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## Tai Chi as an adjunct physical activity for adults aged 45 years and older enrolled in phase III cardiac rehabilitation

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### Abstract

**Background**—Cardiac rehabilitation improves physical, cognitive and psychosocial functioning, yet services are greatly underutilized with increasing patterns of attrition over time. Tai Chi has been suggested as a possible adjunct to cardiac rehabilitation exercise training.

**Aim**—To describe differences in physical, cognitive and psychosocial functioning among adults 45 years old attending phase III cardiac rehabilitation, who have or have not self-selected Tai Chi exercise as an adjunct physical activity.

**Methods**—A cross-sectional design compared subjects attending group-based Wu style Tai Chi classes plus cardiac rehabilitation, with cardiac rehabilitation only. Subjects had a battery of physical and cognitive functioning tests administered to examine aerobic endurance, balance, strength, and flexibility, verbal retrieval/recall, attention, concentration and tracking. Subjects completed a health survey to ascertain cardiac event information, medical history, and psychosocial functioning (i.e. health-related quality of life, stress, depressive symptoms, social support, and Tai Chi self-efficacy).

**Results**—A total of 51 subjects (75% married, 84% college-educated, 96% White/European-American) participated. Subjects were on average 70 ( $\pm$  8) years old and had attended cardiac rehabilitation for 45 ( $\pm$  37) months. Approximately 45% ( $n = 23$ ) attended Tai Chi classes plus cardiac rehabilitation, while 55% ( $n = 28$ ) attended cardiac rehabilitation only. Subjects attending Tai Chi plus cardiac rehabilitation had better balance, perceived physical health, and Tai Chi self-efficacy compared to those attending cardiac rehabilitation only ( $p = 0.03$ ).

**Conclusion**—Tai Chi can be easily implemented in any community/cardiac rehabilitation facility, and may offer adults additional options after a cardiac event.

### Keywords

Rehabilitation; Tai Chi; physical activity; aged adults

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## Introduction

Coronary heart disease (CHD) is the leading cause of death for both men and women in the United States, and in 2006 accounted for 1 in every 6 deaths<sup>1</sup>. In 2010, an estimated 785,000 Americans will have a new CHD event and 470,000 will have a recurrent CHD event<sup>1</sup>. CHD is a chronic condition needing long-term rehabilitation measures to decrease mortality, morbidity and improve quality of life<sup>1</sup>. Substantial research evidence supports multiple benefits of cardiac rehabilitation for medical or surgical revascularization, e.g. following an acute myocardial infarction, acute coronary syndrome, coronary artery bypass grafting, or percutaneous coronary intervention<sup>2-4</sup>. Long-term rehabilitation (i.e. phase III cardiac rehabilitation) generally occurs 6–12 months after the initial CHD event and provides longer term (e.g. 1–4 years) delivery of rehabilitative services for persons with CHD<sup>2</sup>.

Cardiac rehabilitation improves physical, cognitive and psychosocial functioning, yet services are greatly underutilized with increasing patterns of attrition over time<sup>4-6</sup>. Less than 1 in 5 adults enroll in cardiac rehabilitation after a cardiac event<sup>7</sup>. Given the number of persons expected to have a CHD event this year, the identification of novel, adjunct approaches to encourage long-term cardiac rehabilitation exercise participation is needed<sup>8-10</sup>. Tai Chi exercise may fill this gap, and has been suggested as a possible adjunct to cardiac rehabilitation exercise training<sup>11</sup>.

Tai Chi is a low-impact moderate-intensity exercise, appeals to older adults, and may offer benefits beyond cardiac rehabilitation programs, by combining physical movements with mental concentration and relaxation<sup>11,12</sup>. During the performance of Tai Chi exercise, individuals are taught to be mindful of what their bodies are doing and how it feels. The goal is for the whole body to remain relaxed while practicing Tai Chi, integrating mental concentration and breathing control<sup>13</sup>. Tai Chi does not require any special clothing or equipment, making it a cost-effective and affordable form of exercise for both patients and cardiac rehabilitation facilities.

