Comparing tools of balance tests in assessing balance of middle-aged women with or without exercises

Nawanto Agung Prastowo[1], Michelle Olivia Budiarta[1], Kidyarto Suryawinata[2], Ignatio Rika Haryono[1]*

[1]Department of Physiology, Faculty of Medicine and Health Science, Universitas Katolik Indonesia Atma Jaya, Jakarta, Indonesia

[2]Department of Anatomical Pathology, Faculty of Medicine and Health Science, Universitas Katolik Indonesia Atma Jaya, Jakarta, Indonesia

Original Article

ABSTRACT

Background: Fall risks among middle-aged women are relatively high. However, there is a lack of studies on tools of balance tests and their accuracy among middle-aged women.

Objective: The aim of this study is to compare three tools of balance tests to predict falls of middle-aged women who exercise regularly and who do not.

Methods: Eighty-five middle-aged women (50-64 years old) were included in this study, and 40 women of them (47.1%) exercised regularly. The Berg Balance Scale (BBS), Timed Up and Go Test (TUG), and 30-second Chair Stand Test (30-s CST) were the tools examined in this study. The numerical data of this study were analyzed by using a Mann-Whitney test. Those were significant if p<0.05. Accuracy of the tools of balance tests was evaluated by using Receiver Operating Characteristic (ROC) curve. Area under the curve (AUC) was significant if ≥0.70.

Results: Based on this study, the middle-aged women (EG) indicated lower score of TU than sedentary (SG) test (6.9 ± 0.9 vs 8.3 ± 1.7, p = <0.000), and higher score of 30-s than sedentary (SG) test (20.1 ± 3.6 vs 17.2 ± 5.6, p = 0.026). Three participants (3.53%) reported history of falls. The TUG test had better accuracy to predict the falls (AUC 0.922, 95% CI 0.840 - 1.005, sensitivity 1.00, specificity 0.84, p=0.013). Mostly, the participants (≈70%) preferred to practice Tai Chi and Yoga.

Conclusion: The middle-aged women who exercised could have a better score of the balance tests, and the TUG test could predict falls of them.

Latar Belakang: *Risiko jatuh pada perempuan paruh baya cukup tinggi. Namun, studi tentang tes keseimbangan dan akurasi tes tersebut pada perempuan paruh baya belum banyak diungkap.*

Tujuan Penelitian: *Tujuan dari penelitian ini adalah untuk membandingkan tiga tes keseimbangan dalam memprediksi risiko jatuh pada perempuan paruh baya yang melakukan olahraga dan yang tidak melakukan olahraga.*

Metode: *Delapan puluh lima perempuan berusia 50-64 tahun mengikuti penelitian, 40 orang (47.1%) mengikuti olahraga. Uji keseimbangan yang dipergunakan adalah Skala Berg Balance (BBS), Timed Up and Go Test (TUG), dan Chair Stand Test 30 detik (30-s CST). Perbedaan variabel numerik antar kelompok dianalisis menggunakan uji Mann-Whitney. Hasil bermakna ditentukan bila p<0.05. Akurasi tes keseimbangan dievaluasi menggunakan area ROC. Area di bawah kurva (AUC) bermakna jika ≥0.70.*

Hasil: *Perempuan yang mengikuti latihan jasmani (EG) memiliki skor tes TUG lebih rendah dibanding SG (6.9 ± 0.9 vs 8.3 ± 1.7, p = <0.000), dan skor 30-CST lebih tinggi dibanding SG (20.1 ± 3.6 vs 17.2 ± 5.6, p*

= 0.026). Tiga subjek (3.53%) melaporkan riwayat jatuh. Tes TUG memiliki akurasi yang lebih baik dalam memprediksi jatuh (AUC 0.922, 95% CI 0.840 - 1.005, sensitivitas 1.00, spesifisitas 0.84, p = 0.013). Sebagian besar subjek (≈70%) mengikuti latihan Tai Chi dan Yoga.

