EFFECTS OF TAI CHI EXERCISE ON THE HEALTHY ELDERLY AS MEASURED BY EVENT-RELATED POTENTIALS

WENCHAO WANG[1], CHEN QIU[2], TOYOSAKU OTA[1], MASAYUKI SAWADA[1,3], NAOKO KISHIMOTO[1], and TOSHIFUMI KISHIMOTO[1]

1)Department of Psychiatry, Nara Medical University School of Medicine

2) Wushu Department, Xi'an Physical Education University

3) Hannan Hospital

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Abstract : Aim: Tai Chi exercise could be recommended as a mental training method to ameliorate cognitive function, especially attention function. Event-related potentials (ERPs) are commonly used as physiological measures of cognitive function as they are easily measured and non-invasive. However, to our knowledge, there is no report to indicate Tai Chi's effect on cognitive function using ERPs. Therefore, in the present study we examined the effects of Tai Chi exercise on the healthy elderly as measured by ERPs.

Methods: Eight healthy elderly subjects participated after giving consent. Based on the guidelines for evoked potential measurement, mismatch negativity (MMN) and P300 were obtained by auditory odd-ball tasks. We measured both MMN and P300 in the conditions before and after the Tai Chi term.

Results: The MMN amplitudes after the Tai Chi term tend to be greater than those before the Tai Chi term at Fz and Cz. The P300 latency after the Tai Chi term was significantly shorter than that before the Tai Chi term at Pz.

Conclusion: MMN and P300 might be sensitive tools for measuring the effects of Tai Chi exercise on the healthy elderly.

Key words : Tai Chi, event-related potentials, mismatch negativity, P300, cognitive function

INTRODUCTION

Tai Chi exercise, often called Tai Chi, has been regarded as both the highest form of martial arts[1] and an important regimen,[2] and for these reasons it has enjoyed growing popularity not only in the Far East but also in many Western countries. Tai Chi has come to attention as an exercise for its beneficial effects physiologically and psychologically.[3] And it could be recommended as a mental training method to ameliorate cognitive function, especially attention function.[4] However, to our knowledge there are few studies that have reported the cognitive effect of Tai Chi on the elderly using objective measures.

Event-related potentials (ERPs) are commonly used as physiological measures of cognitive

function because they are easily measured and are non-invasive. In particular, disturbance of the P300 component, an indicator of cognition, has been suggested.[5),6)] We had examined the effect of Tai Chi on the elderly with cerebral vascular disorder (CVD) using P300, and reported that there was no significant difference between the conditions before and after the Tai Chi term.[7)] However, one of the reasons for this result was the short term (about 12 weeks). Therefore, in the present study, we recruited participants who could participate in Tai Chi exercise over a long term (at least 5 months).

Furthermore, we had examined the effect of Tai Chi using not only P300 but also mismatch negativity (MMN). The MMN component, an ERP component that functions in a distinctive stimulus discrimination process that utilizes the sensory memory of prior stimuli, is considered to be an important mechanism for rapid detection of changes in the outer world, except those concerning the field of consciousness. Therefore, it reflects an automatic cerebral discrimination process, not under attentive control.[8)] To our knowledge, there is no report to indicate the effect of Tai Chi on cognitive function in the healthy elderly using event-related potentials (MMN and P300). Therefore, in the present study, we examined the effect of Tai Chi on cognitive function in the healthy elderly using event-related potentials (MMN and P300).

METHODS

Study design

This pilot study is a prospective clinical trial to evaluate the psychological effects of Tai Chi for the healthy elderly using ERPs (MMN and P300). This study was approved by the Institutional Review Board of Nara Medical University. Written informed consent was obtained from all subjects before the study.

Study setting and population

The participants were voluntarily recruited using posters. We excluded participants that were under 60 years old, had a psychiatric and/or physical medical history, or had already experienced Tai Chi. The present study enrolled 8 healthy participants. They consisted of 4 males and 4 females. All subjects were Japanese and right-handed. Their mean age was 62.75 (SD: 2.71; range: 60-68) years. The MMN latencies and amplitudes and P300 latencies and amplitudes were estimated for the subjects both before and after the Tai Chi exercise term at the same time of day (10:00-11:00 a.m.). The subjects were made to participate in Tai Chi exercise as soon as possible after measuring the ERPs, and the ERPs were measured as soon as possible after the Tai Chi exercise term.

Tai Chi

The Tai Chi program[9)] was based on 24-style. Participants were made to perform 100-minutes Tai Chi sessions once a week for about 6 months (their mean term of Tai Chi: 6.50; SD: 1.85; range: 5-10 months) by the Tai Chi expert (W.W). Each session included the following: (1) 30 minutes of warm-up and a review of Tai Chi principles, (2) 60 minutes of Tai Chi practice, and (3) 10 minutes of cooling down.

