The effect of tai chi exercise on gait speed and the rate of fall in elderly women

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Abstract
Background and aims: Decreased physical functioning and increased risk of fall are among the most common age-related problems among elderly people. This study aimed at assessing the effects of tai chi exercise on gait speed (GS) and fall rate among a group of elderly women in Iran.

Methods: This randomized controlled trial was conducted in 2018. Participants were sixty elderly women purposefully selected from comprehensive healthcare centers in Lahijan, Iran, and randomly assigned to an intervention and a control group. Study intervention was Yang-style tai chi exercise implemented in two group sessions per week for twelve consecutive weeks. GS was assessed before and after the intervention using the short physical performance battery and fall rate was assessed using a researcher-made self-report fall assessment checklist. The SPSS program for Windows (v. 18.0) was employed for data analysis at a significance level of less than 0.05.

Results: Between-group differences respecting the pretest and the posttest GS were not statistically significant (P > 0.05). Moreover, posttest fall rate in the intervention group was less than the control group.

Conclusion: Tai chi exercise is effective in increasing GS and reducing fall rate among elderly women and is recommended for elderly people.

Keywords: Tai chi exercise, Fall, Physical functioning, Gait speed

Introduction
Aging is a natural biological process (1) and an undeniable part of life. Advances in healthcare sciences have resulted in improved life expectancy and elderly population growth, and hence, have increased the number of elderly people who need healthcare services (2,3). Estimates show that elderly population in developing countries will reach 16% of the global population by 2050 (4). The 2016 National Census in Iran also showed that elderly people aged over 65 years constituted 6.1% of the total population of Iran (5).

Although population aging is considered as a great healthcare achievement, it has turned into the main challenge of the 21st century and resulted in the increased need for healthcare and social services for maximizing elderly people’s functional capacity, social contribution, and safety (6). Aging causes negative structural and functional changes in different body organs, systems, and tissues, and hence, results in impaired physiological functioning of most body systems, different problems in physical functioning, muscular flexibility, muscular strength, and balance, growing dependence in doing the activities of daily living, hospitalization, reduced quality of life, and poor walking ability (7-9).

Walking is a fundamental skill which humans learn in the first year of life and attempt to independently maintain throughout life without the need for others’ help or using assistive equipment such as walking sticks (10). Although walking is a complex, harmonic and dynamic skill (11) and one of the most difficult-to-learn skills for humans, it gradually turns into a simple task (12). Walking ability is indicative of muscular strength, stamina, balance, and flexibility and is considered as a major need of humans for safely performing their daily activities (13). However, aging considerably affects walking ability, so that after the seventh decade of life, gait speed (GS) reduces by 12–16% and risk of fall increases due to reduced muscular strength and problems in balance (14).

Reduced GS is considered as a significant predictor of fall (15) and fall is a major threat to elderly people’s health (16). A study showed that around 30% of elderly people above 65 years experience at least one fall incident each year (17). A study in Iran also showed that 20–28% of elderly people in Iran experience fall (16). Fall is caused by different biological, socioeconomic, behavioral, and environmental factors (18) and is associated with many...
different problems and complications. The World Health Organization reported fall as the third leading cause of chronic disability in the world (19). Fall affects not only elderly people's quality of life, but also the health, well-being, and quality of life of families and communities (14,16). It can result in severe fractures, particularly in the femoral neck, pelvis, and wrist, soft tissue injuries (20), hospitalization, loss of self-confidence, fear over another fall, limitations in joint movements, social isolation, dependence on others, increased financial costs, and even death (21,22). Fall is also considered as the first leading cause of injury and the fifth leading cause of injury-related death, particularly among elderly women (18). Studies showed that compared with men, women with a history of fall are more likely to experience imbalance, have greater fear over fall, and hence, are more at risk for frequent falls and fall-associated injuries (23,24). Although the overall rate of fall-induced death is greater among elderly men, the rate of fall-induced death among elderly women increases with age (25).

Given the high proportion of elderly population in Iran (about 7.3% of the total population), special attention should be paid to elderly issues (19) and nurses should use effective strategies to reduce fall among elderly people (26). Physical exercise is an important factor in preventing fall and its associated injuries and improving balance and walking ability among elderly people (27). Studies show that regular physical activity is an effective strategy for reducing physiological weaknesses and preventing or reducing fall rate among elderly people (28–33).

