The difference between playing table tennis and irregular exercise of the elderly in the go/no-go task performance

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Abstract: The main purpose was to investigate the differences in cognitive function as measured by behavioral indices as well as N1 and P3 components of event-related potentials between table tennis playing participants and non-exercise participants. Older males (60 to 70 years) were divided into a table tennis group (mean age 67.25 ± 3.73 years; mean education level 16.0 ± 3.21 years) and a non-exercise group (mean age 62.0 ± 5.34 years; mean education level 15.63 ± 1.69 years), and each performed a go/no-go task with different degrees of cognitive interference for two types of stimuli. In each block, the right hand was used for the go responses. For behavioral data, the results showed that there was no significant difference in reaction time and accuracy. For the P3 and N1 components, there were no significant differences in amplitude and latency between the two groups for go and no-go conditions. However, the main effects of N1 (Cz) and P3 (Oz) latency were still observed. This study showed that the elderly are influenced by aging so they utilize more neural processes when responding, and also require more attention for motor reaction.

Keywords: Event-related potential, aging brain, Go/No-go, cognitive function

1. INTRODUCTION

Aging is a global issue, with the whole world entering a new stage of the aging society. In Taiwan, the population aged over 65 was 10.7% of the total population at the end of 2010. The elderly population is consistently rising each year, resulting in a huge amount of medical and long-term care expenditures. Moreover, aging also results in many illnesses, some of which are closely related to the degradation of neuro-cognitive functions, such as Alzheimer disease, Parkinson disease, and depression. Studies have shown that prefrontal cognitive abilities can degrade due to aging, with a high correlation to the dopamine system, and may result in information processing errors such as the inability to feedback environmental messages properly, and failure to respond [1]. In addition, neurons in the brain's gray matter gradually shrink with age, and the most significant rate of atrophy is in the frontal lobe gray matter [2-3]. Past studies have found that elderly people with dementia had more distinct atrophy on the left prefrontal and left temporal lobe [4]. Therefore, aging has been shown to correlate highly with structural change and functional derogation in the frontal lobe. This region is closely associated with cognitive function execution. The frontal lobe and prefrontal lobe mainly manipulate short-term working memory, judgment, planning, and inhibition, and are responsible for connection and integration between the right and left hemispheres. Aging in this region can have a significant impact on the connection among regions and damage information integration and judgment [5].

Scientists are struggling to search for effective methods to slow down or prevent aging. In the study of preventive medicine for the elderly, one of the most recommended prescriptions is exercise. Exercise has a beneficial effect on mental health, including reducing anxiety, depression, and stress; stimulating positive emotions; promoting self-esteem; and improving cognitive function [6]. Regarding neuro-cognitive functions, Churchill et al. [7] stated that regular exercise promotes synaptic growth, synaptic density, neurotransmitters, brain-derived neurotrophic factor (BDNF), glial cells, and angiogenesis, which help to maintain cognitive function. Event-related potential (ERP) studies have indicated that the amplitude of N1, the largest negative-going peak amplitude 70-150 ms after stimulus onset, is related with perceptual processing or selective attention during early stimulation [8]. As for specific types of exercise, Colcombe et al. [9] found that aerobic exercise increased cognitive performance in the elderly.

The no-go P300 (P3) component of ERPs obtained by time-locked, averaged electroencephalography (EEG) has been used to investigate the neural processes of response inhibition during a go/no-go paradigm. The amplitude of no-go-P300 was larger than that of go P300, even though go and no-go stimuli were presented at even probability [10]. The difference between go and no-go waveforms is frequently described as the ‘go/no-go effect’, which has been mainly evoked using visual stimulation. Higher levels of aerobic fitness in the elderly result in a larger P3 amplitude when executing cognitive tasks, indicating that they allocate more attention to task processing [11]. Many previous studies have focused more on aerobic exercise effects on cognitive function, with less discussion on the effects of the type of exercise. However, physical activities have selective impacts on improving cognitive function in the elderly. The more complex motor skills learning a particular activity requires, the more linking density improves between synapses and dendritic cells in the cerebellum, resulting in enhanced cognitive performance [12]. Therefore, the purpose of this study was to employ ERP to assess the effects of table tennis participation on executive control functions in the elderly. We hypothesized that compared to the irregular exercise group, the table tennis group would show a larger amplitude and shorter latency in the N1 and P3 components of the ERP. It was further hypothesized that table tennis group would respond faster and more accurately than the irregular exercise group.