A growing body of evidence examining Tai Chi exercise research in non-CHD populations (e.g. community-dwelling older adults) indicates significant improvements in physical, cognitive and psychosocial functioning<sup>14-18</sup>. Tai Chi has been safely performed by adults with a variety of chronic diseases including osteoarthritis<sup>17,18</sup>, multiple sclerosis<sup>19,20</sup>, and chronic heart failure<sup>21,22</sup>. To date, there are only 2 published studies on the effects of Tai Chi among cardiac rehabilitation subjects<sup>23,24</sup>, and only hemodynamic status and aerobic endurance were examined. The study by Channer and colleagues<sup>23</sup> reported that Tai Chi subjects had significant within group reductions in blood pressure ( $p < 0.05$ ), while Lan and colleagues<sup>24</sup> reported that Tai Chi subjects had significant improvements in aerobic endurance, compared to subjects in a walking program ( $p < 0.01$ ).

In these studies, only phase II subjects were enrolled, different Tai Chi styles were used (Wu short form-47 postures<sup>23</sup> vs. Yang long form-108 postures<sup>24</sup>), and had different intervention lengths (8 weeks<sup>23</sup> vs. 52 weeks<sup>24</sup>). However, phase III cardiac rehabilitation subjects are different from phase II subjects, as phase II are telemetry monitored, gradually increasing their exercise intensity and duration during the first 3–6 months after the CHD event, due to

a greater risk for adverse events during exercise<sup>4</sup>. In addition, comprehensive outcomes for phase III subjects need to be expanded to include physical, cognitive and psychosocial functioning. No reported studies have examined Tai Chi exercise for phase III cardiac rehabilitation subjects. Therefore, the overall objective of this study was to describe differences in physical, cognitive and psychosocial functioning between adults aged 45 years and older attending phase III cardiac rehabilitation who have or have not self-selected Tai Chi exercise as an adjunct physical activity.

## Methods

### Research design

A cross-sectional design was used to compare subjects attending group-based Wu style Tai Chi classes plus cardiac rehabilitation, with those attending cardiac rehabilitation only. Data were collected from December 2008 through March 2010.

### Subjects

Men and women aged 45 years and older, attending phase III cardiac rehabilitation were targeted for enrollment in the study. Tai Chi exercise classes taught by the same instructor (E.S.), are offered at two different cardiac rehabilitation facilities in Tucson, AZ for those enrolled in cardiac rehabilitation. Potential subjects from both facilities, who had or had not self-selected Tai Chi exercise as an adjunct physical activity to phase III cardiac rehabilitation were recruited. Subjects were able to understand the English language sufficiently to give study consent, answer questions, and follow instructions. Persons under 45 years of age were excluded, as there is a lower incidence of CHD in this age group<sup>1</sup>.

Approval to conduct the study was obtained from the Institutional Review Boards at the University of Arizona and Northwest Medical Center, Tucson, AZ. The investigation was carried out according to the principles outlined in the Declaration of Helsinki, including written informed consent from all subjects.

### Cardiac rehabilitation program

The cardiac rehabilitation facilities included in this study both employ comprehensive cardiac rehabilitation programs with several phases of progression. Phase I begins in the hospital while patients are recovering from a cardiac event, with low-level activity and education emphasized. During phase II, participants are closely monitored and supervised. Phase II cardiac rehabilitation begins soon after leaving the hospital and typically lasts between eight and twelve weeks. Participants improve their cardiovascular endurance and overall health through monitored exercise sessions, educational classes, and guidance from cardiac rehabilitation staff. Exercise sessions include aerobic conditioning, muscular strengthening, and flexibility exercises. Heart rate, blood pressure, electrocardiographic monitoring, oxygen saturation, and blood glucose levels are recorded before, during, and after each exercise session. Educational class topics include heart anatomy and disease, cardiac risk factors, exercise, nutrition, and stress management. A registered dietitian is also available for nutritional consultation. When participants no longer require intensive monitoring, they enter phase III of the cardiac rehabilitation program. The goal of phase III

is to have participants maintain the cardiovascular endurance and heart-healthy lifestyle behaviors achieved during phase II. Exercise regimens are guided by participants' goals, needs, and capabilities.

