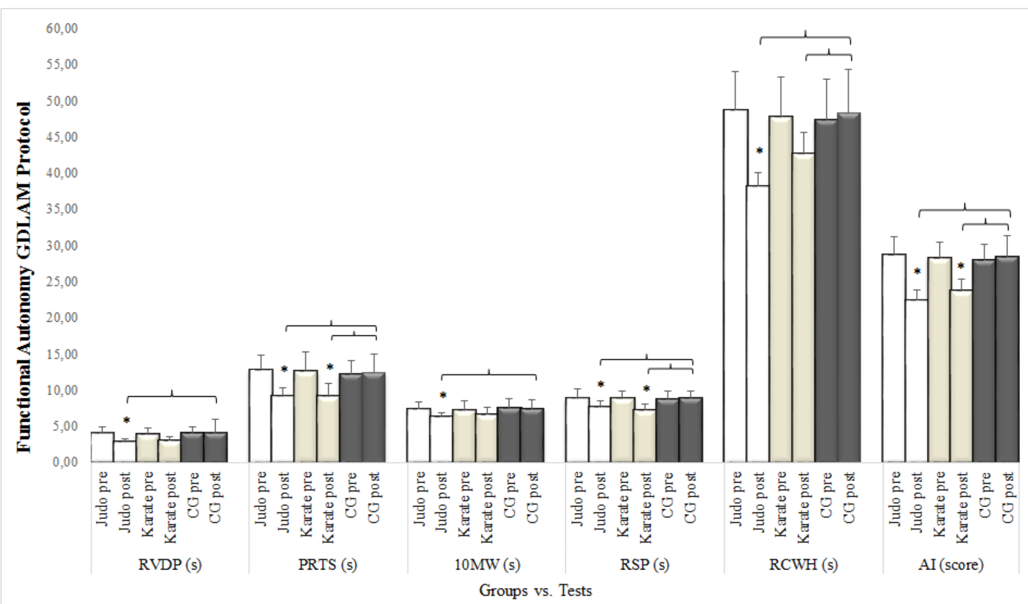

Figure 3. Present the pre and post-tests for FA tests and GDLAM (AI). The "tests" indicate pre and post evaluations. The symbol (*) indicate intra-groups differences ($p<0.05$) and the symbol () indicate inter-groups differences ($p<0.05$).

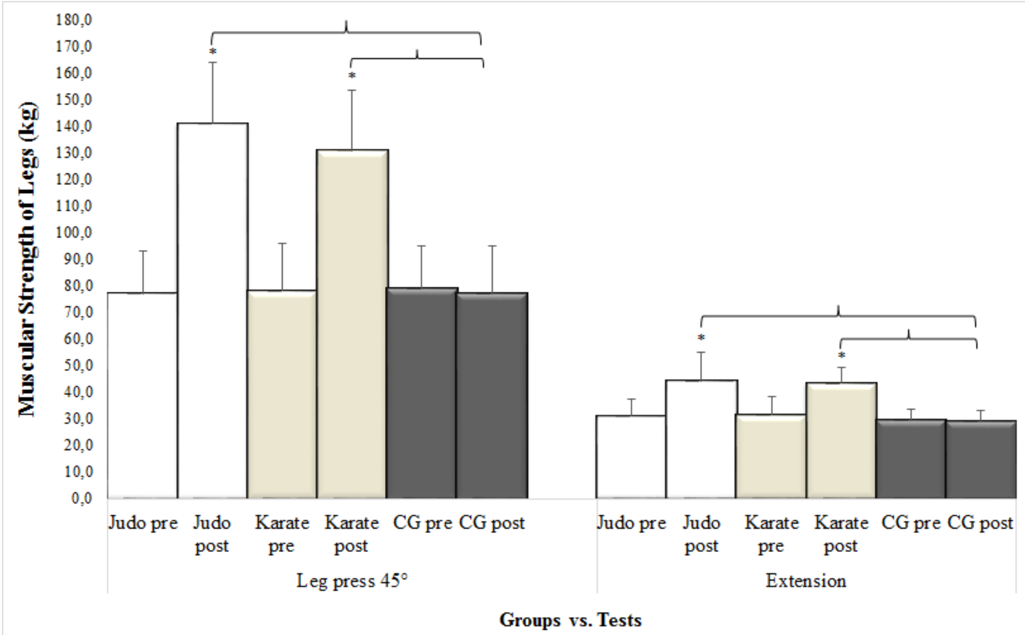

Figure 4. Present the pre and post-tests for muscular strength. The "tests" indicate pre and post evaluations. The symbol (*) indicate intra-groups differences (p<0.001) and the symbol () indicate inter-groups differences (p<0.001).

