Tai Chi for Balance Problems in Geriatrics - Scientific Evidence and Clinical Practice

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Outline

- Background
  - Aging, falls and balance
- Tai Chi and Balance – scientific evidence
- Sitting Tai Chi – demonstration and sharing
- Sitting Tai Chi – scientific evidence
- Practice of Sitting Tai Chi
- Q & A

The aging population - Hong Kong

- Life expectancy

<table>
<thead>
<tr>
<th>Year</th>
<th>1981</th>
<th>2001</th>
<th>2031</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (years)</td>
<td>72.3</td>
<td>78.2</td>
<td>82.3</td>
</tr>
<tr>
<td>Female (years)</td>
<td>78.5</td>
<td>84.1</td>
<td>87.8</td>
</tr>
</tbody>
</table>

(Census and Statistics Department, Hong Kong 2002)

Falls in the elderly

- Some 25-35% of elderly subjects aged >65 fall once or more each year (Tinetti et al. 1988)
- Fall rate increases with age
  - 34% - 65 to 74 years old
  - 35% - 75 to 84 years old
  - 51% - 85 and above (Whitney & Rossi 1999)
- Fall-related injuries are the leading cause of death from injury in this age group (Kanten et al. 1993)
Causes of falls

Extrinsic (within the environment)
  - Impaired postural control
  - Others

Intrinsic (within the person)

Risk Factors of Falls: 16 Multivariate Studies

<table>
<thead>
<tr>
<th>Factor</th>
<th>Signif/All</th>
<th>Mean RR</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weakness</td>
<td>10/11</td>
<td>4.4</td>
<td>1.5 - 10.3</td>
</tr>
<tr>
<td>Prior fall</td>
<td>12/13</td>
<td>3.0</td>
<td>1.7 - 7.0</td>
</tr>
<tr>
<td>Balance deficit</td>
<td>8/11</td>
<td>2.9</td>
<td>1.6 - 5.4</td>
</tr>
<tr>
<td>Gait deficit</td>
<td>10/12</td>
<td>2.9</td>
<td>1.3 - 5.6</td>
</tr>
<tr>
<td>Assistive device</td>
<td>8/8</td>
<td>2.6</td>
<td>1.2 - 4.6</td>
</tr>
<tr>
<td>Vision deficit</td>
<td>6/12</td>
<td>2.5</td>
<td>1.6 - 3.5</td>
</tr>
<tr>
<td>Arthritis</td>
<td>3/7</td>
<td>2.4</td>
<td>1.9 - 2.9</td>
</tr>
<tr>
<td>ADL deficit</td>
<td>8/9</td>
<td>2.3</td>
<td>1.5 - 3.1</td>
</tr>
<tr>
<td>Depression</td>
<td>3/6</td>
<td>2.2</td>
<td>1.7 - 2.3</td>
</tr>
<tr>
<td>Cognitive deficit</td>
<td>4/11</td>
<td>1.8</td>
<td>1.0 - 2.3</td>
</tr>
<tr>
<td>Age &gt; 80</td>
<td>5/8</td>
<td>1.7</td>
<td>1.1 - 2.5</td>
</tr>
</tbody>
</table>


Balance control & ageing

- Degeneration in the vestibular sensory epithelium
  - 40% reduction in subjects aged >70 (Rosenthal & Rubin 1975)
- Impaired vision
  - Multiple fallers have impaired depth perception, contrast sensitivity, and low-contrast visual acuity (Lord & Dayhew 2001)
- Decreased joint proprioception (Yan & Hui-Chan 2001)
Balance control & ageing

- Decreased muscle strength
  - A decrease of 20 – 40% from age 20s to 70s (Stalberg et al. 1989)
  - A relationship between knee and ankle weakness and falls exists (Whipple et al. 1987)

- Elderly subject performed less well than young subjects when standing under reduced or conflicting sensory conditions (Woollacott et al. 1986; Tsang, Wong, Fu & Hui-Chan, 2004)

Tai Chi

- Tai Chi is a traditional exercise practiced by millions of Chinese for over 300 years
- There are 108 forms with different styles
  - Yang, Chen, Sun, Wu and Yin (Tsao 1995)

(Kirtley 1998)
Somatosensory system and limb proprioception

- Limb proprioception is defined as a sense of position and movement of one’s own limbs and body in the absence of vision, termed “limb position sense” and “kinesthesia” respectively
  
  (Gardner 2000)

Tai Chi - rationale

- Tai Chi puts a great emphasis on the exact joint position and direction
- Could its repeated practice improve joint position sense of the limbs?  
  
