TAI CHI CHUAN IMPROVES FUNCTIONALITY AND QUALITY OF LIFE IN ELDERLY MEN WITH LOW BONE MINERAL DENSITY

Tai Chi Chuan melhora funcionalidade e qualidade de vida em homens idosos com baixa densidade mineral óssea

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ABSTRACT

OBJECTIVE: The purpose was to assess the effect of *Tai Chi Chuan* (TCC) on functional capacity (FC) and quality of life (QoL) in elderly men with low bone mineral density (BMD). **METHODS**: This quasi-experimental, controlled blinded trial evaluated 41 senior men (≥ 60 years), divided into two groups: control group 1 – G1 (TCC; n = 20; 69.2 ± 6.2 years) and control group 2 – G2 (control; n = 21; 69.0 ± 5.7 years). The BMD (of lumbar spine and femur neck) was assessed by dual energy x-ray absorptiometry (DEXA). FC was assessed for aerobic endurance, for upper and lower limbs strength and flexibility, for static, dynamic and functional balance testes, and for risk of falls. QoL was assessed by the SF-36 questionnaire (MOS 36-item Short-Form Health Survey). G1 practiced the 24-form Yang style of TCC, for 12 weeks twice a week on low intensity; G2 did not practice oriented physical activity. **RESULTS**: TCC practitioners had significantly higher scores for aerobic endurance, upper and lower limbs strength, and dynamic balance. In terms of QoL, values were significantly better in total score and aspects such as FC, general health, vitality, and mental health. **DISCUSSION**: TCC was proven beneficial to FC and QoL scores, which adds evidence for its practice by elderly men with low BMD. **CONCLUSION**: TCC training is effective in improving FC and QoL in elderly men with low BMD.
KEYWORDS: tai chi chuan; aged; osteoporosis; quality of life.

RESUMO

OBJETIVO: Avaliar efeitos do *Tai Chi Chuan* (TCC) na capacidade funcional (CF) e na qualidade de vida (QV) de homens idosos com baixa densidade mineral óssea (DMO). **MÉTODO**: Estudo quasi-experimental, controlado, cego, com 41 idosos (≥ 60 anos) divididos em dois grupos: grupo experimental – G1 (TCC; n = 20; 69,2 ± 6,2 anos) e grupo controle – G2 (controle; n = 21; 69,0 ± 5,7 anos). A DMO (coluna lombar e colo do fêmur) foi avaliada com raios-x de dupla energia (DEXA). Para aferir CF foram utilizados: testes de resistência aeróbia (RA); de força e flexibilidade de membros superiores e inferiores; de equilíbrio em condições estática, dinâmica e funcional; e de alcance funcional, assim como para risco de quedas. A QV foi pesquisada pelo questionário SF-36 (*MOS 36 Item Short-Form Health Survey)*. O G1 praticou TCC estilo Yang, com 24 movimentos por 12 semanas, 2 vezes por semana, em intensidade leve; o G2 não praticou atividade física orientada. **RESULTADOS**: Praticantes de TCC apresentaram valores significativamente maiores em resistência aeróbia, em força de membros superiores e inferiores, e para equilíbrio dinâmico. Ao aferir a QV, surgiu significância para escore total, assim como para as dimensões de capacidade funcional, estado geral de saúde, vitalidade e saúde mental. **DISCUSSÃO**: Constataram-se efeitos benéficos do TCC em CF e QV, o que agrega evidências à sua utilização em homens idosos com baixa DMO. **CONCLUSÃO**: O TCC é eficaz na melhora da CF e da QV em homens idosos com baixa DMO.
PALAVRAS-CHAVE: tai chi chuan; idoso; osteoporose; qualidade de vida.

