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Original Article

Effects of assisted aquatic movement and horseback riding therapies on emotion and brain activation in patients with cerebral palsy

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Abstract. [Purpose] The purpose of this study was to determine the effects of assisted aquatic movement and horseback riding therapies on emotion and brain activation in patients with cerebral palsy. [Subjects and Methods] Thirty-two right-handed patients with cerebral palsy (18 male, 14 female) whose ages ranged from 8 to 48 years participated in this experiment. Their cerebral palsy levels ranged from 1 to 3. The participants were assigned to one of three groups according to the experimental conditions: an assisted aquatic movement therapy group, a horseback riding therapy group, or a control group. Electroencephalograms, the Feeling Scale and the Felt Arousal Scale were examined as dependent variables. [Results] Analysis of self-reported data demonstrated a significant positive improvement in the emotions of participants in the assisted aquatic movement therapy group in comparison with the control group. With regard to the electroencephalogram analysis, the results of this study showed increased alpha power in the assisted aquatic movement therapy group compared with the horseback riding and control groups. [Conclusion] The results of this study suggest that professionals can consider assisted aquatic movement therapy as an effective therapeutic intervention for the improvement of mental health and brain activation.

Key words: Assisted aquatic movement, Horseback riding, Brain activation

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INTRODUCTION

Cerebral palsy (CP) is recognized as a relatively permanent disorder of body movement and posture as a consequence of brain lesions, primarily arising in early infancy[1)]. In general, patients with CP have some or serious difficulty controlling their body movements. Therefore, assisted movement therapy has been widely applied in rehabilitation and therapeutic programs for patients with CP. Notably, assisted movement therapy has been shown to be an effective means to promote muscle symmetry[2)], improve walking[3)], enhance the mobility of upper extremities[4)], promote range of movement in joints, and decrease spasticity in individuals affected with CP[5)]. In addition to assisted movement therapy, horseback riding therapy (HRT) has also been proposed as an effective intervention to boost the health and well-being of patients with CP[6)]. Research has indicated several physical and psychological benefits of HRT including improvement of gross motor skills[7)], balance and posture[8)], and muscle symmetry[2)], increased movement economy[9)], and reduction of anger[10)], respectively.

However, there is a paucity of prospective studies concerning emotional and cognitive concerns with an emphasis on the psychophysiological approach for therapeutic interventions in CP. The use of psychophysiological methods is assumed to provide direct evidence of emotion-related responses that may not be obtained from self-report or questionnaire measures. To date, no study has demonstrated emotional responses in relation to therapeutic interventions, including assisted aquatic

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Table 1. Demographics and characteristics of the participants

Group factor	Years (Mean ± SD)	Height (Mean ± SD)	Weight (Mean ± SD)	CP level (Mean ± SD)
AATG (n=10)	11.6 ± 2.2	147.8 ± 6.3	43.9 ± 2.9	1.1 ± 0.3
HRTG (n=11)	34.5 ± 5.1	158.6 ± 8.1	57.8 ± 18.2	1.4 ± 0.6
CC (n=11)	33.9 ± 7.1	158.2 ± 11.3	52.3 ± 7.6	1.5 ± 0.6

AATG: assisted aquatic movement group; HRTG: horseback riding group; CC: control group

movements and horseback riding, using a psychophysiological approach. Therefore, the purpose of this study was to determine the psychophysiological effects of assisted aquatic movement and horseback riding therapies in patients with CP. It is expected that alpha power would be higher in groups incorporating assisted aquatic movement and horseback riding therapies than in a control group.

SUBJECTS AND METHODS

Thirty-two right-handed patients with CP (18 male, 14 female) whose ages ranged from 8 to 48 years participated in this experiment. Their CP levels ranged from 1 to 3 (Table 1). All participants took part in the study voluntarily. They were recruited from the Gyongnam CP centers in South Korea. All participants were randomly assigned to one of three groups according to the experimental conditions: an assisted aquatic movement therapy group (AATG; n=10), a horseback riding therapy group (HRTG; n=11), or a control group (CG; n=11). Each group was equivalent in terms of the levels of CP, which were classified by the gross motor function classification system for cerebral palsy (GMFCS)[11]. All participants were given 30 US dollars as compensation. Two participants were wheelchair users. All participants signed informed consent forms prior to the experiment in accordance with the ethical standard of the Declaration of Helsinki.

