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Original Article

Effects of Tai Chi on telomerase activity and gerotranscendence in middle aged and elderly adults in Chinese society

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ABSTRACT

Introduction: Telomeres are DNA protein structures at the end of chromosomes and are linked to the physical aging process. The improvement of quality of life is closely associated with aerobic exercise, and the dynamic effects of exercise on physiology and psychology are evident with aging. Tai Chi is popularly practiced in China. However, findings on the effects of Tai Chi on telomerase activity (TA) in peripheral blood mononuclear cells, and gerotranscendence (GT), as well as the association of TA and GT with Tai Chi, have been inconsistent.

Purpose: This study aims to assess TA in peripheral blood mononuclear cells, GT, and the associations between them. The associations among these variables are determined during six months of Tai Chi intervention among Chinese middle aged and elderly adults.

Methods: TA assessment was obtained by TE-ELISA (human telomerase–enzyme linked immunosorbent assay), and GT was measured at the baseline level after six months of Tai Chi intervention.

Results: TA increased significantly in the Tai Chi group from 23.75 ± 3.78 u/mmol (pre-intervention) to 26.31 ± 2.93 u/mmol (after 6 months) ($p < 0.05$). Compared with the TA in the control group, the TA in the intervention group was statistically significant after six months ($p < 0.05$). Compared with the GT in the control group, the GT in the intervention group improved significantly after six months ($p < 0.05$). TA and GT had a positive correlation ($r = 0.325$, $p < 0.01$).

Conclusion: Our data illustrated that Tai Chi had a protective effect on TA and might improve the GT in Chinese middle aged and elderly adults. The TA increased with the increasing GT in Chinese middle aged and elderly adults.

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1. Introduction

Tai Chi is a mind–body exercise that involves a range of specific and gentle physical movements and incorporates the purposeful regulation of the body [1]. Tai Chi was originally developed in China on the basis of theoretical principles inherent to traditional Chinese medicine [2]. Tai Chi involves movements and thoughts by increasing awareness and releasing muscle holding patterns [3]. Many scientific studies have reported that mind–body practices, such as Tai Chi, have a beneficial effect on health [4,5]. The improvement of mental well-being and the immune system improves overall health [6]. Tai Chi has been shown to improve muscle strength, balance, and flexibility [7]; several chronic diseases, such as fibromyalgia [8], osteoarthritis [9], and Parkinson's disease [10], can be improved with Tai Chi training [11]. This intervention is safe and popular among people of different ages. Healthcare providers suggest that Tai Chi should be considered a complementary treatment.

Telomeres are DNA protein structures at the end of chromosomes that shorten with every cell division [12]. Telomeres play important roles in cellular aging and disease. Telomerase maintains the length of a telomere by adding DNA hexameric repeats, thereby promoting cell growth and longevity [13]. Therefore, telomerase is considered an important aging biomarker [13]. Telomerase also serves as an indicator of disease risk and is associated with psychological health [14]. In a study, psychological stress was linked to oxidative stress levels and telomerase activity (TA) levels [15]. In recent years, an increasing number of researchers have paid attention to the link between physical activities and TA. Some studies have illustrated that TA levels may be enhanced by a healthy lifestyle, e.g., a lifestyle involving physical exercise [16], intensive meditation training [17], yoga [18], and comprehensive lifestyle [19]. A research showed that after performing qigong exercise intervention, people in the intervention group with chronic fatigue exhibited higher TA levels than the control group [20]. Understanding the link between physical activities and peripheral blood mononuclear cell telomerase activities for middle aged and elderly adults is significant.

A report showed that the elderly will outnumber children by 2018, and the number of elderly who are over 65 years old is expected to nearly double from 506 million to 1.3 billion [21]. The elderly experiences a decline in physical/mental function, personal relationships, and personal wealth, thus causing depression, pessimism, and dissatisfaction, in addition to the stereotyping that they experience [22]. If the elderly have a negative attitude toward aging, then they encounter some troubles when they face their aging process. Gerotranscendence (GT) is considered the final stage in the natural aging process and is the stage wherein maturation and wisdom are achieved. GT is characterized by a shift from a material and self-centered perspective to a cosmic and transcendental perspective [23]; this perspective guides middle aged and elderly adults to face aging with a positive attitude.

