Tai chi exercise affects the isokinetic torque but not changes hamstrings: quadriceps ratios

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Received March 10, 2009

Abstract: Tai chi, which originated in China, is a form of exercise that focuses on controlled movements. The aim of our study is to examine the differences in the eccentric/concentric functional ratio for the knee in the aged after 12 weeks Tai Chi training. Materials and methods include 20 aged subjects were recruited. To match their physical activity level following the physical performance testing procedures and then 12 week Tai Chi training program (practiced Tai Chi for a minimum of 4 $h \cdot wk^{-1}$). Physical characteristics, functional physical performance and isokinetic performance were measured. Concentric and eccentric isokinetic tests of the subjects' dominant knee extensors and flexors were conducted at an angular velocity of 30 $deg \cdot s^{-1}$. After 12 weeks Tai Chi training, functional physical activity were improving significant ($p < 0.05$). Subjects had higher total work in concentric and eccentric isokinetic contractions of their knee extensors and flexors but not Hamstring/Quadriceps ratio (H/Q) ($p > 0.05$). Conclusively, Tai Chi training enhance knee muscular performance but may not change H/Q. [Life Science Journal. 2009; 6(4): 50 – 55] (ISSN: 1097 – 8135).

Keywords: Micro drilling, Bones, Natural properties

1. Introduction

Conventionally, the quadriceps/hamstring ratio is calculated by dividing the torque of knee extensors and flexors at identical angular velocity and contraction mode. However, previous authors have suggested that to evaluate muscular balance of the knee eccentric (ECC)/concentric (CON) actions of the knee flexors (KF) and knee extensors (KE) should be examined (ECC_{KF}/CON_{KE} or CON_{KF}/ECC_{KE} ratio) and referred to as functional ratio rather than the established ratios often used (ECC_{KF}/CON_{KF} or ECC_{KE}/CON_{KE} ratio) [1]. Analyzing correlative muscle group ratios provides messages on knee function, injury risk ,and knee joint stability [2]. One previous study that used demonstrated that an ECC/CON ratio of less than 60% at 60 $deg \cdot s^{-1}$ represents a 77.5% probability of knee injury in elite soccer players [3]. There seems to be unavailable data on associative risk of injury from functional ratios.

Tai chi, which originated in China, is a form of exercise that adjusts to control movements coherent deep diaphragmatic breathing [4]. There are 5 major styles, Chen, Yang, Wu, Zheng, and Sun, each with its own different characteristics but all based on the same cardinal principles [5]. Sun and Zheng styles have recently become widely used to improve balance and reduce the risk of falls among the elderly population [6], and a specific Sun-style form of Tai Chi is currently endorsed by The Arthritis Foundation in the US as a methods for executive OA pain. In view of the raised popularity of this exercise in both North America and Australia, a growing body of research aimed at exploring the health benefits of Tai Chi has originated. Many of the individual experiments have reported Tai Chi to have positive effects on quality of life, pain, and physical function in populations with chronic situations[7], However, none of these papers have provided a quantitative evaluate of the influence on the prossession of Tai Chi for chronic musculoskeletal conditions. The purpose of this study was to examine the differences between the Functional physical performance and eccentric/concentric functional ratio for the knee in the aged after 12 weeks Tai Chi training.

2. Materials and Methods

2.1 Subject

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31 middle-aged subjects were recruited from several community older adult centers. They had no previous experience in practicing Tai Chi, though some took morning walks or did stretching exercises. To match their physical activity level following the general functional testing procedures and 12 week Zheng style Tai Chi training program (TC) (practiced Tai Chi for a minimum of 4 $h \cdot wk^{-1}$). Subjects visited the laboratory before testing to habituate themselves with the laboratory environment and realize the experimental procedures, including familiarization of concentric/eccentric isokinetic tests. The study received ethical approval from the Institutional Research Ethics Committee.

2.2 Functional physical performance

The functional physical performance [8] was performed the following ssessments for all the subjects before and after the Tai Chi exercise program.

(1) 2-min step marking. Walking endurance was assessed using a 2-min step marking. Each subject stepped marking for 2 minutes as soon as possible and raising knee higher than 1/2 thigh length. The total time of stepping by each subject was recorded.

(2). Chair rise. Subjects were asked to stand up consecutively from a chair with a seat level of 43.2 cm from the floor with their arms folded, and sit down as fast as possible. The time taken to complete the task from sit-to-stand was recorded in 30 seconds.

