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Tai Chi effects on neuropsychological, emotional, and physical functioning following cancer treatment: A pilot study

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A B S T R A C T

Objective: To examine the effects of a 10-week Tai Chi (TC) program on neuropsychological, psychological, and physical health of female cancer survivors.
Design: Twenty-three women with a history of cancer participated in 60-min TC classes two times/week for 10-weeks.
Main Outcome Measures: Before and after the intervention, participants completed neuropsychological tests (memory, executive functioning, language, and attention); 5 tests of balance; and self-report questionnaires of neuropsychological complaints, stress and mood, and fatigue.
Results: After the 10-week session, participants evidenced fewer neuropsychological complaints and enhanced neuropsychological functioning. They also demonstrated improved balance and reported better psychological functioning.
Conclusions: Results suggest that TC may promote gains in neuropsychological functioning, in addition to previously demonstrated improvements in physical and psychological health. These findings support the need for controlled trials examining the potential benefits of TC on neuropsychological functioning after cancer.

1. Introduction

Recent estimates indicate that 11.4 million Americans are currently living with cancer.[1] As medical advances lead to improving survival rates, concerns regarding long-term sequelae of cancer and its treatments are receiving increased attention. One example of this is the growing interest in understanding the nature of neuropsychological difficulties following cancer treatment and identifying potential treatments.

Neuropsychological difficulties have been documented in up to 1/3 of cancer survivors.[2] While a wide range of cognitive domains may be affected (for reviews see[3,4]), relative weaknesses in executive functioning and memory in particular have been noted.[5] Studies of breast cancer survivors indicate that neuropsychological functioning frequently improves over time,[6] yet persistent difficulties may remain many years after treatment completion.[7] Moreover, neuropsychological deficits are associated with lower quality of life in breast cancer survivors.[8] These findings highlight the need for research-supported interventions to address these difficulties.

Although previous research has demonstrated the beneficial effects of skills training[9] and medication (e.g., D-methylphenidate[3]; modafinil[10]) on neuropsychological difficulties following cancer treatment, many cancer survivors turn to complementary and alternative medicine interventions, such as Tai Chi (TC), for symptom relief and health promotion.[11] A recent review of TC research[12] detailed benefits to physical functioning, psychological well-being, and cognitive functioning (i.e., attention) that have been reported in research to date. Recognizing this burgeoning interest, the pilot study detailed herein was designed as a preliminary step in evaluating TC as a potential intervention to improve neuropsychological abilities in women cancer survivors.

TC is a Chinese martial art long practiced for health promotion and maintenance. Training in TC involves practicing forms (slow motion routines) and is based on a number of guiding principles, including mindfulness, breathing awareness, active relaxation, and slow movement.[13] TC has been described as a moderate form of exercise[12]; the Yang style form used in the present study has been shown to have an intensity not exceeding 50% of participants' maximum oxygen intake.[14] Importantly, TC's emphasis on slow movement renders it particularly well suited to a wide range of fitness levels,[15] which may characterize the cancer survivor population.

Prior research with a range of medical populations has demonstrated that TC may have beneficial effects on physical

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functioning and psychological well-being. TC can positively affect balance, flexibility, strength, and aerobic capacity.[13,16] Documented psychological benefits of TC include reduced tension, depression, and anger, and improved quality of life in a wide range of populations,[17] including cancer survivors.[18] Authors of a recent review of the literature recognized the benefits of TC but noted there remains insufficient evidence to either support or refute the potential superiority of TC over other treatments for improving physical and psychological health in cancer patients.[19] However, based on their review of the literature, the authors called for additional research to evaluate this possibility.

To date there has been limited work examining the potential effects of TC on neuropsychological functioning. However, one study of middle-aged women demonstrated changes in electroencephalographic (EEG) activity that was suggestive of increased alertness after practicing TC.[20] Further, another study on the combined effects of a single session of TC and yoga intervention noted improved performance on a simple addition task,[21] perhaps due to improved focus and attentiveness.

