The Effects of Tai Chi on Balance in Healthy Older Adults

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Objectives

- Summarize current research on the effects of tai chi on balance in a healthy older adult population
- Explore cross-cultural possibilities in research
- Compare the effects of tai chi to other exercise interventions or no exercise
- Discuss possible relationships between an increase in balance outcome measures and a decrease in falls risk in an older population
Definitions

- **Tai Chi**
  - Traditional or adapted slow forms of tai chi
  - Low impact, low velocity

- **Older Adult**
  - Greater than 55 years of age

- **Healthy**
  - No cardiopulmonary, neurological, musculoskeletal or chronic conditions that adversely affect mobility or balance
Definitions

- **Balance**
  - The ability to maintain center of gravity within base of support and limits of stability
  - Involves integration of visual, vestibular, somatosensory systems as well as motor control systems to coordinate muscular contractions

- **Postural Stability**
  - The ability to use motor control systems to maintain balance in response to or in advance of perturbations
What is Tai Chi?
What is tai chi?

- style of martial art that originated in China
- over 300 years old
- involves control over the displacement of body mass over one’s base of support, postural orientation, range of motion and emphasis on abdominal and lower-extremity muscle function
- There are different styles of tai chi, Chen, Yang, Wu and Sun. Each style has unique features.
Mind-Body Approach

- relaxation
- slow movements
- breathing
- concentration
Tai Chi and Physiotherapy

- Lack of current research on effects of tai chi
- Relatively new in North America as an exercise for elderly population
- Balance and Falls a major issue in older adult population
- Need for exercise and community programs that physiotherapists can prescribe to the older population.
Research Questions:

Primary Research Question:
- What are the effects of tai chi on balance in the healthy older adult population?

Secondary Research Questions:
- How do long term tai chi practitioners compare to non-practitioners?
- How do long term tai chi practitioners compare to those participating in shorter interventions?
- How does the findings of research done on tai chi in China compare to research done in North America?
Methods

- Conducted initial database search in April 2007
- Conducted Chinese database search in August 2007
- Set up automatic updates and repeated searches periodically
- Final search of all databases conducted in June 2008
- Initial search yielded 8 articles, final search in June yielded one further article
Search Strategy

- **Tai Chi, T'ai Chi, Tai ji, Tai Chi Chu**
- **Balance, Postural Stability, Dynamic Eq**
- **Elderly, Older adult, Aged**

### Databases
- **Cinahl**
  - Titles Reviewed: 153
  - Titles Chosen: 120
  - Duplicates Removed: 197
  - Abstracts Reviewed: 113
  - Selected for Full Text Review: 33
  - Selected for Inclusion: 6
- **Medline**
  - Titles Reviewed: 221
  - Titles Chosen: 49
  - Duplicates Removed: 170
  - Abstracts Reviewed: 55
  - Selected for Full Text Review: 55
  - Selected for Inclusion: 17
- **PEDro**
  - Titles Reviewed: 35
  - Titles Chosen: 5
  - Duplicates Removed: 263
  - Abstracts Reviewed: 22
  - Selected for Full Text Review: 22
  - Selected for Inclusion: 2
- **EMBASE**
  - Titles Reviewed: 263
  - Titles Chosen: 85
  - Duplicates Removed: 84
  - Abstracts Reviewed: 67
  - Selected for Full Text Review: 55
  - Selected for Inclusion: 3
- **EMB Review**
  - Titles Reviewed: 85
  - Titles Chosen: 84
  - Duplicates Removed: 55
  - Abstracts Reviewed: 55
  - Selected for Full Text Review: 55
  - Selected for Inclusion: 3
- **Sport Discus**
  - Titles Reviewed: 67
  - Titles Chosen: 67
  - Duplicates Removed: 55
  - Abstracts Reviewed: 55
  - Selected for Full Text Review: 55
  - Selected for Inclusion: 3
- **Chinese Database**
  - Titles Reviewed: 170
  - Titles Chosen: 17
  - Duplicates Removed: 17
  - Abstracts Reviewed: 17
  - Selected for Full Text Review: 17
  - Selected for Inclusion: 17
Key Words

