Original Article

JER

https://doi.org/10.12965/jer.1836230.115

Journal of Exercise Rehabilitation 2018;14(4):586-591

The effects of whole body vibration exercise intervention on electroencephalogram activation and cognitive function in women with senile dementia

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This study conducted the Korean version of Mini-Mental State Examination (MMSE-K) to women aged 65 or older residing in Gangwon-do Province and screened those who were suspicious to have mild dementia for receiving 23 points or lower in it. For eight weeks, this author tried to verify the effects of whole body vibration exercise intervention on electroencephalogram (EEG) activation and cognitive function in women with senile dementia. According to the results, both EEG activation and cognitive function indicated statistically significant difference in terms of the interactive effect between the measuring times and groups, and there was statistically significant improvement found after the whole body vibration exercise intervention. The results of this study are meaningful because they present the possibility of whole body vibration exercise intervention to be integrated into the plan to improve life quality in patients with senile dementia by stimulating their muscle spindles and sensory organs only with the amplitude and the number of vibrations with no burden of physical activity and enhancing their EEG activation and cognitive function through the responses of the neuromuscular system.

Keywords: Whole body vibration, Senile dementia, Electroencephalogram, Cognitive function, Women

INTRODUCTION

Dementia is one of the typical organic mental disorders resulted from reduced cognitive function accompanying many different cognitive as well as behavioral symptoms (Wesson et al., 2013). Among the diseases resulting in behavioral disorders in the aged, dementia is the most frequently found disease, and its prevalence rate is continuously increasing, and in 2027, the number of patients with it are expected to be over one million (Minister of Health & Welfare, 2011).

Dementia, one of the typical senile diseases, is a clinical syndrome caused by brain damage resulted from either disease or trauma. It can be largely divided into two kinds: Alzheimer disease, a degenerative brain disease, and vascular dementia resulted from cerebrovascular disease. Dementia can be diagnosed by single-photon emission computed tomography (SPECT), functional magnetic resonance imaging (fMRI), or brainwave analysis (EEG). Among these, brainwave analysis is used to observe the changes of brain functions directly and diagnose dementia and trace its progress with the indexes reflecting the development of it (Florence et al., 2004). So far, over 70 or so causes of dementia have been known, but 70% to 80% of them are irreversible and not exactly identified, so it is difficult to provide causative treatment for it (Korean Dementia Association, 2006); however, it is reported that if dementia is detected in an early stage and proper treatment is given, it can influence dementia positively in the aspects of enhancing cognitive as well as physical functions (Ayalon et al., 2006).

To treat senile dementia, both medication and nonmedication methods such as art, music, and exercise therapies are being employed harmoniously. Particularly, exercise therapies are known to

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Received: April 27, 2018 / Accepted: June 5, 2018

activate brain metabolism, increase cerebral blood flow, stimulate the secretion of neurotransmitters, and enhance abilities to live, so it is reported that they can improve life quality in patients with senile dementia positively (Flannery, 2002). Despite the importance of exercise therapy, patients with senile dementia tend to refuse exercise itself due to their malfunctioning body, so it is limited to manage dementia by general exercise. It means that we need to devise exercise methods that reflect the patients' characteristics. Among the types of exercise, whole body vibration exercise is what one can practice with no burden of physical activity. Whole body vibration exercise is done only through one's weight on the platform that produces mechanical vibrations. With a variety of amplitudes and vibrations, it stimulates muscle spindles as well as sensory organs and draws responses from the neuromuscular system. In this way, it can enhance the user's physical functions (Torvinen et al., 2002). This author thinks that it can be integrated into the intervention of exercise therapy effectively for patients with senile dementia whose physical activity is limited.

Here, this study provided the 8-week intervention of whole body vibration exercise to women with senile dementia and examined the effects of it on EEG activation and cognitive function. The purpose of this study is to provide foundational material to improve life quality in patients with senile dementia by developing an effective interventional exercise program.

MATERIALS AND METHODS

Study subjects

This study conducted the Korean version of Mini-Mental State Examination-K (MMSE-K) to women aged 65 or older residing in Gangwon-do Province and screened those who were suspicious to have mild dementia for receiving 23 points or lower in it. When selecting the subjects, this researcher excluded those participating in any physical activity programs as it could influence the result. Also, to prevent the spread of this experimental intervention, the experimental group and control group were chosen from two different places distant from each other. Before the experiment, the participants and their guardians received explanation about the purpose of this study, and those who had permission from their doctor were asked to write an agreement and then joined in this research. Omitting one from the experimental group that missed over two sessions for personal reasons and also one from the control group that was willing to quit it in the middle, this author finally conducted analysis with data gained from total 18 persons, 9 in the experimental group and 9 in the control group. The physical characteristics of the subjects are shown in Table 1.