EEG: The instruments to record EEG data included an eight-channel QEEG system (Model: LXE5208, Poly G-I, Laxtha Inc., South Korea), an elastic cap (Electro-Cap International, Inc., Eaton, OH, USA) designed according to an international 10–20 electrode placement system[12], and a Grass resistance meter (Model: EZM5AB) to control impedance levels.

Feeling Scale (FS): The FS proposed by Hardy and Rejeski was administered to assess affective valence at specified times with respect to the AATG and CG[13]. This scale measures valence in feelings on the two dimensions of pleasure and displeasure using a single 11 point scale. In this scale, 0 is considered neutral, 0 to −5 represents bad feelings, and 0 to +5 indicates valence towards good feelings.

Felt Arousal Scale (FAS): Along with the FS, the FAS suggested by Svebak and Murgatroyd was administered to determine perceived activation with respect to AAT[13]. This is a single-item scale with 6 points, where 1 represents low arousal and 6 represents high arousal, respectively. Both the FS and FAS are considered reliable and valid measures of changes in feelings and have been widely used in affective and mood-related research in exercise settings[14].

Upon arriving at the testing area, participants were seated comfortably in a chair and provided with an explanation about the experimental procedure and the administration process of the FS and FAS. However, the participants were kept unaware about the purpose of the experiment because knowledge of it could influence the results of the FS and FAS. For the pretest, participants removed all types of electronic devices and metallic goods and reported their feelings using the FS and FAS. Next, head circumference was measured, an EEG cap was wired, electrodes were attached using EEG gel, and the impedance resistance level was maintained below 5 kΩ by an expert researcher and two assistants. The reference electrode was attached to the left earlobe, and the ground was attached to Fpz. The sampling rate was 256 Hz samples/sec. The baseline resting EEG was recorded for 2 min with the eyes open and 2 min with the eyes closed from the left (Fp1, F3, C3, and P3) and right hemisphere (Fp2, F4, C4, and P4) scalp sites before and after AAT. The posttest EEG data were recorded after applying assisted aquatic movement therapy for 50 minutes. The FS and FAS were administered before and after and assisted aquatic movement therapy. Similar procedures for administering the FS, FAS, and EEG measurement were followed for the HRTG and CG as well. The interval between pretest and posttest measures was also kept at 50 minutes for the HRTG and CG. The intervention for the AATG consisted of warming up for 10 min (i.e., dorsiflexion, plantar flexion, lateral bending right and left, lifting the legs toward the head while floating on the water, pronation, and supination), assisted aquatic movement therapy for 30 min (i.e., floating on the water using buoyancy, floating on the water in a sitting posture and walking backward and forward, walking right and left backward and forward, on the pool bottom in the water while wearing a weight suit, putting numbers on a wall using a buoyancy ring, and playing ball-catching and throwing game with instructor), and cooling down for 10 min (i.e., cooldown with Watsu basic movement exercise, one and two leg offering, accordion, rotating accordion, near and far leg rotation, over grip rotation, stillness, and follow movement), while the intervention for the HRTG consisted of a warm-up (5 min), slow increase in speed up (5 min), 110 m/min walking (30 min), slow decrease in speed (5 min), and cooldown (5 min). The control group was asked to watch a movie for 50 min between pre- and posttests. The participants were allowed to terminate the experiment at any time if they experienced pain or overexertion.