p=0.005) compared with AKT (Δ% = 4.6%, p=0.001) and compared to CG for walk and lean. In back pain, the AJT showed intra-group improvements (Δ% = 5.5%, p=0.001), and AJT also presented better results (Δ% = 5.8%, p=0.001) compared with AKT and (Δ% = 4.9%, p=0.002) compared to CG. Both groups AJT and AKJ showed improvements intra-groups, respectively, for: sleep (Δ% = 2.7%, p=0.031) and (Δ% = 3.7%, p=0.004); fatigue (Δ% = 3.4%, p=0.002) and (Δ% = 3.1%, p=0.008); work (Δ% = 2.7%, p=0.015) and (Δ% = 2.5%, p=0.025); tension level (Δ% = 3.2%, p=0.024) and (Δ% = 4.8%, p=0.001) (Table 2).

The flexibility, osteoporosis pain, fear of falls and social activity variables presented inter-groups results. In these cases, AJT were better (p<0.05) than AKT and/or CG. However, AKT also were better (p<0.05) than CG in flexibility and locomotion (Table 2). In addition, the AJT showed improvements (p<0.05) intra-group for fear of falls, osteoporosis pain and independence (Table 2). Moreover, the AKT showed improvements intra-group (p<0.05) for body image (Table 2).

Discussion

The literature has shown that PA can have a potential role in aiding or modifying the effects of osteoporosis [12, 21, 24]. However, adapted combat sports are the activity that, generally, not present studies-results in the scientific community for stimulation of osteogenesis and low BMD related-variables [12-14].

The BMD of bone variables analysed in this study were significantly better (p<0.05) for AJT showed intra and inter-group improvement (p<0.05) compared with CG. The AJT showed improvement (p<0.05) to the, L2-L4, neck femur, total femur and total BMD, except for the trochanter, compared with GC. Additionally, the AJT showed improvement (p<0.05) to the, L_2-L_4 and total BMD compared with AKT (Figure 2). It is noteworthy that all groups had medical recommendation to consume specific medicine to control of low BMD. It is worth noting that there was statistically significant difference (p<0.05) in the frequency of training (Table 1) that can have influenced the best results for BMD favourable to AJT.

Borba-Pinheiro et al. [12] are consistent with of results of the present study; because significant differences (p<0.05) were found for BMD in the lumbar spine in favour of the AJT compared with water aerobics and control group. In another two-year study, researchers found significant improvements (p<0.05) in lumbar L_2-L_4 of the AJT after the first year, but in the second year, there were

Table 2. Results for QoL variables of the studied groups.

