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Tai Chi for People with Visual Impairments: A Pilot Study

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Abstract: This pilot study assessed the physical and psychological outcomes of a tai chi exercise program for eight adults with visual impairments. It found that after eight weeks of orientation and mobility training and tai chi practice, the participants' single leg-stance time and total knee flexion work and power improved, as did their frequency of, independence in, and satisfaction with performing mobility tasks.

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Tai chi is an ancient form of classical conditioning exercises that Chinese people have performed for

centuries for the purposes of health and self-defense (Liang, 1977). Based on the holistic approach of balancing the mind and body, tai chi exercises combine a series of postures and slow movements called forms. The forms include a gradual progression of slow, controlled movements that emphasize rotation of the body and trunk, flexion of the hips and knees, weight shifting, reciprocal arm movements, and balance.

Both physiological and psychological benefits of tai chi practice have been demonstrated in sighted people. From a physiological perspective, tai chi practice can maintain the mobility and flexibility of the musculoskeletal system, improve balance, increase aerobic capacity, enhance postural stability, and lower blood pressure in older adults (Hartman et al., 2000; Husted, Pham, Hekking, & Niederman, 1999; Lan, Lai, Chen, & Wong, 1998; Wang, Lan, Chen, & Wong, 2002; Wolf et al., 1996; Young, Appel, Jee, & Miller, 1999). From a psychological perspective, participants use tai chi for developing mind and body interaction, reducing stress, and improving their sense of overall well-being and self-efficacy (Kutner, Barnhart, Wolf, McNeeley, & Xu, 1997; Li, Harmer, McAuley, Fisher et al., 2001). The Atlanta Frailty and Injuries: Cooperative Studies of Intervention Techniques trial demonstrated that tai chi practice can reduce the risk of falls by 47.5% in older adults (Wolf et al., 1996). Although older sighted adults have benefited from tai chi practice, the benefits for older adults who are visually impaired (that is, those who are blind or have

low vision) have not yet been studied. This study is the first effort to explore the possible benefits of tai chi for older individuals with visual impairments.

Vision is an independent predictor of an individual's performance of activities of daily living (Horowitz, 1994). For many people, visual impairment often leads to inactivity and anxiety about travel, which consequently leads to poor physical condition and impaired functioning during activities of daily living. This reduction in activity level may lead to problems with coordination, balance, and gait (Crews & Campbell, 2001). Although orientation and mobility (O&M) training involves many of these mobility-performance skills (coordination, balance, and gait), Ramsey, Blasch, and Kita (in press) found that training at the VA Blind Rehabilitation Center in Decatur, Georgia, had little impact on parameters of gait, balance, and strength. Additional body-movement activities may be required to improve the overall function of people who are visually impaired. Therefore, we hypothesized that an exercise program such as tai chi, in addition to the traditional O&M training, may be an effective intervention for improving balance, strength, coordination, and confidence in older individuals with visual impairments. The purpose of this pilot study was to examine the effects of a tai chi exercise program on physical and psychological parameters in a group of older adults with visual impairments who were involved in O&M training.

Methods

Ten people with visual impairments (3 women and 7 men) who were undergoing rehabilitation training at a local rehabilitation center (the Center for the Visually Impaired, Atlanta, Georgia) were recruited to participate in the study. A total of eight people participated in the study. Participation was limited to individuals who had problems with mobility and were qualified and registered to begin O&M training. In addition, the participants obtained clearance from their physicians to participate in O&M training on the basis of their current health status and their ability to travel on level ground, travel up hills, climb stairs, and stand independently. Individuals were excluded if they had medical or orthopedic conditions that would impede their participation in a low-to-moderately intense level of physical activity. The age range of participants in this pilot study was 36–77 years (mean ± *SD* = 53.6 ± 12.8 years). The age of onset of the participants' visual impairments ranged from birth to 74 years (mean ± *SD* = 39.3 ± 24.3). The causes of the participants' visual impairments were glaucoma, Lieber's disease, cataracts, optic nerve damage, Morin's ulcer, diabetic retinopathy, and corneal scars. The characteristics of the participants are presented in Table 1.

Tai chi exercise

The one-hour tai chi classes were held twice a week for

eight weeks, for a total of 16 classes, and were in addition to the participants' regularly scheduled O&M training. Tai chi training took place at the rehabilitation center so that transportation did not disrupt the participants' regular rehabilitation schedules. If the participants missed more than two consecutive classes, they were encouraged to return to the classes.