### **Tai Chi exercise classes**

Tai Chi classes were taught by a registered nurse (E.S.) with over 45 years of experience. She has been trained in the Classic Wu style of Tai Chi by world renowned masters of the Wu style family. Wu style is often called an “elegant” style and is acknowledged for its' health benefits. All Tai Chi classes were held in a specially designated serene and spacious room within the cardiac rehabilitation facility. Subjects were taught correct body preparation, standing meditation, cat walk, and five basic steps (details located at: <http://www.wutaichitucson.com/>). Chairs were provided for safety and subjects were monitored closely. As subjects demonstrate ability, movements were added one by one. These movements were demonstrated and repeated numerous times. Each movement was broken into its components and practiced in many ways, e.g. using just legs, then just arms, and finally arms and legs together. There was a spectrum of skill. Some subjects were able to learn all 106 movements while others practice twenty or only five. Each subject was treated as an individual and each class was structured to those present. For those desiring further resources, a classic Wu style Tai Chi book<sup>25</sup> and DVD<sup>26</sup> were available to those who wished to purchase them. Each class lasted approximately 75 min. Warm up exercises were performed in the beginning, while stretching and 15 min of arm movements from the first section of Xiang Kung Qi Gong<sup>27</sup> were provided at the end of class. Subjects can participate in Tai Chi classes four days per week, and were encouraged to practice at home daily according to their ability. During class, Tai Chi philosophy, the “Tai Chi Classics”, Chinese culture, along with yin-yang theory are discussed including their application to the Tai Chi movements.

### **Procedure**

Potential subjects were recruited by placing study flyers, ads and brochures in prominent locations at the cardiac rehabilitation facilities. The cardiac rehabilitation staff aided in recruitment of potential subjects, and the facilities provided space to conduct study assessments. Interested subjects contacted the principal investigator for further information and to determine eligibility. If eligible, subjects were invited to complete the informed consent, a battery of physical and cognitive functioning tests, and study questionnaire. Subjects were given a \$10 gift card to a local store, to thank them for their time participating in the study.

### **Measures**

A comprehensive, self-administered health survey was mailed to subjects for completion prior to their study appointment. Survey items included age, gender, marital status, educational level, employment status, household income, birthplace, race/ethnicity, and self-reported cardiac event information, medical history, and psychosocial functioning. Cardiac event information included details on their medical or surgical revascularization, along with the length of time subjects had attended cardiac rehabilitation.

Psychosocial functioning was evaluated using the Medical Outcomes Study Short Form 36-items<sup>28</sup> to assess health-related quality of life, the Perceived Stress Scale<sup>29</sup> to assess perceived stress, the Center for Epidemiological Studies Depression scale<sup>30</sup> to assess depressive symptoms, the Multidimensional Scale of Perceived Social Support<sup>31</sup> to assess perceived social support, and the Tai Chi self-efficacy scale<sup>32</sup> to assess perceived confidence to overcome barriers and perform Tai Chi exercise.

The battery of physical functioning tests administered included a two-minute step-in-place test to assess aerobic endurance<sup>33</sup>, single leg stance and functional reach tests to assess balance<sup>34,35</sup>, arm curl and chair stand tests to assess muscular strength and endurance<sup>33</sup>, and back scratch and chair-sit-and-reach tests to assess flexibility<sup>33</sup>. The cognitive functioning tests administered included a 60-second animal naming test to assess verbal retrieval and recall, while forward and backward digit span tests were used to assess attention, concentration and mental tracking<sup>36</sup>. These measures have been used in other community-dwelling older adults with cardiovascular health problems<sup>14–16</sup>. The psychometric properties of these measures are summarized in Table 1, along with the interpretability of the scores and the estimated time to complete them.

### Data analysis

All forms were reviewed for accuracy and completeness at the study appointment. Frequencies were calculated to check for extreme values. Descriptive statistics were calculated for all variables. To describe differences between subjects attending Tai Chi classes plus cardiac rehabilitation with those attending cardiac rehabilitation only, independent samples t-tests were calculated. Finally, internal consistencies of all psychosocial functioning measures were calculated using Cronbach's alpha coefficients. Data were analyzed using SPSS 16.0 for Windows (SPSS, Inc.).

### Results

A total of 65 persons were screened by phone for eligibility, of those, 60 persons met the inclusion criteria for study participation. Following study screening, 9 persons were unable to participate due to time conflicts (n = 6), or they were no longer interested (n = 3). Approximately 85% (n = 51) of the eligible subjects, enrolled in the study. Among these 51 subjects, 45% (n = 23) attended group-based Wu style Tai Chi classes plus cardiac rehabilitation, while 55% (n = 28) attended cardiac rehabilitation only.