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INTRODUCTION

Osteoporosis is a skeletal systemic disease characterized by low bone mineral density (BMD) and impaired bone strength, leading to bone fragility and consequent increased risk of fractures. In Brazil, the disease was self-reported by 5.1% of elderly men.[1] A study conducted with 151 men in the city of Rio de Janeiro showed a progressive incidence of osteoporosis as age increased: in individuals aged 60-69 years, the prevalence was 16.2%; in those aged 70-79 years, 34.2%; and in those aged 80 years and older, 48.6%.[2]

Although osteoporosis is more commonly described in women, epidemiological data suggest that the risk of fracture, especially spinal-related, is higher among men, with mortality being higher than in women under the same conditions.[3] As a consequence of fractures and their sequelae, individuals lose functional capacity (FC). Due to vertebral fractures, many present with increased thoracic kyphosis and changes in balance. Elderly men with osteoporosis also have shortened stride length, lower flexibility on the hips and lower limbs, and slower walking speed.[4]

Resistance exercises are recommended for osteoporosis patients, as they improve muscle strength, flexibility, and coordination, besides promoting BMD elevation and decreasing risk of falls.[5] However, public health programs that use this type of activity have limitations when it comes to its insertion in large populations, as they usually require individualized care, physical space, and specific equipment. Thus, exercises with overload are complementary to drug treatment, while balance and coordination ones are essential for they promote independence in the prevention of falls and traumatic fractures.

Given this context, Tai Chi Chuan (TCC) is appropriate for elderly subjects: it can be prescribed in varying intensities — light to intense —, does not require specific equipment, and is beneficial to health due to its non-stressing and non-competitive character. Some of this activity's advantage are low cost, easy applicability, and possibility of practice in large groups, being flexible as to proper place, time, and clothing. TCC is a physical activity that meets the recommendations of the American College of Sports Medicine to increase FC, as it mainly affects balance and helps to reduce falls,[6] besides improving aerobic capacity, muscle strength and balance.[7]

There is evidence that regular practice of TCC promotes QoL, including emotional well-being (particularly impacting mood, stress, anxiety, depression, and tension from anger), self-perception (self-efficacy and fear of falling), and physical well-being (chronic pain and sleep disorders).[8,9]

In public health programs in Brazil, there is no agreement on which exercises are more appropriate for subjects with low BMD and which can be widely used by the community. Thus, the objective of this study was to verify the effects of a TCC program on FC and QoL of elderly men with low BMD living in a community.

METHODS

Subjects and intervention

A quasi-experimental study, with controlled and blinded design, was carried out in a convenience sample composed of elderly men (age ≥ 60) enrolled in the Program of Osteoporosis Prevention and Diagnosis of the Federal District Health Secretariat. The subjects were cared for in a public health unit by the same team of health professionals. The study was approved by the Research Ethics Committee of *Universidade de Brasília* (UnB), protocol 145/2008.

In addition to gender and age group, inclusion criteria were:

- low BMD (T-score ≤ 1), with clinical and densitometric diagnosis of osteopenia or osteoporosis;
- not being a regular practitioner of oriented physical activity in the last three months;
- clinical indication for physical exercise; and
- having signed the informed consent form.

Exclusion criteria were: diseases or limitations that could incapacitate FC tests (tendinitis, tenosynovitis, symptomatic osteoarthritis, painful syndromes such as fibromyalgia and low back pain, neurological syndromes such as labyrinthitis and migraine), cognitive deficits — assessed with Folstein's Mini-mental state examination — that could prevent the understanding of safety instructions before motor tests; diabetes mellitus, and other endocrinopathies.

Of 297 elderly men enrolled in the Program at this Health Unit, 78 accepted to participate in the study, and, among these, 41 met the inclusion criteria. Among the 37 subjects excluded, 21 had normal BMD, and the remaining 16 with low BMD had comorbidities such as osteoarthritis, low back pain, hyperthyroidism, and diabetes.

The sample was divided, for convenience, in an experimental group (G1), in which subjects practiced TCC, and control group (G2), with no physical activity in the same period. Both groups maintained their daily life activities (DLAs) unchanged during the study. Evaluations were

performed at two moments (T1 = pre-test and T2 = post-test) for dependent variables FC and QoL.

Tests were applied by the first author of the research, along with properly trained physical therapists and under supervision. None of the evaluators were aware of the group in which each patient was included.

TCC sessions took place in the morning, in a leveled and sun-protected open space, with an experienced physical-education professional. The exercises were designed based on the 24-form Yang style adapted for the elderly, bearing in mind patients' safety. Sessions were composed of exercises with low degree of difficulty, short choreographies, and few changes in direction. Exercise intensity was mild, with subjective perception of effort (SPE) equal to 2 to 3 on the Borg Rating of Perceived Exertion scale (RPE). The program lasted 12 weeks, with 50-minute sessions twice a week. The practices complied with the three pillars of physical education: warm-up, training, and relaxation.