Table 2. Mean and standard deviation of FAS, FS, and brain activation across the three groups

Group factor	Variable	Pretest (Mean ± SD)	Posttest (Mean ± SD)	Group comparison
AATG (n=10)	FAS (score)	3.00 ± 0.47	5.10 ± 0.31*	AATG>HRTG, CC
	FS (score)	0.00 ± 0.47	3.00 ± 0.94*	
	Alpha power (μV)	31.2 ± 27.3	52.6 ± 30.9*	AATG>HRTG, CC
	Theta power (μV)	87.8 ± 82.1	175.6 ± 210.2	
	Asymmetry index	−0.05 ± 0.04	0.05 ± 0.03	
HRTG (n=11)	FAS (score)	3.36 ± 0.50	3.73 ± 1.00*	
	FS (score)	0.27 ± 0.46	0.27 ± 0.46	
	Alpha power (μV)	16.6 ± 13.3	15.4 ± 8.04	
	Theta power (μV)	12.0 ± 11.0	10.8 ± 10.2	
	Asymmetry index	−0.04 ± 0.33	−0.09 ± 0.22	
CC (n=11)	FAS (score)	3.09 ± 0.30	3.09 ± 0.30	
	FS (score)	1.18 ± 1.94	1.00 ± 1.54	
	Alpha power (μV)	23.8 ± 24.4	15.0 ± 10.6	
	Theta power (μV)	21.5 ± 24.8	12.63 ± 9.50	
	Asymmetry index	−0.01 ± 0.20	0.07 ± 0.24	

*p<0.05. AATG: assisted aquatic movement group; HRTG: horseback riding group; CG: control group; FAS: Felt Arousal Scale; FS: Feeling Scale

EEG data were analyzed using the TeleScan (CD-TS-3.1, Laxtha, South Korea) software program. Electrooculography (EOG) was automatically removed by the TeleScan EOG removal program. Each epoch was screened to exclude those in which the amplitudes exceeded ± 100 μV. The window was set to 256 (1 s duration) with Fast Fourier transform (FFT) overlap of 60%, and band-pass filters between 0.1 Hz and 30 Hz were applied to the moving window. The epoch length was 240 s. The average spectral power density (absolute power) was calculated as the mean amplitude of spectral lines of the theta (3.5–7 Hz) and alpha (8–13 Hz). Eyes open and eyes closed data were averaged before inclusion in the analysis.

Analysis of covariance was conducted to measure differences among groups for emotion and brain activation at each testing point. Age was taken as a covariate. Group (2) ×test (2) ANOVAs with repeated measures on the last factor were conducted for the FS and FAS, respectively. For all analyses, PASW version 18.0 (SPSS Inc., Chicago, IL, USA) was used, and the significance level was set at α=0.05.

RESULTS

Analysis of the FAS data revealed significant main effects for group (F(2, 80)=8.28, p<0.001, η_p^2= 0.372). The AATG showed a higher FAS score than the HRTG and CG. A significant interaction was found for test by group (F(2, 28)=9.603, p<0.05, η_p^2= 0.407). A follow-up test indicated that the FAS posttest scores in the AATG were higher than the pretest scores (Table 2).

Analysis of the FS data revealed that there was a significant interaction for test by group (F(2, 28)=15.88, p<0.001, η_p^2= 0.532). *Post hoc* analysis indicated that the FS score for the posttest in the AATG increased compared with that for the pretest.

Analysis of the EEG theta power revealed no significant main effects for group (F(2, 28)=2.93, p>0.05, η_p^2= 0.069) and age (F(1, 28)= 0.083, p<0.05, η_p^2= 0.775). Moreover, no interactions were found.

Analysis of the EEG alpha power revealed a significant main effect for group (F(2, 28)=4.48, p<0.05, η_p^2= 0.243). Post hoc tests indicated that the AATG showed higher alpha power than the HRTG and CG (Table 2).

Analysis of the frontal EEG asymmetry revealed no main effect for group (F(1, 28)= 0.732, p>0.05, η_p^2= 0.050), age (F(1, 28)= 0.168, η_p^2= 0.006), or test (F(1, 28)= 0.241, p>0.05, η_p^2= 0.009). No test ×group (F(2, 28)=1.691, p>0.05, η_p^2= 0.108), or test ×age (F(1, 28)= 0.596, p>0.05, η_p^2= 0.021) interactions were found.

