Effects of Tai Chi Exercise on Functional and Life Quality Assessments in Senile Osteoporosis

Fiziksel Egzersizin Yaşlı Osteoporozlu Popülasyonda Denge ve Yaşam Kalitesi Üzerindeki Etkileri

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Geliş Tarihi/*Received:* 02.06.2008
Kabul Tarihi/*Accepted:* 04.09.2008

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ABSTRACT Objectives: To investigate and describe the effects of Tai Chi exercise program on functional ability and life quality assessments for subjects with senile osteoporosis. **Material and Methods:** A randomized controlled study was carried out to assess the therapeutic efficacy of Tai Chi exercises. Forty-four sedentary women (mean age 70.2) with bone mineral density T scores ≤ -2.5 and less were randomized into 2 groups (Tai Chi group; n= 22 and control group; n= 22) and were enrolled in a 6-months training study. According to the Tai Chi exercise regimen, the hour-long practice icluded a brief warm-up and stretching, a complete long-form Tai Chi for 40 minutes and cool down/relaxation. The control group was instructed not to change their life style for the duration. Patients in both groups were given home-based active range of motion exercises. The groups were evaluated by Nottingham Health Profile (NHP), Short Form Health Survey (SF-36), sensitized Romberg test (SRT), and time sit to stand (TSS). **Results:** Comparisons of the two groups revealed that the improvement in NHP physical activity score (p= 0.04), NHP tenderness score (p= 0.004), NHP total score (p= 0.02), SF-36 physical function (p= 0.04), SF-36 physical role limitations (p= 0.01), SF-36 pain (p= 0.03), SRT eyes open (p= 0.007), SRT eyes closed (p= 0.001) and TSS (p= 0.002) were significantly higher in the Tai Chi group than in the control group at the end of 6 months. **Conclusion:** Tai Chi training is effective in senile osteoporotic subjects to promote functional ability and life quality.

Key Words: Quality of life; osteoporosis; Tai Chi

ÖZET Amaç: Bu çalışmada, yaşlı osteoporotik hastalarda Tai Chi egzersiz programının yaşam kalitesi ve fonksiyonel durum üzerindeki etkilerini araştırmak amaçlandı. **Gereç ve Yöntemler:** Tai Chi egzersizlerinin terapötik etkinliğinin değerlendirildiği randomize kontrollü bir çalışma yapılmıştır. Kemik mineral yoğunluğu T skoru -2.5 ve daha az olan 44 sedanter kadın (yaş ortalaması 70.2) iki gruba randomize edilerek (Tai Chi grubu s= 22 hasta, kontrol grubu s= 22 hasta) 6 ay süreli bir çalışmaya alındı. Tai Chi egzersiz programına göre 1 saatlik program ısınma, esneme, 40 dakikalık tam uzunlukta Tai Chi ve soğuma/gevşeme öğelerini içermekteydi. Kontrol grubunun çalışma boyunca yaşam şekillerini değiştirmemeleri istendi. Her iki gruba da aktif eklem hareket açıklığı egzersizleri ev egzersizleri programı olarak verildi. Gruplar Nottingham Health Profile (NHP), Short Form Health Survey (SF-36), Sensitize Romberg Testi (SRT) ve oturma-kalkma süresi (TSS) parametreleri ile değerlendirildi. **Bulgular:** Altıncı ayın sonunda gruplar birbiriyle karşılaştırıldığında NHP fiziksel aktivite skorunda (p= 0.04), NHP duyarlılık skorunda (p= 0.004), NHP total skorunda (p= 0.02), SF-36 fiziksel fonksiyon skorunda (p= 0.04), SF-36 fiziksel rol kısıtlanmalarında (p= 0.01), SF-36 ağrı skorunda (p= 0.03), gözler açık iken SRT de (p= 0.007), gözler kapalı iken SRT'de (p= 0.001) ve TSS'de (p= 0.002), Tai Chi grubu, kontrol grubuna göre üstün bulundu. **Sonuç:** Tai Chi egzersizleri yaşlı osteoporotik hastalarda fonksiyonel durumu ve yaşam kalitesini artırmada etkili bulundu.