  (Tsao 1995)

Passive knee joint positioning

- Blindfold was used to occlude visual input
- Air-splint was applied to the ankle to minimize cutaneous input
- Dominant knee was tested at 30° of knee flexion with the knee joint passively extended by 3° at 3°/s
- After return to the initial position, the knee joint was passively moved at the same speed of 3°/s
- When the perceived target position was reached, subject pressed a thumb switch
- Absolute angle error was calculated
- 3 trials were recorded

Knee joint repositioning test: Results

<table>
<thead>
<tr>
<th></th>
<th>Golfer</th>
<th>Tai Chi subjects</th>
<th>Elderly control subjects</th>
<th>Young control subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute angle error (0)</td>
<td>1.3±0.7</td>
<td>1.7±1.3</td>
<td>3.9±3.1</td>
<td>1.1±0.5</td>
</tr>
</tbody>
</table>

* Denotes significant difference at $p < 0.05$ between elderly control subjects vs others
  
  (Tsang & Hui-Chan 2004)
Main findings demonstrated that Tai Chi practitioners had better knee proprioception sense.

- They produced significantly less knee angle errors than control subjects in passive repositioning test.

**Sensory organization**

- When a combination of inputs is used:
  - ↓ weight to less accurate information
  - ↑ weight to more accurate information
- Process of selecting and integrating appropriate sensory information at the level of the CNS is termed sensory organization (Nashner 1994)

**Rationale**

- Practicing Tai Chi involves limb, head and trunk movement that will stimulate the somatosensory, visual and vestibular systems.
Posturography

- Sensory Organization Test (SOT)
  - 6 conditions
  - Parameters:
  - Equilibrium score (%) – Increase sway will decrease the score
  - Condition 1
  - Condition 2
  - Condition 3
  - Condition 4
  - Condition 5
  - Condition 6

(NeuroCom International, Inc. 2003)

Sensory Organization Test (SOT)

Equilibrium score = \( \frac{12.5^\circ - (\theta_{\text{max}} - \theta_{\text{min}})}{12.5^\circ} \times 100 \)

Somatosensory contribution = \( \frac{\text{Condition 2}}{\text{Condition 1}} \)

Visual contribution = \( \frac{\text{Condition 4}}{\text{Condition 1}} \)

Vestibular contribution = \( \frac{\text{Condition 5}}{\text{Condition 1}} \)

(Nashner 1993)

Results

Balance control under different sensory conditions

Young subjects
Elderly Tai Chi subjects
Elderly control subjects

somatosensory ratio: 0.98 ± 0.03, 0.98 ± 0.03
visual ratio: 0.82 ± 0.11, 0.74 ± 0.14
vestibular ratio: 0.87 ± 0.08, 0.58 ± 0.17

* Denotes significant difference at P < 0.05 between elderly control subjects with young and elderly Tai Chi subjects by using Bonferroni post-hoc tests (Tsang & Hui-Chan 2004)

Discussion & conclusion

- Elderly Tai Chi practitioners had less body sway than elderly control subjects when standing under reduced or conflicting sensory conditions, especially those requiring an increased reliance on the visual and vestibular systems.
- Of particular interest is that these elderly Tai Chi practitioners attained the same level of balance control performance as young, healthy subjects under what could be considered more functional contexts.
Rationale

- Decrease in muscle strength is another one of the intrinsic factors that causes falls in elderly (Carter et al. 2001)
- With the knees bent most of the time while performing the various Tai Chi forms, the knee muscles could be expected to increase in strength

Objective

- To examine whether elderly Tai Chi practitioners had better concentric and eccentric knee extensor and flexor strength than elderly healthy control subjects

Tsang & Hui-Chan (2005)

Methodology

- Concentric and eccentric isokinetic strength tests of knee extensors and flexors (dominant leg)
  - conducted at 30°/s using the Cybex Norm™ system
  - 5 repetitions each with 1 minute rest (Chan et al. 1996)
- Outcome measure
  - Mean of 3 maximum peak torques from 5 repetitions (Urquhart et al. 1995)

ICC (3,3) of 0.86-0.97 showing high data reproducibility
**Results**

**Knee muscle strength**

![Graph showing comparison of Tai Chi and non-Tai Chi practitioners' peak torque body weight ratio (N.m/kg) for concentric and eccentric muscle actions.]