Variables	Groups						
	AJT n=17		AKT n=17		CG n=16		
	Pre	Post	Pre	Post	Pre	Post	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	ES
Overall Health (points)	18.8±3.8	23.5±3.5*	17.8±3.6	19.7±2.4ǂ	19.7±4.05	19.8±4.1ǂ†	0.97
Mobility (points)	19.8±4.6	22.5±2.8*	19.4±3.3	20.2±2.8	19.06±3.5	20.4±4.8	0.57
Walk and Lean (points)	18.5±5.03	21.1±3.5	16.06±3.4	17.2±3.3ǂ	16.1±3.6	16.4±4.1ǂ	0.95
Back Pain (points)	15.0±6.3	20.5±3.5*	13.7±4.3	14.7±4.5ǂ	15.7±2.4	15.5±4.1ǂ	0.97
Flexibility (points)	15.5±5.1	18.0±2.4	13.7±5.1	14.1±4.6ǂ	17.7±2.4	17.2±2.4†	0.92
Personal Health Care (points)	18.6±2.3	19.6±1.2	17.8±2.3	18.5±2.0	19.4±0.9	19.6±0.6	0.80
House Chores (points)	16.5±4.1	18.2±2.1	17.06±2.4	17.8±2.3	18.5±1.8	18.3±2.06	0.54
Locomotion (points)	16.0±3.3	17.7±2.1	16.2±3.3	16.4±3.5	19.4±1.09	19±1.2†	0.98
Fear of Falls (points)	11.7±5.2	17.7±3.2*	10.9±4.7	13.0±5.5ǂ	12.7±5.5	11.8±5.2ǂ	0.94
Social Activity (points)	18.06±3.3	19.7±2.4	15.9±2.5	16.7±2.6ǂ	16.9±2.8	16.3±2.4ǂ	0.96
Family Support (points)	16.5±2.8	17.2±2.1	15.6±3.2	16.9±3.1	16.6±2.8	16.2±2.9	0.22
Osteoporosis Pain (points)	12.7±6.5	19.1±3.6*	13.3±6.3	13.7±6.1ǂ	17.06±5	17.1±5.2ǂ	0.91
Sleep (points)	12.3±3.3	15.06±2.9*	9.8±3.2	13.6±3.03*	12.7±4.4	12.8±4.3	0.92
Fatigue (points)	11.5±3.5	14.9±2.1*	10.2±4.2	13.3±3.2*	12.9±2.9	13.4±3.1	0.95
Work (points)	13.8±3.9	16.5±2.5*	14.7±3.8	17.3±3.1*	17.5±2.8	17.8±2.5	0.96
Tension Level (points)	14.3±4.2	17.6±2.7*	11.8±4.5	16.7±4.1*	15.8±4.8	15.5±4.4	0.93
Humor (points)	18.8±3.8	20.5±3.2	17.5±3.6	19.4±3.3	18.9±4.7	18.8±4.7	0.39
Body Image (points)	11.3±4.1	13.8±3.9	9.7±3.3	13.5±3.7*	12.1±3.8	12.4±4.1	0.76
Independence (points)	11.7±3.2	13.5±2.1*	12.06±2.7	13.4±1.8	13.2±1.8	12.5±2.06	0.53
Total OPAQ (score)	291.8±56.2	346.8±33.07*	273.5±35.4	306.0±40.2*ǂ	312.3±35.9	311.4±35.7ǂ	0.99

OPAQ – Osteoporosis Assessment Questionnaire; SD – Standard Deviation; ES – Effect Size. The symbol (*) indicate p≤0.05 intra-groups. Symbol (ǂ) indicate p<0.05 inter-groups favorable AJT. And, symbol (†) indicate p<0.05 inter-groups favorable AKT.

no increases in BMD [13]. These results may also be of interest of the scientific community, because there is evidence that children and young athletes of combat sport have high BMD compared to other sports [15-17].

The muscle strength evaluated by leg press 45° and knee extension in this study showed significant increases (p<0.05) in the analysed adapted combat sports groups intra and inter-groups compared with CG.

The exercises of coordination, knee extension, squats, hip adduction, and jumps no have direct action on the lumbar muscles. Though, can have effects piezoelectric effect, as mentioned in [25] for load pushed by the lower limbs that pressed on the lower back, causing dynamic and isometric strength of the lumbar and abdominal muscles. However, training to cushion the falls has a direct impact on lower back. Perhaps this can contribute to improvement in lumbar spine BMD. In addition, the specific techniques of judo training can contribute to improve the other BMD variables.

The leg press 45° and knee extension also improvements for AJT and AJK intra-groups, besides these compared with CG (Figure 4). The scientific literature [24, 26] reinforces the need to develop strength in the elderly because the muscle hypertrophy coincide with significant elevations of attenuated IGF levels, revealing a possible contributory mechanism for sarcopenia control. There is a positive relationship between the increase in muscular strength and BMD [9]. Studies have suggested that periodised exercises programs have a greater possibility for effective strength gains [21, 24].