Anahtar Kelimeler: Yaşam kalitesi; osteoporoz; Tai Chi

Turkiye Klinikleri J Med Sci 2009;29(3):687-95

Senile osteoporosis is involutional osteoporosis over age 65, characterized by cortical and trabecular bone loss due to age-related factors.[1] Decreased control of posture and falling-related injuries, especially fractures are the unwilled complications of senile osteoporosis. The aging population is exposed to this serious problem and disability/immobility resulting from falls has deleterious effects on the elderly.[1]

The age-related changes in muscle type II fiber size cause muscle atrophy, leading to a decline in muscle power output and physical function.[2-4] It is hypothesed that the age related changes in type II fiber size and distribution lead to decreased postural stability and increased incidence of falls in the elderly with fragile bone.

Cognitive serial control exercises and proprioceptive biofeedback exercises are advised to improve control of posture and motion.[1] The international literature contains studies on the effect of Tai Chi, demonstrating its efficacy in postural control and lowering risk of falls.[5,6] Though no difference in fall frequency was found between subjects who practiced Tai Chi and those who followed a more general exercise regimen or balance training, it is concluded that several Tai Chi techniques should be included in group exercises, particularly in women with balance disturbances and those unable to perform higher impact exercises. A recent review about current modes of prevention and treatment in osteoporosis support Tai Chi exercise for balance training in osteoporotic subjects.[7] In a recent study by Gloria Y et al, quality of life is was increased in patients with chronic heart failure by one-hour-long form group Tai Chi classes.[8] Another study showed that Tai Chi improved physiologic parameters, functional outcomes and quality of life.[9]

Tai Chi is a traditional Chinese aerobic exercise.[10] Its exercise intensity is usually of low to moderate level (50 to 70% of maximal heart rate) with an intensity of 4.0 metabolic equivalents (METs) similar in the intensity of brisk walking; thus, older adults and those with chronic illnesses may practice it safely.[11]

Long form of Tai Chi (40 min-1-hour practice) consists of a series of slow but continuous movements of every joint leading to an optimal use of different components of postural control. The slow movements may promote sensory awareness. In addition, precise control of body movement may promote muscle coordination and shift of body position may promote dynamic balance.[12] Tai Chi movements involve continuous knee flexion and extension motion during weight bearing phase of the movement. It includes aerobic, strengthening and range of motion components. Thus, a movement may require a relatively long duration of eccentric activation of leg muscles over a large range of joint motion which improves strength of the muscle, postural stability, cardiorespiratory fitness as well as muscular strength and endurance in elderly individual.[11-13]

Tai Chi is a moderate intensity exercise modality, which can be used in rehabilitation programs to support postural stability and endurance. However, information on the relationship between of Tai-Chi and quality of life is very limited.[14] Therefore, this study was designed to investigate the effects of Tai Chi exercise program on functional ability and life quality assessments of the subjects with senile osteoporosis.

MATERIAL AND METHODS

SUBJECTS

A randomized controlled, longitudinal study was carried out in which the therapeutic efficacy of Tai Chi exercises was investigated in sedentary women with senile osteoporosis. Uludağ University Hospital Ethical Committee approval was obtained for the study. A total of 44 sedentary women with senile osteoporosis (above age 65) were selected among the outpatients of Atatürk Balneotherapy and Rehabilitation Center according to their physical activity level and T scores of Dual Energy X-Ray Absorptiometry (DEXA) as inclusion criteria.[15,16]