Kesimpulan: *Perempuan yang mengikuti latihan jasmani memiliki skor tes keseimbangan yang lebih baik. Tes TUG dapat memprediksi risiko jatuh pada perempuan paruh baya.*

INTRODUCTION

A fall is a serious event that may occur in all ages but commonly in older people.[1] Age is usually associated with the fall, so that older people are at greater risks of the fall. Unfortunately, most previous studies on incidence of the falls tend to focus on older people, while incidence of falls of younger people has been less reported. A prior study reported that incidence of falls in middle-aged groups was quite high (21%).[2] A study by Timsina et al reported that the highest prevalence falls in middle-aged women reached 49%.[3]

High prevalence of falls in middle-aged women is related to decreases of physical functions of a body. The decreases can increase fall risks.[4,5] It is estimated that about 25% of middle-aged people has at least one functional impairment that continues or worsens.[6] Moreover, decreases of muscle performances and physical functions has already begun at age of 50 years old.[7] Relationship between lack of exercises (physical activities) and higher incidence of falls had also been investigated. A prior study indicated that incidence of falls and fall-related injuries were low in middle-aged groups who were physically active.[8] Beneficial effects of exercises in improving physical functions and decreasing fall risks have also been proven.[9,10] Moreover, exercises are recognized as the most frequent interventions to prevent falls for older people.[11]

Women can have higher risk of falls than men. A study by Campbell et al reported that women had greater risks of experiencing falls than men (32.7% vs 23.0%). A higher incidence of falls in women can be influenced by decreases of muscle mass and muscle strength, which occur greater and earlier in female than in male. This could lead to decreases of physical functions and balance.[12] Women are also at greater risks of fractures than men. Decreases of bone mass in women are faster than in men, and menopause of women is considered as a contributing factor increasing fracture risks of women.

Several tests are commonly used to assess the physical functions and balance. Among those, The Timed Up and Go test (TUG), Berg Balance Scale (BBS), and 30-second Chair Stand Test (30-s CST) are most widely used in some examination.[13–15] As reported by previous studies, those tests were simple, reliable, and good to assess physical functions and fall risks.[13–15] However, those test are applicable only for older people and may not have been tested in middle-age. The aim of this study was to compare TUG, BBS, and 30-s CST to evaluate balance between sedentary and active middle-aged women.

METHODS

Ethical clearance was approved by Ethics Committee of the Faculty of Medicine and Health Sciences, Universitas Katolik Indonesia Atma Jaya (02/04/KEP-FKUAJ/2017). This study applied a cross sectional design. Participants of this study were middle-aged women between 50-64 years old. The following inclusion criteria were required: 50-65 years old, community dwelling, following instructions, and walking for daily activities without assistance. Meanwhile, its exclusion criteria were having mobility-limited illnesses, taking medication affecting balance and gait, and having injuries that can restrict mobility. Informed consent was obtained directly from the participants by signing a form.

Exercise activities and history of falls were documented by using questionnaires. Exerciser group was participants following reguler exercise at least for 8 weeks and performing at least three times a week with minimal duration of thirty minutes. This was determined by

considering the participants' time availability to do exercises. Falls were defined as a sudden or involuntary event make a body falling down or weak.[16] Falls in the past two years were recorded.

The 30-s chair stand test

The 30-s CST was conducted by standard procedures and equipments. The participants performed repetitive standing up and sitting down as many as possible for 30 seconds. Its results was classified as normal if they performed 12 times or more.[17]

The timed up and go (TUG) test

The test was conducted by standing from a standard chair, walking 3 meters or 10 feet, turning, walking back to the chair and sitting down. Time spent to complete the activities was recorded. Referring results of a study by Kear et al, the results of this study were categorized into normal if time to complete TUG test was 10 seconds or less. While subjects in their 60s was normal if they were 12 seconds or less.[17–19]

Berg Balance Scale (BBS)

The BBS consisted of 14 items of movements of daily activities. Each movement was assessed by a five-point scale ranging from 0-4, in which '0' indicated the lowest function level and '4' was the highest function level. Total maximum score was 56. The equipment for the test were two standard chairs (one with arm rests, and the others are without), bed, footstool, 15 foot walkway, and stopwatch or wristwatch.[17,19,20] A score of 45 or above was considered as normal.[20]

The participants were taught how to do the tests before running the tests. All the tests were conducted in an examination room and supervised by a medical staff.