We hypothesize that TC may improve neuropsychological functioning via several mechanisms. First, as a form of moderate aerobic exercise, TC may benefit cognitive functioning in a manner similar to other exercise programs.[22] Increased levels of aerobic activity have been associated with better cognitive abilities both when evaluating concurrent exercise habits and cognitive abilities,[23] and when examining this relationship retrospectively.[24] This relationship may reflect enhanced vascular functioning via aerobic exercise, which has also been demonstrated with TC.[25] Second, TC's emphasis on learning new motor skills may provide additional benefits to cognitive functioning beyond what is realized with repetitive aerobic exercise having no learning component (e.g., walking, running on a treadmill). In support of this, a large body of research indicates that engaging in cognitively challenging activities may buffer against cognitive decline with aging.[26] In addition, nonhuman animal research has documented that aerobic exercise requiring new motor learning exceeds the neuroanatomical benefits of other repetitive exercise forms.[27] Finally, TC may surpass other exercise interventions in its ability to affect cognitive functioning because of the additional element of encouraging mindfulness,[13] a state of relaxed, focused attention. In fact, others have hypothesized that meditation alone may positively affect cognitive functioning after cancer treatment,[28] as research with other populations has demonstrated that meditation can improve attention.[29]

Thus, this pilot study was undertaken as a first step in examining the potential benefits of TC to neuropsychological functioning among women with a history of cancer. It was predicted that prior research on the benefits of TC to emotional well-being, self-reported fatigue, and balance would be replicated. In addition, we predicted that participation in TC may positively affect neuropsychological functioning, as assessed by standardized neuropsychological tests and self-report measures.

2. Materials and methods

2.1. Participants

Twenty-three female cancer survivors[d] were recruited from university-based oncology clinics and from the community in a mid-sized, Midwestern city. Individuals were eligible to participate if they had been diagnosed with cancer (any site) and had undergone chemotherapy, with treatment completed at least 12 months prior to the start of the study. Cancer sites included breast ($n = 16$), ovarian ($n = 3$), endometrial ($n = 1$), non-Hodgkin's lymphoma ($n = 2$), and chronic lymphocytic leukemia ($n = 1$). All participants had received chemotherapy; a majority had undergone surgery (65.2%) and/or radiation therapy (60.9%). Eleven participants (47.8%) had taken adjuvant hormone therapies. Exclusion criteria included: brain metastases, prior/current neurological disease/insult (e.g., stroke, multiple sclerosis, traumatic brain injury), and prior/current severe mental illness or substance abuse.

2.2. Procedure

The research protocol, including procedures associated with recruitment, consent, treatment, and follow up evaluation, was approved by the appropriate university institutional review board. Participants received information regarding the study from oncology clinic health care providers and via word of mouth in community and university-based support groups. Informed written consent was obtained from each participant per institutional review board guidelines.

Study participants completed two data collection sessions: the first prior to the start of the 10-week TC course, and the second within one-month after the course was complete. Data collection was completed by a research assistant under the supervision of the principal investigator (SRA); the TC class instructor and study co-investigator (SM) was not involved in data collection, with the exception of recording class attendance. Training in administration of the balance measures was provided to the research assistant by the co-investigator (SM), a licensed occupational therapist with extensive experience in clinical assessment and treatment of physical functioning and balance. During the pre- and post-intervention sessions, participants completed a standard battery of neuropsychological tests, a brief balance screening, and self-report questionnaires. Participants were paid a nominal sum ($20) for each of these two 90-min sessions, as a token of appreciation for their involvement in this research.

The TC classes were taught by the co-investigator (SM), a trained TC instructor. The 1 hour classes met 2 times per week for 10-weeks. The frequency and duration of classes compares favorably to other TC studies and to typical community classes, and was considered to be a realistic and reasonable commitment to ask of study participants. Two sessions of classes were offered, to ensure that the class size did not exceed 15 participants.