All subjects who met the study criteria were informed of the nature of the study and a written consent was obtained. The term sedentary was

functionally defined as < 1.5 km of walking or < 4 hrs of standing a day and activity questionnaires were used to confirm that all subjects were sedentary before enrollment in the protocol.[15] Forty-four sedentary women with bone mineral densities (BMD) more than 2.5 standard deviations below the young normal mean and less (T score ≤ -2.5) were randomized into two groups and were enrolled in a 6-month training study. The mean age of the subjects was 70.2 yrs (range, 65-77 yrs). Physical examinations and routine laboratory analysis were performed to ensure that no preexisting condition would confound results. Anterior-posterior (AP) chest X-rays were taken and cardiology consultations were done for each subject to ensure that they were free of preexisting decompensate cardiovascular and pulmonary system disorders. Musculoskeletal disorder creating difficulties in exercise like new (last 2 months) vertebral or peripheric fractures were the exclusion criteria. The groups were compared for mean age, body mass index (BMI), BMD, joint problems, Nottingham Health Profile (NHP), Short Form Health Survey (SF-36), sensitized Romberg test (SRT), and time sit to stand (TSS). They were homogeneous for all these variables at enrollment (Table 1).

The subjects were instructed not to make any additions or changes in their medications affecting neuromuscular control (sedatives) for the duration of the study. All the subjects took antiosteoporotic medication (antiresorptives like risedronate, alendronate or calcitonin) and their medication was kept stable for the duration.

Participants in the Tai Chi group (n= 22) were specifically instructed not to participate in any exercise class or organized activity except for the exercise sessions of the study. The 22 control subjects were instructed to maintain their sedentary lifestyle for the duration (Figure 1).

Assignment

Participants were randomly assigned to Tai Chi (Group 1) and (Group 2) groups. Simple randomization was done by using a computer generated table of random numbers.

TABLE 1: Baseline values of variables and patient characteristics in each group.

	Group 1 (Tai Chi) (n= 22) (MV ± SD)	Group 2 (Control) (n= 22) (MV ± SD)
Age	69.5 ± 4.9	71.2 ± 6.3
BMI	26 ± 5	24 ± 6
BMD (lumbar total)T score	-3.2 ± 1.1	-3.4 ± 0.9
BMD (femur total) T score	-2.9 ± 0.8	-3.0 ± 1.2
PWJP	7	8
NHP TotalS	8.6 ± 5.4	11 ± 6,8
NHP PAS	2.1 ± 1.3	3.0 ± 1.6*
NHPTS	3.5 ± 2.6	3.8 ± 2.0
SF-36MH	69.9 ± 10.5	60.4 ± 11.9
SF-36PF	74.1 ± 20.5	61.8 ± 19.7
SF-36PRL	58.8 ± 43.2	58.8 ± 46.1
SF-36P	60.6 ± 26.8	58.5 ± 21.6
SRT eyes open	19.9 ± 7	16.9 ± 13.7
SRT eyes closed	5 ± 3.1	5.1 ± 2.5
TSS	48.8 ± 10.7	44.2 ± 11.2

*= p< 0.05, MV ± SD: Mean Value ± Standard Deviation, BMI: Body Mass Index, BMD: Bone Mineral Density, PWJP: Patients With Joint Problems, NHP TotalS: Nottingham Health Profile Total Score, NHPPAS: Nottingham Health Profile Physical Activity Score, NHPTS: Nottingham Health Profile Tenderness Score, SF-36MH: Short Form Health Survey Mental Health, SF-36PF: Short Form Health Survey Physical Function, SF-36PRL: Short Form Health Survey Physical Role Limitations, SF-36P: Short Form Health Survey Pain, SRT: Sensitized Romberg Test, TSS: Time Sit to Stand.

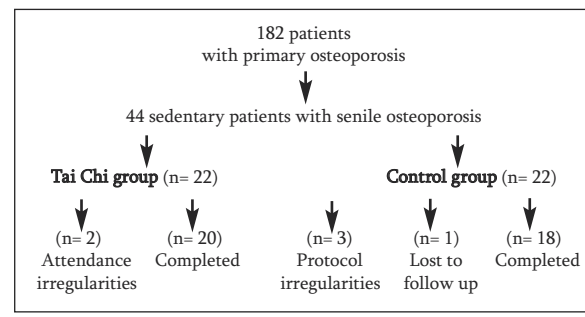

FIGURE 1: Flow chart.