Characteristics of subjects in this study are presented in Table 2. Subjects were on average 70 ( $\pm$  8) years old (range = 49–86 years), and had attended cardiac rehabilitation for 45 ( $\pm$  37) months. The majority were married (75%), college educated (84%), White/European-American (96%), men (71%) with an annual income \$35,000/year (84%). Coronary artery bypass surgery (65%) was the most commonly self-reported cardiac event, followed by angioplasty/stent (57%), and a myocardial infarction (51%). Self-reported CHD risk factors included: 86% hypertension (100% taking medications), 80% dyslipidemia (100% taking medications), 31% engaged in less than 150 minute moderate-intensity physical activity/week, and 2% current smoker. The most commonly self-reported co-morbidities included:

prior cancer (32%-mainly skin and prostate), degenerative disc/joint disease (26%), and chronic back pain (22%).

Subjects attending the group-based Tai Chi classes plus cardiac rehabilitation (n = 23) reported very strong satisfaction with Tai Chi (Table 3). On the other hand, subjects attending cardiac rehabilitation only (n = 28) reported only a moderate level of willingness to learn Tai Chi (61%), or participate in a future 12-week Tai Chi intervention study (57%).

### **Aggregate physical and cognitive functioning compared to age-specific norms**

Reported age-specific normative physical functioning data<sup>34,37,38</sup> indicate that the women (n = 15) in this study scored at the 50th percentile or higher on all physical functioning measures, while the men (n = 36) scored at the 50th percentile or higher only on the balance and strength measures (Table 4). The age-specific normative cognitive functioning data<sup>39,40</sup> indicate that subjects in this study with 13 years of formal education (n = 43) scored above the 50th percentile for verbal retrieval and recall (Table 5). On average subjects were able to complete the physical functioning measures in 27 ( $\pm$  6.4) min, the cognitive functioning measures in 9 ( $\pm$  3.2) min, and the study questionnaire containing the psychosocial measures in 36 ( $\pm$  15.2) min. Cronbach's alpha coefficients for the psychosocial functioning measures were good and ranged from 0.71 (confidence to perform Tai Chi, TCSE-Performance) to 0.95 (perceived social support, MSPSS).

### **Differences in physical, cognitive and psychosocial functioning between groups**

There were no statistically significant differences in aerobic endurance, strength or flexibility between subjects attending Tai Chi classes plus cardiac rehabilitation with those attending cardiac rehabilitation only ( $p > 0.05$ ). However, subjects attending Tai Chi classes plus cardiac rehabilitation had significantly better balance, than those attending cardiac rehabilitation only ( $p = 0.03$ ) (Table 6). Further, there were no statistically significant differences in cognitive functioning between subjects attending Tai Chi classes plus cardiac rehabilitation with those attending cardiac rehabilitation only ( $p > 0.05$ ). Finally, when examining psychosocial functioning, subjects attending Tai Chi classes plus cardiac rehabilitation had significantly higher perceived physical health and Tai Chi self-efficacy ( $p < 0.01$ ), than those attending cardiac rehabilitation only (Table 6).

## **Discussion**

Cardiac rehabilitation efforts are targeted towards optimal physical, cognitive and psychosocial functioning for all persons following a CHD event. The identification of novel, adjunct approaches that encourage long-term cardiac rehabilitation exercise participation may help decrease attrition over time. Tai Chi exercise is a novel, adjunct physical activity for phase III cardiac rehabilitation<sup>11</sup>, and is suitable for adults aged 45 years and older. Prior studies have reported that Tai Chi is an enjoyable form of group-based exercise<sup>11,41,42</sup>. This is consistent with findings in our study, as 100% of the subjects attending Tai Chi classes plus cardiac rehabilitation (n = 23) reported that they would recommend Tai Chi to others and rated their overall satisfaction as very high ( $8.8 \pm 2.1$ ; 1 = not satisfied and 10 = most satisfied).

In this study, most subjects met the expected age and gender-specific 50th percentile physical functioning norms. However, subjects in this study may not be representative of adults aged 45 years and older that normally attend cardiac rehabilitation. The majority of subjects were college educated, married, white/European-American, had attended cardiac rehabilitation on average for 45 months, and had good physical functioning compared to norms. In addition, only 2% of subjects in this study currently smoked, compared to an estimated prevalence of 11.3% for adults aged 65 years and older living in Arizona as reported by the 2006–2008 Centers for Disease Control and Prevention (Western Region-Mountain Division Census Area)<sup>43</sup>. Moreover, approximately 69% of study subjects reported meeting national recommendations of 150 minute moderate-intensity physical activity/week. This is in contrast to the 2007 Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System data for adults aged 65 years and older in Arizona<sup>44</sup> reporting that only 44.3% of these adults are meeting national physical activity recommendations.