Event-related potentials

Measurements

Based on the guidelines for evoked potential measurement, MMN and P300 were obtained by auditory odd-ball tasks. An NEC Multi Stim II (NEC, Tokyo, Japan) was used as the auditory stimulus system.

MMN

Tone bursts at 1000 Hz standard stimuli (P=0.9) and at 1100 Hz deviant stimuli (P=0.1) (each stimulus lasted 50 msec) were presented at 500 msec intervals and at an intensity of 80 dB. Infrequent and frequent stimuli were given in random order via headphones. The MMN was measured while the subjects, as instructed, were reading books or magazines of their choice, without paying particular attention to the auditory stimuli given.

P300

Infrequent target stimuli were presented as tone bursts at 2000 Hz (P=0.2) and frequent non-target stimuli as bursts at 1000 Hz (P=0.8), with each stimulus lasting 50 msec. Both types of stimulus were given at intervals of 1.5 sec and an intensity of 80 dB. Infrequent and frequent stimuli were given in random order via headphones. The subjects were instructed to pay attention to the target stimuli with their eyes open, and to press the button as quickly as possible when each target stimulus was delivered.

Recording and Analyses

ERPs were recorded with an MEB 2200 (NIHON KOHDEN, Tokyo, Japan). Electroencephalograms (EEGs) were obtained at the Fz, Cz, C3, C4, and Pz positions on the scalp using disk electrodes. The bilateral ear lobes were used as the reference electrode sites. The resistance of the electrodes was set at <=5kΩ. MMN was analyzed during the period between the 30 msec pre-stimulus and the 360 msec post-stimulus. P300 was analyzed during the period between the 50 msec pre-stimulus and the 750 msec post-stimulus. Artifact-free responses to the stimuli were added and averaged after EEG amplitude data >=100μV and eye movements were removed. To prevent the subjects from getting tired of, or used to, performing the tasks, each trial was conducted only once.

MMN

Fifty responses to infrequent deviant stimuli and 450 responses to frequent standard stimuli were averaged separately. The waveform of the frequent standard stimuli responses was subtracted from that of the infrequent deviant stimuli responses. From the subtraction waveform, MMN was identified as a negative wave with a peak latency from 100—250 msec. MMN latency and amplitude were measured.

P300

Thirty responses to infrequent target stimuli were averaged. Of the ERPs obtained, P300 was identified as a positive wave with a peak latency from 250—550 msec. P300 latency and

amplitude were also measured.

Statistical analyses

Statistical comparison of subject characteristics between the two groups was performed using a two-tailed paired t test. The latencies and amplitudes of both P300 and MMN were compared between the conditions before Tai Chi exercise and after Tai Chi exercise using a two-tailed paired t test. SPSS 17.0 J for Windows (SPSS, Tokyo, Japan) was used for all analyses.

RESULTS

MMN

The grand average MMN from the healthy elderly after Tai Chi exercise was greater than that before Tai Chi exercise (Fig. 1). The exact figures for amplitudes and latencies are listed in Table 1. The mean MMN amplitudes from the healthy elderly at Fz and Cz after Tai Chi exercise tended to be greater than those before Tai Chi exercise (Table 1).

P300

The grand average P300 from the healthy elderly after Tai Chi exercise was greater than that before Tai Chi exercise (Fig. 2). The exact figures for amplitudes and latencies are listed in Table 1. The mean P300 latency from the healthy elderly at Pz after Tai Chi exercise was significantly shorter than that before Tai Chi exercise (Table 1).

DISCUSSION

P300 latency, which has been found to increase as dementia symptoms increase, is considered a consequence of attention process, reaction speed, and immediate memory. Shorter P300 latencies indicate superior mental performance relative to longer latencies.[10] Our previous study reported that there are no significant differences between the mean P300 latencies from CVD after Tai Chi exercise and those before Tai Chi exercise. In the present study, we reported that the mean P300 latency from the healthy elderly at Pz after Tai Chi exercise was significantly shorter than that before Tai Chi exercise. Therefore, the longer term of Tai Chi exercise might cause shorter P300 latencies. Thus, Tai Chi exercise may promote cognitive function.

Furthermore, we measured MMN in addition to P300. The P300 component, a potential generated in the final stage of sensory and cognitive processing, is likely to be affected by the cognitive factors present prior to P300 generation, limiting investigation based solely on the P300. Consequently, among the pre-P300 potentials that reflect processing itself, there are early negative components that are strongly related to attention function. The MMN component is said to be one of the early negative components. The results of the present study indicate that the mean MMN amplitudes from the healthy elderly at Fz and Cz after Tai Chi exercise tended to be greater than those before Tai Chi exercise. Therefore, the longer term of Tai Chi exercise might cause greater MMN amplitudes. Thus, Tai Chi exercise may also promote attention function.