Masking

In this single-blind study a blind examiner carried out all outcome assessments. In addition statistician was unaware of treatment allocations until completion of analyses.

Physical Activity Scale

The level of physical activity was determined by a graded questionnaire that varied from sedentary to

heavy vocational and non-vocational activity levels.[15] Physical activity was categorized as related to housework, job and sports. These categories were each rated on a scale ranging from 0 to 6 and the total score used in the analysis was defined as the sum of the three components. Walking < 1.5 km/day or standing < 4 hrs/day constitutes the term sedentary and it is categorized as 0-1 according to the scale.[15] Tai Chi exercise 3 times a week for 40 min/day represents moderate physical activity in daily life with moderate intensity.[11,15,16]

Dual Energy X-Ray Absorptiometry

Axial (lumbar 1-4 and femur neck) BMD measurements were done by DEXA (Hologic) in the Department of Radiology School of Medicine Uludağ University. Measurements done in the last 12 months were considered sufficient and new measurements were not required.

Laboratory analysis

Serum liver and renal function tests (serum transaminases, gamma glutamyl transpeptidase, uric acid, urea, creatinine), thyroid function tests (thyroid stimulating hormone, free T3 and T4, total T3 and T4), serum calcium, phosphate, total alkaline phosphatase, glucose, as well as urea, creatinine, calcium, and phosphate levels in 24-hr urine samples were measured for each subject to reveal the presence of underlying metabolic/systemic diseases and to exclude secondary osteoporosis. Routine laboratory analyzers (Abbott Alcyon 300i, Advia Centaur) were used for the measurements. Blood and urine samples were collected between 8:00 and 10:00 a.m. after a 12-hr fast.

Sensitized Romberg Test

This balance test is used to determine how long the patient is able to stand steady with feet approximated (the toes of one foot touching the heel of the foot in front of it), eyes open and then closed. The average length is recorded in seconds.[1]

Time sit to stand (TSS)

The subject is asked to stand up from a sitting position and then sit down again 10 times as quickly as possible, without using a support and shoes (seconds).[1]

Quality of Life

NHP assesses perceived physical, social and emotional health with 38 items answered "yes" or "no".[17,18] The NHP includes physical mobility, pain, emotional reaction, energy level, sleep and social isolation evaluation. Eight questions for pain (NHP-PS) and physical activity (NHP-PAS), 5 for sleep (NHP-SS), 3 for tiredness (NHP-TS), 5 for social isolation (NHP-SIS), and 9 for emotional reaction (NHP-ERS) were asked. The "weighted score" (1) of the related question was given for each "yes" answer and 0 point for each "no" answer. The overall score was calculated separately for each parameter and then the total NHP score total score (NHP TotalS) was obtained by adding the scores of these six parameters.

SF-36 includes 36 items selected from a larger pool of items used in Medical Outcomes Study. The SF-36 assesses 8 health concepts by using multi-item scales; physical functioning (SF-36PF) (10 items), role limitations caused by physical health problems (SF-36PRL) (4 items), role limitations caused by emotional problems (SF-36ERL) (3 items), social functioning (SF-36SF) (2 items), mental health (SF-36MH) (5 items), vitality (SF-36 vitality) (4 items), pain (SF-36P) (2 items) and general health perceptions (SF-36GHP) (5 items). An additional single item assesses change in perceived health. First 4 concepts are physical component scores and last 4 concepts are mental component scores. The scoring is between 0-100 (higher the score, better the health quality).[19]