Univariate tests: * P < 0.05  
** P < 0.01

Comparison of Tai Chi and non-Tai Chi practitioners:

<table>
<thead>
<tr>
<th>Muscle Action</th>
<th>Tai Chi</th>
<th>Non-Tai Chi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentric knee extensors</td>
<td>1.5 ± 0.4</td>
<td>1.1 ± 0.4</td>
</tr>
<tr>
<td>Concentric knee flexors</td>
<td>0.7 ± 0.3</td>
<td>0.5 ± 0.3</td>
</tr>
<tr>
<td>Eccentric knee extensors</td>
<td>1.7 ± 0.8</td>
<td>1.4 ± 0.4</td>
</tr>
<tr>
<td>Eccentric knee flexors</td>
<td>1.1 ± 0.3</td>
<td>0.8 ± 0.3</td>
</tr>
</tbody>
</table>

**Discussion**

Main findings showed that subjects who had practiced Tai Chi for 8.5 (± SD 7.6) years achieved significantly:

- greater knee extensor and flexor strength

**Limits of stability (LOS)**

- The maximum distance a person can lean in a given direction without losing balance, stepping, or reaching

**Limits of stability test**

- Subject’s ability to voluntarily sway to 8 target positions in space, as fast and as accurately as possible
- Outcome measures:
  1. **Reaction time**
     - Time from appearance of target stimulus to initiation of voluntary shifting of the center of gravity
  2. **Maximum excursion**
     - The furthest distance traveled by the COP during a trial
  3. **Directional control**
     - Comparison of the amount of movement in the on-target direction to the amount of off-target movement
Limits of stability test: Results

- Multivariate analysis of variance tests indicated an overall statistically significant effect across the 3 outcome measures between the elderly Tai Chi and control subjects ($P = 0.005$)
- Univariate tests

<table>
<thead>
<tr>
<th></th>
<th>Tai Chi</th>
<th>Control</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction time (s)</td>
<td>0.8 (± 0.2)</td>
<td>1.1 (± 0.3)</td>
<td>0.008**</td>
</tr>
<tr>
<td>Maximum excursion (%)</td>
<td>5.2 (± 0.6)</td>
<td>4.6 (± 0.5)</td>
<td>0.001**</td>
</tr>
<tr>
<td>Directional control (%)</td>
<td>75.9 (±10.0)</td>
<td>68.5 (±6.9)</td>
<td>0.008**</td>
</tr>
</tbody>
</table>

** Denotes significant difference at $p < 0.01$ using univariate tests

Balance control is the interaction of

Balance control is the interaction of Neuro-muscular, Musculo-skeletal, Sensory/perceptual, and Cognition.

Background

- **Tai Chi:**
  - Mind-body exercise that requires a lot of eye-hand coordination and balance control
  - Mental concentration is required during practicing
  - Comparable to complex motor skill training (Wolf et al., 1997)

Methodology

Condition 1

Condition 2

Condition 3
Methodology

1. Reaction time
2. Movement time
3. Accuracy
4. Wrong movement

Results

Movement time (ms)

- *p<0.001
- *p=0.022
- *p=0.010
- *p=0.003

Accuracy (mm)

- *p=0.002
- *p=0.021
- *p=0.016
- *p=0.024

Wrong movement (number)

- *p=0.003
- *p=0.039
Conclusion

- Aging effects:
  - A decline in eye-hand coordination occurs in finger-pointing tasks that require cognitive processing in a choice paradigm

- Tai Chi effects:
  - Tai Chi practitioners attained significantly faster movement times, better accuracy and less wrong movements than the control subjects

Exercise guidelines

- Accurate joint position and direction
- Incorporating the interaction of 3 sensory systems: somatosensory, visual and vestibular systems
- Muscle strength
- Balance limits of stability and directional control
- Concentration / cognitive component

Sitting Tai Chi

Demonstration and Sharing
A 12-form sitting Tai Chi was designed by our team and an experienced Tai Chi master.

Derived from Yang’s style of the classic long-form Tai Chi.