Warm-up (15 minutes) was made with educational exercises, selected from the 24 training movements of TCC, with emphasis to muscle stretching and breathing. Specific training (20 minutes) consisted of typical TCC choreographies, with their slowness, fluidity, and mental-concentration character maintained. Choreographies had eight movements from the series of 24 movements, including paired ones (Tai Chi Tuishou) from the standard 24-form series. In relaxation (15 minutes), psychic and muscular relaxation were pursued through dynamic meditation exercises (Tao Yin) from the TCC training series and in sitting position (sit on the calm), aiming to promote muscle relaxation, recover natural breathing rhythm, and develop mental concentration.

Body mass index

The body mass (kg) was measured in a digital scale with resolution of 0.01 kg and maximum load of 150 kg (Toledo, SP, Brazil). For height (m), a stadiometer with resolution of 1 mm and maximum height of 2 m was used (Cardiomed, PR, Brazil). The body mass index (BMI) was then calculated.

Bone mineral densitometry

Measured at the segments L2-L4 of the lumbar spine and femoral neck by dual-energy x-ray absorptiometry (DEXA) in Lunar model DPX-NT (GE Healthcare, UK). The technique was performed by a trained and experienced evaluator and according to the manufacturer's standards, including quality control and daily equipment calibration rules. The values of bone mineral densitometry collected were expressed in absolute values (g/cm^2) and T-scores compared to the healthy young population. Men who presented T-score >-1 were considered normal in both regions evaluated; and as patients with T-score ≤ -1 in at least one of the regions evaluated were considered to have low BMD (osteopenia or osteoporosis).[10]

Functional capacity

The Fullerton (Functional Fitness Test) batch, developed by Rikli & Jones,[11] was used for the evaluation of FC and consisted of the following tests:

1. 2-minute walk test (TME2') for aerobic endurance (AE);
2. 30-Second Chair Stand (sit and stand up from a chair in 30 seconds) for lower limb strength (LLS);
3. Back Scratch testing for upper limb flexibility (ULF);
4. Chair Sit-and-Reach test for lower limb flexibility (LLF); and
5. 8-Foot Timed-Up-and-Go (8F-TUG) test for dynamic balance.

The six-minute walk test was replaced by TME2', because both allow to evaluate AE in the same way, and because it is the second fastest and which does not require ample physical space for its accomplishment.

Upper limb strength (ULS) was measured by isometric manual grip (kg.f) on a Jamar dynamometer (Asimow Engineering Co., CA, USA), with capacity for 90 kg.f and resolution of 1 kg.f.

Static balance was also evaluated by the unipodal support with visual restraint test (UNIPODAL); anterior postural control by the functional range test (FRT); body balance (both dynamic and static) by the Berg balance scale (BSE) adapted for Brazilian elderly people; and falls possibility index (FPI) was calculated from BSE scores combined with information about history of falls since patients turned 60 years.

Quality of life

QoL was evaluated with the 36-item short-form Health Survey (SF-36), which was translated into Brazilian Portuguese and validated for Brazil.

Statistical analysis

Data were described as mean ($\overline{X}$) and standard deviation (SD) for analysis. The hypothesis that before intervention the distribution of osteopenia and osteoporosis diagnoses would be different between G1 and G2 was tested by the χ^2 test. Shapiro-Wilk and Levene tests were used to evaluate normality

and homoscedasticity, respectively. When the variables did not present normal distributions and homoscedasticity, Student's t-test for independent measurements and Mann-Whitney test for continuous and categorical variables were used to compare groups. Inferential statistical analyses were made to verify inter- and intragroup effects. To compare parametric data, we used the analysis of variance (ANOVA Split-plot) with least-difference difference (LSD) post-hoc tests, and, to compare non-parametric data, χ^2, Mann-Whitney, and Wilcoxon with Bonferroni correction were applied. The level of significance was set at $p \leq 0.05$. Statistical procedures were input in the program SPSS (Statistical Package for the Social Sciences) for Windows 18.0 (IBM, New York, USA).

RESULTS

There were no losses to sample in the study period. The 41 elderly men with low BMD selected were distributed into G1 and G2, with 20 and 21 individuals, respectively. Descriptive measures by age, anthropometry, and densitometry are shown in Table 1.