Each one-hour tai chi session consisted of a 10–15 minute warm-up, 35–45 minutes of tai chi practice, and a 5-minute cooldown. All the sessions were led by an experienced tai chi instructor who explained the warm-up and cooldown exercises; taught the movements; and promoted relaxation, deep breathing, and concentration of the mind. A modified version of the Yang style of tai chi was used that emphasized balance, structure, and body alignment. The participants were also asked, but not required, to practice the skills they learned for 15 minutes outside of class each day. Additional staff were present during each class to ensure the participants' safety and to comply with Institutional Review Board requests. One of the functions of the center's Institutional Review Board was to minimize risk to participants.

A combination of verbal cuing and assisted movement was used with some participants who were in the early stages of learning tai chi. Although the participants relied solely on verbal cuing after a few weeks of tai chi practice, assisted movement was required to teach the tai chi movements when verbal cuing was not

effective or confused the participants. With assisted movement, the tai chi instructor placed the participant's hand or arm on the instructor's arm and then performed the movement while the participant's hand or arm followed the movement. This technique allowed the participant to feel the actual movement, thus creating a memory of the movement pattern that could be replicated when the instructor was not present.

Outcome measures

Absolute muscular strength, work, and power

Absolute muscle strength, work, and power of the knee during extension and flexion were measured on a Kin-Com isokinetic dynamometer. This device moves at a constant velocity while the resistance changes throughout the range of motion.

Each participant was seated with 90 degrees of knee and hip flexion, with a strap secured tightly across the waist and thigh to anchor the participant to the seat with his or her arms across the chest. The ankle was also attached via a Velcro strap to a movable arm that allowed movement about the knee joint. Before the test, each participant was given instructions and allowed one familiarization trial. When given the "go" command, the participants extended and then flexed their knees through a range of motion of 60 degrees at a speed of 120 degrees per second. Two sets of five repetitions were performed with 45 seconds of rest in

between. The average of the two trials was used for analysis.

The outcome variables included total work during extension and flexion, total power during extension and flexion, and mean peak force during extension and flexion. Work is the amount of force applied over a certain distance measured in joules (J), and power refers to the amount of work performed over time measured as watts (W). Total work and power were measured as the absolute total amount of work and power completed during extension and flexion over the five repetitions. Mean peak force was the average peak force (strength) applied over the five repetitions during extension and flexion, measured in newtons (N).

Balance

The Berg balance test was used to assess measures of static and dynamic balance (Berg, Maki, Williams, Holliday, & Wood-Dauphinee, 1992; Berg, Wood-Dauphinee, Williams, & Maki, 1992). This test is both reliable ($r = 0.98$) and valid for a population of sighted older adults (Berg, Wood-Dauphinee et al., 1992) and has been used with individuals with visual impairments (Ramsey et al., in press). The participants were asked to perform tasks, such as rising from a chair without the use of the armrests, alternate foot tapping on an 8-inch bench, turning 360 degrees in a complete circle, and standing on one leg for a maximum of 10 seconds. Each task was scored on a 4-point Likert scale;

however, for tasks that were time dependent, the time was recorded with a stopwatch to the nearest .01 of a second. This additional scoring mechanism allowed for analyses of the change in performance times in addition to the ordinally scaled scores. The test was modified slightly to include more verbal cuing and detailed instructions for the participants. For example, when we asked the participants to pick up a shoe in front of them, we asked them to pick up the shoe that was located approximately 6 inches in front of their right foot. A spotter was present during the test to prevent injury in case a participant lost his or her balance.

Functional reach

Functional reach is a valid and reliable (r = 0.52 to 0.92) clinical measure of anterior and posterior postural stability, performed according to the procedures established by Duncan, Weiner, Chandler, and Studenski (1990). Briefly, the participants stood parallel to a wall with their feet flat on the floor and their arms extended forward. Each participant was asked to reach as far forward as possible while keeping his or her feet flat on the floor. A yardstick was used to measure the distance that the participant reached forward to the nearest eighth of an inch. The best (farthest forward reach distance) of three trials was recorded.