Thus far, no study has evaluated the association of Tai Chi with TA and GT and the correlations between TA and GT.

Whether Tai Chi training has a positive effect on TA and GT in Chinese middle aged and elderly adults remains uncertain. This study aims to explore the association of Tai Chi with TA and GT and the correlations between TA and GT in Chinese middle aged and elderly adults from a community located in Hengyang, Hunan Province.

2. Methods

2.1. Subjects

In this study, men and women aged 55–65 years old were recruited from a community via word of mouth, flyers, and advertisements with the help of community leaders. We provided written informed consent for all subjects. The Institutional Review Board of the University of South China approved the protocol of this study. The following are the inclusion criteria for the participants: (1) 55–65 years of age; (2) able to communicate with others in Chinese; (3) cognitive function was measured using the Small Portable Mental Status Questionnaire (the total score of this questionnaire is 10, normal ≥ 8) [24]; (4) no regular exercises (3 times/week, at least 30 min/time); (5) no history of chronic disease, such as hypertension, diabetes, and cardiovascular diseases; (6) no medical history that could affect our laboratory result.

The screening questionnaires were answered by 256 middle aged and elderly adults in the community. A total of 156 subjects were included on the basis of the inclusion criteria. However, 31 of the 156 subjects were excluded because they were not interested in the intervention program or other causes. Among the remaining, 125 subjects, 23 subjects were further excluded because they disagreed with the collection of blood sample. Therefore, 102 subjects were initially included in our research, but 6 subjects dropped out before the start of our intervention program.

2.2. Study design

We used a randomized controlled design with repeated measures from October 2013 to April 2014. After the subjects completed the screening questionnaires, baseline measurements were obtained. After signing the written informed consent form, the subjects gave blood samples, and each of them acquired an order number. Thereafter, they were randomly allocated into the intervention group and the control group by using a random number table. The group allocation was concealed for laboratory technicians. The intervention program for the intervention group lasted six months, whereas the subjects in the control group kept their original lifestyle unchanged for six months. When the intervention program was finished, the subjects in the control group were encouraged to practice Tai Chi exercises. The TA was examined, and the GT was measured in middle aged and elderly adults. The outcomes of both groups were collected at baseline and after six months of intervention.

2.3. Intervention

The subjects in the intervention group practiced the Yang style of Tai Chi training, which includes 24 postures 5 times per week for 6 months, followed by control group nonexercise training for 6 months. Tai Chi training lasted for approximately 60 min, including warm-up exercises for 10 min to contribute to the flow of qi. Lastly, a 50 min session of Yang style of Tai Chi exercise was delivered by a Tai Chi master who has over 10 years of experience in Tai Chi. The subjects in the intervention group were engaged in Tai Chi training for 6 months. The subjects in the control group were asked to do activities without any regular exercise (at least 3 times/week). No participants in the control group joined regular exercises after the final outcome measurement. We also planned to conduct lectures 3 times every 2 months on the influence of traditional Chinese culture in Tai Chi exercise.

2.4. Measures

2.4.1. TA measures

For every subject, we collected 2 ml of peripheral blood in the sodium citrate tube. Peripheral blood mononuclear cells were isolated from the blood samples by density gradient separation. Thereafter, 1 ml of blood sample was layered and centrifuged at 2000 rpm for 15–20 min at room temperature. The supernatant was then removed. After centrifugation, the monocyte layer was collected. The extracts were stored at -80°C . The TA was tested using a commercially available kit, namely, TE-ELISA (human telomerase–enzyme linked immunosorbent assay, Wuhan Beinglay Company, China), according to the protocol. Finally, the standard density for the

horizontal, OD value for the vertical, and the standard curve were drawn on the graph paper. The reaction was terminated by adding a sulfuric acid solution, and the color change was tested spectrophotometrically at a wavelength of 450 nm. The concentration of the TE in the samples is then determined by comparing the OD of the samples with the standard curve. The TA in each participant was analyzed at pre-intervention after six months of intervention. The blood samples were collected and treated identically at all steps, and each sample was tested in duplicate.

2.4.2. Gerotranscendence scale

The GT scale was a 10-item scale developed by Tornstam [25] and was translated into Chinese by Li [26]. This scale was designed to measure the GT perspective and to encompass three dimensions: cosmic transcendence, coherence, and solitude. These dimensions were measured on a 4-point Likert scale. The answers were scored from 1 to 4, and the total scores ranged from 10 to 40 points. The high score of this scale demonstrated the high level of GT. Content Validity Index [27] was established to be 0.90. In this study, the overall Cronbach's α of this scale was 0.801.