Instruction was based on Tai Chi Fundamentals (TCF), a modification of a classic Yang style TC.[30] The simplified TCF form is taught in a motor progression, making it easier and faster to learn than classic longer forms. The 15 moves are completed in about 5 min, compared to classic forms that are 10–20 min in length. This form was selected because it has been in similar research with people having chronic diseases.[31] Additionally, Yang style is also one of the most popular Tai Chi forms practiced worldwide,[30] increasing the likelihood that this research could be conducted in other communities and making it easier for participants in this study to find similar classes after the project ended.

Each class began with a brief period of instructor-guided sharing between class participants. Class continued with warm up exercises that focused on TC principles such as gathering and sensing qi (energy), posture (body upright), breathing, active relaxation, centering, and balancing. Warm ups included twelve basic moves designed to help persons coordinate breathing with moving in a sequence that progressed in difficulty; these discrete moves corresponded to the sequence of moves learned in form practice during the second half of each class. Moves utilized in the second

[d] Twenty-nine individuals enrolled and 23 participants completed the study. *T*-test analyses revealed no differences between those who completed the study and those who did not in terms of demographic variables, cognitive functioning, physical functioning, or psychological functioning at Time 1 (pre-class).

half of each class meeting included *ward off*, *cloud hands*, *single whip*, *brush knee*, *snake creeps down*, and single leg stances and kicks. All participants were able to engage in the forms in both standing and floor-based positions, with the exception of one participant who did the exercises from a chair due to her mobility limitations. Both silence and stillness were components of the class, but tranquil music composed by the creator of the TCF form[30] was used consistently during form practice.

2.3. Measures

2.3.1. Cognitive

Neuropsychological tests sensitive to cognitive difficulties in cancer survivors[4] were administered. This battery included: (a) *Memory*: Rey Auditory Verbal Learning Test[32]; (b) *Executive functioning*: Trail Making Test B,[33] Stroop Test[34]; (c) *Language*: Controlled Oral Word Association Test[35]; and, (d) *Attention*: WAIS-III Digit Span and Digit Symbol,[36] and Trail Making Test A.[33] Raw scores were transformed to z-scores using age-, education-, and gender-based normative data.[37] These tests were selected for the present study because they have specifically been identified as sensitive to neuropsychological deficits following cancer treatments (see[4] for a summary). Measures were selected to maximize the likelihood of identifying cognitive deficits while limiting participant fatigue and response burden.

Cognitive complaints were assessed with the Multiple Abilities Self-Report Questionnaire (MASQ).[38] With this measure, respondents indicate on a 5-point scale whether they experienced cognitive difficulties in six domains: Verbal Memory, Visual Memory, Attention, Language, and Visuospatial Abilities. This questionnaire has demonstrated utility with cancer survivors in other research.[9]

2.3.2. Psychological

The Impact of Event Scale-Revised (IES-R[39]) was used to measure levels of distress with respect to cancer diagnosis and treatment. This study utilized one subscale measuring intrusive thoughts and a second measuring avoidance behavior, both of which have been used to assess psychological trauma and stress symptoms. A total summary score was also computed. The POMS-SF, which is a 37-item version of the original 65-item POMS, was developed to assess mood in cancer patients.[40] There are six subscales: Depression, Vigor, Confusion, Tension, Anger, and Fatigue.

2.3.3. Physical

Fatigue was evaluated with the POMS-SF Fatigue subscale.[40] Balance was assessed with a short battery of measures[41] that took 10–15 min to complete. This battery included: Five Times Sit to Stand (FTSS – postural control and lower extremity strength), Single Heel Raises (SHR – walking endurance and ankle strength), Multidirectional Reach (MR – balance while reaching in anterior-posterior and medial-lateral directions), Timed Up and Go (TUG – functional mobility), Single Leg Stance (SLS – lower extremity strength and balance), and Habitual Gait Speed (HGS – lower extremity power and dynamic balance).

3. Statistical analyses

Within-subjects ANOVAs were performed to determine whether participants evidenced changes in functioning from prior to the start of the 10-week TC class (Time 1) to after the class (Time 2). Consistent with other research on cognitive functioning in cancer survivors,[8] Reliable Change Index (RCI) analyses[42] were completed to determine whether changes in neuropsychological test score were statistically reliable.