Exercise Program

The group exercise was performed 3 times a week in the rehabilitation department of the hospital by the guidance of an experienced Tai Chi master as an exercise instructor accompanied by a clinic nurse. The exercise class lasted for 6 months. According to the Tai Chi exercise regimen, the hour-long practice included a brief warm-up and stretching (10 minutes), a complete long-form Tai Chi for 40 minutes and cool down/relaxation (10 minutes).[12] Every monday, Tai Chi sessions started with 10 minutes of training for the participants to remember

the physical movements. To minimize the risk for medical complications and promote compliance, duration of exercise for sedentary participants started low and progressed gradually based on tolerance. (1-4 weeks; 15-30 min; 5-24 weeks; 30-40 min).[20] The blood pressures and radial pulses of the subjects were checked before and after the exercise by a chronometer and a sphygmomanometer. The systolic pressure usually increases during the exercise. A moderate rise of the diastolic blood pressure is considered acceptable, but this increase should not exceed 20 mmHg.[21,22] Because the subjects were aged women of unknown cardiovascular fitness, an evaluation of effort tolerance needed to precede the inception of the exercise program. Cardiovascular evaluation was done after 10 minutes of pedalling (moderate intensity) by bicycle ergometer. The subject with radial pulses or blood pressure beyond the appropriate target rate or who developed chest pain, dizziness and dyspnea had to be excluded.[21,22] No subject was beyond the target of the effort tolerance test. However, some subjects who could not tolerate the exercise program for different reasons were asked to rest and then join the group to continue during the Tai Chi session.

STATISTICAL ANALYSIS

The groups were compared with Kruskal-Wallis test to determine whether any differences existed between the initial mean values of the groups for age, BMI (kg/m^2), BMD (g/cm^3), joint problems, NHP, SF-36, TSS and SRT (Table 1). Wilcoxon's rank-sum test was used to determine the changes between baseline and follow-up in each group (Table 2). Because of the abnormal distribution of the raw scores and the small sample sizes, a nonparametric test was selected. Finally, Mann-Whitney U test was used to compare the groups by percent of changes (Table 3). The level of significance for all tests was $p< 0.05$.

RESULTS

At baseline Group 1 (n= 22) and Group 2 (n= 22) were homogeneous for patient characteristics and clinical measurements except for NHP-PAS. NHP-PAS was higher in Group 2 ($p< 0.05$) (Table 1). Two subjects in Group 1 had attendance irregularities. In Group 2, one subject was lost to follow up and three subjects had protocol irregularities like change of life-style or having new medications affecting neuromuscular control. Because the statistical analysis was done according to the Intention to Treat (ITT) principle, all participants were included in the statistical analysis regardless of attendance or protocol irregularities.

Therefore, 20 subjects in Group 1 and 18 subjects in Group 2 were left to continue.

In-group comparisons revealed that there was statistically significant improvement in NHP-PAS (p= 0.015), NHP-TS (p= 0.012), NHP-ERS (p= 0.02), NHP TotalS (p= 0.005), SF-36PF (p= 0.04), SF-36PRL (p= 0.04), SRT eyes open (p= 0.01), SRT eyes closed (p= 0.004) and TSS (p= 0.00) in Group 1. In Group 2, only NHPPAS variable changed significantly (p= 0.03) compared to baseline (Table 2).

Comparison of two groups by percent of changes revealed that improvements observed in NHP-PAS (p= 0.04), NHPTS (p= 0.004), NHP TotalS (p= 0.02), SF-36PF (p= 0.04), SF-36PRL (p= 0.01), SF-36P (p= 0.03), SRT eyes open (p= 0.007), SRT eyes closed (p= 0.001) and TSS (p= 0.002) were significantly higher in Group 1 than in Group 2 at the end of 6 months (Table 3).

DISCUSSION

The results of our study support the beneficial effects of Tai Chi practice on pain/tenderness (p= 0.03, p= 0.004), balance (eyes open; p=0.007, eyes closed; p= 0.001), physical function (p= 0.002) and life quality (NHP TotalS; p= 0.02, SF-36PF; p= 0.04, SF-36PRL; p= 0.01) for senile osteoporotic subjects at the end of 6 months. These findings confirm the hypothesis that precise control of continuous body movement may promote muscle coordination, dynamic balance and consequently functional ability in the elderly which are consequently associated with increase in life quality.