2. Method

2.1. Participants

The participants were 16 healthy men. The experimental group was comprised of eight regular exercise participants (mean age 67.25 years, range 61–70 years ; mean education level 16 years, range 12–22 years) who were playing table tennis, three times a week, at least 30 minutes each time, and lasted for more than one year. The irregular exercise group was comprised of eight irregular exercise participants (mean age 62 years, range 55–69 years; mean education level 15.63 years, range 12–18 years). All participants were free of neurological disorder, hypertension, and diabetes. They fully understood the purpose of this study and gave informed consent.

2.2. Procedure

After the study purpose and procedures were explained to the participants, each of them practiced the go/no-go task (10 trials × 2 blocks = 20 trials), with the targeted rate required to be above 80%. Finally, they formally carried out go/no-go task (30 trials × 7 blocks = 210 trials, an approximate one-minute resting period given between each interval), and ERP data were recorded during the entire process.

2.3. Go/no-go task

Participants sat in front of a PC monitor, and asked to pay attention to a fixed cross in the center of a black background. In the go condition, participants were requested to use their right index finger to press the response key as fast as possible (go target stimuli 147 trials: 70%). In the no-go condition, participants were asked to refrain from responding (no-go non-target stimuli 63 trials: 30%). As soon as they saw the yellow square S1 (500 ms), they had to be prepared. After 1500 ms, they were to press the response key as soon as they saw a green circle S2 (200 ms) or not respond for the red octagon S2 (200 ms), with an inter-stimulus-interval of 1000 ms from stimulus offset to onset. (Fig.1).

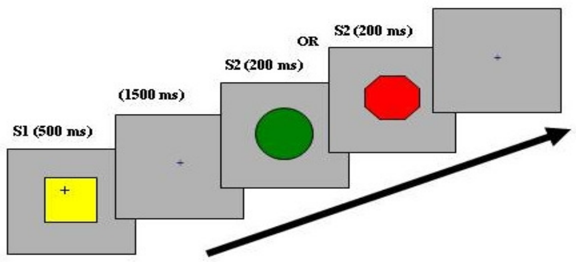

Fig.1. Sequence of events in the go/no-go task.

2.4. EEG recordings and data reduction

A Neuroscan Synamps amplifier was used to record continuous data and Neuroscan Stim software for stimuli responses. ERP activity was recorded at Frontal (Fz), Central (Cz), Parietal (Pz), and Occipital (Oz) electrode sites of the international 10-20 system. Data were re-referenced to averaged mastoids (A1, A2) with Fpz serving as the ground electrode. Additionally, EOG (electro-oculography) activity was monitored above and below the left orbit and on the outer canthus of each eye. Continuous EEG data were merged offline with behavioral data. The ERP data were corrected for ocular artifacts. Epochs were defined as 100 ms pre-stimulus to 1000 ms post-stimulus, and baseline correction was employed by using the 100 ms pre-stimulus interval. A low-pass filter with a 30 Hz cutoff (12 dB/octave) was employed to further attenuate the noise. ERP trials with amplitudes outside the range of ± 100μV were excluded from further analysis. The correct go and no-go trials were separately averaged. For peak detection, the N1 component of the ERP was defined as the maximal negative peak within 75 to 150 ms, and P3 was the maximal positive peak within a 300 to 500 ms latency window.

2.5. Statistical analysis

In order to control extraneous variables, age and education were treated as covariates. RT and response accuracy data were analyzed using one-way ACOVA for independent samples. The amplitude and latency of N1 and P3 at Fz, Cz, Pz, and Oz electrode sites were analyzed using a 2 (Group: table tennis, irregular exercise) × 2 (condition: go, no-go task) mixed two-way ACOVA. Significance was set at α =.05 for all analyses.

3. Results

3.1. Behavioral measures

No significant main effect was observed for RT ($F_{(1,16)}$ = 0.248, P = .628) or for response accuracy ($F_{(1,16)}$ = 3.986, P = .069) in the go condition (Table 1).

Table 1 Group means and standard deviations for reaction time and response accuracy.

	Table tennis		Irregular exercise			
	M	SD	M	SD	*F*	*P*
RT (ms)	360.3	25.9	379.9	25.9	0.248	.628
Accuracy	98.7%	2.7%	92.8%	2.7%	3.986	.069

Note. RT = reaction time; M = mean; SD = standard deviation.

3.2. ERP

3.2.1. N1 amplitude

No significant main effects or interactions of Group × Condition were observed on N1 amplitude at Fz, Cz, Pz and Oz electrode sites.