4. Results

4.1. Demographics

Participants' average age was 62.3 years (SD = 10.8); average education was 16.4 years (SD = 2.1). Participants were an average of 6.5 years post-cancer diagnosis (SD = 4.1).

4.2. Pre-post-intervention changes

4.2.1. Cognitive functioning

As presented in Table 1, statistically significant changes in neuropsychological test scores were observed on measures of immediate memory (Rey Trial 1, Rey Trials 1–5, Logical Memory I), delayed memory (Logical Memory II), verbal fluency (COWAT), attention (Trails A, Digit Symbol) and executive functioning (Trails B, Stroop Test) (all p's $< .05$). Reliable change index (RCI) analyses with group mean scores for these 8 measures indicated they did not meet criteria for reliable change (all RCI's < 1.37). However, RCI analyses for individuals' scores on these 8 measures revealed that a portion of participants (ranging from 8.7% to 26.1%) evidenced statistically reliable improvements over time (see Table 2). Finally, significant improvements in self-reported cognitive functioning were found on two MASQ subscales: Verbal Memory ($p = .01$) and Visual Memory ($p < .05$).

4.2.2. Psychological functioning

As presented in Table 2, analyses revealed improvements in stress levels, as measured by IES Total ($p < .05$). An improvement

Table 1
ANOVA comparisons of pre- and post-intervention cognitive functioning.

Domain	Variable	Time 1	Time 2	F	p	RCI	% RC[c]
Cognitive Test[a]	Rey Trial 1	−.25(1.03)	.34(.88)	$F(1,22) = 5.74$	.026	.82	26.1
	Rey Trial 1–5	.18(1.07)	.65(1.03)	$F(1,22) = 5.03$	.035	.55	17.4
	WMS-LMI	.96(.90)	1.62(.57)	$F(1,22) = 26.32$	<.001	1.27	17.4
	WMS-LMII	1.26(.72)	1.74(.43)	$F(1,21) = 15.97$	=.001	.94	13.6
	COWAT	−.46(.87)	−.07(.87)	$F(1,22) = 12.00$	=.002	.67	13
	Digit Symbol	1.03(.92)	1.27(.84)	$F(1,22) = 3.82$	.064	.47	8.7
	Trails A	.31(1.28)	.99(.58)	$F(1,22) = 12.29$	.002	1.05	17.4
	Trails B	−.36(2.28)	.28(1.86)	$F(1,22) = 18.49$	<.001	1.36	26.1
	Stroop Test	.37(1.06)	.72(.88)	$F(1,22) = 6.46$	.019	.47	4.3
Cognitive Self-Report[b]	MASQ Verbal Memory	3.67(.38)	3.87(.39)	$F(1,21) = 7.83$	.011	–	–
	MASQ Visual Memory	3.98(.30)	4.14(.31)	$F(1,21) = 4.98$	.037	–	–

[a] Values for Cognitive Tests at Time 1 and Time 2 reflect z-scores, computed based on age-, education- and gender-based normative data.
[b] Values for Cognitive Self-Report measures at Time 1 and Time 2 reflect mean scores (to correct for any missing data).
[c] % RC refers to the % of individuals evidencing reliable change, per RCI analyses, on each Cognitive test.

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Table 2
ANOVA comparisons of pre- and post-intervention psychological and physical functioning.

Domain	Variable	Time 1	Time 2	F	p
Psychological[a]	IES Total	.74(.61)	.44(.34)	$F(1,19) = 4.55$	.046
	IES Avoid	.97(.76)	.57(.67)	$F(1,19) = 4.09$	.058
	POMS Vigor	2.27(.44)	2.47(.49)	$F(1,21) = 4.00$	.059
Physical[b]	Habitual Gait	2.53(.88)	2.09(.53)	$F(1,22) = 7.62$	.011
	M. Reach – Rt.	8.44(2.12)	10.55(2.22)	$F(1,22) = 11.91$	.002
	Timed Up/Go	7.66(2.36)	6.41(1.50)	$F(1,22) = 12.48$	.002
	Sit to Stand	10.44(2.81)	8.82(2.50)	$F(1,22) = 13.81$	.001
	Single Heel – Rt.	22.13(5.00)	24.30(3.34)	$F(1,22) = 4.22$	.052