G1 and G2 had similar distributions ($p > 0.05$) as to mean and frequency for most measures (gender, age, BMD, body balance, aerobic endurance, cognitive ability, schooling, and marital status). No significant differences were found between variables at the beginning of the experiment, so the hypothesis that, before intervention, the distribution of osteopenia and osteoporosis diagnoses would be different between groups ($\chi^2 = 1.18$; $p = 0.35$) was ruled out. Although participants in G1 and G2 were distributed for convenience, in a non-random manner, they were similar as to descriptive variables collected at the beginning of the study, which ensured that the number of individuals with both diagnoses in each group was similar.

Effects of *Tai Chi Chuan* on functional capacity

The results of inter- and intragroup comparisons of means obtained for FC after the training are shown in Table 2.

The practice of TCC was shown to promote significant improvement ($p = 0.02$) in FC assessed upon aerobic endurance test ($S[1\text{-}39] = 6.08$, $p = 0.02$), as well as in LLS ($S[1\text{-}39] = 9.49$, $p = 0.01$) and in ULS ($S[1\text{-}39] = 4.34$, $p = 0.04$). At the end of the training, TCC practitioners had significantly better performance when it came to lower limbs, both in inter- ($p = 0.03$) and intragroup ($p = 0.01$) comparison. As to flexibility, TCC did not promote changes in ULF and LLF in G1 compared to G2.

In balance comparisons, TCC promoted significant changes only in dynamic balance, measured by 8F-TUG ($S[1\text{-}39] = 10.82$, $p = 0.01$). Upon Berg equilibrium test, no significant differences were found. At the end of TCC training, significant reduction in average time for test performance was seen both in inter- ($p = 0.02$) and intragroup ($p = 0.001$) comparisons.

In both times measured, no significant differences were seen between groups as to static balance (UNIPODAL), FRT, BSE and FPI.

Effects of TCC on QoL

No significant differences were found between SF-36 scores and median values of both groups at the beginning of the experiment. The results of inter- and intragroup comparisons as to medians in total QoL and domains are presented in Table 3.

TCC practice promoted significant changes in total QoL score ($z = -2.11$, $p = 0.04$). As for the eight domains included in the test, those related to FC ($z = -2.51$, $p = 0.01$), general health status ($z = -2.42$, $p = 0.02$), vitality ($z = -2.38$, $p = 0.02$), and mental health ($z = -2.34$, $p = 0.02$) showed significant changes after the sessions.

No significant difference between groups were seen when pain, physical, social, and emotional aspects were compared.

Table 1 Characterization of the 41 elderly men with low bone mineral density in experimental and control groups.

Variables	Groups	$\bar{X} \pm SD$	p-value
Age (Years)	G1	69.2 ± 6.2	0.91
	G2	69.0 ± 5.7	
Anthropometry			
Mass (kg)	G1	67.7 ± 9.4	0.67
	G2	69.6 ± 11.4	
Stature (cm)	G1	166.0 ± 6.0	0.42
	G2	168.0 ± 5.0	
BMI (kg/m²)	G1	24.5 ± 3.1	0.63
	G2	24.6 ± 3.8	
Densitometry			
femur BMD (g/cm²)	G1	0.84 ± 0.08	0.99
	G2	0.85 ± 0.11	
T-score femur	G1	-1.79 ± 0.65	0.92
	G2	-1.68 ± 0.89	
Lumbar BMD (g/cm²)	G1	0.94 ± 0.08	0.46
	G2	0.96 ± 0.15	
T-score lumbar	G1	-2.29 ± 0.71	0.40
	G2	-2.20 ± 1.26	

$\bar{X}$: mean; SD: standard deviation; *p*: significance in comparison between groups; G1: experimental group; G2: control group; BMI: body mass index; BMD: bone mineral density.

DISCUSSION

Functional capacity

The evaluation of TCC effects on representative variables of FC confirmed previous findings of benefits on different parameters of FC.[12] In our research, the improvement seen in FC (AE, LLS, ULS, and dynamic balance) adds evidence in favor of TCC as a means of physical conditioning and functionality for the elderly, with increased benefits to men with low BMD.