Statistical analysis

Numerical data were demonstrated by mean ± standard deviation (SD), whereas categorical data were demonstrated in frequency and percentage. Comparisons of numerical data between groups were analyzed by using Mann-Whitney test due to abnormal distributions. Their significant levels were determined at $p < 0.05$. The ability of balance tests in predicting falls was evaluated by using a receiver operating (ROC) curve area. If the curve area was > 0.700, it was significant. Statistical analysis was conducted by using statistical analysis software.

RESULTS

Eighty-five women participated in this study, and 40 (47.1%) of them were engaged in regular exercises. Three participants (3.53%) from sedentary group reported history of falls that happened six to twelve months ago. The mechanisms of falls were slipping (2 cases) and stripping (1 case) on the same level, and they occurred inside the home and outside. Minor injuries on lower legs due to the falls were reported, included bruising. No participants

Table 1. Comparison of age and results of the three tests between the groups

Variables	No Exercise (n=45)	Exercise (n=40)	P
Age (years)	55.6 ± 4.9	55.7 ± 4.3	0.767*
BBS score	54.5 ± 1.6	54.6 ± 1.6	0.663*
TUG test	8.3 ± 1.7	6.9 ± 0.9	0.000*
30-s CST test	17.2 ± 5.6	20.1 ± 3.6	0.026*
History of falls			
Absence	42	40	0.242†
Presence	3	0	

*Mann-Whitney test; †Fisher Exact Test.
ND = not determined; BBS = Berg Balance Scale; TUG = The Timed Up and Go; 30-s CST= 30 second Chair Stand Test.

experienced fractures. Mann-Whitney test indicated that age and BBS score were not different between the groups (p=0.767, and p=0.663, respectively), whereas TUG test and 30-s CST score were better in the exerciser group (p<0.001 and p=0.026, respectively) (Table 1). Lower score of TUG test indicated that the participants in EG completed the three tests faster, whereas higher score of 30-s CST indicated that they in EG performed the three tests with more repetitions. The falls were not related to participation in the exercises (p=0.242).

The TUG, 30-s CST, and BBS score revealed different sensitivity and specificity in identifying the falls (Figure 1). The 30-s CST and BBS had no significant results with the area under the ROC curve 0.069 and 0.232. The TUG showed good accuracy with the area under the ROC=0.922 (95% CI=0.840 - 1.005, p = 0.013) (Table 2 and Figure 1). The cutt-off score for TUG test was 8.45 that provided the highest sensitivity (1.00) and specificity (0.84).
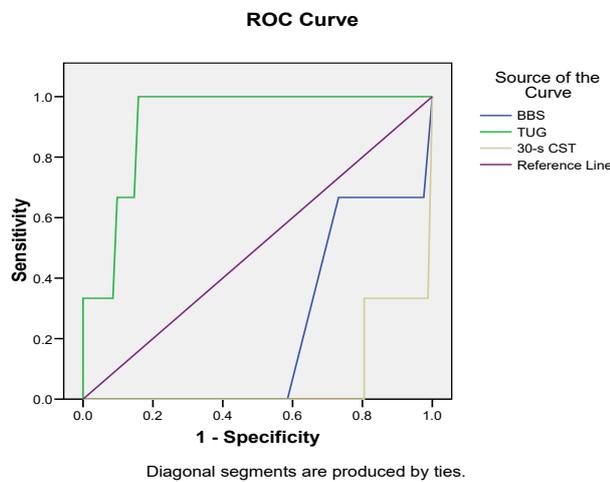

Figure 1. The receiver operating curve of the balance tests

Table 2. Receiver operating curve for the tools of balance assessment

Balance tests	AUC	Sensitivity	Specificity	95%CI	p
BBS test	0.225	0.67	0.27	0.036 - 0.414	0.107
TUG test	0.922	1.00	0.84	0.840 - 1.005	0.013
30-s CST	0.066	0.30	0.20	-0.037 - 0.169	0.011

AUC = area under the curve; BBS = Berg Balance Scale; TUG = Timed Up and Go; 30-s CST= 30 second Chair Stand Test.