- Tai chi / t’ai chi / tai ji / tai chi chuan
- Postural stability / posture / postural equilibrium
- Balance / dynamic equilibrium
- Elderly / aging / aged / older adult
Chinese Literature Search

- Heilongjiang Provincial Library, Harbin, China
- Chinese Journal Full Text Database (1996-present)
Chinese Literature Search

- In Chinese language
- Same key words as used for the English database
- 170 titles reviewed
- 55 abstracts were chosen
- 22 full text articles were selected
- 3 articles were included
Search Strategy

- Titles reviewed by 2 independent reviewers
  - Required one reviewer to accept to be included to next stage
- Abstract reviewed by 2 independent reviewers
  - Required both reviewers to accept to be included, or one reviewer plus 3rd reviewer to settle disputes
- Full Text review completed by 2 independent reviewers
  - Both reviewers applied inclusion and exclusion criteria and completed PEDro scale
  - Inconsistencies were resolved by 3rd reviewer
Inclusion Criteria

- Healthy older adults
  - >55 years of age
  - “satisfactory health”
- Balance outcome measures were used
- Tai chi as the primary intervention
- Control groups participated in comparable exercise program, balance training, or no intervention
Exclusion Criteria

- Pedro scores of 4/11 or lower
- Studies published in only English or Chinese
Data Extraction & Analysis

- Standardized data extraction form
- Information extracted includes:
  - Patient populations
  - Interventions
  - Controls
  - Methodological procedures
  - Outcome measures
Subject Characteristics

- 1310 Participants
- Mean age 72.3 years
- Healthy older adults with no pathologies
- Community dwelling & independent living
Tai Chi Interventions

- Modified Tai Chi group class
  - Yang, Ng, Sun-style or mixed styles of tai chi
- Style of Tai Chi not specified in the Chinese studies
  - Independent practice ranging from 3 months - 18 years
- Length of intervention in English studies:
  - 8 weeks to 12 months
  - 1 hour /week to 6, 1 hour sessions / week
Control Groups

- Varied in both the *amount* and *type* of prescribed activity
- Exercise class
- No exercise
- Education
- Computerized balance training
- Resistance exercise program
- Self-determined level of physical activity
Outcomes Measured

- All outcome measures reported by each study were included in the data extraction process, however only outcome measures pertaining to balance were analyzed for comparison.
Balance Outcome Measures

1. Dynamic Computerized Posturography *(Chattecx™ or SMART™ from NeuroCom International)*

A force plate measures force in several different axes *(anterior/posterior and lateral COM displacement)*
Balance Outcome Measures

2. *Sensory Organization Test (SOT)*
   - EquiTest computerized dynamic posturography system (*Chattecx™* or *SMART™* from *NeuroCom International*)
   - Consists of force platform and visual surround (stationary or sway-referenced)
   - Assesses an individual’s ability to use information received by the somatosensory, visual and vestibular systems by systematically altering visual information and movement of the platform.
Sensory Organization Test (SOT)

SOT is comprised of 6 sensory conditions

1. normal vision, fixed platform
2. eyes closed, fixed platform
3. vision sway-referenced, fixed platform
4. normal vision, sway referenced platform
5. eyes closed, sway referenced platform
6. both vision and platform sway-referenced.
The information obtained from SOT includes:

**Equilibrium Score** - quantifies postural stability under each of the three trials of the six sensory conditions.

**Sensory Analysis** – analyses the ability to use input from each sensory system to maintain balance.
- The somatosensory ratio is condition2/condition1
- The visual ratio score is condition4/condition1
- The vestibular ratio score is the ratio of condition5/condition1

**Strategy Analysis** - quantifies ankle strategy & hip strategy

**Center of Gravity (COG) Alignment** - the patient’s COG position relative to the center of the BOS at the start of each trial.
3. **SwayMeter** measures displacements of the body at the level of the waist.

A 40cm long rod with a mounted pen at the end, attached to the subject posteriorly using a firm belt measures displacement.