However, body composition variables were entered as the most significant contributors for BMD and strength. Although, functional fitness parameters are typically considered in clinical assessments of bone health/strength in older people; although, body composition appears to have a higher relevance in the explanation of BMD and strength [27]. In present study, the baseline (Table 1) presented statistics differences for height, however, BMI and body mass showed not statistics differences inter-groups, this is important because can evidence an increase or decrease for care with falls and greater need of intervention by exercise training.

The drug therapy with bisphosphonate is recommended and safe for beneficial effects on bone health in postmenopausal women, especially, when there is an increased risk of fracture in hip and lumbar spine [28, 29]. According to a study of Mukaiyama et al. [30] the combined effect of alendronate with alfacalcidol and eldecalcitol (analogous to vitamin D), showed significant improvement in BMD of the lumbar spine, maintenance the femur neck and showed no improvement in hip BMD after one year of treatment. The present study utilized 70mg sodium alendronate and vitamin D3 5600 IU concomitant in 18 osteoporotic postmenopausal women; and only vitamin D3 in 32 osteopenic postmenopausal women distributed in the groups: AJT, AJK and CG. In the GC not was observed increase BMD ($p<0.05$) in the variables, characterized as a BMD maintenance.

The study of Park et al. [10] observed changes in muscle mass and strength according to changes in BMD after alendronate-calcitriol therapy and also to assessed subsequent changes in common biomarkers for osteoporosis and sarcopenia, showed improvement in lumbar BMD and in handgrip strength observed after 6 months of alendronate-calcitriol combination therapy. Initial serum interleukin-6 levels (IL-6) presented an inverse relationship with pre-treatment lumbar BMD and handgrip strength. The degree of change in IL-6 levels induced by the combination therapy was correlated with the initial degree of the catabolic status of the bone markers, such as parathyroid hormone and the severity of lumbar BMD derangements that are considered a representative parameter for sarcopenia.

Another study with 164 menopausal women compared four groups: Group 1 (G1) subjects treated with 5mg alendronate/day plus jumping exercises with progressive effort; Group 2 (G2) subjects treated only with 5mg 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) [31].

Although the drug was not analysed as an independent variable in this study, it was likely that the drug can have contributed to the increase or maintenance of the BMD, because, there is evidence that a combination of PA with alendronate shows positive effects on BMD [30, 31]. Therefore, together, alendronate and PA can be more efficient in reducing the risk of fracture [1, 12, 30, 31].

Another variable assessed in this study was FA. The functional capacity of physically active older adult women is considered statistically better – regarding autonomy tests and the GDLAM index, when compared to sedentary older adult women's functional capacity [4, 32]. Studies show that PA can increase and maintain functional independence levels in physically active older adults, especially for the performance of activities of daily living [4, 32].

The results of this study for FA in the AJT and AKT groups showed improvement ($p<0.05$). The results reinforce the studies cited above, showing that the planned exercise has the potential to improve FA of older women. The studies also show the need to maintain FA, because the loss of this capacity compromises basic personal care activities, such as brushing teeth, showering, putting on shoes, and dressing up, among others, causing greater dependency to older adults, besides needing care provided by third parties [33].

The results of the present study corroborate those reported in the other studies that used adapted combat sports as judo and karate, because they can be effective in the BMD, strength, FA and QoL [12-14]. According to a recent study, AKT program promoted improvements ($p<0.05$) for functional autonomy, lower limb strength and flexibility of older women [15]. The subjective effort scale, used in present study, were also used in another studies with adapted combat sports and appears to be efficient to control the intensity of effort during training [12-14].

In addition, these results are in agreement with the recommendations of Lang et al. [24] because they claim that exercises programs show significant increases in muscle strength of the lower limbs, contributing to sarcopenia and BMD controls which helps to maintain mobility, decreasing falls and consequently fractures risk in the elderly. It is therefore, suggested that PAs programs for osteoporotic patients follow ACSM guidelines promoting strength development. Nevertheless, they must also meet the needs of flexibility, balance, strength and FA, since these variables contribute to reducing risk factors for falls, enabling the elderly to enjoy an active lifestyle [1, 2, 21, 34].

The results of QoL for this study showed that experimental groups were effective for most variables of the OPAQ protocol. In terms of effects on QoL, Borba-Pinheiro et al. [12] showed that QoL of AJT group presented significant improvement ($p<0.05$) in comparison to the CG, but it did not show improvements in relation to the others experimental groups of postmenopausal women: water exercise and resistance training.