Among persons with CHD, improvement in aerobic endurance and activities that promote balance, muscular strength and endurance, and flexibility is important to incorporate into a regular exercise program<sup>14</sup>. A study conducted by Pepin and colleagues<sup>45</sup> examined physical functioning among older adults (mean age = 69 years) entering an outpatient cardiac rehabilitation program, that included measures of upper and lower body strength and flexibility. Subjects in our study had higher age-specific percentile scores for the same strength and flexibility measures, compared to subjects' physical functioning scores reported in the Pepin study<sup>45</sup>, despite being the same age. This is another indication that subjects in our study may not be representative of the patients that typically enroll in cardiac rehabilitation.

Among the subjects attending group-based Wu style Tai Chi classes plus cardiac rehabilitation, significantly better balance was observed. Among older adults, balance is a vital aspect of physical functioning, regardless of health condition<sup>14,46</sup>. However, few studies have examined balance control among persons enrolled in cardiac rehabilitation<sup>47</sup>. To our knowledge, this is the first study to report on balance among older adults enrolled in Tai Chi classes plus cardiac rehabilitation.

Cognitive functioning is another major concern among older adults. To our knowledge, this is the first study to report on cognitive functioning among older adults enrolled in cardiac rehabilitation. In this study, the majority of subjects had 13 years of formal education (n = 43) and scored above the 50th percentile for verbal retrieval and recall (animal naming). However, no differences were observed between those attending Tai Chi classes plus cardiac rehabilitation with those attending cardiac rehabilitation only. This finding is in contrast with recently reported research conducted by Taylor-Piliae and colleagues<sup>16</sup> among older adults (mean age = 69 years) examining the effect of Tai Chi on physical and cognitive functioning, compared with western exercise and attention-control groups, in a 2-phase randomized clinical trial. In that study, Tai Chi subjects had greater improvements in a measure of cognitive functioning (digits backward) [ $F = 7.75, p < 0.001$ ], than subjects in the western exercise or control groups at 6 months.

Cognitive functioning encompasses executive functions that are high-level skills (e.g., planning), which influence more basic skills such as attention, memory, and motor skills. A person may perform well on a simple task, such as naming as many animals as possible in 1 min, but struggle with more complex tasks such as repeating a sequence of numbers in reverse order, which is consistent with the findings observed among subjects in our study<sup>48</sup>.

Subjects in this study generally had low levels of perceived stress and depressive symptoms, along with a high amount of perceived social support. The results from a recent meta-analysis<sup>49</sup> representing 6984 CHD patients suggest that those with high levels of social support, i.e. married/partner, are 1.5–2 times more likely to attend cardiac rehabilitation<sup>49</sup>. In our study, 75% of the subjects were married or had a partner, and may in part help to explain the high amount of perceived social support observed. Further, subjects attending Tai Chi classes plus cardiac rehabilitation had significantly higher perceived physical health and Tai Chi self-efficacy (p values < 0.01). This finding is consistent with previous research among older adults that reported significant improvements in physical function and Tai Chi self-efficacy, following participation in a Tai Chi intervention<sup>15,50</sup>. Moreover, we expected that Tai Chi subjects in our study would have higher TCSE than those in cardiac rehabilitation only, as practicing Tai Chi leads to Tai Chi mastery which in turn influences TCSE<sup>51</sup>.

Tai Chi usually is performed in a group setting, which may also enhance exercise participation, adherence, and low rates of attrition. These are important cardiac rehabilitation issues encountered on a daily basis. Persons who feel safe and confident in performing Tai Chi are more likely to continue over the long term, achieving the greatest benefits of cardiac rehabilitation. Tai Chi is a self-paced, noncompetitive exercise that can be performed at any time or place without the need for large space requirements. Tai Chi can be implemented easily in any community setting or cardiac rehabilitation facility.

### Study limitations

The goal of this study was to describe differences in physical, cognitive and psychosocial functioning between adults 45 years attending phase III cardiac rehabilitation who had or had not self-selected Tai Chi exercise as an adjunct physical activity. As such, this study utilized a cross-sectional study design with data collected at a single point in time. This type of study design is inexpensive, without any loss to follow-up, and appropriate for describing variables and their distribution patterns. The results often define the demographic and clinical characteristics of the study group and can reveal cross-sectional associations of interest. However, results from our study need to be interpreted with caution as we are unable to determine any causal relationships from the data collected. Furthermore, the generalizability of the findings obtained may be limited, as subjects in our study may not be representative of adults aged 45 and older who enroll in phase III cardiac rehabilitation. However, the data obtained in this study are useful for planning future Tai Chi intervention studies.