Table 3 presented several types of exercise training done by the participants. Eight types of exercise training were documented. Most participants participated in an exercise modality (28 or 65%). Tai Chi and Yoga were the most preferred exercise. Thirty participants (69.8%) practiced Tai Chi and Yoga as a single exercise or combined them with other exercise modalities.

Thirteen participants practiced Tai Chi, and none of them combined it with any other types of exercises. Seventeen participants practiced Yoga, and 12 of them (71%) also participated in other forms of exercises, especially fitness (8 or 18.6%). The duration of exercise activities was 30-90 minutes per session for 3 - 5 times a week.

Table 3. Types and duration of exercises

Exercise Activities	Participants (%)	Duration/session	Times/week
Taichi	13 (30.2%)	60 min	3-5
Yoga	5 (11.6%)	60-90 min	3
Fitness	4 (9.3%)	60-90 min	3-4
Pilates	1 (2.3%)	90 min	4
Zumba	1 (2.3%)	60 min	3
Aerobic dance	1 (2.3%)	60 min	4
Swimming	3 (7.0%)	60 min	3
Yoga, fitness	8 (18.6%)	45-60 min	3-5
Yoga, pilates	1 (2.3%)	30 min	5
Yoga, swimming	1 (2.3%)	30 min	4
Yoga, cycling	1 (2.3%)	45 min	5
Yoga, fitness, cycling	1 (2.3%)	30 min	3
Aerobic dance, jogging	2 (4.7%)	30-45 min	5
Zumba, jogging	1 (2.3%)	30 min	5
Total	43 (100.0%)		

DISCUSSION

Fall risks and physical functions in elderly people have been previously investigated, but there are only few studies examining fall risks and physical functions in middle-aged women. This study attempted to evaluate the risks and the physical functions by using different tools of balance tests in middle-aged women between 50-64 years old and to document types of exercise activities practiced by the participants. Prevalence of falls in middle-aged women in this study was 3.53%, which mostly occurred in women who did not exercise. Women practicing exercises showed a higher balance score of TUG and 30-s CST. The TUG test had a higher sensitivity and specificity in identifying the fall risks. In addition, most of the participants preferred to practiceTai Chi and Yoga as a single exercise or a combination of other exercises.

The TUG, BBS, and 30-s CST are commonly used to assess the fall risks. The tests are originally designed and developed for older adults and for those who have obvious balance impairment. As the lowest level of physical functions starts at 50, and the incidence of falls is quite high in middle age, the tests are also applied for young adults.[2,3,6,7] The normative reference values of TUG test for younger-aged women have been developed and could be applied in recent studies.[18] However, normative reference values of 30-s CST and BBS for younger people has not been available yet. The cut off values of 30-s CST and BBS are for age of 60 years old or older, and both may be not appropiate for younger aged-participants in this study.

The participants who practiced exercises had better results in TUG test and 30-s CST but not BBS test. This could support results of a previous study that found BBS being unable to detect mild changes in balance.[21] Compared to the BBS, measurements in TUG and 30-s CST are to test strength and speed rather than the only balance. Sitting up followed by walking 3 meters back and forth in the TUG test, and repetitive sitting-to-standing for 30 seconds in the CST test require not only lower limb strength, but also speed and muscle endurance.[22] This may indicate that speed and strength of lower limb can decrease earlier in middle-aged women than their balance.

Findings of this study revealed that the TUG was the only test having good accuracy in predicting the falls in middle-aged women, whereas BBS and 30-s CST were not. However, a previous study by Jeon & Kim argued that the BBS had good sensitivity and specificity and could predict the falls.[23] This discrepancy may due to the very low incidence of falls in this study compared to the previous studies showing percentage of 47.4%. A better predictive function of TUG compared to the BBS and 30-s CST in this study could not be explicitly explained. It might be influenced by decreases of physical ability as they grow older, especially speed. If decreases of speed occur earlier than other parameters such as strength and endurance, the first decrease that will be found is TUG test.