QoL is impaired in women with low BMD, as shown in the study by Romagnoli et al. [35] that compared the QoL of 361 women, either normal or with osteopenia or osteoporosis. 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. In another study, a tai chi program can be effective for improved QoL for women and man in older age [36].

This present study showed that the experimental groups (AJT and AKT) showed intra-results $p<0.05$ for QoL total, besides the AJT showed better results compared to CG. In addition, the AJT presented better results ($p<0.05$) for variables, potentially, associated with low BMD and fracture risk as: fear of falls, back pain, osteoporosis pain compared with AKT and CG (Table 2). The study Borba-Pinheiro et al. [12], also show evidence of the AJT to improve the fear of falls, pain of osteoporosis and back pain compared to water exercise training and CG. Thus, Sikorski and Błach [11] believes that judo training can be an important component for the body protection against falls and fractures, because it involves learning techniques to cushion the falls in all directions. This is evidenced in the researches of Borba-Pinheiro et al. [12], and also evidenced in this study when it is observed that the fear of falls decreases in the volunteers of AJT, which did not occurred with AKJ and CG. According with study of Nowak and Nowak [8] is necessary to promote a change in lifestyle in contemporary society, valuing the exercise to promote health in all age groups and especially in older people. It is worth noting that there was statistically significant difference ($p<0.05$) in the frequency of training (Table 1) that can have influenced the best results for QoL favourable to AJT.

Another variable that is associated with the lifestyle is the socioeconomic level; studies show that people with lower socioeconomic levels increase the risk factors for low BMD, such as Borba-Pinheiro et al. [7] research that showed lower balance, lumbar BMD and alimentary habits of older women with lower socioeconomic level when compared to the best socioeconomic conditions. In this study, all voluntary groups presented classification C1 (18-22.9 points) to low socioeconomic level with family income in the Brazilian currency R$ 1.685.00 equivalent to $ 470.67 in USA currency [20]. However, only the experimental groups show improvement ($p<0.05$) for the QoL. This can be one more reason for that treatment for people with low BMD and related-variables to falls risk have association care regarding pharmacological treatment and change of lifestyle with adequate physical exercise and nutrition [2, 7, 8].

Although, studies show the benefits of exercise for BMD and health-variables of postmenopausal women [1, 12, 21, 34]. The sample size has been a problem reported in the literature for studies involving exercise and skeletal structure, because the potentially beneficial effects for BMD, geometry, bone strength and fractures in human weakened by a small sample size [37, 38]. The difficulty of researchers to maintain a large number of elderly volunteers for a long period can be one of these difficulties. This was observed in the present study. The limitations of this study include the non-use of alendronate, vitamin D^+ and nutritional dietary as independent variables, besides. Therefore, additional studies are recommended.

Conclusions

The study showed that both experimental groups presented favourable results for strength, FA and QoL compared with CG. However, the AJT showed the best results for BMD compared to AKJ and CG after 13 months of intervention. Therefore combat sport based on throws and grips of immobilisation of opponent's body (judo, sambo, wrestling etc.) they are likely to be optimal in achieving training effects measured in this work. Particularly that certain differences of training effects were referenced to hand-grip strength between athletes specializing in throws and grips of immobilisation of opponent's body (Greco-Roman and free style wrestling, judo, sambo) and specializing in martial arts basic on hits/strokes (hand-to-hand combat, karate, taekwondo) [39]. It is necessary an accurate documentation of training load [40], including use of training (specific exercises in the training session, the microcycle and over longer periods). It is not about the accuracy with which these measures should be monitored from the perspective of expected effects of sports [41-44], but about long-term, preventive health effect [11, 36, 45].

Highlights

- Increase of information about adapted combat sports on multiple-variables that decrease falls-risk is of interest to researchers who study aging.

- Adapted combat sports associated with drug therapy can be suggested that more effective to increase BMD, than only the drug therapy.

- Effects of adapted combat sports on multiple-variables of falls-risk increased the independence and quality-of-life in older women with low BMD.

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