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Original article

Acute effect of Tai Chi Yuttari-exercise on oxidative stress and antioxidant capacity in older women

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ABSTRACT

Objective: To compare the acute effects of Tai Chi Yuttari-exercise and walking exercises (with the same level of intensity) on oxidative stress and antioxidative capacity in older women.

Methods: Six older women (average age, 72 years) performed 30 minutes of Tai Chi Yuttari-exercise and 30 minutes of walking (average speed, 2.72 km/h) 1 week apart. Their reactive oxygen metabolite-derived compounds (d-ROMs), as an indicator of oxidative stress, and biological antioxidant potential (BAP), as an indicator of antioxidant capacity, were measured before, immediately after, and 30 minutes after the exercise. We performed intragroup and intergroup comparisons for d-ROMs, BAP, and BAP/d-ROMs.

Results: In the intragroup comparison, no significant differences were found in either group regarding d-ROMs, BAP, or BAP/d-ROM ratio in any of the time point. In the intergroup comparison, the walking exercise group exhibited significantly lower pre-exercise values for BAP and BAP/d-ROM ratio than the Tai Chi Yuttari-exercise group ($P<.05$), but there was no significant difference in any indicators immediately after or 30 minutes after the exercise.

Conclusion: After performing Tai Chi Yuttari-exercise, our results may suggest that older women showed similar d-ROMs as indicators of oxidative stress, BAP, and BAP/d-ROMs ratios to those resulting from comfortable walking.

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INTRODUCTION

The production of oxidants during ordinary metabolism damages DNA, proteins, and fat, causing aging, cardiovascular disease, diabetes, immune system decline, and brain dysfunction[1]. Antioxidant action maintains the oxidant/antioxidant balance in the body with respect to oxidative stress[2]. The oxidant/antioxidant balance after meals is improved by standing rather than sitting, which is effective for reducing oxidative stress[3]. Antioxidant capacity is reportedly affected by exercise intensity[4]. Although exercising below the maximum capacity may increase antioxidant capacity, vigorous physical movements increase the production of reactive oxygen, causing oxidative damage in the body[5]. Meanwhile, walking exercise with an intensity of 80% of VO_2 max maintains the oxidant/antioxidant balance and does not increase oxidative stress[6]; therefore, walking is considered the optimal exercise for oxidant/antioxidant balance.

Tai Chi Yuttari-exercise is a form of calisthenics that can be safely performed by older people. One study reported that the

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average metabolic equivalents (METs) of healthy older women (average age, 74 years) while performing Tai Chi Yuttari-exercise ranged between 1.34 and 1.87 and that the maximum heart-lung Borg scale response was 9 (very light)[7]. A previous study reported that 3 months of consistent Tai Chi Yuttari-exercise increased physical function[8] and improved the cardio-ankle vascular index[9]. However, the effect of Tai Chi Yuttari-exercise on oxidant/antioxidant balance is unclear.

The objective of this study was to compare the acute effects of Tai Chi Yuttari-exercise and walking exercises (with the same level of intensity) on oxidative stress and antioxidative capacity in older women Tai Chi Yuttari-exercise in order to further clarify the safety and efficacy of Tai Chi Yuttari-exercise.

METHODS

Subjects and study procedure

Our subjects were residents of Kashiwara, Osaka, Japan. Individuals who attended an exercise lecture about preventing disease held in September 2015 were oriented about this study. During the lecture, we conducted a questionnaire on lifestyle, including exercise (individuals who have been exercising at least twice a week for 30 minutes each time over the course of at least 1 year) and drinking habits (individuals who drink at least 3 days a week, with an amount equivalent to at least 180 mL of sake each day), as well as their medical history and current medical status. After excluding those with motor system disease, those with limited movement, those who cannot perform independent activities of daily living, and those with a medical history that impacts physical function, 6 older women were included in this study. They provided written informed consent to participate in this study and underwent a total of 2 measurements. The study conformed to the tenets of the Declaration of Helsinki, and the study protocol was approved by the Research Ethics Committee of the Kansai University of Welfare Science (approval no. 15-41).

The measurements were conducted in November and December 2015, with each subject undergoing 2 measurements at an interval of 1 week. Each time, the subjects performed 1 of 2 exercises selected at random. The subjects were prohibited from performing vigorous exercise during the day prior to measurement and were told to avoid caffeinated beverages and alcohol. On the day of the measurement, the subjects ate breakfast between 7:30 and 8:00 a.m., which consisted of 150 g of white rice (210 kcal, 2.9 g protein, 0 g fat, 48.5 g carbohydrates, 0 g sodium; Satosyokuhin, Niigata, Japan) as the staple for the meal, whereas the main dish was a Japanese-style meal set (320 kcal, 22.4 g protein, 13.1 g fat, 25.7 g carbohydrates, 6.9 g dietary fiber, 1.2 g sodium; Nichirei Foods, Tokyo, Japan) at their home. They then proceeded to our laboratory and underwent assessment to ensure that they have no physical conditions that may preclude them from participating in the experiment. Prior to exercise, a blood sample was taken from each subject using a lancet, and they started 30 minutes of exercise at 9:30 a.m. Another blood sample was taken immediately after exercising and then after 30 minutes of seated rest.