3. Statistical analysis

The demographics of the subjects in the two groups were compared pre-intervention by using the chi-square tests for the categorical data and mean and standard deviations for continuous data to assess the success of the randomization procedures. We used t test to compare the group differences between two time points. All data analyses were conducted

Table 1 – Baseline characteristics.

Demographics		Intervention group		Control group		p^a
		N (%)	Mean (SD)	N (%)	Mean (SD)	
Sex	Male	16 (20.00)		16 (20.00)		0.583
	Female	27 (33.75)		21 (26.25)		
Age (years)			59.58 (5.56)		59.89 (5.69)	0.806
Body weight (kg)			61.29 (9.80)		57.93 (8.72)	0.113
BMI (kg/m^2)			22.70 (2.49)		22.09 (2.12)	0.243
SBP (mmHg)			111.28 (15.99)		121.92 (12.37)	0.417
DBP (mmHg)			78.91 (9.91)		79.40 (6.41)	0.788
Education level	Junior high school or below	31 (38.75)		30 (37.50)		0.572
	Senior high school or above	12 (15.00)		7 (8.75)		
Living arrangement	Alone	12 (15.00)		9 (11.25)		0.935
	With spouse	19 (23.75)		17 (21.25)		
	Other	12 (15.00)		11 (13.75)		
Income (Yuan/Month)	<1000	10 (12.50)		9 (11.25)		0.626
	–2000	27 (33.75)		21 (26.25)		
	>2000	6 (7.50)		7 (8.75)		
Smoking	Yes	10 (12.50)		11 (13.75)		0.512
	No	33 (41.25)		26 (32.50)		
Alcohol drinking	Yes	13 (16.25)		15 (18.75)		0.335
	No	30 (37.50)		22 (27.50)		

BMI: Body Mass Index; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure.

^a Chi-squared test for categorical variables and t/F test for continuous variables.

using SPSS 13.0, and $p < 0.05$ was considered statistically significant.

4. Results

A total of 96 subjects were recruited. A total of 16 subjects (16.67%) (5 in the intervention group and 11 in the control group) dropped out. Two subjects were excluded in the intervention group because they had to look after their family members with serious disease. Three other subjects were unavailable for the blood sample collection. One subject was excluded in the control group because she moved out of the community to Hong Kong. The other participants in the control group dropped out because of their lack of interest in the study schedule or unavailability for the blood sample collection. Detailed information on individual characteristics including sex, age, body weight, body mass index (BMI), systolic blood pressure (SBP), diastolic blood pressure (DBP), education level, living arrangement, income, smoking, and alcohol drinking was collected via questionnaires.

4.1. Baseline characteristics

Table 1 shows that the demographic characteristics were reasonably well balanced between the two groups. No significant differences existed for the demographic characteristics between the two groups ($p > 0.05$).

Table 2 – Correlation between TA and gerotranscendence (r).

Variables	TA	GT	Cosmic	Coherence	Solitude
TA	1.00				
GT	0.325**	1.00			
Cosmic	0.312**	0.811**	1.00		
Coherence	0.045	0.542**	0.163	1.00	
Solitude	0.296**	0.717**	0.255*	0.361**	1.00

** $p < 0.01$; * $p < 0.05$; TA: Telomerase Activity; GT: Gerotranscendence.

4.2. Efficacy of Tai Chi exercise

Table 2 shows that TA had a positive correlation with GT ($r = 0.325$, $p < 0.01$). Among the three dimensions of GT, two dimensions had positive correlations with TA. The two dimensions were “cosmic” ($r = 0.312$, $p < 0.01$) and “solitude” ($r = 0.296$, $p < 0.01$).

Table 3 shows the differences of the outcome measures on the TA between the intragroup and intergroup. The TA was significantly increased in the Tai Chi group from 23.75 ± 3.78 u/mmol at pre-intervention to 26.31 ± 2.93 u/mmol after six months ($p < 0.05$). In the control group, the TA insignificantly changed after six months. The intervention group and control group exhibited a significant difference on TA after six months ($p < 0.05$), but an insignificant difference existed between them at pre-intervention.