Five different tests were used in this study to assess balance, similarly to the study by Voukelatos et al.[13], who applied a batch of six tests aiming at different aspects of this variable. The authors found significant benefits of TCC (Sun style, one hour per week) on practitioners' performance in all tests — except for FRT — and reducing falls. We only found improvement on dynamic balance upon 8F-TUG test, with no reduction in the risk of falls. Thus, both studies agree on the benefit of TCC on balance to some degree, but differ as to the extent of such effects. A possible explanation for these conflicting findings could be the TCC style in interventions. In addition, the authors mentioned a heterogeneous sample as to gender (85% females).

Li et al.[14] assessed static/dynamic balance, and flexibility in the elderly after sessions of the same style of TCC used

Table 2 Functional capacity in 41 elderly men with low bone mineral density.

Tests	Groups	Pre-sessions ($\bar{X} \pm SD$)	Post-sessions ($\bar{X} \pm SD$)	p-value
Aerobic endurance				
AE (steps)	G1	93.3 ± 11.8	101.7 ± 20.8*	0.02
	G2	92.5 ± 10.4	88.7 ± 12.8	
Muscle strength				
LLS (lifting)	G1	15.5 ± 1.3	18.3 ± 4.7*	0.01
	G2	14.7 ± 3.2	15.3 ± 3.0	
ULS (kg.f)	G1	36.5 ± 6.4	39.0 ± 11.3*	0.04
	G2	33.2 ± 7.8	32.4 ± 6.6	
Flexibility				
LLF (cm)	G1	16.2 ± 9.4	17.8 ± 7.5	0.25
	G2	18.9 ± 11.0	21.8 ± 10.2	
ULF (cm)	G1	-11.3 ± 7.9	-11.5 ± 8.1	0.44
	G2	-13.0 ± 9.8	-14.6 ± 10.8	
Balance				
UNIPODAL (s)	G1	3.0 ± 0.9	3.0 ± 1.5	0.27
	G2	2.7 ± 1.4	3.2 ± 1.6	
8F-TUG (s)	G1	5.9 ± 0.9	4.8 ± 0.5*	0.01
	G2	6.1 ± 1.2	5.4 ± 1.2	
FRT (cm)	G1	35.4 ± 7.4	34.6 ± 9.1	0.87
	G2	36.5 ± 6.6	35.1 ± 6.2	
BSE (score)	G1	54.1 ± 4.0	55.3 ± 0.9	0.32
	G2	53.0 ± 5.8	54.4 ± 2.3	
FPI (%)	G1	9.5 ± 23.1	2.7 ± 4.6	0.20
	G2	17.9 ± 34.2	9.5 ± 21.1	

$\bar{X}$: mean; SD: standard deviation; *p*: significance ($p \leq 0.05$); G1: experimental group; G2: control group; AE: aerobic endurance (two-minute stationary gait test);
LLS: lower limb strength (sit and stand up from a chair); ULS: upper limb strength (manual grip); LLF: lower limb flexibility (sit and reach); ULF: upper limb flexibility (reach the back); UNIPODAL: unipodal support with visual restraint test; 8F-TUG: Eight-Foot Timed-Up-and-Go (sit, walk, go back, and sit again); FRT: functional range test; BSE: Berg balance scale; FPI: falls possibility index; *significant difference in post-hoc tests.

Table 3 Quality-of-life measures in 41 elderly men with low bone mineral density.

QoL domains	Groups	Pre-sessions ($\bar{X} \pm SD$)	Post-sessions ($\bar{x} \pm SD$)	p-value
QoL1 Functional capacity	G1	79.2 ± 17.3	90.8 ± 10.6*	0.01
	G2	80.2 ± 19.8	72.4 ± 26.4	
QoL 2 Physical aspect	G1	95.0 ± 13.1	86.2 ± 26.2	0.52
	G2	86.9 ± 18.7	79.8 ± 30.2	
QoL 3 Pain	G1	62.6 ± 23.3	71.8 ± 25.6	0.13
	G2	72.4 ± 29.2	60.2 ± 25.4	
QoL 4 Overall health status	G1	78.3 ± 15.9	88.2 ± 15.1*	0.02
	G2	82.0 ± 10.0	77.2 ± 17.8	
QoL 5 Vitality	G1	76.5 ± 17.2	84.8 ± 19.8*	0.02
	G2	76.4 ± 15.9	73.6 ± 22.2	
QoL 6 Social aspects	G1	84.4 ± 22.8	91.4 ± 15.7	0.29
	G2	88.1 ± 21.4	81.1 ± 27.7	
QoL7 Emotional aspect	G1	98.4 ± 7.2	96.7 ± 10.2	0.33
	G2	87.3 ± 24.8	84.1 ± 34.4	
QoL8 Mental health	G1	82.4 ± 15.6	89.8 ± 11.1*	0.02
	G2	86.5 ± 12.2	76.6 ± 20.6	
QoL Total score	G1	82.1 ± 10.7	87.4 ± 12.1*	0.04
	G2	82.5 ± 13.8	75.6 ± 20.4	