The subject tries to stand as still as possible for 30 seconds under the 4 test conditions
- on floor with eyes open
- on floor with eyes closed
- on foam rubber mat with eyes open
- on foam rubber mat with eyes closed
Balance Outcome Measures

4. *Maximal Balance Range and Coordinated Stability Tests*

- Require subjects to adjust their balance in a controlled manner when near limits of BOS
- Assessed by measuring maximal lateral sway with feet placed in a near tandem position and eyes open.
5. *Choice Stepping Reaction Time.*

- Consists of a low platform with six plates
- Two base plates on which the participant stands and four stepping plates that can be illuminated in a random order.
- Participants are instructed to step onto a plate as quickly as possible when it becomes illuminated. Each panel contains a pressure switch to determine the time of foot contact.

Figure from Lord et al. (2001)
Balance Outcome Measures

6. **Limits of Stability Test (LOS test)**

- LOS measures a subject’s ability to voluntarily weight shift within their BOS, and briefly maintain stability over time.

- System consists of dual force plates and a video screen on which the subject's current normalized COP is displayed.

- Eight target positions are on the screen: front, right front, right, right back, back, left back, left, and left front.

- The LOS system has three outcome measures: reaction time, maximum excursion, and directional control.
Balance Outcome Measures

7. *Fear of Falling Questionnaires*

8. *Heel to toe Walking* – involves heel to toe walking. Assesses lateral foot displacement during gait over 10 feet walked.

9. *Timed Up and Go (TUG) test* – assesses several functional manoeuvres such as standing up, walking over 3m, turning and sitting down.

10. *Modified Wolfson Test* - uses a belt to apply a recorded amount of force in order to pull the subject off balance.
Summary of Results …
Wolf et al. (1997) RCT

- **Interventions:**
  - TC: 2x/wk, 1 hour, 15 weeks
  - ED: 1x/wk, 1 hour, 15 weeks
  - CBT: 1x/wk, 1 hour, 15 weeks

- **Outcomes Measured**
  - Chattex Balance System
  - Fear of Falling Questionaire

- **Results - Improvement in Postural Stability?**
  - TC: NO improvements
  - CBT: Some improvements
Yang et al. (2007) RCT

- Interventions:
  - TC  3x/week  1 hour  6 months
  - CG  maintained normal activity level

- Outcomes Measured
  - Sensory Organization Test (SOT)
  - BOS & Stance Width (Foot trace measurements)

- Results - TC vs Control group?
  - SOT  Vestibular score was 47% greater in TC
  - BOS  Increase in quiet stance in TC
Interventions:
- TC community 1 hour/week 16 weeks
- CG instructed not to do TC for 24 weeks

Outcomes Measured
- Number of falls (self reported)
- Static balance measured using sway meter

Results - TC vs Control group on sway meter?
- Better on 5/6 measurements on sway meter
- NO improvements in max leaning balance
Woo et al. (2007) RCT

- **Interventions:**
  - TC: 3x/week for 12 months
  - RTE: Resistance band exercises 3x/week for 12 months
  - CG: No exercise for 12 months

- **Outcomes Measured**
  - SMART Balance Master
  - Stance time in: semi-tandem, tandem and single stance
  - Bend reach performance test
  - Other: BMD, muscle strength, grip strength & gait velocity

- **Results - Changes in TC vs RTE or CG?**
  - NO changes in balance, flexibility or number of falls
Interventions:
- TC 6x/week 1.5 hours 8 weeks
- ED morning walk & gentle stretching, similar contact time

Outcomes Measured
- Sensory Organization Test (SOT)
- Limits of Stability Test (LOS)

Results - Improvements in static balance?
- SOT TC had better vestibular ratio
- LOS TC had better directional control of their leaning trajectory
Li et al. (2007)

- **Interventions:**
  - TC 1x/week 1 hour 12 months
  - CG maintained normal physical activity levels

- **Outcomes Measured**
  - Timed single leg stance (static balance)
  - Line walking test (dynamic balance)
  - Other: Finger choice reaction time test, Muscle strength & Ankle flexibility

- **Results - Improvements in TC vs CG?**
  - TC Improvements in static balance
  - NO difference between groups at 12 months for any outcome measure
Xiao et al. (2006)

- **Interventions:**
  - TC 3x/week 1 hour > 24 months
  - CG Other exercise and house work

- **Outcomes Measured**
  - Dynamic Balance: Tandem walking
    - Stepping on spot with eyes closed
  - Static Balance: Rhomberg test
    - One leg stand with eyes closed
  - Sensory Organization Test (SOT)
  - TUG
  - Other: Step length & Wolfson test

Results - Improvements in TC vs CG?