3.2.2. N1 latency

A main effect for condition was observed at the Cz site ($F_{(1,16)} = 4.794$, $P < .05$, $\eta^2 = 0.285$), with shorter latency for the no-go condition compared with the go condition. No significant interactions of group × condition were revealed on N100 latency at Fz, Cz, Pz and Oz electrode sites.

3.2.3. P3 amplitude

No significant main effects or interactions of group × condition were observed on P300 amplitude at Fz, Cz, Pz and Oz electrode sites.

3.2.4. P3 latency

Main effects at Oz site ($F_{(1,16)} = 13.787$, $P < .05$, $\eta^2 = 0.535$) were found, indicating faster latency for the no-go condition compared with the go condition. No significant interactions of group × condition were observed on P300 latency at Fz, Cz, Pz and Oz electrode sites (Table 2).

Table2. Group means of N100 (N1) and P300 (P3) Latency (L) and Amplitude (A)

Group	Table tennis				Irregular exercise			
	N1 L	N1 A	P3 L	P3 A	N1 L	N1 A	P3 L	P3 A
Go								
Fz	100.75	-1.91	438.25	9.19	109.25	-1.86	408.75	8.61
Cz	97.50	-1.60	422.00	7.08	98.50	-1.64	432.50	10.90
Pz	104.00	-0.87	425.00	10.26	92.75	-1.09	454.25	13.07
Oz	113.75	-0.84	398.50	8.24	115.25	-0.95	408.25	8.30
NoGo								
Fz	109.00	-2.40	429.50	12.39	103.25	-1.23	414.50	12.38
Cz	98.00	-1.91	427.00	12.26	93.50	-0.76	428.25	13.08
Pz	95.50	-1.22	442.25	10.33	87.50	-0.90	439.75	10.33
Oz	113.25	-1.89	416.25	6.21	116.75	-2.36	386.50	5.84

Latency (ms); Amplitude (μv); $*P < .05$. Frontal (Fz), Central (Cz), Parietal (Pz), and Occipital (Oz)

4. DISCUSSION

The main purpose was to compare the different cognitive functions between a table tennis playing group and an irregular exercise group by means of analyzing reaction time, amplitude, and latency of N1 and P3 ERP components. The results showed that there was no significant difference in reaction time and accuracy between groups. For P3 and N1 components, there were also no significant differences in amplitude and latency between the two groups for the go or no-go conditions. Nevertheless, the main effects of conditions for N1 (Cz) and P3 (Oz) latency could be observed.

In the go condition, results did not show differences in reaction time and response accuracy between the two groups. This result implies that both groups spent a similar amount of time for the stimulus evaluation and discrimination of the task, and also resulted in a similar performance in term of response accuracy. As for ERP data, all participants exhibited shorter N1 latency at Cz in the no-go condition. The N1 component is related to selective attention [8]. Participants were requested to respond in the go condition but not in the no-go condition. Also, Cz is assumed to represent the activity of the motor cortex. It was thus inferred that all participants invested more attention to the execution of motor response in the go condition. Moreover, all participants displayed shorter P3 latency at Oz in the no-go condition than in the go condition. P3 component is associated with the speed of stimulus classification [13] and Oz represents occipital lobe which relates to visual system. For that reason, it is suggested that all participants required more attention resource after the appearance of stimulus for speed of response. Vallesi (2001) found that the elderly participants had a longer latency than younger adults in the go condition during go/no-go tasks, suggesting that the elderly spent more time on information processing. This study illustrates that the elderly were influenced by aging, requiring more cerebral neural processes to respond, and focused more attention on motor reaction [14].

No significant difference in reaction time and amplitude and latency of ERP components was revealed between the two groups in the go/no-go task. Physical activity is assumed to benefit cognitive function for the elderly, but the results failed to support this argument. One possible explanation is the lack of statistical power due to small sample size. Hillman, Belopolsky, Snook, Kramer, and McAuley (2004) indicated that the best sample size for this kind of cross-sectional comparison is twelve or more. However, we only had eight participants for each group [15]. Future studies should take sample size into consideration. Another possibility is the nature of the task; prior studies indicated that different cognitive task characteristics were differentially affected by physical activity for the elderly [9, 15]. The task used in the current study may have been too easy to reflect the beneficial effects of table tennis. More complicated tasks should be incorporated to distinguish any possible difference [16].

In conclusion, the current study found no difference in the performance of a go/no-go task at both the behavioral and electrophysiological levels. Diverse difficulty of cognitive tasks is recommended for future studies. Moreover, recruitment of an adequate number of participants is recommended to further address the question of whether participation in table tennis has a better benefit on cognitive function than other aerobic exercise in the elderly population.

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