Tai chi exercise is a useful physical exercise for elderly people. It is an ancient Chinese martial exercise with controlled, regular, and slow movements associated with deep breathing, concentration, and appropriate body posture. It includes many different balance exercises involving the slow transfer of balance from one leg to the other and hence, can improve balance and walking speed and prevent fall among elderly people (34,35). A study showed that tai chi exercise can improve walking ability through improving muscular strength, muscular flexibility, reaction time, balance, and posture control (15). Another study reported that Yang-style tai chi exercise improved gait parameters and musculoskeletal flexibility among healthy elderly women (36). Moreover, two meta-analyses also reported the effectiveness of tai chi exercise in reducing fall (17,37) and improving balance (37) among elderly people. Similarly, a study showed that tai chi exercise reduced fall among elderly people by 25% (38). However, there are limited studies into the effects of tai chi exercise on elderly people in Iran. Therefore, the present study was conducted to assess the effects of tai chi exercise on GS and fall rate among a group of elderly women in Iran.

Methods

Design
This randomized controlled trial was conducted in 2018.

Participants and setting
Participants were 60 elderly women selected from comprehensive health care centers in Lahijan, Iran. Inclusion criteria were an age of 60–74 years, a history of at least one fall in the past year, risk of fall (as determined by a score of 7 or more for the Fall Screening Tool) (39), agreement for participation, ability to speak in Persian, basic literacy skills, no affliction by mental disorders (as determined by a score of 8 or more for the ten-item Abbreviated Mental Test) (40), no self-report experience of performing tai chi exercise in the past twelve months, ability to perform the activities of daily living (as determined by a score of 12 or more for the Activities of Daily Living Instrument) (41), no medical contraindication to physical exercise, and no hearing or visual impairment. Exclusion criteria were voluntary withdrawal from the study, self-report inability to complete the tai chi exercise intervention of the study, and irregular participation in tai chi exercise sessions. Eligible participants were invited to the study through telephone contact. Each two participants were matched with each other respecting characteristics such as age, weight, body mass index, educational level, chronic illnesses, and medication intake and then, were randomly assigned to an intervention and a control group.

Instruments

Data collection instruments were a demographic questionnaire, the short physical performance battery, the Fall Screening Tool, and a researcher-made fall assessment checklist. The short physical performance battery is a standard and specific instrument for physical functioning assessment in elderly people. It consists of three subscales, namely balance, GS, and lower limb muscular strength. This instrument was first translated into Persian through the forward-backward translation method. Accordingly, two experienced English-Persian translators translated the instrument into Persian and then, two other translators back-translated the Persian translation into English. After that, the face validity of the Persian instrument was assessed and confirmed by ten instructors of Ramsar and East Guilan Faculties of Nursing and Midwifery, Ramsar and Langroud, Iran. The reliability of the instrument was also confirmed in a former study with a Cronbach’s alpha of 0.87 (42). Reliability assessment in the present study also showed a test-retest correlation coefficient of 0.86. For GS assessment, each participant was provided with explanations about the GS test and then, was asked to stand behind the start line and start walking with the “Ready, start” command. A chronometer was used to measure the total duration of the test. The first author accompanied the intended participant throughout the test in order support her. The GS test was twice performed for each participant and the shortest duration was documented for her. The possible total score of the test was 0 (“Complete disability”) to 4 (“Highest functional ability”). The scoring of the test was as follows: score 4: walking of the four-meter length of the test in less than...
4.82 seconds; score 3: walking in 4.82–6.20 seconds; score 2: walking in 6.21–8.70 seconds; score 1: walking in more than 8.70 seconds; and score 0: inability to perform the test. Pretest GS assessment was performed by the first author, while posttest GS assessment was performed by a research assistant who was blind to the pretest GS scores. The Fall Risk Screening Instrument was used to assess the risk of fall. The cutoff score of the instrument was 7, denoting that participants with scores 7 or more were at risk for fall. The validity and reliability of this instrument were assessed and confirmed in a former study with a Cronbach’s alpha of 0.71 (39).

