

# Effects of horseback riding exercise therapy on background electroencephalograms of elderly people

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**Abstract.** [Purpose] This study investigated the effect of horseback riding exercise on the background electroencephalograms of elderly people who performed horseback riding for 8 weeks. [Subjects] Twenty elderly people were divided into the horseback riding exercise and control group ( $n = 10$  each). [Methods] The exercise was performed for 15 minutes, 3 times per week for 8 weeks. Electroencephalograms were analyzed. Post-exercise evaluation was performed after 8 weeks. [Results] After the horseback riding exercise, the relative slower alpha power index was active in the T3 and P4 domains but suppressed in the Fp1, Fp2, F3, F4, T4, and P3 domains. Moreover, the relative faster alpha power index was active in all domains of the horseback riding exercise group but was suppressed in all domains of the control group. There was a significant difference between groups in the F3 domain. [Conclusion] The alpha power index increased significantly after horseback riding exercise, suggesting the exercise improved background electroencephalogram.

**Key words:** Exercise therapy, Electroencephalogram, Horseback riding

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## INTRODUCTION

Regular exercise is an important factor for overall health promotion<sup>1)</sup>. Physical activities can preserve brain function and improve blood flow and oxygen transfer<sup>2)</sup> as well as slow the loss of hippocampal formational tissue in the aging brain.

Because of its unique three-dimensional movement, horseback riding has been applied as a physical therapy to stimulate movement to maintain balance<sup>3)</sup>. One of its effects is to transfer movement to the pelvis, producing an effect very similar to pelvic tilting<sup>4)</sup>. In addition, horseback riding exercises parts of the body that are not used by other frequently performed exercises, including agonistic muscles, which are deep muscles that contract and relax to maintain

balance<sup>5)</sup>.

Psychological research on horseback riding exercise indicates it decreases depression in teenagers with emotional disorders<sup>6)</sup> as well as improves teenagers' self-esteem and self-control<sup>7)</sup>.

However, there is little information about horseback riding exercise as a physical therapy and even less information about whether such exercise is effective for elderly people or indeed how it may affect them. Therefore, this study investigated the effects of horseback riding exercise on the background electroencephalogram (EEG) of elderly people who performed horseback riding for 8 weeks.

## SUBJECTS AND METHODS

This study involved 20 elderly people in U city. Elderly people are aged 65 or over 65. All participants or their guardians provided informed consent prior to participation. Before the start of the study, the purpose and methods were explained in detail to the participants. The participants were divided into 2 groups: a horseback riding exercise group and a control group ( $n = 10$  each). The horseback riding training was performed before the main horseback riding interven-

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**Table 1.** General characteristics of participants ( $N = 20$ )

Category	Horseback riding (n=10)	Control (n=10)
Age (years)	69.5 ± 3.2	69.7 ± 3.5
Height (cm)	157.6 ± 8.7	158.5 ± 6.8
Weight (kg)	58.8 ± 7.9	59.2 ± 6.7
BMI (kg/m <sup>2</sup> )	23.6 ± 2.3	23.6 ± 2.6

Data are mean ± SD. BMI: body mass index

tion. Riding was performed for 15 minutes, 3 times per week for 8 weeks. The post-exercise tests were performed over a period of 8 weeks in the same manner as pre-study tests. The control group didn't do any exercise.

