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Wheelchair Tai Chi on balance control and quality life among survivors of spinal cord injuries: A randomized controlled trial

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ABSTRACT

Background: Wheelchair-related falls are common in survivors with spinal cord injury (SCI). We aimed to assess the effects of wheelchair Tai Chi (WCTC) practice on balance control and quality of life (QOL) among SCI survivors.

Materials and methods: Forty SCI survivors were equally divided into WCTC and control groups. The control participants only received the normal rehabilitation intervention, while the WCTC intervention involved 30-min sessions, 2 sessions/day, and 5 days/week for 6 weeks. Static sitting balance, trunk muscle strength, handgrip strength, and QOL were evaluated and statistically analyzed.

Results: Compared with the control group, static sitting balance, left handgrip strength, and the psychological domain of QOL improved significantly in the WCTC group (time by group interaction, $p < 0.05$).

Conclusion: Six weeks' WCTC training improved static sitting balance and QOL in survivors with SCI. It may be a feasible, safe, and effective exercise for SCI survivors.

1. Introduction

Most daily activities of survivors with spinal cord injury (SCI) are performed in a wheelchair. As a consequence, wheelchairs become lifelong tools of mobility for them. Wheelchair-related falls are common in survivors with SCI [1,2]. It has been reported that eighteen out of fifty wheelchair-bound subjects (36%) have experienced falls [3], which can result in physical and psychological consequences [3,4].

Previous studies have confirmed that falls occur for many complicated reasons. Among them, the most important is poor balance [5,6]. It is likely that improving balance control can prevent and reduce the risk of falls [12,13]. Factors contributing to loss of balance include poor trunk and waist muscle strength, loss of neural control, sensory decrease, equipment failure, muscle spasms, excessive speed, not wearing protective straps, gait disorders, and narcolepsy [5,6].

Improving static sitting balance in survivors with SCI can prevent them from sliding and decrease their risk of falling. Physical control ability and quality of life (QOL) in active survivors with SCI is better than in those who do not perform any physical activity [8,9]. However, because of limitations imposed by their dysfunction, only a few survivors with SCI can practice sports activity.

Tai Chi (TC) is a traditional exercise in China. Previous studies have confirmed the effect of TC training programs on balance control and fall risk in performers [10,12,13,25]. Traditional TC is performed in a standing position. Studies have shown that 10-form and 18-form TC exercise programs improved the dynamic balance function in survivors with SCI [11,12].

We designed a customized 16-form wheelchair Tai Chi (WCTC) program to meet the need to improve exercise options for survivors with SCI. This trial aimed to assess the effects of practicing WCTC on static sitting balance control and QOL among survivors with SCI.

2. Methods

2.1. Participants

Recruiting advertisements were posted in a hospital. Some participants were self-referred, some were recommended by rehab specialist, and some were recommended by other participants. The participants were right-handed SCI inpatients recruited during their recovery period from a rehabilitation center. Using a random number generator, 40 wheelchair users with SCI were randomly assigned to either the WCTC

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intervention group (20 persons) or the control group (20 persons). The inclusion criteria were people who met the diagnostic criteria for SCI according to the American Spinal Injury Association [15], between 20 and 70 years old, able to communicate and follow instructions, and able to maintain a sitting posture for more than 30 min in a wheelchair. The exclusion criteria were people with an unstable spine, spine tumor, metastatic cancer, serious cardiopulmonary disease, poorly controlled hypertension, poorly controlled trunk and upper limb hypertonia, or serious complications related to SCI (e.g., pressure ulcers, contracture).

The study protocol was approved by the ethics committee of the rehabilitation center and written informed consent was obtained from all participants before the study commenced.

2.2. Interventions

2.2.1. Normal rehabilitation intervention

All participants in both groups were undergoing individual normal rehabilitation intervention according to each patient's condition. Participants in the control group only received the normal rehabilitation intervention.

Because the SCI survivors had various bodily capabilities, the normal rehabilitation intervention needed to be individualized. The rehabilitation goal is improving the survivors' ability to perform daily activities and return to society. The rehabilitation intervention consisted of personalized rehabilitation education, teaching mobility and transfer skills, preventing injury progression, handling spasticity, managing secondary complications, and helping patients to become more independent. Based on the survivors' individualized rehabilitation goals, their rehabilitation protocol was designed by the whole team, consisting of rehabilitation doctors, physical therapists, occupational therapists, social workers, and nurses, and was delivered by the rehabilitation doctors.