The researcher-made self-report fall assessment checklist was used to document fall incidents. The checklist consisted of five items on different aspects of fall incident, namely occurrence of fall incidents, number of fall incidents, place of fall incidents, associated injuries, and need for medical services for fall (23, 43). Ten instructors of Ramsar and East Guilan Faculties of Nursing and Midwifery, Ramsar and Langroud, Iran, assessed and confirmed the face and content validity of the checklist while its reliability was confirmed with a Cronbach’s alpha of 0.87. The checklist was provided to all participants and they were asked to document any fall incident and its characteristics during the first three months after the study intervention. At the end of each month during the three-month post-intervention fall assessment period, participants referred to the study setting, delivered their checklists to the first study author, and received a new checklist for the next month. The first author made weekly telephone contacts with each participant to remind her of completing the checklist.

**Intervention**

The study intervention for participants in the intervention group was Yang-style tai chi exercise implemented in two group sessions per week for twelve consecutive weeks. Each session lasted sixty minutes and consisted of warm-up exercises (10 minutes), main tai chi exercises (forty minutes), and cool-down exercises (10 minutes). The main tai chi exercises were ten exercises of the Yang-style tai chi which were performed consecutively as a ten-exercise form. The study intervention was implemented in a public gym in Lahijan, Iran, under the supervision of the first author and a physical trainer who was expert in tai chi exercise. Tai chi-specific music was also played during sessions. Participants were provided with the opportunity to sit on chair and take a two-minute rest between tai chi forms. Moreover, they were asked to report any abnormal symptoms such as chest pain, dizziness, vomiting, etc. during the intervention. All intervention sessions were held in 08:00–9:00 and hence, all participants were asked to take a light breakfast before the sessions. At the beginning of the study intervention, a medical specialist examined all participants in the intervention group and approved their ability to perform tai chi exercise. Moreover, necessary arrangements respecting any need for hospitalization and emergency medical care delivery to participants were made with the emergency department of a local hospital. Participants in the control group had their routine daily activities and received no tai chi exercise intervention.

**Data analysis**

The SPSS program for Windows (v. 18.0) was employed for data analysis. Study data were described using the measures of descriptive statistics (namely mean, standard deviation, and frequency) and were analyzed using the chi-square, the Wilcoxon’s, the Mann-Whitney U, and the Fisher’s exact tests. The level of significance was set at less than 0.05.

**Results**

In total, sixty elderly women in two thirty-person groups participated in this study. One participant from the intervention group voluntarily withdrew from the study and hence, the study was completed with 29 participants in the intervention group and thirty participants in the control group.

The results of the chi-square and the Fisher’s exact tests indicated no significant differences between the study groups in terms of participants’ age, gender, marital status, employment status, educational level, body mass index, use of assistive equipment for mobility, and history of chronic illnesses ($P > 0.05$; Table 1).

There were no significant between-group differences respecting GS at pretest ($P = 0.641$) and posttest ($0.862$) (Table 2). However, within-group comparisons also revealed that while GS did not significantly change in the control group ($P = 0.739$), it significantly increased in the intervention group ($P < 0.001$) (Table 2). The pretest-posttest difference in the mean of GS in the intervention group was also significantly greater than the control group ($0.517$ vs. $0.33; P < 0.001$).

At posttest, fall rate in the intervention group was less than the control group (17.24% vs. 26.67%; Table 3). The most common fall-associated injury in the intervention group was erosion (60%), while the most common fall-associated injuries in the control group were erosion (37.5%) and bruising (37.5%) (Table 3).

**Discussion**

The aim of this study was to assess the effects of tai chi exercise on GS and fall rate among a group of elderly women in Iran. Findings indicated that tai chi exercise significantly improved GS among elderly women. This is in line with the findings of most previous studies. For example, a study showed that eight-week tai chi exercise significantly improved GS, stride length, pelvic flexibility, and ankle flexibility (36). Another study reported that tai chi exercise had significant positive effects on balance, physical functioning, walking, and flexibility among elderly men (15). Similarly, a study showed that tai chi exercise was associated with significant improvements...
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**Table 1.** Between-group comparisons concerning participants' socio-demographic characteristics