Quality of life

The Blind Rehabilitation Service Follow-up Outcomes Survey (VA-13) examines functional abilities that are associated with each of the four major areas of rehabilitation-related skills (O&M, communication and activities of daily living, manual skills, and visual skills) and other behaviors associated with the general adjustment to visual impairment (De l'Aune, Williams, & Welsh, 1999). The Department of Veterans Affairs has used the VA-13 extensively over the past five years to track the functional gains of 5,120 visually impaired veterans who have participated in vision rehabilitation. The VA-13 measures the degree of independence, frequency, and satisfaction associated with specific functional tasks and is calculated as a summed, standardized overall composite. Reliability coefficients for the internal consistency of the VA-13 (Cronbach's alpha) have been shown to range from .86 to .93 (De l'Aune et al., 1999). This measurement instrument is responsive to rehabilitation-related changes (De L'Aune, Welsh, & Williams, 2000; De l'Aune et al., 1999). It was administered to each participant after the physiological testing was complete. Each participant's frequency of, independence in, and satisfaction with performing mobility tasks related to O&M were assessed and recorded using a Likert scale.

Statistical analyses

The Levene statistic was used to test the homogeneity of variance assumption between and within populations. The results indicated bilateral symmetry,

that is, that there were no statistically significant differences in muscle strength, power, or work between the left and right legs ($p > .05$) at the baseline and posttest. On the basis of this finding, the average bilateral pre- and posttest scores for the muscle strength, power, and work variables were used for analysis; the average of the right and left leg values were combined.

Descriptive analyses (mean ± *SD*) for the participants' characteristics and outcome measures were performed using SPSS (version 10). Because this was a pilot study and the sample was small, no further statistical analyses were performed.

Results

Two participants dropped out before the tai chi intervention and O&M training started. Their reasons for dropping out included the detection of medical problems and the lack of transportation, which led to their disqualification from O&M training. No injuries resulted from practicing tai chi.

We found that teaching tai chi to older adults with visual impairments was different from teaching it to sighted older adults. The instructor relied heavily on verbal cuing and manual body placement to teach the forms. To be able to construct the verbal cues that the participants needed to create the correct body movements, the instructor needed to understand the

kinematics behind each tai chi movement and be able to describe each movement from its muscular point of origin. Furthermore, the instructor needed to be adept at linear thinking and able to communicate directional thoughts, so the participants could understand why and how they were moving. In addition, when making visual references to the tai chi movements, knowledge of each participant's degree of visual impairment and age of onset of the visual impairment was necessary for correct verbal cuing. Individuals who had recently lost their sight had visual references that made verbal cuing easier than it did for those who had been blind since birth and had no visual references. Using verbal cues with reference to daily tasks improved the participants' understanding of a desired movement.

When we compared the pre- and the posttest means, we observed improvements in most of the variables. All muscular strength, power, and work outcome variables improved; however, larger differences were observed for total power during knee flexion (30% ± 15%) and mean peak force during knee extension (17% ± 15%) (see Table 2). The change in functional reach and the total score on the Berg balance test after the tai chi intervention (see Table 3) was small: 0.75% ± 2% and 2.0% ± 4%, respectively. The participants exhibited a greater improvement in single-stance time after tai chi practice, 6.3% ± 0.4%. The results of the VA-13 demonstrated an improvement in the frequency of (37.4%), independence in (27.5%), and satisfaction with (31.6%) performing mobility tasks after the tai chi

intervention.

Discussion

Tai chi has been shown significantly to improve strength, balance, aerobic capacity, and physical function in sighted older adults (Lan et al., 1998; Lan, Lai, Chen, & Wong, 2000; Li et al., 2001) and has been performed safely by older individuals with severe osteoarthritis (Hartman et al., 2000) and persons with multiple sclerosis (Husted et al., 1999). However, there have been no studies of tai chi interventions with people who are visually impaired. This pilot study provides preliminary data to indicate that tai chi is a safe and effective exercise for improving the strength, balance, and quality of life of older adults with visual impairments.

People who are visually impaired are typically less active and have more health problems and a higher prevalence of diabetes, heart disease, arthritis, hypertension, stroke, falls, and osteoporosis than do sighted people (Crews & Campbell, 2001). The combination of these factors leads to greater difficulty walking compared to sighted older adults (Crews and Campbell, 2001). The stiff and hesitant walking pattern that is typically displayed by adults and children with visual impairments leads to balance difficulties, which may make participation in traditional exercise programs difficult (Sleeuwenhoek, Boter, & Vermeer, 1995). Moderately intense exercise is recommended by

the Surgeon General of the United States (U.S. Department of Health and Human Services, 1996) and is included in the objectives of *Healthy People 2010* (Centers for Disease Control and Prevention, 2000) as a means of reducing mortality and morbidity. The moderate intensity of tai chi exercises has been compared to a brisk walk (Jin, 1992), which has been shown to confer cardioprotective and musculoskeletal improvements. Thus, tai chi would seem to be an appropriate alternative or addition to traditional exercises, such as walking, swimming, and bicycling.