Enhance control in weight shifting in different directions, and promote sensorimotor coordination involving the eyes, head, hands and trunk in a smooth and coordinated manner.

Kinematics and energy expenditure analyses provide scientific knowledge of sitting Tai Chi.

As a therapeutic exercise in intervention.

Methods:
- A Tai Chi master with 3 years of experience in teaching the sitting Tai Chi.
- Age, 63 years old
- Body weight, 55kg
- Height, 1.68m
- BMI, 19.6 kg/m2
Experiment protocol - kinematics

- The master was asked to perform the 12 forms of the sitting Tai Chi. Each form was captured separately.
- The maximum displacements in the anteroposterior (AP), mediolateral (ML) and vertical directions were normalized using the subject’s standing height.
- The corresponding traditional 12 forms of standing Tai Chi were also captured for comparison.

Equipment - Kinematics

- Centre of mass (COM) displacements were determined using a Vicon motion analysis system (Oxford Metrics Ltd., UK).
- The system tracked and recorded the trajectories of 30 retro-reflective markers positioned on the subject’s body.
- The trajectories of the retro-reflective markers in the frontal, sagittal and axial planes were recorded by 8 infrared-cameras (MX F20 x 4 and MX F40 x 4).
- The 3-dimensional reconstructions of the trajectory of the COM were processed by Vicon’s Nexus 1.3.106.30033 software.

Example – Form 8 (左右蹬腳)

Sitting Tai Chi - Kinematics

Displacement of center of mass

- anteroposterior: 10.3% (body height)
- mediolateral: 5.7% (body height)
- vertical: 7.5% (body height)
Displacements of the COM during sitting Tai Chi

- Maximal displacement of the COM in the AP direction of each sitting form ranged from 1.5% to 10.3% of the subject’s standing height (mean = 3.5%)

- Form 7 (needle on the sea bottom [海底針]) had the largest AP displacement among the 12 forms (10.3%)

Medial-lateral (ML) displacement

- In the ML direction, the maximum COM displacement ranged from 0.4% to 5.7% of the subject’s standing height with a mean of 3.3%

- Form 8 (wave hands as clouds [雲手]) had the greatest ML displacement (5.7%)

Vertical displacement

- The COM displacements in the vertical direction ranged from 2.3% to 7.5% of the subject’s standing height, with a mean of 3.6%

- Form 10 (turn and kick with heel [左右蹬腳]) had the largest vertical COM displacement (7.5%)

Trajectory of COM displacements

- Form 8 (wave hands as clouds [雲手]) was selected as one of the 12 forms

- Expected to demand well controlled, continuous weight shifting which would demonstrate clearly the trajectory of the COM
Comparisons of COM displacements between sitting and traditional standing Tai Chi

- Mean values of the maximum displacement of the COM in the AP, ML and vertical directions in sitting Tai Chi were 3.5%, 3.3% and 3.6%, with a total mean of 3.5%

- Corresponding means in traditional standing were 21.4%, 20.0% and 10.9% with an overall mean of 17.3%

Clinical implications

- Provides information useful for selecting forms for individuals with different capabilities, and it provides general guidelines for progression

- Balance training can be progressed from forms with smaller displacements to larger excursions, depending on the degree of fragility

- Can be performed in a less stable sitting condition, such as on a cushion or even a wobble board if balance training is therapeutic objective (Leung & Tsang 2008)

Experiment protocol – energy expenditure

- Oxygen consumption (VO2) was measured for 5 minutes at rest, and measurement was then continued during 10 minutes of Tai Chi practice (Levine 2007)

- The VO2 during the 10 minutes of Tai Chi movements was then averaged

- The Tai Chi master repeated the 12 forms in four different positions

Equipment – energy expenditure

- Oxygen consumption during the Tai Chi performed in different positions was measured using a portable cardiopulmonary exercise testing (K4b2, Cosmed S.R.L., Rome, Italy)

- Before each trial, the system was calibrated using ambient room air and calibration gas

- Calibration of the turbine was performed using a 3 litre syringe
Energy expenditures of Tai Chi

1. Sitting: 1.9 METs
2. Sitting with sandbags anchored on limbs: 2.5 METs
3. Standing without lower movement: 2.7 METs
4. Traditional standing manner: 4.6 METs

Discussion

- Sitting Tai Chi is a low intensity exercise, which is in line with the findings of other studies (Fontana et al 2000).
- Fontana and colleagues estimated the energy cost of a sitting T'ai Chi Ch'ih routine (a modified form of traditional Tai Chi) to be 1.5 METs.
- Slightly greater MET values (1.9 METs) in our 12 forms, which is similar to the activity level of arts and crafts in standing with light to moderate effort (Ainsworth et al 2000).
- The slightly greater METs may be due to the involvement of large muscle groups in the lower limbs in the 12-form sitting Tai Chi routine.

