

The Effect of the Yoga Participating Senior Citizens' Exercise Flow on the EEG Following the Color Lighting Environment

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ABSTRACT

The purpose of this study was to examine the effect of yoga exercise within the color lighting environment on the senior citizens' exercise flow and the electroencephalogram (EEG). In this study, a yoga exercise program was conducted once a week for 19 senior citizens living in Yeonsu-gu, Incheon, who voluntarily agreed to participate in the study. As for the experimental design of the study, utilizing a within-subject design, it was conducted by using a randomized crossover trial based on the 2 types of experiments such as by treating them with the color lighting environment and treating them with the white lighting environment for the lighting environment for the yoga participants. A one week interval was placed so as not to influence the measurement results during the measurement. As for the EEG test, measurement was taken by attaching 2 channels to the frontal lobe on the right and left, and as for the exercise flow, the exercise flow measurement consisted of the 5 sub factors of Clear Goals, Sense of Control, Loss of Self-Consciousness, Transformation of Time, and Autotelic Experience were used. The EEG test was conducted before and after the yoga exercise, and the exercise flow questionnaire was required to be prepared after the yoga exercise. The results of this study have demonstrated significant changes in the Theta wave, Alpha wave, and the Gamma wave following the exercise flow in the color lighting environment. To the contrary, the Low-Beta waves, Middle-Beta waves, and the High-Beta waves demonstrated no significant changes. Hence, it can be concluded that the exercise flow following the color lighting environment of the yoga participating senior citizens increases the Alpha waves and the Theta waves, while reducing the Gamma waves. Such results of this study are significant in that they present the basic data on the physiological responses of the yoga studies for which color lighting is applied in Korea in the future.

1. Introduction

1.1 Need for the Study

The outbreak of COVID-19, which took place in 2020, has completely transformed our daily lives. All members of our society have had to practice social and physical distancing, and consequently, the number of people experiencing various psychological and mental stress has increased steeply (Yoon et al., 2021). Amidst COVID-19, a new word, ‘Corona black,’ a feeling of despair, following ‘Corona blue,’ a feeling of depression, and ‘Corona red,’ a feeling of violent rage, has also emerged (Munhwanews, 2021). Therefore, there is a growing need for the measures to help not only the physical health but also the mental health.

It has already been uncovered across numerous previous studies that regular exercise is beneficial not only for the physical health (Kim, 2013; Ko et al., 2017), but also for the mental health (Kang & Cho, 2016; Kang & Lee, 2000). It has been reported that the continuity of regular exercise brings positive effects on the various dimensions of health such as physical function, overall health perception, mental health, social function, and vitality (Choi et al., 2004), and negative thoughts are blocked together with the increased physical strength, while having a significant effect on the mental health, such as by increasing the social bond (Craft et al., 2004). The effect of such exercise is increasing as the interest in home training and home yoga regardless of time and place contactlessly with people in the current situation where the outdoor activities are impracticable due to the social distancing (Yun & Kim, 2021).

Among which, yoga (Lee, 2004), which has attracted attention as a representative form of leisure for well-being which can promote the mental and physical stability and the overall health, is known to help relieve stress (Ko et al., 2014; Kim, 2020; Park & Kim, 2014; Yoon et al., 2016). Yoga is an exercise by which one practices correct posture for the body alignment, and control the mind and cultivates the spirit through the meditation and breathing (Park, 2010). At which time, the situation in which focus is placed on yoga can be compared with the immersion in sports (Kim, 2013).

The physical activities and breathing conducted during the yoga practice have a significant effect on the change of mind, and the immersion experience of yoga leads to the satisfaction of life, thereby helping to lead a positive and happy daily life (Lee, 2002). Immersion is an intrinsically pleasurable state, which is accompanied by order in the consciousness experiencing the clarity of goals and knowledge of performance, complete concentration, a sense of control, and a feeling of complete harmony with the performance. As for the senior citizens, as an experiential characteristic of the exercise flow experienced, the feeling of thrill which was difficult to experience in the ordinary immersion of life lasts to some extent even after the immersion exercise is over, and one may gain a greater satisfaction by experiencing the immersion through the body movements. (Jeon et al., 2018).

Recently, color is a factor related to the stress relief and concentration. Color calms the people’s mind and also has the effect of having one concentrate on a more positive meaning psychologically, mentally, and visually (Birren, 2010). According to the previous studies, color has been demonstrated to have an effect on the stress relief (Lee & Kim, 2020; Lee & Seo, 2018; Lee & Park, 2013). Given the healing properties of color, color is used across numerous fields as well as psychology

and medicine today, and active studies are conducted in the 21st century as to be called the era of color (Lee & Lee, 2012). However, the studies articulating the effect of yoga in a color environment are very inadequate.