We investigated the background EEGs, specifically the relative alpha power index, in both groups. For the exercise, we used Jeju horses from the I rehabilitation center-affiliated horse riding course; these horses are normally used to provide riding experiences to visitors and are therefore healthy, accustomed to their surrounding environment, well trained, tame, and have stable strides. All participants wore protective gear including safety helmets, vests, and boots. At the beginning of the tests, the participants were led to perform warm-up exercises. The warm-up exercises were performed at a walking speed, which was the slowest speed (110 m/min). For this study, the slowest walking speed was maintained for the participants' safety and comfort. In the exercise, an instructor led a horse by the bridle while another assistant supported a participant by holding him or her by the leg prevent them from falling from the horse and provide assistance as needed. Quantitative electroencephalography can be used to diagnose neurological changes in the brain; it constitutes an electric signal due to an active change in the brain that can capture the electrical flow between neurons through electrodes attached to the surface of the head<sup>8</sup>). We collected the EEG data using a computerized polygraph (PolyG-I, Laxtha Inc., Korea) and TeleScan, which is a real-time analysis program. The EEG electrodes were attached to the surface of the head of the participants as they were seated in a comfortable reclining chair. To reliably capture data, the same researcher attached the electrodes and operated the testing instruments. Body and head movements were controlled as much as possible, and the participant kept their eyes closed for 3 minutes while resting in order to minimize the interruption of waves caused by eye movement. The participant was required to stop chewing and talking during EEG measurements. The EEG signals were analyzed for 60–120 seconds, excluding the first and last 60 seconds when the test might have been influenced by external environments. The background EEG data were analyzed on the basis of a monopolar derivation from 8 points on the surface of the head; the 8 electrodes were attached to Fp1, Fp2, F3, F4, T3, T4, P3, and P4 according to the International 10–20 Electrode System. The saved data were transformed into frequencies using a fast Fourier transform, which expresses the quantitative relationship between EEG frequencies and their intensity. Power spectrum analysis was subsequently applied, and the band-to-band power was calculated. The relative alpha power (8–13 Hz/4–50 Hz), which emerges in

**Table 2.** Relative slow alpha power before and after the intervention

		Pre-intervention	Post-intervention
Horseback riding	Fp1	0.321 ± 0.147	0.308 ± 0.177
	Fp2	0.337 ± 0.150	0.326 ± 0.148
	F3	0.339 ± 0.140	0.337 ± 0.151
	F4	0.341 ± 0.159	0.319 ± 0.164
	T3	0.288 ± 0.131	0.314 ± 0.119
	T4	0.254 ± 0.154	0.212 ± 0.096
	P3	0.369 ± 0.146	0.367 ± 0.147
	P4	0.345 ± 0.197	0.351 ± 0.166
	Fp1	0.243 ± 0.137	0.288 ± 0.177
	Fp2	0.246 ± 0.135	0.277 ± 0.176
Control	F3	0.251 ± 0.141	0.302 ± 0.181
	F4	0.237 ± 0.153	0.279 ± 0.201
	T3	0.216 ± 0.116	0.225 ± 0.131
	T4	0.164 ± 0.141	0.210 ± 0.155
	P3	0.291 ± 0.120	0.309 ± 0.150
	P4	0.277 ± 0.151	0.325 ± 0.180

Data are mean ± SD. \* $p < 0.05$

a state of relaxation and rest, was subdivided into the relative slow alpha power (8–11 Hz/4–50 Hz) and the relative fast alpha power (11–13 Hz/4–50 Hz) and analyzed.

All experiments were reviewed and approved by IRB of the Kangwon National University. The pre- and post-intervention data were compared within each group and between groups by using paired t-tests independent t-tests, respectively. The level of significance set at  $p < 0.05$ .

## RESULTS

There were no significant differences in the general characteristics between groups ( $p > 0.05$ ) (Table 1).

After the horseback riding program, the relative slower alpha power was analyzed; it appeared to be active in the T3 and P4 domains but was suppressed in the Fp1, Fp2, F3, F4, T4, and P3 domains (Table 2). Moreover, after the horseback riding program, the relative faster alpha power appeared to be active in all domains of the horseback riding exercise group but suppressed in all domains of the control group (Table 3). There was a significant difference between the horseback riding exercise and control groups with respect to the F3 domain ( $p < 0.05$ ) (Table 4).

## DISCUSSION

During acute graded maximal exercise, the alpha wave power is reportedly decreased in the frontal and temporal lobes<sup>8,9</sup>). Alpha wave power is an index of stable emotional status or mental health; in this regard, alpha wave power appears to be more closely associated with mental stress than exercise intensity, which is physically recognized. The present study evaluated the changes in background EEG, specifically alpha wave power, which indicates stability and relaxation<sup>10,11</sup>).