2.2.2. The WCTC intervention

Besides the abovementioned normal rehabilitation intervention, participants in the WCTC group also received WCTC training. The WCTC intervention involved a 30-min session, two sessions per day, and five days per week for a total of six weeks. The program consisted of three parts: a 5-min warm-up session, WCTC movements that encompassed 16 easy-to-learn and easy-to-perform forms, and a 5-min cool-down session. A 16-form WCTC style was designed for the study (Appendix A and B). A TC master conducted the training. The assessors and rehabilitation specialists were blinded to treatment group. Attendance was recorded.

2.3. Test parameters and approach

2.3.1. Body mass index (BMI)

Height and body mass of each participant were measured. BMI was calculated by BMI = Body Mass/Height^2.

2.3.2. Muscle strength

Trunk extensor peak torque, extensor relative peak torque, flexor peak torque, and flexor relative peak torque were measured at angular velocity 60°/s with an isokinetic dynamometer (IsoMed2000).

A hand dynamometer was used to measure both left and right handgrip muscle strength. Participants were instructed to sit on their wheelchair with the test shoulder adducted and rotated neutrally, the elbow flexed at 90°, the forearm in a neutral position, the wrist between 0 and 30° of extension and between 0 and 15° of ulnar deviation. Familiarization trials were allowed before the test. The results of three measurements provided the maximum strength for comparison.

2.3.3. Static sitting balance

A chair was designed for this experiment with the seating surface fixed at the average wheelchair height. Participants were asked to sit on the chair for 90 s with their eyes open and as still as possible. They were seated upright such that their thigh-trunk angle was at approximately 90°, and both hands were resting on their thighs. Participants were asked to maintain visual contact with a target set at eye level, 2 m in front of them.

The chair and foot support surfaces were instrumented with a 600 mm × 400 mm force platform (AMTI BP400600-2000, Advanced Mechanical Technology, Inc., Newton, MA, USA). The center of pressure (COP) sway underneath both the seat and the foot support surfaces were sampled at a rate of 1000 Hz. The total displacement of COP in the anteroposterior (COP_{AP}) and mediolateral (COP_{ML}) directions were collected and statistically analyzed.

2.3.4. Quality of life

The short version of the World Health Organization's Quality of Life Instrument (WHOQOL-BREF) has been widely validated and popularly used in assessing the subjective QOL of patients in mainland China. The Chinese version of the World Health Organization's QOL Scale (WHOQOL-BREF) has previously been shown to have high intra-rater reliability [17]. Its validity has been established as a tool for measuring the QOL of Chinese individuals with SCI [18]. The WHOQOL-BREF instrument includes four domains: physical capacity (7 items), psychological well-being (6 items), social relationships (3 items), and environment (8 items); the instrument has two additional items that measure overall QOL and general health respectively. These 26 items are rated on a 5-point scale with a higher score representing a higher QOL. Cronbach's alpha values in the four domains fell in the range of 0.77–0.85 [26].

2.4. Statistics analyses

The sample size was determined through a power calculation based on our previous study of six-week WCTC training. Demographic characteristics and baseline data of the experimental group were compared with those of the control group, using the chi-square test for categorical variables and *t*-test for continuous variables to analyze the homogeneity between the groups.

Two-way repeated measures MANOVA was performed to analyze if any intergroup differences in the tests were due to the effect of WCTC on balance, strength, and QOL measures between, before, and after the intervention. A significance level (α) of 0.05 was chosen for the statistical comparisons. All statistical analyses were conducted using SPSS version 23 software (SPSS Inc., Chicago, IL, USA).

3. Results

The characteristics of the two groups are summarized in Table 1. There were no significant differences in gender distribution, average age, BMI, injury level, time since injury, or smoking history between the two groups.

3.1. Muscle strength

No significant time by group interaction was found in extensor peak torque, flexor peak torque, extensor relative peak torque (PT/BW), and flexor relative peak torque (PT/BW) between and within groups, before and after the intervention.

As show in Table 2, two-way repeated measures MANOVA test of right handgrip strength showed no significant time difference by group interaction. However, paired *t*-tests revealed that the WCTC group had significant improvements in dominant handgrip strength after six weeks of training ($P < 0.05$). Left handgrip strength showed a significant time by group interaction ($P = 0.03$). There was no significant improvement in left handgrip strength in the WCTC group or the control group after six weeks of intervention ($P > 0.05$).