In general, the EEG is used as a method to verify the changes in the brain function, cerebral blood flows, and the stress conditions (Jeong et al., 2005; Moraes et al., 2007). While the rhythm of such EEG is analyzed in detail, in general, according to the 4 spectra, it is analyzed as the delta wave (delta: less than 4 Hz), theta wave (theta: 4-8 Hz), alpha wave (alpha: 8-12 Hz), and the beta wave (beta: 13-30Hz), respectively. Of which, the EEG studies related to the physical activities have paid attention to the changes in the alpha waves, which indicate the stability, and the beta waves, which indicate the level of arousal (Moraes et al., 2007).

As noted earlier, given the fact that yoga and color can help relieve the stress, the fact that the exercise flow revamps the positive mood, and the fact that it also brings one a greater satisfaction (Jeon et al., 2018), the exercise flow through yoga in a color environment is expected to have a significantly positive effect on the mental health. Therefore, this study intends to analyze the effect of the exercise flow according to the lighting environment on the EEG under the research hypothesis that the exercise flow according to the lighting environment of the senior citizens participating in yoga will influence the EEG. Furthermore, the purpose of this study is to present the basic data on the physiological response of the yoga research for which color lighting is applied in the future.

1.2. Research hypothesis

- 1) The exercise flow following the color lighting environment of the senior citizens participating in yoga will have a significant effect on the Theta waves.
- 2) The exercise flow following the color lighting environment of the senior citizens participating in yoga will have a significant effect on the Alpha waves.
- 3) The exercise flow following the color lighting environment of the senior citizens participating in yoga will have a significant effect on the Low-Beta waves.
- 4) The exercise flow following the color lighting environment of the senior citizens participating in yoga will have a significant effect on the Middle-Beta waves.
- 5) The exercise flow following the color lighting environment of the senior citizens participating in yoga will have a significant effect on the High-Beta waves.
- 6) The exercise flow following the color lighting environment of the senior citizens participating in yoga will have a significant effect on the Gamma waves.

2. Methodology

2.1 Research subject

This study was conducted with 19 senior citizens aged 65 and older, living in Yeonsu-gu, Incheon-shi. After explaining the purpose of the experiment and the research procedures to all 65-year-old senior

citizens, they signed a consent form for their participation in the experiment. Furthermore, for the ethical protection of this study, the experiment was carried out after undergoing deliberation of the Institutional Review Board and securing the approval of the study (1044396-202007-HR-124-01). The sample size for this study was calculated by using the G-Power 3.1 program. The minimum number of participants in this study was 15 people since the α level test power and the effect size were set to 0.05, 0.80 and 0.80, each respectively. The physical characteristics of the study subjects are illustrated in Table 1.

Table 1. Characteristics of the Study Subjects (n=19)

Age	Height	Weight
72.60	153.79	58.93
±5.11	±5.20	±8.21
Mean±SD		

2.2 Experimental procedures

As for the experimental design of the study, utilizing a within-subject design, it was conducted by using a randomized crossover trial based on the 2 types of experiments such as by treating them with the color lighting environment and treating them with the white lighting environment for the lighting environment for the yoga participants. A one week interval was placed so as not to influence the measurement results during the measurement.

Table 2. Research Design

	Meditation & warm-up	Main exercise	Cool-down & meditation
Lighting color	Orange	Green	Yellow
Color temperature (K)	4000	4000	4000
Illuminance (lx)	350	350	350

As for the color lighting environment, after changing the color environment in the space by setting the color lighting environment as illustrated in Table 2, the EEG was measured before and after the yoga exercise program, and the exercise flow questionnaire test was conducted after yoga. The white lighting environment was set to the color temperature (6000K) of the daylight fluorescent lamp, and was proceeded in the same manner as the color lighting environment.

2.3 Research tools

2.3.1 Brain wave test

As for the EEG measurement, the OMNIFIT Mindcare of the installed kiosk type was used, and the EEG was measured with a two-channel frontal brain wave sensor. The types of the EEG were Theta (4-7.99Hz), Alpha (8-11.99Hz), Low-Beta (12-14.99Hz), Middle-Beta (15-19.99Hz),

High-Beta (20-29.99Hz), and Gamma (30 Hz-), respectively. Before the EEG test was conducted, they meditated for 5 minutes with their eyes closed to achieve the psychological stability. The EEG was measured during the last minute before and after the yoga exercise in the state of meditation, respectively.

2.3.2 Exercise flow scale questionnaire

To measure the exercise flow of the senior citizens participating in yoga according to the lighting environment, the questionnaire of Sooyeon Suh (2005), who adapted the Flow State Scale measuring the state of immersion created by Jackson and Marsh (1996) based on the immersion experience factors of Csikszentmihalyi (1990; 1993), was revised and used in line with the purpose of this study. Consisted of a total of 20 questions, the questionnaire spanned the 5 sub-areas of Clear Goals, Sense of Control, Loss of Self-Consciousness, Transformation of Time, and Autotelic Experience, respectively. According to the characteristics of each question, responses are required to be provided based on a 5-point Likert scale, and the higher the score, the more immersed the physical activity situation. The reliability coefficients of the measurement variables of the exercise flow measurement used for this study were verified to be 0.87 for the Clear Goals, 0.84 for the Sense of Control, 0.97 for the Loss of Self-Consciousness, 0.88 for the Transformation of Time, and 0.81 for the Autotelic Experience, which turned out to be relatively stable, respectively.