- Static Balance
  - Improvements in single leg stance & Rhomberg test in TC
- Dynamic Balance
  - Greater improvements in TC
- SOT
  - Improvements in 3 of 6 conditions (eyes closed)
- TUG & Others
  - NO difference
Yan et al. (2005)

- **Interventions:**
  - TC: 3x/week 30 minutes, > 3 months
  - EG: 3x/week 30 minutes, > 3 months
  - CG: No regular exercise

- **Outcomes Measured**
  - Balance performance monitor: Gait Analysis, COM
  - Static Balance: Rhomberg, Modified Rhomberg
  - TUG

- **Results - Improvements in TC vs EG and CG?**
  - Improvements in ALL outcome measures
Wang et al. (2003)

- **Interventions:**
  - TC: Long term practice
  - CG: Healthy older adults with similar education and lifestyle

- **Outcomes Measured**
  - Static balance (force plate measures)
  - Other: gait analysis, ROM and Biodex isokinetic dynamometer (LE strength)

- **Results - Improvements in TC vs CG?**
  - Improvements in force plate measures in eyes open conditions
  - No difference in eyes closed conditions
<table>
<thead>
<tr>
<th>STUDY</th>
<th>PEDro</th>
<th>Sacketts</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woo et al (2007)</td>
<td>9/11</td>
<td>1B</td>
<td>TC showed no changes in muscle strength, balance, flexibility or number of falls.</td>
</tr>
<tr>
<td>Yang et al (2007)</td>
<td>8/11</td>
<td>1B</td>
<td>TC vestibular ratio score was 47% greater at 6 months, and had an increase in quiet stance BOS.</td>
</tr>
<tr>
<td>Voukelatos et al (2007)</td>
<td>8/11</td>
<td>1B</td>
<td>TC was better on 5/6 variables measured on sway meter. No improvement in max leaning balance.</td>
</tr>
<tr>
<td>Tsang et al (2004)</td>
<td>5/11</td>
<td>2B</td>
<td>TC had better vestibular ratio (SOT), better directional control of leaning trajectory (LOS).</td>
</tr>
<tr>
<td>Li et al (2007)</td>
<td>4/11</td>
<td>4C</td>
<td>TC improvements in static balance measured by timed one leg stance, BUT no difference at 12 months.</td>
</tr>
<tr>
<td>Yan et al (2005)</td>
<td>5/11</td>
<td>3C</td>
<td>TC showed improvements in Rhomberg and Modified Rhomberg tests, completed the TUG faster &amp; improvements in static balance using force plate measures.</td>
</tr>
<tr>
<td>Xiao et al (2006)</td>
<td>5/11</td>
<td>3C</td>
<td>TC showed improvements in static balance measured by single leg stance and Rhomberg test. Also improvements in dynamic balance. No difference in TUG.</td>
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</table>
Discussion: Quality of Studies

- PEDro ratings for all studies had an average of 6/11
- RCTs, CCTs and Cross-sectional studies
- Methodological quality could be improved by:
  - Blinding of assessors
  - Randomization of intervention and control groups
  - Standardization of interventions
  - Addition of intention to treat analysis
Discussion: Outcome Measures

- Studies used many different outcome measures related to balance
- Outcome measures can be generalized into clinical or non-clinical
- We used a combination of previous literature validating outcome measures and our own judgment on what outcome measures are most appropriate for the study population
Discussion: Outcome Measures

- What are the best outcome measures for balance?
  - Which ones are validated in the literature?
  - Why is this important?