Table 1. The physical characteristics of the subjects

Varaible	Exercise group (n=9)	Control group (n=9)
Age (yr)	79.22±4.02	81.44±3.75
Height (cm)	156.48±2.08	156.84±2.81
Weight (kg)	57.03±2.71	58.87±2.72

Values are presented as mean±standard deviation.

Measured items & methods for measurement

In order to examine how 8-week whole body vibration exercise intervention changes EEG activation and cognitive function in women with senile dementia, this researcher employed brainwave analysis (EEG) and MMSE-K. Before the experiment, the subjects were aware of the requirements, exercise procedures, exercise methods, and the measuring methods. After the 8-week whole body vibration exercise intervention was provided, data gained before the experiment and after the 8-week experiment were analyzed comparatively.

EEG activation was measured by using a brainwave measuring instrument (LXE3208, LAXHA Inc., Daejeon, Korea). Electrodes were attached to total 8 spots, Fp1, Fp2, F3, F4, T3, T4, P3, and P4, grounded on the International 10/20 Electrode System. After the reference electrode was applied to the right earlobe and the ground electrode to the forehead, measurement was done in a monopolar way. Sampling frequency per second was set as 256 Hz, and gain as 6,944 μV. Brainwaves were begun to be recorded when no artifacts were detected for over 10 sec continuously (Fig. 1).

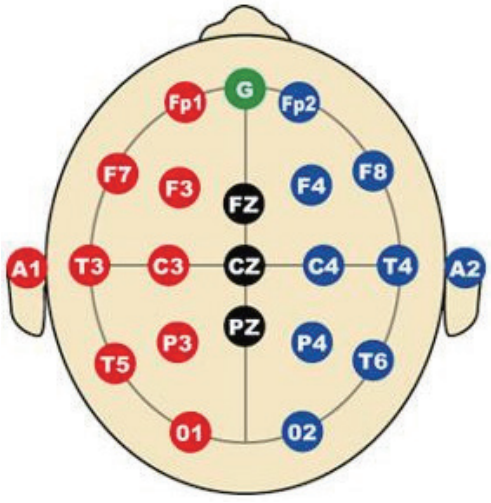

Fig. 1. The international electrode system.

Cognitive function was measured by MMSE-K. It was measured by a specialized investigator trained for MMSE-K through one-to-one interviews. MMSE-K consists of total five areas and 30 questions: 10 questions for orientation about time and space, 6 questions for memory regarding registration and remembrance, 5 questions for concentration and calculation in numeracy, and 7 questions for linguistic skills such as naming, 3-step ordering, copying, and repeating, and 2 questions for understanding and judgment. They got 1 point for a right answer and 0 for no answer. If the total score was over 24, they were regarded normal, 20 to 23 points as mild disorder, and under 19 points as severe disorder (Park and Kwon, 1989).

The whole body vibration exercise program

The intervention with the whole body vibration exercise program used in this study is grounded on the American College of Sports Medicine Exercise Guideline with Recommendations (American College of Sports Medicine, 2014). It recommends the aged to exercise 3 to 5 times a week for 30 to 40 min each time continuously for 8 to 12 weeks to see the effect. In consideration of the subjects' physical characteristics, whole body vibration exercise was done 5 times a week for 8 weeks. As warm-up and warm-down exercise, whole body stretching was done mildly.

In the whole body vibration exercise program, a whole body vibration exerciser (VM-10, Korea) was used. The exercise involved 5 sets of the standing position, squat position, and sumo squat position lasting for 2 min, and between the positions, they took a rest for 1 min. This researcher decided on the intensity of whole body vibration exercise by reviewing a journal (Bruyere et al., 2005) and having an expert meeting. It began with the frequency of 20 Hz, and it increased gradually as 5 Hz every 2 weeks.

Data processing

This study adopted pretest-posttest control group design and employed a computer statistical program, IBM SPSS Statistics ver. 22.0 (IBM Co., Armonk, NY, USA), to analyze the effects of whole body vibration exercise intervention. To examine the subjects' physical characteristics, this author performed descriptive statistical analysis and calculated the mean and standard deviation. To look into the effects of whole body vibration exercise intervention on EEG activation and cognitive function in women with senile dementia, repeated measure analysis of variance was done. Also, regarding the significant level of the results, because it is influenced by the number of samples, this researcher calculated partial η^2 and presented the intensity of correlation. The statistically significant level was set as 0.05 to verify the results.