[a] Values for Psychological measures at Time 1 and Time 2 reflect mean scores (to correct for any missing data).
[b] Units of data for Physical functioning measures at Time 1 and Time 2 are: Habitual Gait Speed (feet/second), Multidirectional Reach Test – Right (inches), Timed Up and Go (feet/seconds), Sit to Stand (seconds), and Single Heel Raises – Right (# of heel raises).

approaching significance was also noted in self-reported vigor (POMS Vigor: $p = .059$). There were no significant effects with other POMS scales, the FACT-G, or the MAC [all F's < 1.97].

4.2.3. Physical functioning

Analyses revealed significant improvements from Time 1 to Time 2 on multiple measures of balance, including: Habitual Gait Speed, Multidirectional Reach (right arm only), Timed Up and Go, Sit to Stand, and Single Heel Raises (right foot only) (all p's $\leq .05$). No significant changes were documented in fatigue: POMS Fatigue ($F = .25$). See Table 2.

5. Discussion

Consistent with prior research, data from this pilot study of a TC intervention for cancer survivors suggested that participants experienced improved balance, as indicated by multiple measures, following 10-weeks of TC. Study participants also reported lower feelings of stress and increased vigor following the completion of the class. Such benefits to physical and psychological well-being have been reported in generally healthy populations and in individuals with chronic medical issues (e.g., fibromyalgia[31]), as well as in persons with cancer.[18] They provide further support for the potential benefit of TC to improve emotional well-being and physical functioning.

In addition, this study presents novel findings suggesting that participation in TC may be associated with reductions neuropsychological difficulties among cancer patients. First, pre-post evaluation revealed significant improvements in self-reported memory functioning among this group of cancer survivors. Moreover, statistically reliable improvements in performances on neuropsychological tests, particularly those involving memory and attention, were noted among a portion of study participants. These findings point to need for future research examining the potential utility of TC interventions for addressing cognitive difficulties following diagnosis and treatment for cancer.

As a pilot study, this research was intended to provide initial data that might stimulate future studies on the potential benefits of TC to cognitive functioning among cancer survivors. However, several limitations of this work must be noted. First, future research would be improved with a larger sample size and greater sample homogeneity (e.g., participants with a single cancer site). Second, the absence of a control group leaves several questions unanswered. For example, it remains possible that gains in functioning may reflect normal improvements over time rather than direct benefit from the intervention. Additionally, without active treatment comparison groups, it is not possible to identify what specific components of the TC intervention may be driving some of the observed benefits. Comparisons with an exercise intervention would help clarify whether effects are specific to TC or if they may occur with other types of exercise. Use of a control condition involving social support (e.g., traditional social support group) or a mindfulness component (e.g., MBSR) would shed light on whether the psychological and cognitive benefits observed in this study may have been secondary to a non-exercise component of TC. Finally, while the music utilized in this intervention was a standard component of the Tai Chi Fundamentals program,[30] the specific effects of including this as part of a TC intervention are unknown. To enhance health care providers' ability to replicate findings of benefit with cancer survivors in other settings, future research would benefit from also controlling for this component of the intervention to distinguish its particular effects.

Despite these limitations, this research provides preliminary findings suggesting that TC has the potential to promote gains in cognitive functioning as well as physical and psychological well-being in cancer survivors. Because approximately 1/3 of cancer survivors may be experiencing cognitive difficulties following cancer treatment,[2] there is great need to identify feasible and effective interventions to treat this potential long-term consequence of cancer and its treatments. Moreover, given the growing interest in complementary therapies, examination of TC to address these consequences among cancer survivors may have particular merit.

Conflict of interest

The authors have no conflicts of interest related to this work.

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