## Future directions

Given the limited number of studies that have been conducted using Tai Chi as an exercise intervention among persons enrolled in cardiac rehabilitation, further studies are needed before widespread recommendations can be made. This study examined physical, cognitive and psychological functioning among persons enrolled in Tai Chi plus cardiac rehabilitation or cardiac rehabilitation only. Future studies may like to examine the effect of Tai Chi exercise programs on the reduction of other CHD risk factors, such as lipid levels, weight reduction, or smoking cessation. Additional forms of cardiac rehabilitation exercise training may aid with patient participation and program adherence<sup>11</sup>. Thus, future research among persons with CHD comparing the efficacy of a Tai Chi exercise intervention with traditional cardiac rehabilitation exercise training may be warranted. Researchers may like to ascertain if the addition of Tai Chi to a traditional cardiac rehabilitation program improves cardiac rehabilitation enrollment and adherence rates. Finally, future studies examining Tai Chi exercise using a randomized clinical trial design with an attention-control group are needed to reduce potential confounding effects and rule out improvements unrelated to Tai Chi.

## Conclusion

Exercise is a well-recognized and effective strategy for secondary prevention in patients with established CHD. The majority of the cardiac rehabilitation subjects in our study met the expected age and gender-specific 50th percentile physical functioning norms. Tai Chi provided additional benefits, with significantly better balance observed. Among older adults, balance is a vital aspect of physical functioning, regardless of health condition. Tai Chi may be a reasonable adjunct to traditional cardiac rehabilitation, particularly for patients that are unable or unwilling to engage in other forms of physical activity, or as a bridge to more rigorous exercise programs in frail or de-conditioned patients, such as those living with chronic heart failure.

Tai Chi does not require any special clothing or equipment, making it a cost-effective and affordable form of exercise for both patients and cardiac rehabilitation facilities. Finally, Tai Chi may offer patients additional options following a cardiac event, whether as an adjunct to a formal cardiac rehabilitation program, as part of a maintenance program for persons with CHD, or as an exercise alternative at any point along this continuum.

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**Table 1**  
**Summary of reported psychometric properties and interpretability of study measures**

Measure	Reliability	Type of validity	Items	Scoring/range	Meaning of high score	Est. time to complete
<i>Physical functioning</i>						
Step-in-place test	Test-retest ICC = 0.90 <sup>33</sup>	Criterion, convergent and known-groups <sup>33</sup>	1	Number of steps in 2 min	Better aerobic endurance	4 min
Functional reach	Test-retest ICC = 0.81 <sup>34</sup>	Criterion and convergent <sup>34</sup>	1	Distance in inches	Better dynamic balance	2–3 min
Single leg stance	Inter-rater ICC = 0.76 <sup>35</sup>	Known-groups <sup>52</sup>	1	0–60 s	Better static balance	1–2 min
Arm curls	Test-retest ICC = 0.81 <sup>33</sup>	Criterion, convergent and known-groups <sup>33</sup>	1	Number in 30 s	Better upper body strength	1–2 min
Chair stand	Test-retest ICC = 0.89 <sup>33</sup>	Criterion, convergent and known-groups <sup>33</sup>	1	Number in 30 s	Better low body strength	1–2 min
Back scratch	Test-retest ICC = 0.96 <sup>33</sup>	Content and known-groups <sup>33</sup>	1	Overlap/gap in inches	Better upper body flexibility	2–3 min
Chair sit-and-reach	Test-retest ICC = 0.95 <sup>33</sup>	Criterion, convergent and known-groups <sup>33</sup>	1	Distance in inches	Better lower body flexibility	2–3 min
<i>Cognitive functioning</i>						
Animal naming	Test-retest r = 0.65–0.88 <sup>36</sup>	Convergent and known-groups <sup>39</sup>	1	Number in 60 s	Better verbal retrieval and recall	2 min
Forward and backward digit span tests	Test-retest r = 0.66–0.89 <sup>53,54</sup>	Convergent and known-groups <sup>36,40</sup>	Up to 30	Number of correct sequences	Better attention, concentration and mental tracking	4–5 min
<i>Psychosocial functioning</i>						
MOS SF-36	Internal consistency r = 0.78–0.93 <sup>35</sup>	Convergent and discriminate <sup>55,56</sup>	36	0 to 100	Better perceived health-related quality of life	5–10 min
PSS	Test-retest r = 0.85 <sup>29</sup>	Concurrent, predictive, and known-groups <sup>29,57</sup>	10	0 to 40	More perceived stress	5–10 min
CES-D	Split-half r = 0.76–0.85 <sup>30</sup>	Convergent, discriminate and known-groups <sup>30,58</sup>	20	0 to 60	More depressive symptoms clinical cut-point	5–10 min
MSPSS	Test-retest r = 0.85 <sup>31</sup>	Content, convergent and factorial <sup>31,59</sup>	12	1 to 7	More perceived social support	5 min
TCSE	Internal consistency r = 0.95–0.97 <sup>32</sup>	Content, known-groups <sup>32</sup>	14	0 to 100	More confidence or perceived self-efficacy	5 min
Total est. time						44–66 min