- What are the best outcome measures for the older adult population?
  - What makes them good for an older adult population?
  - Which ones are validated in the literature?
  - Why is this important?
Correlation to Falls Risk

- It is important to have balance outcome measures that correlate to falls risk because it makes them more relevant in the older adult population.
- The ability to predict falls risk and also measure our ability to reduce it can affect clinical outcomes.
- Difficult to measure falls because must rely on self reporting by subjects.
- Rogers et al. and Lord et al. described a positive correlation between an improvement in balance outcomes and risk of falls.
- Rogers et al. described that many physical parameters including reduced postural stability, decreased dynamic balance and decreased mobility are associated with an increase in fall risk in the older population.
Discussion: East vs. West Research Cultures

Western Research Culture

- Emphasis on standardization of procedures
- Methodological details are included
- Different disciplines are able to understand methods and interpret findings
Discussion:
East vs. West Research Culture

Eastern Research Culture
- Use the study design most appropriate for the subject being studied
- Methodological details are omitted
- Generally written for use by researchers within the same discipline
## Difference between included Eastern and Western studies

<table>
<thead>
<tr>
<th>Western Studies</th>
<th>Eastern Studies</th>
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<tbody>
<tr>
<td>- RCT and CCT</td>
<td>- Cross sectional studies</td>
</tr>
<tr>
<td>- Mainly non-clinical balance outcome measures</td>
<td>- Both clinical and non-clinical balance measures</td>
</tr>
<tr>
<td>- Smaller sample size</td>
<td>- Larger sample size</td>
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</table>
Discussion: Tai Chi Interventions

- Tai chi interventions in this study used a number of different forms of tai chi.
- Chinese articles did not specify the tai chi being done.
- Frequency, Intensity Time and Type varied between studies making comparison difficult.
- Variation in type to tai chi increases generalizability to a realistic community setting.
Limitations

- Small sample sizes
  - decreased power of results
  - May have missed some of the effects of tai chi on balance
- Difficult to blind tai chi intervention
- Difficult to measure the holistic nature of tai chi
  - research outcome measures may miss some important aspects of tai chi
Limitations

- Difficult to summarize the ideal tai chi program for improving balance
  - each study used different tai chi interventions
- Subjects that were considered unhealthy were not included
  - Possible effects of tai chi on this population were therefore missed
- Only one member of the research group spoke Chinese
  - used second reviewer with experience in Chinese medical research to maintain rigor
Summary

- Effects of tai chi on balance related outcome measures
  - Improved ability to utilize vestibular and somatosensory information
  - Decreased sway
  - Increased lateral stability
  - Use of increased BOS
  - Decreased reaction times
  - Decreased fear of falling/increased confidence in balance abilities
Future Research Questions

1. What is the appropriate length of intervention in order to adequately determine the effects of tai chi?
2. Is the westernized version of tai chi used in research a valid example of traditional tai chi used in the east?
3. Does western research overlook important aspects of tai chi that are not measurable by current scientific outcome measures?
4. What is the relationship between balance outcome measures and fall risk?
Future Research Questions

5. What are the best FITT (Frequency, Intensity, Type, Time) parameters for tai chi for improvements in balance, and what are the best FITT parameters to maintain these improvements?

6. What balance outcome measures are best suited, as well as valid and reliable for use in the older adult population?

7. Do different styles of tai chi have different effects on balance?

8. What is the effect of tai chi on balance in an unhealthy population?
Research implications

- Technology enables easier access and sharing of information
  - global PT knowledge translation
- It is possible to study topics across cultures
  - broader understanding of the topic
  - larger audience for findings
Clinical Implications

- No adverse effects
  - safe
- High compliance
  - interest
- No equipment/special facility required
  - cost efficient
Clinical implications

- Older population specific benefits
  - Social
  - Physical activity
  - Body awareness
  - Increased confidence in balance ability
  - Decreased fear of falling/anxiety
Clinical implications

- Tai chi may not be any more beneficial for balance than RTE or BT
- Tai chi is another option PTs can use to encourage/facilitate physical activity
- Interest-adherence / cost-feasibility
- Communication is key to finding the best fit for individualized PA recommendations
So……

- Tai chi is a safe, cheap, social, relaxing, and enjoyable way to participate in physical activity and potentially improve balance, which makes it suitable for an older population.
Acknowledgements

- Dr. Elizabeth Dean
- Dr. Susan Harris
- Charlotte Beck
- Dr. Angela Bush
- Jiao Fang Mei
Questions?
References


References