| Characteristics          | Groups | intervention       | control      | Test results |
|-------------------------|--------|-------------------|--------------|--------------|
|                         | No.    | %                 | No.          | %            |             |
| Age (y)                 |        |                   |              |              |
| 60–65                   | 17     | 58.62             | 17           | 56.67        | $P = 0.197^a$ df = 2 |
| 65.1–70                 | 7      | 24.14             | 3            | 10           |
| 70.1–74                 | 5      | 17.24             | 10           | 33.33        |
| Body mass index (kg/m$^2$) |       |                   |              |              |
| 20–25                   | 12     | 41.38             | 6            | 20           | $P = 0.195^a$ df = 2 |
| 25.1–30                 | 16     | 55.17             | 22           | 73.33        |
| 30 and more             | 1      | 3.45              | 2            | 6.67         |
| Educational level       |        |                   |              |              |
| Primary                 | 9      | 31.03             | 10           | 33.3         | $P = 0.256^a$ df = 2 |
| Secondary               | 3      | 10.35             | 6            | 20           |
| Diploma                 | 14     | 48.28             | 13           | 43.3         |
| University              | 3      | 10.34             | 1            | 3.3          |
| Marital status          |        |                   |              |              |
| Married                 | 22     | 75.76             | 20           | 66.7         | $P = 0.354^a$ df = 2 |
| Single                  | 1      | 3.45              | 0            | 0            |
| Widowed                 | 6      | 69/20             | 10           | 33.3         |
| Employment status       |        |                   |              |              |
| Farmer                  | 2      | 6.9               | 1            | 3.3          | $P = 0.186^a$ df = 2 |
| Housewife               | 25     | 86.2              | 26           | 86.7         |
| Retired                 | 2      | 6.9               | 3            | 10           |
| Use of assistive equipment for mobility | | | | |
| Yes                     | 9      | 31.03             | 12           | 40           | $P = 0.372^a$ df = 1 |
| No                      | 20     | 68.97             | 18           | 60           |
| Afflicting chronic illnesses |     |                   |              |              |
| None                    | 2      | 6.9               | 3            | 10           | $P = 0.791^a$ df = 3 |
| Hypertension            | 14     | 48.28             | 13           | 43.3         |
| Diabetes mellitus       | 10     | 34.48             | 12           | 40           |
| Other illnesses         | 3      | 10.34             | 2            | 6.7          |

*The results of the chi-square test; † The results of the Fisher's exact test.

**Table 2.** Between- and within-group comparisons concerning the mean score of GS

| Group       | Time       | Test results $^b$ | Pretest-posttest mean difference | Test results $^b$ |
|-------------|------------|-------------------|---------------------------------|-------------------|
|             | Pretest    | Posttest          | Z = 3.638 $P < 0.001$           | 0.517 ± 0.574 $P = 0.001$ |
| Intervention| 1.34 ± 0.351 | 1.46 ± 4.49      | Z = 3.33 $P = 0.739$            | 0.031 ± 0.556 $P = 0.862$ |
| Control     | 1.31 ± 0.479 | 1.37 ± 0.49       | Z = 0.233 $P = 0.664$           | 0.174 $P = 0.062$ |

$^a$ The results of the Mann-Whitney $U$ test; $^b$ The results of the Wilcoxon's test.

in balance, GS, and quality of life among patients with chronic stroke (44). Moreover, a study found that six-week balance training significantly improved GS and stride length among elderly women (45). A meta-analysis also confirmed that exercise is beneficial to GS, balance, and physical functioning during the activities of daily living (46). Another meta-analysis revealed that therapeutic exercises such as strength, aerobic, stretching, and endurance exercises can improve gait parameters, while inappropriate performance of these exercises can cause problems for elderly people (47). Tai chi exercise includes slow movements and muscular relaxation with regular rhythm, breathing control, mind-body coordination, and balance control and hence, can improve gait parameters