Proprioceptive input is one of the three primary forms (other forms are visual and vestibular) of sensory input that control posture. Elderly per-

TABLE 2: Changes from baseline in Group 1 and Group 2

		Initial Evaluation			Last Evaluation			
		Mean	Median	SD	Mean	Median	SD	p
NHP-PAS	G1	2.1	2	1.3	1.2	1	1.3	0.015*
	G2	3.0	3.5	1.6	2.7	2.5	1.6	0.03*
NH-PTS	G1	3.5	3	2.6	1.6	0	2.2	0.012*
	G2	3.8	3.5	2.0	3.8	4	1.9	1.00
NHP-SS	G1	1.2	1	1.1	0.7	0	0.8	0.06
	G2	2.5	3.5	2.1	2.2	2	2.0	0.18
NHP-SIS	G1	0.2	0	0.2	0.2	0	0.4	0.31
	G2	0.9	0	1.5	0.9	0	1.5	1.00
NHP-ERS	G1	1.5	1	1.9	0.9	0	0.8	0.02*
	G2	3.1	3	2.4	2.8	3	2.4	0.18
NHP TotalS	G1	8.6	8	5.4	4.7	3	4.3	0.005**
	G2	11	12	6.8	12.3	12.5	6.5	0.15
SF-36PF	G1	74.1	75	20.5	79.1	85	16.2	0.04*
	G2	61.8	65	19.7	62.0	65	19.5	0.31
SF-36PRL	G1	58.8	75	43.2	77.9	100	38.4	0.04*
	G2	58.8	87.5	46.1	58.7	87.4	43.8	1.00
SF-36SF	G1	80.1	75	19.8	80.9	87.5	20.8	0.78
	G2	85.6	100	21.9	85.6	100	21.9	1.00
SF-36MH	G1	69.9	68	10.5	69.9	68	10.8	1.00
	G2	60.4	60	11.9	60.6	60	11.7	0.32
SF-36 vitality	G1	52.6	55	7.5	54.4	55	11.8	0.59
	G2	48.3	50	14.5	48.5	50	14.1	0.31
SF-36P	G1	60.6	50	26.8	69.4	70	25.9	0.06
	G2	58.5	60	21.6	59.0	60	21.5	0.32
SF-36GHP	G1	55.4	58.3	7.6	61.5	62.5	16.0	0.15
	G2	60.2	56.3	8.5	53.3	58.3	17.6	0.74
SF-36ERL	G1	74.5	100	43.3	80.4	100	39.2	0.32
	G2	56.7	66.7	43.4	60.0	66.7	41.3	0.31
SRT eyes open	G1	19.9	19	7.0	23.6	21	6.8	0.01*
	G2	16.9	12	13.7	11.4	11.5	5.1	0.35
SRT eyes closed	G1	5.0	5	3.1	7.1	7	2.9	0.004**
	G2	5.1	4.5	2.5	5.0	4	2.6	0.95
TSS	G1	48.8	49	10.7	39.2	40	10.6	0.00***
	G2	44.2	44.5	11.2	41.7	39.5	11.2	0.13

*: p< 0.05, **: p< 0.01, ***: p< 0.001, G1: Group 1, G2: Group 2, IE: Initial Evaluation, LE: Last Evaluation, NHP-PAS: Nottingham Health Profile Physical Activity Score, NHP-TS: Nottingham Health Profile Tenderness Score, NHP-SS: Nottingham Health Profile Sleepness Score, NHP-SIS: Nottingham Health Profile Social Isolation Score, NHP-ERS: Nottingham Health Profile Emotional Reaction Score, NHP TotalS: Nottingham Health Profile total score, SF-36PF: Short Form Health Survey Physical Functioning, SF-36PRL: Short Form Health Survey Physical Role Limitations, SF-36SF: Short Form Health Survey Social Functioning, SF-36MH: Short Form Health Survey Mental Health, SF-36vitality: Short Form Health Survey Vitality, SF-36P: Short Form Health Survey Pain, SF-36GHP: Short Form Health Survey General Health Perceptions, SF-36ERL: Short Form Health Survey Emotional Role Limitations, SRT: Sensitized Romberg Test, TSS: Time Sit to Stand.