(3) Bicep curl. Subjects were asked to hold the dumbbells (2.27 kg) in dominate hand, consecutively rised with their arms from straight arm to curl, and as fast as possible. The time taken to complete the task was recorded in 30 seconds.

(4) Sit and reach. Subjects were asked to sit on a 43.2 cm chair and bent the dominate leg in 90 degrees. Then Subjects stretched undominate leg and two arms, and bend down the back as closer fingers to toes as possible. The closest distance taken to complete the task from fingers to toes was recorded.

(5) Timed up and go test. The subjects were asked to rise from a chair (0.42 m in height), walk 2.44 m, turn and return to the chair and sit down, as quickly as possible. The time required to perform the entire procedure was recorded.

2.3 Isokinetic test

Isokinetic concentric/eccentric knee extension and flexion were measured using a calibrated Biodex system 3 (Shirley, NY, USA). A specially designed chair was used which allowed for the various thigh lengths of the subjects. At all testing sessions, a standardized procedure included a warm-up of 2-min cycling on a Monark cycle ergometer 814E (Monark, Varberg, Sweden) at a moderate intensity and 2 minutes of stretching the hamstring and quadriceps muscles before the knee test. The dominant limb, determined from kicking preference, was used for assessment. Subjects were prepared for a seated position and the axis of rotation of the dynamometer lever arm was aligned with the lateral epicondyle of the knee. The force pad was placed approximately 3 cm superior to the medial malleolus with the foot in a plantar flexed position. The subject was asked to relax their leg so that passive determination of the effects of gravity on the limb and lever arm could be measured. Range of motion (ROM) for the knee test during concentric actions were 90 degrees and 15degrees for eccentric actions, due to the need for an applied preload torque of the eccentric limits. This reduction in ROM for eccentric actions was made necessary by the need for the preload activation torque that could not be performed at the terminal of the ROM, especially in the aged subjects. To ensure full extension, anatomical 0° was determined as maximal voluntary knee extension for each subject. Testing occurred at 30 $deg \cdot s^{-1}$. Subjects were guided to push the lever up, and pull it down, as hard and as fast as possible with extension/flexion undertaken first for concentric actions. For eccentric actions, subjects were instructed to opposing the lever arm with extension as the first movement. The subjects performed three maximal efforts to determine maximal peak torque during CON/CON and ECC/ECC cycles. A 2-min rest period was given between cycles with CON actions tested before ECC actions. All subjects were encouraged to give a maximal effort for each action by using both visual feedback and strong verbal encouragement.

2.4 Statistical analyses

Maximal CON and ECC isokinetic peak extension torque (PET) , peak flexion torque(PFT) and time to peak torque identified from the efforts were gravity corrected, filtered and windowed to only include constant velocity periods. At 30 deg·s^{-1} and 180 deg·s^{-1}, for CON and ECC actions respectively, Data were analysed using Statistical Package for Social Sciences (SPSS) (V10.0, SPSS, Inc., Chicago, IL, USA). Functional physical performance, ECC_{KF}/CON_{KE} and CON_{KF}/ECC_{KE} ratio for the knee joint were examined using before/after by paired *t*-test. Significance was accepted at the $p < 0.05$ level.

3.Results

3.1 Physical characteristics

Twenty participants completed the program and were later reassessed. Eleven participants failed to complete the exercise program assessment or intervention, primarily because of changes in address and worsening personal or family health. The mean age of the participants in the study group was 65.3(4.6) years. Additionally, 80.0% were housewives and 76.0% were retired. Among the participants, 92.0% were married, and 8.0% were single. The highest level of education attained among the participants was: 8% completed the elementary school level, 32% completed middle and high school, and 76% completed university. Furthermore, 28% lived alone. Of the participants, 4% had a history of geriatric falls. During the exercise period no falls by any of the participants were observed. Also, no analysis or record of the frequency of falling was done.

There is no physical characteristics difference after 12 weeks Tai Chi training (TABLE 1).

TABLE 1. Comparision of age ,height, weight, blood pressure and bone density after 12 weeks Tai Chi training (N=20)

ITEM	UNIT	Pre-training	Post-training
age	year	65.3(4.6)	65.5(4.8)
height	cm	159(7.2)	160(6.9)
weight	kg	67.5(10.2)	64.7(8.2)
fat	%	30.2(5.9)	29.5(4.3)
WHR	Ratio	0.9(0.12)	0.89(0.08)
systolic	mmHg	128(3.2)	122(2.5)
diostolic	mmHg	81(5.1)	82(4.9)
Bone density	T score	-2.0(1.5)	-1.8(1.6)