Est. = estimated, ICC = intraclass correlation coefficient, MOS SF-36 = Medical Outcomes Study Short Form 36-items, PSS = Perceived Stress Scale, CES-D = Center for Epidemiological Studies Depression scale, MSPSS = Multidimensional Scale of Perceived Social Support, TCSE = Tai Chi exercise self-efficacy.

**Table 2**  
**Self-reported subject characteristics, n = 51**

	<b>% (n)</b>
Women	29% (15)
Married/partner	75% (38)
Tertiary education	84% (43)
Working full/part-time	24% (12)
Annual income	
<\$34,999	16% (8)
\$35,000–\$74,999	37% (19)
>\$75,000	39% (20)
Refuse to answer	8% (4)
Race/ethnicity	
White/European-American	94% (48)
Other	6% (3)
Age in years, (mean $\pm$ SD)	69.7 $\pm$ 7.9
Age range	48.6 to 86.1 years
Cardiac event information	
Myocardial infarction	51% (26)
Unstable angina	12% (6)
Coronary artery bypass surgery	65% (33)
Angioplasty/stent	57% (29)
Heart valve surgery	16% (8)
Months in cardiac rehab, (mean $\pm$ SD)	44.7 $\pm$ 36.7
Self-selected Tai Chi exercise classes	45% (23)
Other cardiovascular health problems	
Heart failure	18% (9)
Peripheral artery disease	16% (8)
Prior stroke	4% (2)
TIA symptoms	12% (6)
Angina	29% (15)
Irregular heart beat	37% (19)
Heart conduction problem	28% (14)
Self-reported co-morbidities	
Prior cancer	32% (21)
Degenerative disc/joint disease	26% (13)
Chronic back pain	22% (11)
Arthritis (all types)	20% (10)
Asthma	16% (8)
COPD/emphysema	14% (7)

**Table 3**  
**Satisfaction with Tai Chi exercise (Tai Chi + cardiac rehab subjects only), n = 23**

	<b>% agree</b>
Facility well-maintained	100%
Convenient time	91%
Able to follow directions	96%
Gained personal benefits	91%
Felt health improved	91%
Would recommend to others	100%
Overall satisfaction, (mean $\pm$ SD) (1 = not satisfied, 10 = most satisfied)	8.8 $\pm$ 2.1

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**Table 4**  
**Physical functioning compared to normative data, by gender**

	Women, n = 15		Men, n = 36	
	Mean ± SD	50th % score, age = 71 years <sup>33-35</sup>	Mean ± SD	50th % score, age = 69 years <sup>33-35</sup>
Aerobic endurance, # of steps in 2-min	89.7 ± 17.2	84	87.5 ± 19.9	101
Balance				
Functional reach, inches	16.7 ± 4.0	10.5	17.1 ± 3.3	15
Single leg stance, right (number of seconds)	27.1 ± 23.7	17.2	37.1 ± 23.5	27
Single leg stance, left (number of seconds)	30.0 ± 22.5	17.2	27.9 ± 23.8	27
Strength				
Upper body, # of arms curls in 30 s	15.2 ± 3.2	15	17.8 ± 5.1	18
Lower body, # of chair stands in 30 s	13.7 ± 3.3	13	12.1 ± 3.1	15
Flexibility				
Shoulder (back scratch), inches	-1.6 ± 4.2	-1.5	-5.9 ± 5.1	-4.0
Hamstring (sit-and-reach), inches	-0.4 ± 5.7	1.5	-3.1 ± 5.8	0