There were two main limitations on the present study. First, the sample size was small. However, we were able to enter 8 participants over the long term. Second, the study had no control group. Therefore, future ERP studies with large samples and a control group are needed to determine whether Tai Chi is effective for improving cognitive function. Finally, in the present study, no mental and/or physical adverse events were reported. Therefore, Tai Chi exercise may promote cognitive function - attention function in particular - and ERPs might be sensitive tools for measuring the effects of Tai Chi exercise in the healthy elderly.

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Table 1. Amplitudes and latencies of mismatch negativity (MMN) and P300

	Before Tai Chi		After Tai Chi		
	mean	SD	mean	SD	p value
MMN latency					
Fz	190.2	42.3	191.7	39.1	.867
Cz	181.4	21.3	184.3	28.5	.771
Pz	190.9	28.3	188.1	30.6	.706
C3	175.2	22.0	180.3	28.2	.582
C4	176.2	17.4	182.8	31.3	.283
MMN amplitude					
Fz	3.1	1.9	6.2	5.8	.105
Cz	2.7	1.6	5.8	5.1	.106
Pz	2.5	1.5	5.3	4.7	.141
C3	3.2	1.5	5.6	5.6	.226
C4	3.0	2.0	6.1	5.0	.128
P300 latency					
Fz	351.9	32.2	344.5	23.2	.394
Cz	348.8	33.9	337.1	29.3	.130
Pz	355.9	31.3	336.8	29.7	.018*
C3	349.1	31.5	339.0	28.5	.230
C4	351.9	33.0	339.9	31.3	.143
P300 amplitude					
Fz	−18.5	9.2	−24.0	15.1	.200
Cz	−15.2	4.4	−18.0	10.4	.408
Pz	−17.9	3.3	−17.4	8.2	.832
C3	−15.2	4.7	−17.7	9.2	.329
C4	−16.7	5.3	−18.4	10.2	.506