Ps.Value are mean(SD) . WHR, waist and hip ratio

3.2 Functional physical performance

Statistically significant improvement($p < 0.05$) was observed on all the Functional physical performance tests for the subjects after 12 weeks Tai Chi training,. It means that 12 weeks Tai Chi training can strengthen Functional physical performance and functional fitness for the aged [8]. **(** TABLE 2**)**

TABLE 2. Comparision of functional physical performance after 12 weeks Tai Chi training[8]. (N=20)

ITEM	UNIT	Pre-training	Post-training
Sit and reach	cm	-6(8.6)	0.5(4.4)*
	%	0.7(11)	35(5)*
30 sec Chair rise	time	16.2(5.8)	18.7(8.1)
	%	66(8)	83.5(8.3)*
30 sec bicep curl	time	17.1(6.2)	20.5(5.2)
	%	60(4.1)	82.5(2.1)*
Timed up and go	sec	6.0(6.1)	5.0(4.6)
	%	25(23.1)	55(21.5)*
2 min step marking	time	94.6(7.8)	112(6.2)
	%	56(2.2)	80(2.1)*

Ps.Value are mean(SD) .*: vs. Pre-training group, $p < 0.05$.

3.3 Knee isokinetic performance.

The isokinetic tests of the knee strength results indicated overall statistically significant effects including time to peak torque (*P=.043*), total work (*P=.038*), and fatique index (*P=.047*) after 12 weeks Tai Chi training. But Hamstring/Quadriceps ratio (H/Q) was in significant. It showed that there were statistically significant differences in the muscular endurance, and neuromuscular controlling. strength of concentric knee extensors Tai Chi practitioners achieved significantly higher peak torque-to-body weight ratios with both their

knee extensors and flexors in both concentric and eccentric isokinetic testing at 30 deg·s^{-1}. An examination of the concentric H/Q strength ratios for Pre/Post Tai Chi training subjects yielded 0.562 and 0.591, respectively (P=0.795 in the paired t-test). Our findings thus show that Tai Chi practitioners had similar agonist/antagonist strength ratios in concentric muscle contractions after training as before **(**TABLE 3**)**

TABLE 3. Comparision of isokinetic performance (30 deg·s^{-1}×6 repetitions) after 12 weeks Tai Chi training. (N=20)

ITEM	UNIT	Pre-training		Post-training	
		KE	KF	KE	KF
Peak torque	N-M	146 (12)	84 (11)	161 (13)	95 (12)
Time to peak torque	msec	451 (53.1)	516 (177.8)	399.6* (67.1)	485 (123.1)
Total work	J	483.1 (178.2)	323 (186.2)	531.1* (272.3)	352.3 (134.3)
Work fatique	%	13.6 (9.7)	12.1 (8.6)	7.1* (3.5)	6.8* (7.3)
H/Q	%	56.2(8.6)		59.1(7.9)	

Ps.Value are mean(SD). *: vs. Pre-training group, $p < 0.05$.

The low values for CON_{KF}/ECC_{KE} (0.33–0.51) **(**TABLE 4**)** are also consistent with previous literature [1] and suggest that either the hamstring muscles have reduced capacity for knee joint stabilization during dynamic knee flexion movements or that the quadriceps have a high eccentric capacity during concentric knee flexion.

TABLE 4. Comparision of isokinetic performance (30 deg·s^{-1}×6 repetition) after 12 weeks Tai Chi training (N=20)

ITEM	UNIT	Pre-training	Post-training
CON_{KF}/ECC_{KE}	%	42.2(11.9)	47.2(9.6)
ECC_{KF}/CON_{KE}	%	70.4(11.8) †	77.3(13.7) †

Ps.Value are mean (SD). *: vs. Pre-training group, $p < 0.05$.
† :vs. CON_{KF}/ECC_{KE} in the same group, $p < 0.05$.

4. Discussions

4.1 Tai Chi training

In our study, TC was effective for enhancing quadriceps strength in older men and women. After 12 weeks of TC, subjects showed strength increases ranging from 66% to 83.5% in chair sit. Other functional physical performances including flexibility, agility, cardiovascular/muscular endurance were raising too. In addition, increasing ranging from 483.1J to 531.1 J in total works during concentric contractions at 30 degrees angular velocities were also noted. Although TC practice requires no instrument and uses only body weight as the training workload, it appears that a significant demand is placed on lower extremities during the performance of TC. A similar result has been presented by Heislein and colleagues[9] reported an increase of 21% in knee extensor isometric strength after an 8-week low-to-moderate resistance program. Heislein's program consisted of exercises performed in a progressive weight-bearing sequence and placed significant demands on the quadriceps throughout the exercise. Previous studies have shown that exercise including concentric and eccentric contractions is more effective for enhancing muscular strength[10]. TC is achieved in a semi-squat posture at a slow speed. During the programming, various degrees of concentric and eccentric contraction are require playing lower terminals. The greater parts of TC actions are performed in a closed kinetic chain. The slow motion and low posture integrate a higher training load on the lower limbs for extensors/flexor. The overload stress to joints may be prevented during TC. The risk of musculoskeletal injury during TC practice was low, and TC is safe even for patients with rheumatoid arthritis [11].