There was only 3 participants reported as getting falls in this study. The falls occurred mostly at home on the same level. They had minor injuries on their lower limbs. This finding is similar with a study by Hefny et al.[24] However, the fall incidence was much lower than what was reported by Talbot et al who also included men as participants.[2] Physically more active than women, men are more exposed to a conducive situation to injury. This puts men at higher risk of falls leading to higher incidence of falls.

Effects of exercise to minimize fall risks have been widely investigated. In general, most studies indicate that any types of exercises are helpful to reduce fall risks at the elderly people.[9,25–27] A previous study suggested that daily physical activities performed by middle-aged women could improve risks of functional limitation and disability in future.[28] In addition, multimodal or multicomponent exercises ought to be more advantageous because they can impact on many aspects associated with fall risks, such as strength, balance, gait, coordination, etc.[9,29] The fall risks were not evaluated in this study. However, considering the results of three tests, middle-aged women practicing exercises indicated lower risk of falls.

Tai Chi and Yoga were the most favored exercise in this study. The effects of Tai Chi in reducing fall risks have been widely investigated

but their results were not established. Meta-analysis studies demonstrated that Tai Chi could improve physical capabilities and reduce risks and rates of falls in elderly people.[30–32] However, RCT studies showed that effects of Tai Chi on fall risks were not different compared to other exercises.[33,34] Effects of Yoga in reducing fall risks have also been widely investigated. Two studies reported that Yoga was effective to improve mobility and balance; therefore, it could reduce fall risks.[35,36] Mechanisms of the effect of Yoga and Tai Chi to improve balance have been proposed. It is hypothesized that the effect of Yoga is alleged through down-regulation of the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system (SNS), whereas Tai Chi is felt by enhancing sensory motor and proprioceptive system.[37,38] The participants practicing Tai Chi in this study did not practice another exercise, while the participants practicing Yoga mostly got involved in other types of exercises. The participants in Tai Chi believed that practicing Tai Chi alone was appropriate to improve their health; meanwhile, the participants in Yoga believed that practicing other exercises could enhance the effects of Yoga. Furthermore, being conversant of any types of exercises could help the participants to choose what type of exercise is suitable for them.

This study also has some limitations. The first limitation is related to its sample size. Larger samples are needed to obtain more representative and valid data and more fall incidence. The second limitation was related to its study design. A cross-sectional design is considered to be less strong in verifying the cause-effect relationship between the exercise activities and the test performance. A longitudinal study comparing the effects of some exercise types on the test performance would be more useful and conclusive.

CONCLUSION

In conclusion, the TUG test has the highest sensitivity and specificity to predict fall risks of middle-aged women compared to the BBS, and 30-s CST. The women practicing exercises had

better score of balance tests.

CONFLICT OF INTEREST

Authors declare that there is no conflict of interest.