* $P < 0.05$

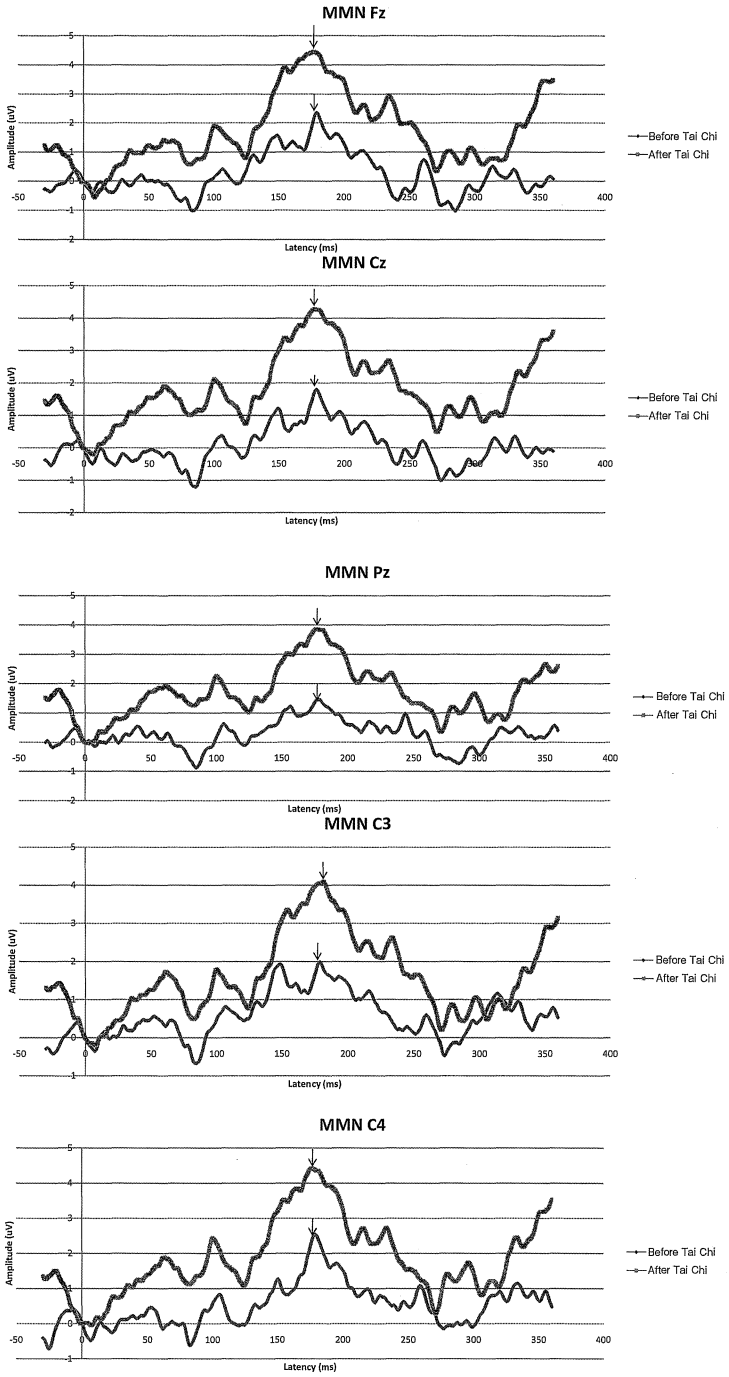

Fig. 1. Grand average mismatch negativity (MMN) of healthy elderly subjects before and after Tai Chi exercise
The grand average waveform of MMN before Tai Chi exercise is the gray line, the grand average waveform of MMN after Tai Chi exercise is the black line, and MMN is shown by an arrow.

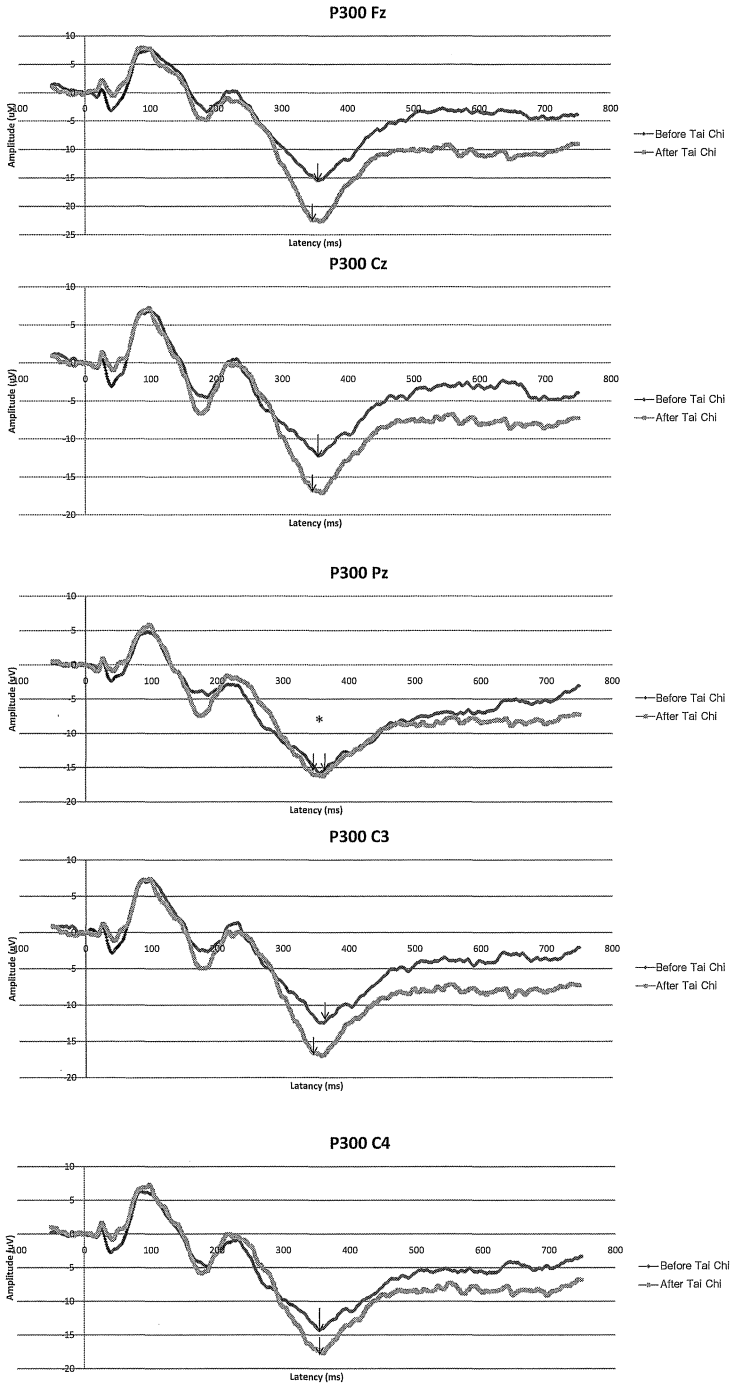

Fig. 2. Grand average P300 of healthy elderly subjects before and after Tai Chi exercise
The grand average waveform of P300 before Tai Chi exercise is the gray line, the grand average waveform of P300 after Tai Chi exercise is the black line, and P300 is shown by an arrow.