Table 3 shows that the GT score significantly increased in the Tai Chi group from 2.23 ± 0.51 at the baseline to 2.69 ± 0.45 after six months ($p < 0.05$). In the control group, the TA insignificantly changed after six months ($p > 0.05$). The intervention group and control group showed a significant difference on GT after six months ($p < 0.05$) but had an insignificant difference at pre-intervention ($p > 0.05$). Compared with the control group, the two dimensions (i.e., cosmic and solitude) of GT had statistical significance in the intervention group after six months of Tai Chi exercise.

5. Discussion

This study aims to measure the effect of Tai Chi on the TA of Chinese middle aged and elderly adults. The findings from this study illustrated that TA improved among Chinese middle aged and elderly adults who received Tai Chi training for six months. Compared with the change in TA in the control group, the change in TA in the Tai Chi group was statistically significant. This result was consistent with previous studies that showed aerobic exercises [17,18] and comprehensive lifestyle changes [19] could improve TA. Jacobs et al. [17] reported that three months of intensive meditation training not

Table 3 – Comparison of TA and GT of the two groups in the pre-intervention and post-intervention.

Variables		Pre-intervention	Post-intervention (6 months later)	p
TA (u/mmol)	IG ($n = 43$)	23.75 ± 3.78	26.31 ± 2.93	0.000
	CG ($n = 37$)	23.93 ± 4.72	23.06 ± 2.76	0.314
	p	0.903	0.000	
Cosmic	IG ($n = 43$)	2.42 ± 0.63	2.81 ± 0.68	0.008
	CG ($n = 37$)	2.60 ± 0.62	2.26 ± 0.62	0.019
	p	0.211	0.000	
Coherence	IG ($n = 43$)	2.05 ± 0.58	2.16 ± 0.62	0.372
	CG ($n = 37$)	2.08 ± 0.64	1.93 ± 0.53	0.280
	p	0.800	0.082	
Solitude	IG ($n = 43$)	2.03 ± 0.72	2.82 ± 0.66	0.000
	CG ($n = 37$)	1.98 ± 0.64	2.31 ± 0.71	0.009
	p	0.750	0.001	
GT	IG ($n = 43$)	2.23 ± 0.51	2.69 ± 0.45	0.001
	CG ($n = 37$)	2.31 ± 0.51	2.21 ± 0.46	0.197
	p	0.466	0.000	

TA: Telomerase Activity; IG: Intervention Group; CG: Control Group; GT: Gerotranscendence.

only contributed to positive psychology but also increased TA in the intervention group. In recent years, a pilot randomized controlled trial [18] concluded that the mental health and TA of the meditation group showed greater improvements than those in the control group. This study suggested that yogic meditation as a behavioral intervention can enhance the quality of life of caregivers whose family member has dementia with mild depressive symptoms. TA may play an important role in predicting genomic stability and cellular viability. A study of comprehensive lifestyle intervention in men with low-risk prostate cancer [19] showed that this type of intervention was significantly associated with increased TA. This finding illustrated that low TA could lead to shortened telomeres by influencing genetic stability and cell function [28]. In the present study, we considered the possible mechanism that might explain the effects of Tai Chi intervention on TA. First, as a mind–body intervention, Tai Chi can increase TA by reducing oxidative stress [29,30] and balancing the immune system [17,29]. Second, as a moderate-intensity exercise, Tai Chi played an important role in enhancing the serum concentrations of insulin-like growth factor-1 (IGF-1), which is related to TA regulation and cellular aging [31]. Third, the hypothalamic–pituitary–adrenal axis might be an effective pathway for enhancing TA [32]. However, Ludlow et al. [33] did not find that a significant correlation existed between physical activity and TA. However, a research focusing on the underlying mechanism on the beneficial effects of physical activity in mice illustrated that physical activity up-regulates TA by mediating telomerase reverse transcriptase, endothelial nitric oxide synthase, and IGF-1 [31]. Another study also showed that physical activity up-regulates the TA in a mouse model in which the mouse suffered schizophrenia [16].