Clinical implications

- 1.9 METs reaches the minimal effective training intensity (30% VO2 reserve) (Swain et al 2002) for elderly subjects nearly 80 years of age (Foster et al 1986) or patients with stable heart failure (Wisloff et al 2007).
- Individuals with compromised aerobic capacity may find it an alternative exercise for cardio-respiratory training.
- Provide a guideline for clinicians or practitioners selecting conditions/positions to suit different functional and aerobic needs.
Changes of frontal lobe oxygenation and heart rate variability during Tai Chi practice and ergometer cycling.

Question A

- Is there a difference between the mind-body exercise like Tai Chi and the bodily focused exercise cycling on the autonomic control of heart?

Question B

- What different effects of mind-body exercise on the prefrontal cortex activity from the bodily focused exercise based on its characteristics of mind-body relationship?

Methodology

- Single subject case study
  - Subject profile
    - Tai Chi master with >20 years Tai Chi practicing experience
    - No cardiovascular disease, no neurological insufficiency
    - Height and weight: 168cm, 56kg
  - Procedure
    - Two assessments at similar time of two days in the same laboratory
    - rest in sitting 10 min → exercise (standing static Tai Chi or standing arm ergometer cycling) 12 min → recovery in sitting 10 min
Methodology

- Equipment
  - Cerebral oxygenation measurement
    - Near Infrared Spectroscopy: NIRO-200 (Hamamatsu Photonics, Japan)
  - Heart rate variability measurement
    - R-R intervals recorded by a RR recorder (Polar S810, Polar Electro Ltd., Finland)
  - Respiratory parameters
    - K4B2 (COSMED Srl, Italy)

- Data Analyses
  - Level of oxyhaemoglobin (O$_2$Hb) and total haemoglobin (cHb) changes during two exercises
    - Baseline—the second 5 min of rest
    - 12 min of exercises—every one minute normalized to baseline value
    - Recovery—5 min followed by exercise
  - Short-time Fourier transformation (SFFT) of the RR intervals
    - It is used in exercise condition
    - HF power—indicator of vagal control
    - LF power—indicator of sympathetic control (controversial)
    - LF/HF—the sympatho-vagal balance

(Cottin et al., 2002, 2004; Martinmaki et al., 2006, 2008; Martinmaki and Rusko, 2008)

Results

- The respiratory parameters of two exercises

<table>
<thead>
<tr>
<th></th>
<th>Tai Chi</th>
<th>Egometer cycling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity (METs)</td>
<td>2.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Respiratory frequency (Hz)</td>
<td>0.31</td>
<td>0.34</td>
</tr>
<tr>
<td>Tidal volume (L)</td>
<td>0.85</td>
<td>0.79</td>
</tr>
<tr>
<td>Heart rate (bpm)</td>
<td>105</td>
<td>96</td>
</tr>
</tbody>
</table>

(Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996)
Results

- Changes of $O_2$Hb and cHb during the two exercises

![Graph A](image)

![Graph B](image)

Results

- HRV during the two exercises

![Graph C](image)

Discussions

- The exercise intensity were similar during the two exercises
  Tai Chi: combine both elements  
  Physical exercise only

- Higher prefrontal oxygenation level during TC indicated the mental activity during TC was more than that during arm ergometer cycling

- Lower LF/HF ratio and higher HF power during TC showed that the parasympathetic activity was dominant when compared with arm ergometer cycling
研究目的

- 設計一套坐式太極，讓站立有困難及體弱長者練習
- 研究坐式太極對長者的影響
  - 坐姿平衡
  - 手眼協調
  - 個人生活滿意程度

坐式太極訓練

- 十二式太極
- 專注於
  - 身體重心轉移
  - 手眼協調
  - 手腳及身體活動
  - 流暢動作
- 安全 → 長者不必擔心跌倒
- 每星期三次，每次一小時
- 每班5至8人
- 由物理治療師教導