**Table 3.** The posttest prevalence of fall incident and its associated injuries

| Variables | Groups | Levels | N (%) | Total N (%) |
|-----------|--------|--------|-------|-------------|
| Fall incident |       |        |       |             |
| Intervention | Yes    | 5 (17.24) | 29 (100) |
|            | No     | 24 (82.76) |         |
| Control    | Yes    | 8 (26.67)  | 30 (100) |
|            | No     | 22 (33.73)  |         |
| Fall-associated injuries |       |        |       |             |
| Intervention | None   | 1 (20)   | 5 (100)  |
| Erosion    |        | 3 (60)   |         |
| Bruising   |        | 1 (20)   |         |
| Control    | None   | 2 (25)   | 8 (100)  |
| Erosion    |        | 3 (37.5) |         |
| Bruising   |        | 3 (37.5) |         |
The findings of the present study also indicated the significant positive effects of tai chi exercise on fall rate. In line with this finding, several previous studies indicated that tai chi exercise significantly reduced fall rate among both healthy and ill elderly people (17,37,48,52–56). Tai chi exercise is based on the principles of balance, weight shift, and proprioception and includes standing on one foot and transferring weight gradually from that foot to the other along with conscious attitude towards the body which can improve balance and reduce fall rate (57,58).

Unlike our findings, a study revealed that a thirteen-week tai chi exercise was not effective in significantly reducing fall rate among home-dwelling elderly people (39). This contradiction is attributable to the differences between the studies in terms of their participants’ characteristics, sample size, tai chi exercise style and intensity, and GS measurement test.

Our findings also showed that most fall incidents in the intervention group happened in outdoor areas and kitchen, while most fall incidents in the control group happened respectively in the bedroom, stairs, hall, kitchen, bathroom, and outdoor areas. Previous studies reported that most fall incidents happened at home (48), steep surfaces, stairs (60), and same-level surfaces (61). Fall in outdoor areas can be due to inappropriate environmental conditions and steeps which can disturb balance and result in fall. A study reported that the most common causes of fall at same-level surfaces were balance disorders, walking disorders, visual impairment, orthostatic hypotension, and inappropriate environmental conditions (60).

Another study showed that most fall incidents happened in stairs and the most common cause of fall incidents was the lack of rails and grab bars (62). Moreover, a study reported bathroom as the location of most fall incidents among elderly people (63).

We also found erosion as the most common fall-associated injury in the intervention group and erosion and bruising as the most common fall-associated injuries in the control group. Previous studies reported that the most common fall-associated injuries were upper limb injuries (60), upper and lower limb injuries (61), femur joint injuries (64), and head and chest traumas (65).

Moreover, our findings showed that one of the eight participants in the control group who had experienced fall needed intensive care services. Irrespective of injury type, fall incident is associated with serious complications, hospital bed occupation, and increased financial and care burden (66). Some strategies for fall prevention among elderly people are adherence to safety principles, walking in safe routes in outdoor areas, and regular performance of balance exercises. Moreover, careful elderly assessment is needed to determine elderly people who are at risk for fall, the level of fall risk, fall risk factors, and the best strategies for fall prevention. Therefore, healthcare providers should be provided with education about accurate fall risk assessment. It is noteworthy that fall risk assessment should be considered as an ongoing process and should be performed according to environmental conditions as well as the unique medical and functional conditions of each elderly person (67,68).

**Limitations**

One of the study limitations was that the study sample was rather small and consisted only of community-dwelling elderly people which can reduce the generalizability of the findings. Studies with larger samples of male and female elderly people from different age groups are recommended.

**Conclusion**

This study suggests the effectiveness of tai chi exercise in significantly increasing GS and reducing fall rate among elderly women. As tai chi exercise is a simple, mild-intensity, safe, and pleasurable exercise with positive effects on GS and fall rate, healthcare providers are suggested to train and recommend it to elderly people.

**Ethical Approval**

This study was approved by the Ethics Committee of Babol University of Medical Sciences, Babol, Iran (code: MUBABOL.HRI.REC.1396.231) and was registered in the Iranian Registry of Clinical Trials (identifier: IRT20180426039425N1). All participants in both groups received information about the study aims, voluntariness.

**What does this paper contribute to the wider global clinical community?**

- Tai chi exercise can improve muscular strength, muscular flexibility, reaction time, balance, and posture control among elderly people.
- Tai chi exercise can increase gait speed among elderly people.
- Tai chi exercise can reduce fall rate.
of participation, freedom to withdraw from the study, and confidential management of their data and written consent was obtained from all of them. At the end of the study, participants in the control group were provided with the opportunity to participate in two tai chi exercise sessions. Moreover, a tai chi educational CD was provided to all participants in both groups.

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