sons with diminished proprioception and decreased postural control are more susceptible to ankle trauma and falls than those with greater postural control.[23,24] Research on postural responses to surface translations has shown that balance is not based on a fixed set of equilibrium reflexes but on flexible and functional motor skills that can adapt with training and experience.[25] Large displacement of "Center Of Pressure" in Tai Chi movements may induce the lower extremities to recruit more muscles with a higher magnitude of contraction than in normal walking.[26] Mao et al analyzed characteristics of foot movements in Tai Chi and identified 7 foot support patterns and 6 step directions.[27]

TABLE 3: Comparison of the percent changes for each variable in Group 1 (Tai Chi) and Group 2 (control).

	G1			G2			
	Mean	Median	SD	Mean	Median	SD	p
NHP-PAS (%)	-44.1	0	42.6	-9.6	0	17.8	0.04*
NHP-TS (%)	-45.6	0	25.2	11.7	0	68.6	0.004**
NHP-SS (%)	-18.6	0	36.3	-7.8	0	23.9	0.27
NHP-SIS (%)	-5.9	0	24.3	0	0	0	0.28
NHP-ERS (%)	-33.8	0	47.6	-6.3	0	22.8	0.05
NHP TotalS (%)	-42.0	-40	43	14.9	0	92	0.02*
SF-36PF (%)	17.7	0	5.2	0.6	0	2.5	0.04*
SF-36PRL (%)	68.6	0	14.1	0	0	0	0.01*
SF-36SF (%)	1.3	0	12.9	0	0	0	0.61
SF-36MH (%)	0	0	2.1	0.4	0	1.7	0.58
SF-36vitality (%)	3.9	0	23.5	0.6	0	2.8	0.91
SF-36P (%)	23.1	0	25.6	1.0	0	4.5	0.03*
SF-36GHP (%)	15.6	13.3	41.7	-7.4	7.7	365	0.14
SF-36ERL (%)	5.9	0	24.3	3.3	0	14.9	0.87
SRT eyes open (%)	24.2	19.4	28.4	-9.8	-10.8	37.6	0.007**
SRT eyes closed (%)	91.2	40	54.7	5.9	4.5	9.8	0.001**
TSS (%)	-19.6	17.3	13.4	-5.0	-2.0	12	0.002**

*: p< 0.05, **: p< 0.01, G1: Group 1, G2: Group 2, IE: Initial Evaluation, LE: Last Evaluation, NHPPAS: Nottingham Health Profile Physical Activity Score, NHPTS: Nottingham Health Profile Tenderness Score, NHPSS: Nottingham Health Profile Sleepness Score, NHPSIS: Nottingham Health Profile Social Isolation Score, NHPERS: Nottingham Health Profile Emotional Reaction Score, NHPTotalS: Nottingham Health Profile total score, SF-36PF: Short Form Health Survey Physical Functioning, SF-36PRL: Short Form Health Survey Physical Role Limitations, SF-36SF: Short Form Health Survey Social Functioning, SF-36MH: Short Form Health Survey Mental Health, SF-36vitality: Short Form Health Survey Vitality, SF-36P: Short Form Health Survey Pain, SF-36GHP: Short Form Health Survey General Health Perceptions, SF-36ERL: Short Form Health Survey Emotional Role Limitations, SRT: Sensitized Romberg Test, TSS: Time Sit to Stand

When compared with normal walking, Tai Chi movement had more double-limb support. Support patterns changed slowly, combined with various step directions and they were found to be better than those of walking in simulating the gait challenges that may be encountered in daily activities. Therefore, coordination training by Tai Chi is expected to increase proprioception, decrease postural sway and tendency to falls. This expectancy is justified by our present findings by means of the sensitized romberg test witheyes open or eyes closed. The improvement in postural control was better when the visual component of sensory input was excluded (p= 0.001).