The result of the present study demonstrated that Tai Chi improves the GT in Chinese middle aged and elderly adults. This result confirmed the findings of the beneficial effects of Tai Chi between the sedentary group and active group [34]. Spending a significant amount of time alone may lead to feelings of loneliness. Tai Chi, which is a moderate-intensity exercise that is popular among people of different ages, might have many benefits, such as improvement of social interaction and promotion of physical activities by training in groups under the help of the supervisor [35]. A qualitative study showed that social interaction is improved when several members join a group [36]. Individuals who lost interests in keeping certain social and personal relationships can be considered at risk for negative disengagement. The participants who joined in these studies might possibly benefit from the psychological effects of Tai Chi. A systematic review comparing mindfulness-based exercises versus non-mindfulness exercises in people with psychological problems showed that the former improved solving psychological problems [37]. In a prior pilot randomized controlled trial [37], the psychological health for middle aged and elderly adults was measured by the GT scale. Their psychological health was significantly improved in the intervention group compared with the control group; however, no significant differences existed between pre-intervention and post-intervention in the control group. A research suggested that the depression of institutionalized elders in the GT support group can be slightly reduced [24]. When facing the process of aging, the elders in

this group gradually changed their negative view to a positive view. This observation indicated that GT has a positive effect on the mental health of middle aged and elderly adults, including depression, anxiety, and life satisfaction. GT suggested an increased progression toward internal wellness and maturity with age; however, the degree of GT may vary between individuals. When people age, their physical activity decrease and may withdraw from their social role to prepare for death [38]. However, activities can prevent depression during the latter stages of life [39]. Therefore, elderly people should be encouraged to exercise and socialize. This finding confirms the result of our study. As people age, they can appreciate the small things in daily life that bring joy. Tai Chi exercises can help the elderly socialize and find friends. During Tai Chi training, people can find new friends from one another. They can gather together to talk about life, career, and children after their training. With age and maturation, they relived and thought considerably about their childhood. Many of them think of their childhood with joy, whereas others think of it with sadness. Many of the elderly discuss their childhood home, school, or siblings. They also determined that having enough assets is important to living a pleasant life; however, a general opinion exists stating that money and possessions are unimportant and are only a practical necessity. Our results suggested that short-term Tai Chi training may improve GT in Chinese middle aged and elderly adults; however, the improvement in TA and GT may instead require long-term Tai Chi exercises.

Table 2 shows that TA had a positive correlation with GT. Tai Chi training could promote a sense of purpose and direction in life. In this study, as a psychological indicator, GT was based on the idea that broad appraisals of a person's life as meaningful might result in flexible coping and high stress resilience [40]. The improvement of GT increased the purpose of life, and the increasing purpose of life might mediate TA at post-intervention. Boyle et al. [41] determined that those who have a great purpose have increased longevity and decreased mortality. Given that an average TA predicts mortality [42], GT reflected the positive attitude toward life and promoted increased TA to a certain extent.

TA and GT could be improved by Tai Chi training. Our study illustrated that Tai Chi can improve the physiology and the psychology of the elderly, thereby improving their quality of life. In general, our study demonstrated that when patients are discharged, health care providers can encourage them to join regular Tai Chi training under the whole evaluation of their physical conditions because aerobic exercises can promote health and prevent diseases [43]. Aerobic exercises also lay the foundation for close relationship between the community and the hospital. Participating in these activities also reduces the morbidity of chronic diseases and health care costs. Diseases may be modulated by Tai Chi and other aerobic exercises by improving mood, immune functions, and autonomic nervous system functions. Aging is associated with declines in these health components; thus, complementary and alternative medicine should be used to improve the wellness of a person because adjunctive therapies are more beneficial than single therapies.

A limitation of the proposed approach is that the effects of Tai Chi on TA may be confounded by possible factors, such as

inflammation or infections [20,44]. The TA and GT were not assessed during Tai Chi training. Therefore, given the unknown reaction time for changing TA and GT, up-regulated TA and GT might be challenged. The association of Tai Chi exercise, TA, and GT observed in this study should be cautious because of the aforementioned limitations. Although this study has limitations, it provides the possibility of TA as an important biomarker for aging interventions.

6. Conclusions

Our study suggests that Tai Chi may upregulate TA and improve GT in Chinese middle aged and elderly adults. The TA increased with the improvement of GT in Chinese middle aged and elderly adults. The results suggest that Tai Chi may be considered a comprehensive therapy or rehabilitation program to prolong aging.

Conflict of interest statement

We declare no potential conflicts of interest with respect to the research.

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