DISCUSSION

We investigated the psychophysiological effects of horseback riding and assisted aquatic movement therapies in patients with CP. The analysis of self-reported data related to emotional experience demonstrated a significant positive improvement in the emotions of participants in the AATG in comparison with those in the HRTG and CG. Our hypothesis was supported by evidence that the AAT resulted in positive emotions and high alpha power in patients with CP. This result is in line with a study by Dorval et al.[15] indicating that physical activities in an aquatic environment for nine months resulted in significant improvement in emotional development in individuals with cerebral palsy. In contrast, the present study showed a positive effect of AAT on emotional states with a 30-min treatment period. Thus it demonstrated that acute assisted aquatic movement therapy, rather than long-term aquatic therapy, may be sufficient to improve the emotional state of patients with CP. As an explanation for this finding, it may be that AAT provides an opportunity for patients with CP to experience an increase in limb mobility with less pain, which presumably improves their enjoyment and comfort in exercising. This notion is supported by previous research. For example, Lai et al.[16] offered aquatic therapeutic exercises as a treatment intervention for children with CP and found that the subjects reported higher posttest scores on the Physical Activity Enjoyment Scale in comparison with participants in their control group.

With regards to the EEG analysis, the results of this study showed an increased alpha power in the AATG as compared with that in the HRTG and CG. A possible interpretation of this finding is that alpha power in the AATG increased due to the improved emotions induced by the aquatic intervention, which enabled patients with CP to perform exercise or movement (walking and standing without limping or pain) in the water that they cannot do on land. Thus, AAT may provide patients with CP a comfortable feeling and a positive emotional boost.

Our results demonstrated that alpha power in the HRTG was lower than that in the AATG. Decreased alpha power in the left, central, and right frontal brain areas has been associated with negative emotional states[17]. The condition of CP is characterized by motor dysfunctions and neurological disorders due to lesions in certain brain areas. Specifically, with respect to patients with CP, Sajedi et al.[18] demonstrated decreased resting alpha activity in relation to increased motor dysfunctions. Thus, it can be assumed that decreased alpha power in the frontal regions in the HRTG could possibly be an EEG characteristic linked with negative psychological states in subjects with CP.

In addition, the lower alpha power in the HRTG relative to the AATG may be the result of fear of falling during the horseback riding intervention. Patients with CP are particularly characterized by weak muscles[19], decreased bone density, and poor neuromuscular coordination[20], which contribute to decreased postural balance and body control[21]. Horseback riding relies heavily on motor skills including coordination and balance and good postural control[22]. It is likely that participants in the HRTG experienced difficulty in maintaining their balance while riding horseback, possibly inducing a fear of falling that further resulted in diverting their attention from enjoyment of the activity to maintaining their postural balance on the horse's back.

In conclusion, data from the self-reported and psychophysiological measures provided evidence that assisted aquatic movement therapy helped to improve emotional feelings and mood states in patients with CP. These findings suggest that professionals in a therapeutic setting can consider assisted aquatic therapy as an effective intervention for the improvement of mental health and increased psychological wellness for these patients. Indeed, further studies need to explore the chronic effect of assisted aquatic therapy on emotional well-being, using a psychophysiological approach, while providing different types of exercises with various intensities and durations in an aquatic environment for individuals diagnosed with CP. Limitations of this study were that the ages of the subjects in the three groups were not equivalent and that each AAT and HRT was done only one time in this study. In this regard, since all the participants in this study were patients, it would have been difficult to control attendance and maintain the physical and mental conditions of the patients if the experiment was taken longer. Considering these limitations, this study focused on examining the effect of acute AAT and HRT. Future investigations should overcome these limitations by assessing affective responses in relation to the implementation of assisted aquatic therapy in children, adolescents, and older populations, respectively.

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