The association between eccentric strength of knee extensors and improvement in proprioceptive input during quiet stance was shown in previous studies.[10,12,28-31] During Tai Chi practice, knee extensors are eccentrically active to control the speed of knee flexion while the weight-bearing leg changes continuously but slowly from extension to flexion. Lan et al have reported the isokinetic strength change in elderly people after practicing Tai Chi for 6 months.[10] They measured both concentric and eccentric strengths at various speeds and found significant improvements in all strength measures. Time sit to stand test (chair test) which was used in our study is an evaluation method for the kinesthetic improvement in leg muscles, including eccentric and concentric components of contraction during the chair test activity. Based on the results observed, strengthening of the leg muscles by Tai Chi practice is thought to be associated with a shorter time for sit to stand; an indicator of the functional improvement which is seen to be accompanied by the improvement in physical role limitations. Though initial NHP physical activity scores were worse in the control group (Table 1, p< 0.05), the improvement was less than in the Tai Chi exercise group (Table 3, p< 0.05). This also shows the supe-

riority of Tai Chi practice in the restoration of physical activity limitations.

The close relation between eccentric muscle strength and quality of life was previously reported.[3] Bassey et al showed that decreased leg muscle power in frail elders was among the most important limiting factors for performing daily activities such as stair climbing, rising from a chair and walking.[4] Moreover, a close association was reported between an individual's functional disability and his/her susceptibility to falls.[32] For example fallers have significantly more disabilities in performing activities of daily living than non-fallers[10] and persons with limited physical function are more likely to sustain injuries from their falls than those without any functional limitations.[32-34]

Physical activity is known to be associated with a better longevity and reduced morbidity. In addition, exercise has a mood elevating effect, which counteracts the emotional blues of having a chronic disease.[35] Though there was no significant improvement in our Tai Chi practitioners ($p > 0.05$), Ko et al reported that Tai Chi improved SF-36 vitality and mental health scores in healthy Chinese women but the study was limited by the lack of a control group.[14] In another study, daily activities improved with Tai Chi in sedentary older adults ranging from walking and lifting to running measured by the physical function subscale of SF-20 Health Survey.[36] The Tai Chi group improved 65% in daily activities (physical function) after completing a 1 hour twice a week, 6-month Tai Chi program while the wait-list control group improved 22%. In a recent review on comprehensive therapeutic benefits of Tai Chi, 17 controlled studies were examined and evidence was found to confirm improvement in quality of life, physical function, cardiovascular function, pain management, balance, flexibility, strength, and kinesthetic sense.[37] However, data interpreting life quality asssessments in senile osteoporopic population who practiced Tai Chi exercise is lacking.

Pain amelioration and decrease in tenderness are additional benefits of Tai Chi practice, as in the present study. It may be attributed to the improvement in musculoskeletal flexibility and stability, preventing subclinical injuries. In addition, aerobic exercise may decrease peripheral muscle resistance and increase alpha wave activity in central nervous system as a central relaxation sign which can indirectly contribute to diminished pain perception.[38] Another mechanism may be the direct effect of increased central beta endorphine levels during exercise which promotes pain tresholds.[39] The neural adaptations in sensory receptors and golgi tendon organs can lead to improvement in the interacting parameters; pain, functional status and life quality in that way with increased expression of muscular force and balance.

Several limitations of the study must be mentioned. One is that the control group did not receive regular medical check ups and regular social contacts with each other in contrast to the intervention group. Therefore, comparison of the life quality scores between the intervention and the control groups after 6 months may be misleading and results may be suggestive rather than conclusive. Another limitation is that the Physical Summary Scale and Mental Summary Scale of SF-36 were not presented for the body and mind aspects of Tai Chi.

In conclusion, Tai Chi was effective in senile osteoporotic subjects to promote, functional ability and life quality. It is an alternative form of exercise with a potential to ameliorate pain, functional impairments and disability owing to its aerobic, strengthening and range of motion components. However, future studies are needed to compare the benefits during Tai Chi and other types of physical activities in terms of postural control and life quality assessments in this part of the population.

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