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Practicing Tai Chi had lower energy metabolism than walking but similar health benefits in terms of aerobic fitness, resting energy expenditure, body composition and self-perceived physical health☆

Stanley Sai-chuen Hui[a,*], Yao Jie Xie[b], Jean Woo[c], Timothy Chi-yui Kwok[c]

[a] Department of Sports Science and Physical Education, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong Special Administrative Region
[b] School of Nursing, The Hong Kong Polytechnic University, Hunghom, Kowloon, Hong Kong Special Administrative Region
[c] Department of Medicine and Therapeutics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong Special Administrative Region

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ABSTRACT

Objective: To examine the effects of Tai Chi and walking training on aerobic fitness, resting energy expenditure (REE), body composition, and quality of life; as well as analyzing the energy metabolism during exercises, to determine which one had better advantage in improving health status.
Methods: Three hundred seventy-four middle-aged Chinese subjects who were recruited from nine geographic areas in Sha Tin were randomized into Tai Chi, walking, or control groups at area level. The 12-week (45 min per day, 5 days per week) Tai Chi or brisk walking training were conducted in respective intervention groups. Measures were performed at baseline and end of trial. Another 30 subjects were recruited to compare the energy metabolism between practicing Tai Chi and walking.
Results: The between-group difference of VO_2max was 3.3 ml/min/kg for Tai Chi vs. control and 3.7 ml/min/kg for walking vs. control (both $P < 0.001$). BMI, skinfold thicknesses, and SF-12 physical component scores all improved significantly compared with the control group (all $P < 0.01$). Tai Chi had higher effect on improving REE-VO_2 and REE-kilocalorie expenditure than walking. Regarding to energy metabolism test, the self-paced walking produced approximately 46% higher metabolic costs than Tai Chi.
Conclusion: Practicing Tai Chi consumes a smaller amount of energy metabolism but similar health benefits as self-paced brisk walking.

1. Background

Physical activity (PA) is a well-known lifestyle factor that is beneficial to both physical and mental health.[1,2] Healthcare professionals often prescribe recreational activities for disease prevention, rehabilitation, and health maintenance purposes.[3] Daily accumulation of 30 min of moderate physical activity (MPA) would improve metabolic health and lower the risks of many chronic diseases.[1,3] Hong Kong is the most westernized and urbanized city of China, characterized by busy work schedules and a sedentary lifestyle.[4] Initiatives are necessary to develop an easy-to-practice, convenient, and effective daily MPA approach for Hong Kong citizens.

Walking is one of the often recommended MPAs suitable for both healthy population and patients in all age groups.[5,6] Walking can be done easily without the use of any special device, and its positive effects on health have been observed in numerous studies. Tai Chi (also called Tai Chi Chuan or Taiji), a traditional Chinese martial art that widely practiced in Chinese population,[7] and spread worldwide,[8–10] is a mind-body exercise that integrates physical and spiritual elements to slowly and gently move *qi* (vital energy) throughout the body. Tai Chi reflects Chinese classical philosophical

Abbreviations: BMI, body mass index; C-RCT, cluster randomized controlled trial; EE, energy expenditure; HR, heart rate; ITT, intention-to-treat analysis; MCS, the mental component summary scores; METS, Metabolic Equivalent of Task; MPA, moderate physical activity; PA, physical activity; PCS, the physical component summary scores; REE, resting energy expenditure; RER, respiratory exchange ratio; SF-12, 12-item short form; TCC, simplified 32 Yang-style Tai Chi Chuan performed at regular pace; VE, minute ventilation; WLK-HRC, walking under controlled heart rate similar to the Tai Chi exercise; WLK-SSP, brisk walking in self-selected pace.

☆ Trial registry name: Evaluation of Energy Expenditure and Cardiovascular Health Effects from Tai Chi and Walking Exercise. Registration identification number: NCT02163798. URL: http://clinicaltrials.gov/show/NCT02163798.

* Corresponding author.
E-mail addresses: hui2162@cuhk.edu.hk, stanley.hui.36081@gmail.com (S.S.-c. Hui), grace.yj.xie@polyu.edu.hk (Y.J. Xie), jeanwoowong@cuhk.edu.hk (J. Woo), tkwok@cuhk.edu.hk (T.C.-y. Kwok).

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principles, particularly those of Taoism. The name Tai Chi originated from Chuang Tzu, a famous Taoist philosopher who lived during the 4th century BC in China. *Wu Wei* (action through inaction) is the central value of Taoist thought[11] indicating that nature goes its own way and forces nothing. It is far from being inactive. It is a supreme activity because it acts at rest, and can be done without effort.[12] Tai Chi teaches "stillness in movement", reflects the simultaneous separation and merging of *Yin* and *Yang* energy in the form of "*qi*".[13]

Evidence has shown that several benefits of Tai Chi on health,[10] such as attenuating psychobiological stress reactivity,[9] promoting psychological well-being,[14–16] lowering blood pressure,[17] improving flexibility and muscular strength,[18,19] improving the outcomes of several chronic diseases,[20–23] and decreasing disease burden.[24] Tai Chi and walking are easy-to-practice MPAs that are gaining popularity worldwide. However, questions have to be answered about which MPA has the stronger effect on promoting health under the same frequency and duration and whether or not Tai Chi is more beneficial to mental health than walking. Compared with other MPAs, Tai Chi may have relatively lower exercise intensity and energy cost. However, few studies on the metabolic cost of a single session of Tai Chi practice have been published. Only one study indicated that 24 min of Yang-style Tai Chi exercise resulted in more than 70% of maximal heart rate.[25] What are the differences of energy metabolism during these two forms of exercise? Only a few studies compared the health benefits between Tai Chi and walking,[14,26,27] but the sample sizes were small and no comparison between energy metabolism was conducted.