Exercise performance

Tai Chi Yuttari-exercise and walking exercises were performed in a laboratory at a temperature of 24°C and a relative humidity of 50%. The Tai Chi Yuttari-exercise consisted of 4 types: basic and applied versions performed in both seated and standing positions. It was designed to be performed even by older people with frailty, who can perform the exercise in a chair in order to prevent falls[8]. The exercise has the characteristics of Tai Chi Chuan with regard to both continuous and slow movements, which are features of aerobic exercise and also involves resistance exercise for the legs, as they have a stooped posture. Tai Chi Yuttari-exercise was performed continuously while watching a video showing the Tai Chi Yuttari-exercise movements starting from the basic version performed in seated position (approximately 14 minutes; average METs, 1.51±0.21) to the applied version performed in standing position (approximately 17 minutes; average METs, 1.80±0.29).

In the walking exercise, a treadmill (AR200; Minato Medical Science Co., Ltd, Tokyo, Japan) was used to determine a comfortable walking pace for each subject. Since the heart-lung Borg scale for the Tai Chi Yuttari-exercise is at most 9 (very light)[7], the treadmill speed for walking was set to result in a Borg scale of 9 (very light) to 11 (fairly light). The resulting average walking speed was 2.72±0.66 km/h. Walking was performed continuously for 30 minutes on the treadmill.

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Table 1. Characteristics of study subjects (n=6)

Parameters	Mean (SD) or n	Range
Age (years)	72.1±1.9	69–74
Body height (cm)	149.5±3.6	144.5–153.0
Bodyweight (kg)	49.0±2.9	45.5–53.5
Body mass index (kg/m^2)	21.9±0.8	21.1–23.1
Systolic blood pressure at rest (mmHg)	129.7±13.7	119–148
Diastolic blood pressure at rest (mmHg)	77.9±6.1	68–84
Presence of exercise habits	4	NA
Presence of drinking habits	2	NA
Presence of smoking habits	0	NA

SD, standard deviation; NA, not available.

Table 2. Change in d-ROMs, BAP, and BAP/d-ROMs before, immediately after, and 30 minutes after exercise

Parameters	Before exercise	Immediately after exercise	30 min after the exercise	*P* value
Tai Chi Yuttari-exercise				
d-ROMs (U.CARR)	367.3 ± 34.6	375.8 ± 24.9	373.0 ± 31.2	NS
BAP (μmol/L)	2119.7 ± 183.4	2156.7 ± 149.5	2020.1 ± 127.9	NS
BAP/d-ROM ratio	5.81 ± 0.71	5.75 ± 0.45	5.43 ± 0.39	NS
Walking exercise				
d-ROMs (U.CARR)	380.8 ± 31.7	374.1 ± 36.0	369.5 ± 37.7	NS
BAP (μmol/L)	1948.4 ± 173.5*	2125.7 ± 119.0	2031.0 ± 211.7	NS
BAP/d-ROM ratio	5.13 ± 0.56*	5.71 ± 0.53	5.51 ± 0.55	NS

d-ROMs, reactive oxygen metabolite-derived compounds; U.CARR, Carratelli units; BAP, biological antioxidant potential; NS, not significant. *P* values were derived from repeated 1-way analysis of variance.

Oxidative stress and biological antioxidant potential

In the reactive oxygen metabolite–derived compound (d-ROMs) test, reactive oxygen, and free radicals in the body were not directly measured. Instead, the color reaction, which primarily measures the concentration of hydroperoxides (ROOH, a marker of oxidative stress level) in the blood that they form, and thus an overall evaluation of the oxidative stress level in the body, was assessed[10]. Normal values for d-ROMs are considered to be 200-300 Carratelli units (U.CARR)[10,11]. We used the biological antioxidant potential (BAP) test to measure the reducing power of endogenous antioxidants, such as albumin, bilirubin, reduced glutathione, and uric acid, and of exogenous antioxidants, such as vitamins C and E and polyphenol[12]. Normal values for BAP are ≥2,200[13].

Blood samples were drawn from a fingertip using a disposable lancet according to self-measurement of the subject. After adding and mixing the blood to an acidic buffering solution (R2 reagent, pH 4.8), an aqueous solution of an aromatic amine (R1 reagent; chromogen) was added and mixed. We used FREE® Carpe Diem (Diacron International, Grosseto, Italy) for the d-ROM and BAP analyses.

Statistical analysis

We used the measured values for d-ROMs and BAP as well as the BAP/d-ROM ratio for the statistical analysis. The changes in these values before, immediately after, and 30 minutes after the exercise were compared between the groups using a 1-way repeated measures analysis of variance. In addition, Mann-Whitney U test was used to compare the d-ROMs, BAP, and BAP/d-ROM ratio between the groups before, immediately after, and 30 minutes after the exercise. Statistics were analyzed using SPSS Statistics version 24 (IBM Corp., Armonk, NY, USA). A *P* value <.05 was considered statistically significant.