The observed improvements in muscle strength and power were similar to those observed in other studies. After one year of tai chi practice, four to seven days per week, older adults significantly increased their maximal knee extension and flexion strength 18.1% and 15.4%, respectively (Lan et al., 1998). A shorter-duration (six-month) tai chi intervention resulted in improvements in isokinetic peak torque (13% – 24%) and muscular endurance (9% – 19%) (Lan et al., 2000). (In the referenced study, isokinetic peak torque refers to the peak angular work performed by the quardriceps muscles on the knee joint during an isokinetic movement.) These findings, along with those of the current study, demonstrate that tai chi can improve measures of muscle strength. Since muscle strength is significantly related to physical function (Buchner & de Lateur, 1991), an improvement in strength may lead to improvements in functional performance. Thus, the benefits of tai chi could be logically extended to the

performance of such daily tasks as rising from a chair and climbing stairs.

The primary lower-body position for most tai chi forms requires flexion of the knees, hips, and ankles, which lowers the individual's center of mass and hence improves postural stability and balance. It is plausible that the participants in this study used this common lower-body position to stabilize themselves for the balance measure, which improved after the tai chi intervention. However, the same lower-body position may have limited their ability to increase their functional reach. Thus, the participants were able to get lower to the ground and remain in a stable position, but they were not able to reach farther forward while keeping their feet flat on the ground. They may have learned how to maintain their center of mass over their base of support during static activity; however, doing so may have reduced their ability to move *outside* their base of support during dynamic activity. Hain, Fuller, Weil, and Kotsias (1999) found similar results in a group of adults (aged 20–76) with self-perceived mild balance disorders.

VA-13 is typically used in rehabilitation settings where visually impaired individuals are assessed before and after rehabilitation training. This measure of satisfaction with, independence in, and frequency of performing mobility tasks was appropriate for the participants in this study. Similar to reports by others (Kutner et al., 1997; Li, Harmer, McAuley, Duncan et

al., 2001), our study found that the participants' satisfaction with, independence in, and frequency of performing mobility tasks increased after the tai chi intervention. Others have also reported a reduction in fear of falling after regular tai chi practice (Kutner et al., 1997). Anecdotally, the participants in our study reported an elevated mood during the tai chi classes and in daily life, greater confidence with mobility, less fear of falling, and an overall improvement in well-being.

The observed improvements in balance, strength, and quality of life may have functional implications for people with visual impairments. As was evidenced by the improvements in the variables related to performance, the participants were more confident in their mobility-related abilities and engaged in social activities more frequently, thus enhancing their socialization and involvement with the community. Greater strength and balance may improve people's performance of instrumental activities of daily living and confidence in moving in the environment. Increased social-community involvement and physical activity can reduce morbidity and hence may result in a healthier, as well as longer, life. Thus, incorporating tai chi practice into rehabilitation training may be beneficial for persons who are visually impaired.

Limitations of the study

The results of this pilot study should be interpreted

with caution considering the study's limitations. First, a post hoc power analysis revealed a critical effect size of 1.67 and power of 0.75 on our measure of mean peak knee extension force. Thus, we did not have enough statistical power to detect statistically significant differences between the pre- and posttest scores. Second, tai chi practice outside class time was not recorded. The variability in practice may have skewed our results. Last, there was no control group, which limits our ability to state that the results were due to the tai chi intervention itself.

Implications for practice

Although this was a pilot study, the results provide preliminary evidence to support the use of tai chi as an effective modality for improving the balance, strength, and quality of life of individuals with visual impairments. At this time, it would be premature to prescribe tai chi for all individuals who are undergoing O&M training because further research is needed to support these pilot data (i.e., larger randomized controlled trials and an examination of the effects of other types of exercise programs). However, with further research, we hope to provide support for incorporating tai chi into rehabilitation programs in rehabilitation centers, as well as in community centers to foster socialization and involvement in the community.

In summary, this study demonstrated that tai chi

practice can safely and effectively improve strength, balance, and quality of life in older individuals who are visually impaired. Since adults with visual impairments are consistently less active than are sighted adults and have poorer health status, tai chi may be an appropriate moderate-intensity exercise for them. Further research is needed to support the efficacy of tai chi for these individuals. A randomized control trial that examines the effects of tai chi on physical function and falls in visually impaired persons is warranted.

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