REFERENCES
1. Yoshida S. A Global Report on Falls Prevention Epidemiology of Falls. WHO report. 2012.
2. Talbot LA, Musiol RJ, Witham EK, Metter EJ. Falls in young, middle-aged and older community dwelling adults: Perceived cause, environmental factors and injury. BMC Public Health. 2005;5:1–9.
3. Timsina LR, Willetts JL, Brennan MJ, Marucci-Wellman H, Lombardi DA, Courtney TK, et al. Circumstances of fall-related injuries by age and gender among community-dwelling adults in the United States. PLoS One. 2017;12(5):1–21.
4. Ambrose AF, Paul G, Hausdorff JM. Risk factors for falls among older adults: A review of the literature. Maturitas. 2013;75(1):51–61.
5. Dhargave P, Sendhilkumar R. Prevalence of risk factors for falls among elderly people living in long-term care homes. Journal of Clinical Gerontology and Geriatrics. 2016;7(3):99–103.
6. Brown RT, Diaz-Ramirez LG, Boscardin WJ, Lee SJ, Steinman MA. Functional Impairment and Decline in Middle Age: A Cohort Study. Annals of internal medicine. 2017;167(11):761–8.
7. Akbari M, Mousavikhatir R. Changes in the muscle strength and functional performance of healthy women with aging. Medical Journal of the Islamic Republic of Iran. 2012;26(3):125–31.
8. Caban-Martinez AJ, Courtney TK, Chang WR, Lombardi DA, Huang YH, Brennan MJ, et al. Leisure-Time Physical Activity, Falls, and Fall Injuries in Middle-Aged Adults. American Journal of Preventive Medicine. 2015;49(6):888–901.
9. Takano E, Teranishi T, Watanabe T, Ohno K, Kitaji S, Sawa S, et al. Differences in the effect of exercise interventions between pre-frail older adults and older adults without frailty: A pilot study. Geriatrics and Gerontology International. 2017;17(9):1265–9.
10. Liu CJ, Changa WP, De Carvalho IA, Savagea KEL, Radforda LW, Thiyagarajan JA. Effects of physical exercise in older adults with reduced physical capacity: Meta-analysis of resistance exercise and multimodal exercise. International Journal of Rehabilitation Research. 2017;40(4):303–14.
11. Campbell AJ, Spears GF, Borrie MJ. Examination by logistic regression modelling of the variables which increase the relative risk of elderly women falling compared to elderly men. Journal of Clinical Epidemiology. 1990;43(12):1415–20.
12. Cheng SJ, Yang YR, Cheng FY, Chen IH, Wang RY. The changes of muscle strength and functional activities during aging in male and female populations. International Journal of Gerontology. 2014;8(4):197–202.
13. Barry E, Galvin R, Keogh C, Horgan F, Fahey T. Is the Timed Up and Go test a useful predictor of risk of falls in community dwelling older adults: A systematic review and meta-analysis. BMC Geriatrics. 2014;14(1):1–14.
14. Macfarlane DJ, Chou KL, Cheng YH, Chi I. Validity and normative data for thirty-second chair stand test in elderly community-dwelling Hong Kong Chinese. American journal of human biology : the official journal of the Human Biology Council. 2006;18(3):418–21.
15. Park SH, Lee YS. The Diagnostic Accuracy of the Berg Balance Scale in Predicting Falls. Western Journal of Nursing Research. 2017;39(11):1502–25.
16. Rubenstein LZ, Robbins AS, Josephson KR, Schulman BL, Osterweil D. The value of assessing falls in an elderly population. A randomized clinical trial. Annals of Internal Medicine. 1990;113(4):308–16.

17. Hayes KW, Johnson ME. Measures of adult general performance tests: The Berg Balance Scale, Dynamic Gait Index (DGI), Gait Velocity, Physical Performance Test (PPT), Timed Chair Stand Test, Timed Up and Go, and Tinetti Performance-Oriented Mobility Assessment (POMA). Arthritis & Rheumatism. 2003;49(S5):S28–42.

18. Kear BM, Guck TP, McGaha AL. Timed Up and Go (TUG) Test. Journal of Primary Care & Community Health. 2017 Jan 25;8(1):9–13.

19. Jones J, Rikli RE. Measuring functional. In: The Journal on Active Aging. 2002. p. 24–30.

20. Berg KO, Wood-Dauphinee SL, Williams JI, Maki B. Measuring balance in the elderly: Validation of an instrument. In: Canadian Journal of Public Health. 1992.

21. Downs S, Marquez J, Chiarelli P. The Berg Balance Scale has high intra- and inter-rater reliability but absolute reliability varies across the scale: a systematic review. Journal of Physiotherapy. 2013;59(2):93–9.

22. Applebaum EV., Breton D, Feng ZW, Ta A-T, Walsh K, Chassé K, et al. Modified 30-second Sit to Stand test predicts falls in a cohort of institutionalized older veterans. Bowen M, editor. PLOS ONE. 2017;12(5):e0176946.