QoL: quality of life; $\bar{X}$: mean; SD: standard deviation; *p*: significance ($p \leq 0.05$); G1: experimental group; G2: control group; *significant difference.

in our research (24-form Yang style), but with a slightly different protocol (lower weekly frequency for one year). These authors did not find significant improvements for the variables assessed in the TCC group. However, Yang et al.[15] used a longer and more complex sequence (Yang style) for half the intervention time (six months) and noted improved balance. This suggests that the effects of TCC on balance may be more related to complexity of choreography and weekly frequency than to the total period of intervention.

In this study, no significant differences were found between groups as to flexibility, static balance, functional range, and risk of falls, although there was a tendency of G1 to present higher values compared to G2 for these variables. Even authors who found no evidence of TCC efficacy on postural stability,[16] balance, AE, and strength,[17] recognize that the incidence of falls and fear of falling is reduced in elderly practitioners of this modality.

Although Logghe et al.[18] argue that the improvement in FC with the practice of TCC only applies to institutionalized frail elderly, our findings are not compatible with this statement. Our sample consisted of elderly individuals living in the community, with high level of independence to perform DLT. A possible explanation for this controversy is suggested by Li et al.,[19] who affirm that the quality of the publications about TCC practice by the elderly should be more rigorous, for there are few studies with design and methodology that allow generalization and replication of results. In this sense, our research applied methodological rigor in all steps of the intervention, thus allowing reproduction. In order to reduce selection bias, individuals who presented baseline measures for age, anthropometry, BMD, FC, and QoL whose similarity allowed statistical comparison between groups (experimental and control) were selected. A common feature in TCC studies conducted with the elderly is the use of heterogeneous groups. Hence, this work adds value to the literature by experimentally controlling these parameters.

Improvement in AE is a finding that requires further research on TCC dose-response in individuals with low BMD, since the intensity of exercises prescribed in our study was not within the range of aerobic training for the elderly in general, being shown just enough to increase AE of men with low BMD.

The same trained evaluator for the application of motor tests was able, in our study, to decrease the possibility of calibration bias. However, it is possible that the results of physical performance measures have been influenced by motivational factors.

Quality of life

The literature brings evidence of the beneficial effects of TCC on QoL.[9,20,21] The present study reports significantly higher total QoL score among TCC practitioners compared to G2. A review by Jahnke et al.[20] reported that most studies establish TCC as having a great potential to increase QoL, both in healthy or chronically ill elderly people.

Those who stand for the effects of TCC on QoL, in turn, have varying opinions about the extent of such effects. Reports indicate that TCC improves all dimensions of QoL,[21] but, for some researchers, elderly practitioners of TCC show improvement mainly in physical capacity and health domains of QoL compared to G2,[22] while others report that this practice is able to increase gains in domains such as vitality, physical and social aspects.[23] Vitality, an aspect framed in physical well-being, is related to balance. Improvement in physical well-being may also be related to improvements in nighttime sleep disorders and reduction in daytime sleepiness, that is, a nonpharmacological solution for sleep disorders in the elderly.[24] Another possible mechanism of this benefit relates to the effects of physical activity on cerebrovascular function.

There are several possible causes for positive effects of TCC on QoL. Physically active elderly people often report better QoL than sedentary individuals.[25] In our study, we could not ascertain whether the men studied were sedentary when the intervention first started. Irwin et al.[24] attribute the benefits of TCC on QoL to relaxation and diaphragmatic respiratory exercises accompanied by mental meditation. Yau and Packer[26] consider that participants' expectations, who associate this activity with health and mental tranquility, causes them to improve through suggestibility. Jin[27] adds that TCC practitioners forget about what causes them anxiety because of the concentration required by exercises. The importance of participants' expectations and the placebo effect require further research.