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**Table 5**  
**Cognitive functioning compared to normative data, by highest education**

	< 13 years, n = 8		13 years, n = 43	
	mean ± SD	50th % score, age = 70 years <sup>36,53,54</sup>	mean ± SD	50th % score, age = 70 years <sup>36,53,54</sup>
Animal naming, # of animal in 60 s	16 ± 3.3	17	21.3 ± 6.5	19
Digits forward, sequence length	5.9 ± 1.0	7.1	6.7 ± 1.1	7.1
Digits backward, sequence length	3.8 ± 1.4	5.3	4.9 ± 1.4	5.3

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**Table 6**  
**Physical, cognitive, and psychosocial functioning by group, n = 51**

	Cardiac rehab only, n = 28 mean ± SD	Tai Chi + cardiac rehab, n = 23 mean ± SD	Difference between groups t-test, p-value
<i>Physical functioning</i>			
Aerobic endurance, # of steps in 2-min	69.0 ± 30.6	81.6 ± 22.5	t <sub>48</sub> = 1.62, p = 0.11
Balance			
Functional reach, inches	17.1 ± 3.2	16.9 ± 3.9	t <sub>49</sub> = 0.20, p = 0.84
Single leg stance, right (number of seconds)	27.7 ± 23.1	41.9 ± 22.6	<b>t<sub>49</sub> = -2.21, p = 0.03</b>
Single leg stance, left (number of seconds)	20.1 ± 20.0	38.7 ± 23.1	<b>t<sub>49</sub> = -3.08, p &lt; 0.01</b>
Strength			
Upper body, # of arms curls in 30s	17.3 ± 5.0	16.6 ± 4.6	t <sub>49</sub> = 0.53, p = 0.60
Lower body, # of chair stands in 30s	12.6 ± 2.5	13.8 ± 4.0	t <sub>49</sub> = -1.30, p = 0.20
Flexibility			
Shoulder (back scratch), inches	-5.4 ± 5.4	-3.6 ± 4.9	t <sub>49</sub> = -1.30, p = 0.21
Hamstring (sit-and-reach), inches	-3.4 ± 5.9	-0.9 ± 5.7	t <sub>49</sub> = -1.5, p = 0.14
<i>Cognitive functioning</i>			
Animal naming, # of animal in 60 s	21.1 ± 6.6	19.7 ± 6.2	t <sub>49</sub> = 0.80, p = 0.43
Digits forward, sequence length	6.7 ± 1.1	6.4 ± 1.2	t <sub>49</sub> = 0.91, p = 0.37
Digits backward, sequence length	4.8 ± 1.4	4.7 ± 1.6	t <sub>49</sub> = 0.21, p = 0.83
<i>Psychosocial functioning</i>			
Perceived physical health, SF-36	42.3 ± 10.1	49.3 ± 5.9	<b>t<sub>49</sub> = -2.95, p &lt; 0.01</b>
Perceived mental health, SF-36	54.5 ± 8.7	51.1 ± 8.8	t <sub>49</sub> = 1.39, p = 0.17
Perceived stress, PSS	9.2 ± 6.3	10.8 ± 5.6	t <sub>49</sub> = -0.96, p = 0.34
Depressive symptoms, CES-D	8.2 ± 7.6	8.2 ± 7.0	t <sub>49</sub> = -0.20, p = 0.99
Perceived social support, MSPSS	6.1 ± 1.0	5.8 ± 1.5	t <sub>49</sub> = 0.88, p = 0.38
Confidence to overcome barriers to Tai Chi, TCSE-barriers	44.3 ± 28.8	65.8 ± 23.6	<b>t<sub>49</sub> = -2.88, p &lt; 0.01</b>
Confidence to perform Tai Chi, TCSE-performance	60.7 ± 33.5	90.0 ± 21.73	<b>t<sub>49</sub> = -3.61, p &lt; 0.01</b>

Bold = p < 0.05, # = number, SF-36 = Medical Outcomes Study Short Form 36-items, PSS = Perceived Stress Scale, CES-D = Center for Epidemio-logical Studies Depression scale, MSPSS = Multidimensional Scale of Perceived Social Support, TCSE = Tai Chi exercise self-efficacy.