RESULTS

The changes of EEG activation according to the whole body vibration exercise intervention

According to the results of conducting a homogeneity test on the matrixes of EEG activation's variates and covariates in women with senile dementia in association with the whole body vibration exercise intervention, in Fp1, Box $M = 5.319$, $F(3, 46{,}080.000) = 1.533$, and $P = 0.204$, and in Fp2, Box $M = 4.370$, $F(3, 46{,}080.000) = 1.259$, and $P = 0.287$. In F3, Box $M = 0.389$, $F(3, 46{,}080.000) = 0.112$, and $P = 0.953$, and in F4, Box $M = 5.437$, $F(3, 46{,}080.000) = 1.567$, and $P = 0.195$. In T3, Box $M = 2.757$, $F(3, 46{,}080.000) = 0.794$, and $P = 0.497$, and in T4, Box $M = 1.208$, $F(3, 46{,}080.000) = 0.348$, and $P = 0.791$. Also, in P3, Box $M = 5.669$, $F(3, 46{,}080.000) = 1.634$, and $P = 0.179$, and lastly, in P4, Box $M = 3.280$, $F(3, 46{,}080.000) = 0.945$, and $P = 0.418$. The equivalence assumption

Table 2. The results of electroencephalogram activation after the whole body vibration exercise intervention

Spot	Group	Pretest	Posttest		*F*	*P*	ηp^2
Fp1	EG	0.032±0.006	0.056±0.006	Group	24.252	0.001	0.603
	CG	0.032±0.005	0.032±0.004	Time	220.855	0.001	0.932
				G×T	225.042	0.001	0.934
Fp2	EG	0.035±0.004	0.049±0.006	Group	8.398	0.010	0.344
	CG	0.037±0.004	0.035±0.003	Time	49.866	0.001	0.757
				G×T	85.664	0.001	0.843
F3	EG	0.048±0.006	0.062±0.005	Group	7.513	0.014	0.320
	CG	0.049±0.005	0.048±0.005	Time	178.382	0.001	0.918
				G×T	189.888	0.001	0.922
F4	EG	0.076±0.004	0.086±0.003	Group	5.132	0.038	0.243
	CG	0.078±0.005	0.076±0.005	Time	44.316	0.001	0.735
				G×T	98.802	0.001	0.861
T3	EG	0.279±0.017	0.310±0.020	Group	4.624	0.047	0.224
	CG	0.275±0.022	0.273±0.022	Time	251.834	0.001	0.940
				G×T	308.765	0.001	0.951
T4	EG	0.376±0.037	0.512±0.038	Group	20.242	0.001	0.559
	CG	0.369±0.034	0.367±0.035	Time	3,203.720	0.001	0.995
				G×T	3,397.190	0.001	0.995
P3	EG	0.358±0.035	0.493±0.030	Group	25.518	0.001	0.615
	CG	0.353±0.029	0.351±0.029	Time	1,605.043	0.001	0.990
				G×T	1,686.850	0.001	0.991
P4	EG	0.470±0.039	0.594±0.041	Group	16.853	0.001	0.513
	CG	0.463±0.031	0.462±0.031	Time	6,466.749	0.001	0.998
				G×T	6,560.554	0.001	0.998

Values are presented as mean±standard deviation.
EG, exercise group; CG, control group.

https://doi.org/10.12965/jer.1836230.115

of variate and covariate matrixes is satisfied, and according to the results of verifying Mauchly's sphericity assumption, Huynh-Feldt's ε equals 1 in all the variables, so the sphericity assumption is satisfied.

The results of EEG activation in women with senile dementia after the whole body vibration exercise intervention are presented in Table 2. As shown in Table 2, Fp1, Fp2, F3, F4, T3, T4, P3, and P4 all indicated interactive effects in terms of EEG activation in women with senile dementia after the whole body vibration exercise intervention.

The changes of cognitive function according to the whole body vibration exercise intervention

According to the results of conducting a homogeneity test on the matrixes of cognitive function's variates and covariates in women with senile dementia in association with the whole body vibration exercise intervention, Box $M = 1.419$, $F(3, 46{,}080.000) = 0.409$, and $P = 0.747$, which means that the equivalence assumption of variate and covariate matrixes is satisfied, and according to the results of verifying Mauchly's sphericity assumption, Huynh-Feldt's ε equals 1, so the sphericity assumption is satisfied.

The results of cognitive function in women with senile dementia after the whole body vibration exercise intervention are presented in Table 3. As shown in Table 3, cognitive function indicated interactive effects in women with senile dementia after the whole body vibration exercise intervention.

DISCUSSION

This study provides scientific ground materials about the effects of whole body vibration exercise intervention in patients with senile dementia. In order to improve life quality in patients with senile dementia, this author has examined the effects of 8-week whole body vibration exercise intervention on EEG activation and cognitive function and also analyzed the findings with those in advanced research comparatively.

Table 3. The results of cognitive function after the whole body vibration exercise intervention

Group	Pretest	Posttest		*F*	*P*	ηp^2
EG	20.889±1.27	23.556±1.24	Group	4.692	0.046	0.227
CG	21.333±1.12	20.889±1.05	Time	29.091	0.001	0.645
			G×T	57.018	0.001	0.781

Values are presented as mean±standard deviation.
EG, exercise group; CG, control group.