**Table 3.** Relative fast alpha power before and after the intervention

	Pre-intervention	Post-intervention	
Horseback riding	Fp1	0.055 ± 0.033	0.058 ± 0.033
	Fp2	0.060 ± 0.034	0.061 ± 0.034
	F3	0.059 ± 0.028	0.067 ± 0.038
	F4	0.057 ± 0.025	0.062 ± 0.039
	T3	0.060 ± 0.025	0.073 ± 0.031*
	T4	0.054 ± 0.019	0.055 ± 0.029
	P3	0.088 ± 0.072	0.098 ± 0.059
	P4	0.078 ± 0.057	0.093 ± 0.049*
	Fp1	0.048 ± 0.026	0.045 ± 0.028
	Fp2	0.047 ± 0.030	0.045 ± 0.031
Control	F3	0.058 ± 0.037	0.050 ± 0.034
	F4	0.051 ± 0.042	0.046 ± 0.035
	T3	0.059 ± 0.037	0.050 ± 0.034
	T4	0.040 ± 0.024	0.039 ± 0.018
	P3	0.064 ± 0.042	0.054 ± 0.038*
	P4	0.054 ± 0.037	0.048 ± 0.027

Data are mean ± SD. \*p < 0.05

The relative slow alpha power was analyzed before and after the horseback riding exercise program; the results show it increased equally in all brain wave domains in the control group. In the horseback riding exercise group, the relative slow alpha power was active in the T3 and P4 domains but suppressed in the Fp1, Fp2, F3, F4, T4, and P3 domains. After the horseback riding exercise program, the relative fast alpha power was increased in all domains of the horseback riding exercise group. However, it was suppressed in all domains of the control group. The F3 domain differed significantly between the horseback riding exercise and control groups. Horseback riding exercise is considered to enhance concentration and comfort by activating the brain waves in all domains. The relative alpha power by the motor learning process is reported to increase in the Fz, Cz, Oz, C3, C4, T3, and T4 domains during learning through exercise imagination but is decreased in those observing and performing behaviors<sup>12, 13</sup>. After the learning process, the relative alpha power differs significantly in participants who observe and actually perform behaviors compared to those who perform exercise imagination in the Pz, Oz, C4, T3, and T4 domains, indicating the brain activation level is higher during exercise learning through behavior observation and actual performance than imagination exercise learning.

In the present study, there were small differences in the attachment points of the 8 brain wave channels, background EEG, and evoked EEG. However, the results corroborate the notion that learning through exercises helps increase the relative alpha power. The main limitation of this study is its lack of generalizability owing to the relatively small sample as well as the fact that the daily life habits aside from the horseback riding exercise program were known only through personal interviews. Therefore, individual life habits may have affected the results. Accordingly, further studies with more subjects and better evaluation methods

**Table 4.** Comparison of relative fast and slow alpha power

		Horseback riding	Control	
RSA	Fp1	0.013 ± 0.124	-0.025 ± 0.093	
	Fp2	0.020 ± 0.137	-0.012 ± 0.131	
	F3	0.006 ± 0.133	-0.037 ± 0.114	
	F4	0.020 ± 0.152	-0.043 ± 0.136	
	T3	-0.013 ± 0.112	-0.018 ± 0.075	
	T4	0.040 ± 0.150	-0.031 ± 0.113	
	P3	0.000 ± 0.092	-0.018 ± 0.122	
	P4	-0.026 ± 0.183	-0.018 ± 0.137	
	RFA	Fp1	0.000 ± 0.053	0.013 ± 0.034
		Fp2	0.000 ± 0.053	0.006 ± 0.025
F3		-0.020 ± 0.041	0.019 ± 0.040*	
F4		-0.007 ± 0.059	0.000 ± 0.036	
T3		-0.007 ± 0.025	0.013 ± 0.050	
T4		-0.007 ± 0.045	0.006 ± 0.044	
P3		-0.007 ± 0.025	0.000 ± 0.051	
P4		-0.013 ± 0.035	0.000 ± 0.051	

\*p < 0.05, RSA: relative slow alpha power, RFA: relative fast alpha power

are required to confirm the results. Moreover, further studies should investigate the psychological, cognitive, and physical changes as a result of horseback riding. Finally, comparative studies involving different age groups and patients suffering from differing diseases and conditions should be performed.

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