A determining factor of psychological benefits by TCC is the personality of practitioners and their socio-cultural differences. Toda et al.[28] report that TCC has significantly more beneficial effects on emotional well-being (depression, mood, anger, and confusion) and physical well-being (fatigue) in subjects with an "impatient" personality than in those classified as "calm". Taylor-Piliae et al.[29] point out that one factor possibly leading to errors in results is the study being conducted with an Asian ethnic group, for this people usually carry the cultural tradition of not showing negative emotions in public and conforming to social rules.

FINAL REMARKS

This study had limitations that should be solved in further interventions. The first one was low adherence to the protocol, represented by acceptance of only 78 individuals to participate in the study among 297 elderly men enrolled in the program for prevention and diagnosis at the health unit.

The second one, to the statistical extent, is related to sample size: in order to guarantee a low probability of type II error ($\beta \leq 20\%$) and power above 80%, each group should hold 28 individuals, which was not achieved. Thus, we tried to more accurately control the probability of type I error ($\alpha \leq 5\%$).

Another limitation was related to FC tests, all being submaximal and indirect. These tests are validated and indicated as the safest for the elderly population, so it was chosen as first option due to the characteristics of elderly patients with chronic disease. However, high initial values in most of them establish the need for further research with more direct and sensitive methods.

Additional means of assessment should be comparison between different TCC styles, and levels of response by individuals according to the chronic diseases they present.

The data obtained indicate that TCC is effective for relative improvement of CF and QoL among elderly men with low BMD. Increases in CF related to AE, ULS, LLS, and dynamic balance pose clinically based indication of TCC practice for men with low BMD, which was already stated in other groups of elderly people of both genders.

Thus, our study's findings suggest TCC as an alternative for safe physical training aimed at increasing FC and QoL in men with low BMD. This practice in programs aimed at the care of large populations is also justifiable, more specifically in the public health network, in situations in which it is not possible to implement exercise programs requiring specific equipment, spaces or clothing from the technical or economic point of view.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