We thereby conducted this study to examine and compare the effects of Tai Chi and walking on aerobic fitness, resting energy expenditure (REE), body composition and health-related quality of life under the same exercise frequency and duration, and to compare the energy metabolism associated with Tai Chi and walking at similar practice intensity, to determine which exercise had better advantage in improving health status.

2. Methods

2.1. Study design

A 3-arm cluster randomized controlled trial (C-RCT) and a supplementary test of energy metabolism for practicing Tai Chi and walking were conducted. The dissemination report of this research project has been briefly presented elsewhere.[28] The study protocol was approved by the Joint Chinese University of Hong Kong—New Territories East Cluster Clinical Research Ethics Committee.

2.2. Units and subjects

The target subjects were residents of large housing estates in the Sha Tin district of Hong Kong. As one of the 18 districts of Hong Kong, Sha Tin Town was developed in 1970s, grew rapidly in recent 20 years. According to 2014 official census data,[29] in total there were 643,000 residents, 65% of them aged from 25 to 64 years. The median monthly household income was 26,000 HK$ (HK$7.75 = US$1), which was in the middle level of the 18 districts. District councilors and management companies helped recruiting the subjects from 9 geographic areas in this district from May to November in 2005. Flyers, surface mails, and bulletin boards were used for advertising. The preliminary registered participants were required to fill in an assessment form for screening eligibility before randomization. The inclusion criteria were: (1) Chinese adult aged 36–60 years; (2) able to understand Cantonese and read Chinese; (3) self-reported no exercise habits (at least 3 days a week for total 30 min or more; (4) reachable by telephone; and (5) would not move from the local area during the study period. The exclusion criteria were: (1) self-reported history of cardiovascular and pulmonary diseases, neurological disorder, musculo-skeletal disorder, and osteoarthritis; (2) receiving medically prescribed diet or PA intervention; (3) for women, currently pregnant; (4) have been taking any medications or long-term supplement such as herbs. Another 30 healthy individuals aged 36–60 years who met above conditions and with 2–4 years of Tai Chi experience were recruited for the supplementary Tai Chi and walking exercises test, to measure the different energy metabolism during exercises. All participants provided written informed consent.

2.3. Sample size

Based on an earlier study,[6] which showed that maximal oxygen intake (VO_2max) improved from $27.4 \pm 5.4\,ml\,min^{-1}\,kg^{-1}$ to $31.3 \pm 6.6\,ml\,min^{-1}\,kg^{-1}$ after a 12-week walking program, and based on the assumption that Tai Chi would have a similar effect as walking, under the consideration of fixed three clusters per group (9 geographic areas/3 groups) in our study, a sample size of 41 individuals per cluster was needed to achieve 80% power and detect a difference of 5.0 ml/min/kg between the group means when the standard deviation was 6.0 ml/min/kg and the intracluster correlation was 0.05 using a Two-Sided *t*-test with a significance level of 0.05.[30,31] Therefore, a total of 123 participants were needed in each group.

2.4. Randomization

The randomization was conducted at geographic area level. To avoid contamination among participants from different geographical areas, participants recruited from one geographical area were considered as one unit. Nine units were randomly assigned to three groups with the allocation ratio of 1:1. An independent statistician conducted the randomization using Excel to generate the allocation sequence. As a result, three areas were assigned to the Tai Chi group, three were assigned to the walking group, and the remaining three areas were used as control.

2.5. Exercise intervention

Two types of 12-week exercise programs were designed. For the Tai Chi group, a modified 32 Yang-style Tai Chi Chuan was used because it was easy to learn within a relatively short time. This short form Tai Chi included 32 movements. Several qualified Tai Chi Chuan instructors guided the participants during practice. One practice session lasted for 45 min, which consisted of 10 min of warm-up stretching, 30 min of Tai Chi exercise, and 5 min of cool-down stretching. Participants were required to practice 1 session per day, 5 days per week for 12 weeks. Within 1 week, 3 days of practices were led by the instructors and 2 other days were assigned for self-practice. During the first few sessions of learning period, the instructors taught 4 movements per session and accumulated from session to session, hence, all participants learned all movements within 3 weeks. After that, participants just followed the instructors to repeatedly practice all 32 movements in each instructor-led session with the standard time duration. The instructors monitored the performance of each participant. The feedback from instructors showed that participants had good compliance in their sessions. For the walking group, the qualified instructors demonstrated the standard self-paced brisk walking to the participants. One practice session consisted of 10 min of warm-up stretching, 30 min of self-paced brisk walking, and 5 min of cool down stretching. The frequency and duration of practice were the same as those for the Tai Chi group. Each instructor-led session contained 15–10 participants. All these sessions were conducted