TC is an exercise with fine gymnastic movements and can be practiced easily; it is possible for a large group of the aged. TC can support keeping strength gains achieved by more intensive high-tech training in gym. In the present study, our data indicated that TC can increase muscular strength of quadriceps concentrically and eccentrically. The results suggest that TC is as good as high-tech training for strength enhancement. TC is an exercise with low velocity and low impact, and the

orthopedic complication is minimal. Moreover, TC is a easy way to conditioning performance for the aged and with very low cost.

4.2 Isokinetic performance

Current literature suggests that the manifestation of the fact that hamstrings are used to a much greater extent than the quadriceps for limb deceleration during knee extension movements [8]. However, data from the present study indicate that if concentric hamstring torque that contributes to knee stability with simultaneous eccentric quadriceps actions, then the extent of this contribution remains constant across movement velocities. The ECC_{KF}/CON_{KE} ratio was significantly higher. Others have suggested that this increase in the ratio at higher velocities is due to the significant anterior tibial translation or shear at high quadriceps forces, and extend internal rotation of the tibia in relation to the femur. Irrespective of age, the increases in co-activation of the hamstrings during high velocity movements appear to significantly contribute to equilibrate this tibial sheer or rotation [9]. Although isolated isokinetic movements used in the present study do not measure the simultaneous activity of agonist and antagonist muscles, the functional ECC/CON ratio appears to be a more reative measurement of the capacity for muscular knee joint stability than accustomed ratios [1].

4.3 Tai Chi training specificity

Loss of muscular endurance also occurs with aging. Nevertheless, muscular endurance is maintained better throughout aging than muscular strength[12]. Exercise training may improve muscular endurance, and the effect may be ascribed to the increase of oxidative capacity of muscle fibers. In this study, muscular endurance in the TC raised from 66% to 83.5% after 12 weeks TC. It seems that a TC can promote muscular endurance as well as muscular strength. Most strength training studies have used instrument in the gym/laboratory[13]. Although a machine-dependent training program can improve systematized muscle strength, it is difficult for persons to keep such training permanently. Therefore, gymnastic exercises easily implemented daily should be worth more attention. In fact, gymnastic exercises using postural change or cheap instruments are efficient in increasing muscular performance in the aged.

4.4 Limitations

There were some limitations in our study, however. First of all, the results would be more conclusive had the study group been larger. Unfortunately, it was difficult to convince the would-be subjects to join the Tai Chi unit three times a week. Weather conditions, difficulty finding transportation and personal reasons were all factors, which played a role in limiting participation. Subjects who completed the study were all consistent with their involvement. Falling, an important potential health problem in this age group, was not included in the evaluation due to time limitations. Also, participants who were active and had a high physical capacity might also be thought as a restrictive factor. The study lacking controls weakens the internal validity of our major findings. In addition, isokinetic tests need to determine the baseline peak torque in the aged because the test-retest reliability is relatively low in this parts. Another source of error lies in the difficulties of measuring the workload during TC. Our results strongly suggest that TCC training may be beneficial to elderly individuals for muscular strength and endurance enhancement. Further controlled study is needed to validate this evidence.

5. Conclusion

Isokinetic performance ratio between knee flexors (KF) and knee extensors (KE) have been widely used during muscular balance evaluations. Such evaluations can be predictive overload actions of knee, frequently caused by inadequate hamstrings recruitment, when they should be a joint stabilizer. TC, being a form of exercise that focuses on controlled movements have recently become widely used to improve lower limbs performance among the aged. In our investigations have demonstrated that the use of eccentric contractions provide a more functional index (ECC_{KF}/CON_{KE}). We find that TC can increase muscular strength of quadriceps concentrically and eccentrically. Therefore, TC is a potential alternative for strength training because of its efficacy and safety.

Acknowledgement

The financial support by the National Science Council, Republic of China, through Grant NSC 97-2622-H-230-002-CC3 is gratefully acknowledged.

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