RESULTS

The basic characteristics of the subjects are shown in Table 1.

The body mass index (BMI) for all subjects was within the normal range. Two of the subjects were within the range of stage I hypertension. The exercises performed by 4 subjects included full-body calisthenics (n=3) and walking (n=1).

The intragroup comparison revealed no significant difference in d-ROMs, BAP, or the BAP/d-ROM ratio before, immediately after, and 30 minutes after exercising (Table 2). The intergroup comparison revealed that the walking exercise group had significantly lower BAP and BAP/d-ROM ratio values compared with the Tai Chi Yuttari-exercise group before exercising ($P<.05$). No significant intergroup differences were found for any of the indicators immediately after or after 30 minutes after exercise.

DISCUSSION

In this study, we performed a comparative investigation of oxidative stress and antioxidant capacity in older women (average age 72 years) when performing Tai Chi Yuttari-exercise and walking exercises in order to shed more light on the safety and efficacy of Tai Chi Yuttari-exercise. The average BMI of the 6 subjects was 21.9 kg/m^2, which signifies a low risk of disease[14]; none were smokers, and 4 (66%) of the subjects regularly exercise; thus, they could be described as subjects who are mindful of their health. Meanwhile, before exercise, the subjects' average d-ROM was 374 U.CARR and BAP was 2,034 μmol/L, which were higher and lower than the normal standard values, respectively[10,11,13]. Aging has been reported to increase oxidative stress and decrease antioxidant capacity[15]. The fact that the d-ROMs and BAP deviated from the normal standard values in our study has been attributed to aging.

Mitochondria are central mediators that guide the health of skeletal muscles. Although mitochondrial function decreases with age concomitant with the loss of skeletal muscle, regular exercise prevents this loss of mitochondrial function that accompanies aging and thus contributes to the maintenance of oxidant/antioxidant balance[16]. Rosado-Pérez et al compared the effects of Tai Chi and walking in older individuals aged ≥60 years and reported that Tai Chi had a greater antioxidant effect[17]. Meanwhile, Tai Chi causes a greater load on the leg joints than walking[18], and thus, older individuals with frailty find it difficult to continue the exercise. Thus, the Tai Chi Yuttari-exercise was developed in order to accommodate the capabilities of older people with frailty, and it has proven safety and efficacy[7-9]. In the present study, we did not find a significant change in d-ROMs, BAP, or BAP/d-ROMs before, immediately after, and 30 minutes after Tai Chi Yuttari-exercise or walking exercise. In addition, although the BAP and BAP/d-ROMs values before exercise were significantly lower in the walking exercise group, there was no significant difference immediately after or 30 minutes after exercising. The results of this study provide evidence that an exercise program that can be sustained even by older people with reduced physical capacity can maintain a oxidant/antioxidant balance similar to that of walking. The American College of Sports Medicine and the American Heart Association recommend moderate-intensity exercise for at least 30 minutes per day, at least 5 days per week, or vigorous intensity exercise for at least 20 minutes per day, at least 3 days per week, for older people[19]. Meanwhile, individuals ≥65 years who perform low-volume exercise twice per week (totaling 100 minutes per week) for a total of 12 consecutive weeks experience a reduction in oxidative stress[20]. Regular physical activity increases antioxidant capacity and reduces oxidative stress, particularly in post-menopausal women[21]. Tai Chi Yuttari-exercise may be an optimal exercise program that can normalize the oxidant/antioxidant balance in older women.

The limitations of this study are as follows. First, the significant difference in BAP values in the Tai Chi Yuttari-exercise and walking exercise groups before exercise may have affected the post-exercise d-ROMs, BAP, and BAP/d-ROM ratio. Second, subjects were a mix of those who exercised habitually and those who did not; thus, the differences in background factors may have affected the results. Furthermore, there were only 6 subjects, which may have affected the statistical strength of our findings. Third, compared to Tai Chi Yuttari-exercise, walking had a relatively low subjective exercise intensity of 11 (fairly light) on the Borg scale; thus, no comparison with more intense walking was made. This could be a topic for future research. Fourth, the results of this study are solely an investigation of immediate changes in d-ROMs and BAP after a single round of exercise; thus, the long-term effects of continued Tai Chi Yuttari-exercise on oxidative stress and

antioxidant capacity are still unclear. Therefore, this study warrants further research to clarify these issues.

CONCLUSION

Older women exhibited similar d-ROMs, BAP, and BAP/d-ROM ratio values after Tai Chi Yuttari-exercise and after walking at an average of 2.72 km/h. Therefore, medical professionals involved in the care of older women may consider the addition of a Tai Chi Yuttari-exercise program to their patients' treatment protocol to normalize the oxidant/antioxidant balance.

DISCLOSURE

The authors have no conflicts of interest relevant to this article.

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