訓練前測試
坐式太極訓練 一般運動訓練
訓練後測試

- 坐式太極組(40人)(8男32女)
- 對照組(61人)(17男44女)

訓練項目

- 白鶴亮翅 左右穿梭
- 金雞獨立 左蹬腿
- 海底針
一般運動訓練

- 關節活動鍛鍊
- 肌肉鍛鍊
- 伸展訓練

研究對象

<table>
<thead>
<tr>
<th></th>
<th>對照組 (61人)</th>
<th>坐式太極組 (40人)</th>
</tr>
</thead>
<tbody>
<tr>
<td>年齡</td>
<td>84.7 ± 7.5</td>
<td>83.1 ± 8.5</td>
</tr>
<tr>
<td>性別 (男/女)</td>
<td>17 / 44</td>
<td>8 / 32</td>
</tr>
<tr>
<td>簡短智能測驗 (MMSE)數值</td>
<td>18.7 ± 4.6</td>
<td>19.6 ± 5.2</td>
</tr>
</tbody>
</table>

坐姿平衡

- 坐定前伸測試 (Sit-and-forward reach)

研究結果
坐定前伸測試

- 坐式太極組比對照組可前伸至更遠距離

日常生活中有不少活動，如更衣、轉移到床或椅等，都需要維持坐姿平衡

練習坐式太極後，長者可在坐下時維持較佳的平衡

手眼協調

- 要求長者以最快速度，準確地接觸於電腦上三個不同位置的目標

測試：
- 反應時間
- 移動時間
- 準確度
手眼協調 - 反應時間

<table>
<thead>
<tr>
<th></th>
<th>對照組</th>
<th>坐式太極組</th>
<th>P值</th>
</tr>
</thead>
<tbody>
<tr>
<td>反應時間</td>
<td>35.6 ± 10.2</td>
<td>33 ± 7.2</td>
<td>0.049*</td>
</tr>
</tbody>
</table>

手眼協調 - 移動時間

<table>
<thead>
<tr>
<th></th>
<th>對照組</th>
<th>坐式太極組</th>
<th>P值</th>
</tr>
</thead>
<tbody>
<tr>
<td>移動時間</td>
<td>1.2 ± 5.1</td>
<td>2.0 ± 4.6</td>
<td>0.787</td>
</tr>
</tbody>
</table>

手眼協調 - 誤差度

<table>
<thead>
<tr>
<th></th>
<th>對照組</th>
<th>坐式太極組</th>
<th>P值</th>
</tr>
</thead>
<tbody>
<tr>
<td>誤差度</td>
<td>21.1 ± 7.8</td>
<td>-5.8 ± 3.6</td>
<td>0.024*</td>
</tr>
</tbody>
</table>

注：*表示統計上顯著差異。
坐式太極組長者較對照組長者優勝:

- 反應時間
- 接觸目標準確度

讓長者可在日常生活中更容易提取物件

個人生活滿意程度

(Personal Wellbeing Index)

Q0 – 整個人生個人際遇
Q1 – 生活水平指數
Q2 – 生活水平指數
Q3 – 身體健康狀況
Q4 – 與其他人相處關係
Q5 – 社會融洽程度
Q6 – 未來人生保障
Q7 – 個人安全感

PWI Value – Q1至Q7平均數值
總結

● 簡短智能測驗（MMSE）中平均值：19.6
→ 有輕微認知障礙 (<24, 總分 = 30)
→ 仍能學習坐式太極

Future

● Tai Chi, Qigong and Physiotherapy
● Target population
  ● Frail and institutionalized elderly
  ● Subjects with spinal cord injury
  ● Stroke survivors
  ● Mild cognitive impairments

Questions – Tai Chi-falls-balance relationship

● Optimal style
● Frequency
● Duration
● Intensity parameters for varying populations
● Use of consistent, clinically relevant falls-related outcomes

(Harmer and Li 2008)
Our reference list:

2. Leung DPK, Chan CKL, Tsang HWH, Tsang WWN. Tai Chi as an intervention to improve balance and reduce falls in older adults: A systematic and meta-analytical review. Alternative Therapies in Health and Medicine 2010; In press.
4. Tsang WWN, Fu.