The changes of EEG activation

There are ways to diagnose dementia objectively, for example, SPECT, fMRI, or brainwave analysis (EEG). Among them, EEG is mainly used as it is easy, economical, and noninvasive. EEG has been used as one of the most examination tools to diagnose dementia since 1931 when Berger reported that patients with senile dementia indicate the low wave phenomenon in their brainwave. EEG activation shows the functional state of a brain as an electrical signal attributed to the activity of cerebral nerves. Since patients with dementia indicate lower EEG activation than normal elders, it is needed to devise interventions to elevate it (Mahendra, 2012). Therefore, considering the characteristics of patients with senile dementia tending to refuse exercise itself due to their physical functional disorders, this author came up with whole body vibration exercise intervention that could draw responses from the neuromuscular system through mechanical vibrations with no burden of physical activity and observed the changes of EEG activation.

According to the results of verifying the effects of the whole body vibration exercise intervention on EEG activation in women with senile dementia, statistically significant differences were found in Fp1, Fp2, F3, F4, T3, T4, P3, and P4 all in terms of interactive effects between the measuring times and groups. Significant improvement was observed after the whole body vibration exercise intervention. This means that the whole body vibration exercise intervention elevates EEG activation positively in women with senile dementia. The result of this study corresponds to the result of Crabbe and Dishman (2004) that has measured brainwaves before, during, and after the exercise in patients with senile dementia and found the alpha waves of the frontal region significantly increase during and after the exercise, to the result of Praamstra et al. (2005) that when concentration is improved, the frontal region is activated, and to the result of Vogt et al. (2010) that has measured brainwaves five minutes before and right after the walking exercise and found that the left frontal lobe's alpha waves increase significantly after the walking exercise. These results support the findings of this study. The findings tell us that in patients with senile dementia having limitations in exercising due to their cognitive or behavioral disorders, whole body vibration exercise intervention will enhance EEG activation by stimulating their muscle spindles and sensory organs with the amplitudes and vibrations with no burden of physical activity and drawing responses from the neuromuscular system.

To sum up the above results, whole body vibration exercise intervention can be a safe and effective exercise method that can in-

crease EEG activation in women with senile dementia and delay and prevent functional decline in their brain. Therefore, the findings of this study are meaningful as they present the possibility of integrating whole body vibration exercise into the plan to improve the neuromuscular system safely and enhance life quality in patients with senile dementia indicating cognitive as well as behavioral disorders.

The changes of cognitive function

Dementia is a phenomenon of losing long-term memory in old age due to the damage of the cerebral cortex in charge of long-term memory and is accompanied with such symptoms as reduction in linguistic skills, space perception, and cognitive function. Among them, cognitive function is particularly more important because if one loses it, one may not be able to lead an ordinary life, obtain independency in life, or live a social life desirably (Wheatley, 2001). For them to secure independency in everyday life, it is demanded to devise interventions that can prevent reduction in cognitive function. In fact, exercise therapy is known as an effective method to prevent decline in cognitive function if it is practiced regularly in a long-term period (Vogel et al., 2009). Here in this study, whole body vibration exercise intervention was applied as anyone can participate in it safely as well as easily with no burden of physical activity, and then, this researcher observed how their cognitive function changed.

According to the results of verifying the effects of the whole body vibration exercise intervention on cognitive function in women with senile dementia, statistically significant differences were found in terms of interactive effects between the measuring times and groups. After the whole body vibration exercise intervention, significant improvement was observed. This implies that the whole body vibration exercise intervention enhances cognitive function positively in women with senile dementia. The findings correspond to the result of Rolland and Chevrollier (2001) that regular exercise prevents decline in cognitive function resulted from dementia positively, to the result of Kemoun et al. (2010) that a 15-week physical activity program provided to patients with dementia enhances the experimental group's cognitive function significantly, and also to the result of Schuit et al. (2001) that in patients with dementia, the increase of physical activity reduces the risk of reduction in cognitive function. They all support the findings of this study. The result seems to be attributed to the fact that the whole body vibration exercise intervention provided to women with senile dementia increases blood circulation safely with no physical burden and influences cognitive function positively through activated cerebrovascular circulation.

To sum up the above results, whole body vibration exercise intervention allows patients with senile dementia to participate in regular exercise with no feeling of refusal. It enhances the functional plasticity of the cerebral cortex, increases connectivity between the dendrites of neurons, and improves the functions of the central nervous system efficiently (Chodzko-Zajko and Moore, 1994). Since it does improve brain functions in this way, it can be regarded as a proper exercise type for patients with senile dementia. Accordingly, we can conclude that whole body vibration exercise intervention that anyone can be applied to safely with no burden can be used to improve brain functions, obtain independency in everyday life, and elevate life quality desirably.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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