23. Jeon Y-J, Kim G-M. Comparison of the Berg Balance Scale and Fullerton Advanced Balance Scale to predict falls in community-dwelling adults. Journal of Physical Therapy Science. 2017;29(2):232–4.

24. Hefny AF, Abbas AK, Abu-Zidan FM. Geriatric fall-related injuries. African Health Sciences. 2016 Jul 1;16(2):554.

25. Rimland JM, Abraha I, Dell'Aquila G, Cruz-Jentoft A, Soiza R, Gudmusson A, et al. Effectiveness of Non-Pharmacological Interventions to Prevent Falls in Older People: A Systematic Overview. The SENATOR Project ONTOP Series. Laks J, editor. PLOS ONE. 2016;11(8):e0161579.

26. El-Khoury F, Cassou B, Charles MA, Dargent-Molina P. The effect of fall prevention exercise programmes on fall induced injuries in community dwelling older adults: Systematic review and meta-analysis of randomised controlled trials. BMJ. 2013;347(20):1348.

27. Alvarez KJ, Kirchner S, Chu S, Smith S, Winnick-Baskin W, Mielenz TJ. Falls reduction and exercise training in an assisted living population. Journal of Aging Research. 2015;2015:1–4.

28. Pettee Gabriel K, Sternfeld B, Colvin A, Stewart A, Strotmeyer ES, Cauley JA, et al. Physical activity trajectories during midlife and subsequent risk of physical functioning decline in late mid-life: The Study of Women's Health Across the Nation (SWAN). Preventive Medicine. 2017;105:287–94.

29. Arrieta H, Rezola-Pardo C, Gil SM, Irazusta J, Rodriguez-Larrad A. Physical training maintains or improves gait ability in long-term nursing home residents: A systematic review of randomized controlled trials. Maturitas. 2018;109:45–52.

30. Hu YN, Chung YJ, Yu HK, Chen YC, Tsai CT, Hu GC. Effect of Tai Chi Exercise on Fall Prevention in Older Adults: Systematic Review and Meta-analysis of Randomized Controlled Trials. International Journal of Gerontology. 2016;10(3):131–6.

31. Huang ZG, Feng YH, Li YH, Lv CS. BMJ Open Systematic review and meta-analysis: Tai Chi for preventing falls in older adults. BMJ Open. 2017;7(2).

32. Lomas-Vega R, Obrero-Gaitán E, Molina-Ortega FJ, Del-Pino-Casado R. Tai Chi for Risk of Falls. A Meta-analysis. Journal of the American Geriatrics Society. 2017;65(9):2037–43.

33. Day L, Hill KD, Stathakis VZ, Flicker L, Segal L, Cicuttini F, et al. Impact of Tai-Chi on falls among preclinically disabled older people: A randomized controlled trial. Journal of the American Medical Directors Association. 2015;16(5):420–6.

34. Taylor D, Hale L, Schluter P, Waters DL, Binns EE, McCracken H, et al. Effectiveness of tai chi as a community-based falls prevention intervention: A randomized controlled trial. Journal of the American Geriatrics Society. 2012;60(5):841–8.

35. Cooper N, Suri P, Litman A, Morgenroth DC. The Effect of Yoga on Balance and Mobility

in Populations with Balance and Mobility Impairment: a Systematic Review with Meta-Analysis. Current Physical Medicine and Rehabilitation Reports. 2018;6(1):1–14.

36. Subramaniam S, Bhatt T. Effect of Yoga practice on reducing cognitive-motor interference for improving dynamic balance control in healthy adults. Complementary Therapies in Medicine. 2017;30:30–5.

37. Ross A, Thomas S. The health benefits of yoga and exercise: A review of comparison studies. Journal of Alternative and Complementary Medicine. 2010;16(1):3–12.

38. Li Y, Devault CN, Van Oteghen S. Effects of extended Tai Chi intervention on balance and selected motor functions of the elderly. American Journal of Chinese Medicine. 2007;35(3):383–91.