REFERENCES

1. Martini LA, Moura EC, Santos LC, Malta DC, Pinheiro MM. Prevalência de diagnóstico auto-referido de osteoporose, Brasil, 2006. Rev Saúde Pública. 2009;43(Suppl. 2):107-16.
2. Lopes RF, Marchesi AO, Fossari RN, Cezar MC, Coeli CM, Farias MLF. Análise densitométrica da região femoral de homens acima de 50 anos oriundos de um ambulatório de urologia. Rev Bras Reumatol. 2009;49:402-12.
3. Compston J, Cooper A, Cooper C, Francis R, Kanis JA, Marsh D, et al. Guidelines for the diagnosis and management of osteoporosis in postmenopausal women and men from the age of 50 years in the UK. Maturitas. 2009;62:105-8.
4. Rolland Y, Kan GA, Bénétos A, Blain H, Bonnefoy M, Chassagne P, et al. Frailty, osteoporosis and hip fracture: causes, consequences and therapeutic perspectives. J Nutr Health Aging. 2008;12:335-46.
5. Aldahr MHS. Bone mineral status response to aerobic *versus* resistance exercise training in postmenopausal women. World Appl Sci J. 2012;16:806-13.
6. Huang Y, Liu X. Improvement of balance control ability and flexibility in the elderly *Tai Chi Chuan* (TCC) practitioners: A systematic review and meta-analysis. Arch Gerontol Geriat. 2015;60:233-8.
7. Lan C, Chen SY, Lai JS, Wong AMK. *Tai Chi Chuan* in medicine and health promotion. Evid Based Complement Alternat Med. 2013. Article ID 502131:1-17.
8. Hall A, Maher C, Latimer J, Ferreira M. The effectiveness of *tai chi* for chronic musculoskeletal pain conditions: a systematic review and meta-analysis. Arthritis Rheum. 2009;61:717-24.
9. Wang C, Bannuru R, Ramel J, Kupelnick B, Scott T, Schmid CH. Tai Chi on psychological well-being: systematic review and meta-analysis. BMC Complement Alternat Med. 2010;10:23.
10. Brandão CMA, Camargos BM, Zerbini CA, Plapler PG, Mendonça LMC, Albergaria B, et al. Posições oficiais 2008 da Sociedade Brasileira de Densitometria Clínica (SBDens). Arq Br Endocrinol Metab. 2009;53:107-12.
11. Rikli RE, Jones CJ. Developmental and validation of a functional fitness test for community-residing older adults. J Aging Phys Act. 1999;7:129-61.
12. Rogers CR, Larkey LK, Keller C. A Review of Clinical Trials of Tai Chi and Qigong in Older Adults. West J Nurs Res. 2009;31:245-79.
13. Voukelatos A, Cumming RG, Lord SR, Rissel C. A randomized, controlled trial of tai chi for the prevention of falls: the Central Sydney tai chi trial. J Am Geriatr Soc. 2007;55:1185-91.
14. Li Y, Devault CN, Van Oteghen S. Effects of extended Tai Chi intervention on balance and selected motor functions of the elderly. Am J Chinese Med. 2007;35:383-91.
15. Yang Y, Verkuilen JV, Grubisich SA, Reed MR, Rosengren KS. The effect of Taiji (T'ai Chi/Qigong/ Ch'i Kung) on balance in older adults. Carle Selected Papers. 2007;50:8-18.
16. Marinho MS, Silva JF, Pereira LSM, Salmela LFT. Efeitos do Tai Chi Chuan na incidência de quedas, no medo de cair e no equilíbrio em idosos: uma revisão sistemática de ensaios clínicos aleatorizados. Rev Bras Geriat Gerontol. 2007;10:243-56.
17. Woo J, Hong A, Lau E, Lynn H. A randomized controlled trial of Tai Chi and resistance exercise on bone health, muscle strength and balance in community-living elderly people. Age Ageing. 2007;36:262-8.
18. Logghe IHJ, Verhagen AP, Rademaker ACHJ, Bierma-Zeinstra SMA, Rossum E, Faber MJ, et al. The effects of Tai Chi on fall prevention, fear of falling and balance in older people: A meta-analysis. Prev Med. 2010;51:222-7.
19. Li J, Zhang YF, Smith GS, Xue CJ, Luo YN, Chen WH, et al. Quality of Reporting of Randomized Clinical Trials in Tai Chi Interventions – A Systematic Review. Evid Based Complement Alternat Med. 2011;2011:1-10.
20. Jahnke R, Larkey L, Rogers C, Etnier J, Lin F. A comprehensive review of health benefits of qigong and tai chi. Am J Health Promot. 2010;24:e1-25.
21. Lee LYK, Lee DTF, Woo J. Effect of tai chi on state self-esteem and health-related quality of life in older Chinese residential care home residents. J Clin Nurs. 2007;16:1580-2.
22. Ho TJ, Liang W-M, Lien CH, Ma TC, Kuo HW, Chu BC, et al. Health-related quality of life in the elderly practicing Tai Chi Chuan. J Alternat Complement Med. 2007;13:1077-84.
23. Tsang T, Rhonda O, Lam P, Comino EJ, Fiatarone-Singh M. Health benefits of tai chi for older patients with type 2 diabetes: the "move it for diabetes study" – A randomized controlled trial. Clin Interv Aging. 2007;2:429-39.

24. Irwin MR, Olmstead R, Motivala SJ. Improving sleep quality in older adults with moderate sleep complaints: a randomized controlled trial of Tai Chi Chuan. Sleep. 2008;31:1001-8.

25. Oliveira AC, Oliveira NMD, Arantes PMM, Alencar MA. Qualidade de vida em idosos que praticam atividade física - uma revisão sistemática. Rev Bras Geriat Gerontol. 2010;13:301-12.

26. Yau MK, Packer TL. Health and well-being through Tai Chi: perceptions of older adults in Hong Kong. Leisure Stud. 2002;21:163-78.

27. Jin P. Changes in heart rate, noradrenaline, cortisol and mood during Tai Chi. J Psychosom Res. 1989;33:197-206.

28. Toda M, Den R, Hasegawa-Ohira M, Morimoto K. Influence of personal patterns of behavior on the effect of Tai Chi: a pilot study. Environ Health Prev Med. 2011;16:61-3.

29. Taylor-Piliae RE, Haskell WL, Waters CM, Froelicher ES. Change in perceived psychosocial status following a 12-week Tai Chi exercise program. J Adv Nurs. 2006;54:313-29.