2.4 Yoga exercise program

The yoga exercise program was conducted by treating the color lighting environment and the white lighting environment in a random manner for 60 minutes per session per week, for a total of 2 weeks, and the yoga exercise program is as illustrated in Table 3.

Table 3. Yoga Exercise Program

Classification	Movement		Time
Meditation & warm-up	Meditation	Sukasana	10 minutes
	Stretching	Chest(3), Wrist, Low back, Ankle, Achilles' tendon(2), Trunk, Back	
Main exercise	standing	Utthita Trikonasana	40 minutes
		Adho Mukha Svanasana	
	Sitting	Ardha-Matsyendrasana	
		Paschoimottanasana	
Prone & Supine		Janusirasana	
		Bhujangasana	
		Setu-bandhaSarvangasana	
		Jathara Parivartanasana	
Cool-down & meditation	Stretching	Pavanmuktasana	10 minutes
		Ananda Balasana	
	Meditation	Savasana	

2.5 Data analysis

In this study, to statistically analyze the data collected, the SPSS ver. 23 program was used. To examine the effect of the exercise flow according to the lighting environment of the senior citizens participating in yoga on the EEG, the multiple regression analysis was performed on the exercise flow between the color lighting and the white lighting and the changes in the EEG before and after the exercise. In all of the analyses, the statistical level of significance was set to $p < 0.05$ level.

3. Results

3.1 The effect of the yoga participating senior citizens' exercise flow following the lighting environment on the Theta wave

The first research hypothesis established in this study was whether the exercise flow following the lighting environment of the senior citizens participating in yoga has a significant effect on the Theta wave. To address such an issue, the results of the multiple regression analysis on the effect of the exercise flow following the lighting environment of the senior citizens participating in yoga on theta wave are as illustrated in Table 4. Table 4 was prepared for the contents of the white lighting and color lighting to be compared together according to the lighting environment.

According to Table 4, prior to the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = 0.059$), Sense of Control ($\beta = -0.300$), Loss of Self-Consciousness ($\beta = 0.173$), Transformation of Time ($\beta = -0.379$), and Autotelic Experience ($\beta = -0.386$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Theta waves statistically. After the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = -0.530$), Sense of Control ($\beta = -0.292$), Loss of Self-Consciousness ($\beta = 0.470$), Transformation of Time ($\beta = -0.005$), and Autotelic Experience ($\beta = -0.061$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Theta waves statistically.

Before the experiment of the senior citizens participating in yoga according to the color lighting environment, Clear Goals ($\beta = -0.489$), Sense of Control ($\beta = 0.482$), Loss of Self-Consciousness ($\beta = -0.292$), Transformation of Time ($\beta = -0.266$), and Autotelic Experience ($\beta = 0.569$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Theta waves statistically.

After the experiment of the senior citizens participating in yoga according to the color lighting environment, the Sense of Control ($\beta = 0.706$), which is a sub-factor of the exercise flow, turned out to have an effect, yet the Clear Goals ($\beta = -0.382$), Loss of Self-Consciousness ($\beta = -0.267$), Transformation of Time ($\beta = -0.371$), and Autotelic Experience ($\beta = 0.222$), turned out to have no significant effect on the Theta waves statistically. Furthermore, after the experiment, the ratio

of the exercise flow following the color lighting environment of the senior citizens participating in yoga, explaining the identity of the Theta waves turned out to represent approximately 19.3% ($R^2 = 0.193$) of the explanatory power of the total variance.

3.2 The effect of the yoga participating senior citizens' exercise flow following the lighting environment on the Alpha wave

The second research hypothesis established in this study was whether the exercise flow following the lighting environment of the senior citizens participating in yoga has a significant effect on the Alpha wave. To address such an issue, the results of the multiple regression analysis on the effect of the exercise flow following the lighting environment of the senior citizens participating in yoga on Alpha wave are as illustrated in Table 5. Table 5 was prepared for the contents of the white lighting and color lighting to be compared together according to the lighting environment.

According to Table 5, prior to the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = -0.023$), Sense of Control ($\beta = -0.185$), Loss of Self-Consciousness ($\beta = 0.324$), Transformation of Time ($\beta = -0.372$), and Autotelic Experience ($\beta = -0.472$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Alpha waves statistically.

After the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = -0.234$), Sense of Control ($\beta = -0.577$), Loss of Self-Consciousness ($\beta = 0.514$), Transformation of Time ($\beta = 0.037$), and Autotelic Experience ($\beta = -0.224$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Alpha waves statistically.

Before the experiment of the senior citizens participating in yoga according to the color lighting environment, Clear Goals ($\beta = -0.504$), Sense of Control ($\beta = 0.391$), Loss of Self-Consciousness ($\beta = -0.099$), Transformation of Time ($\beta = -0.297$), and Autotelic Experience ($\beta = 0.180$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Alpha waves statistically.

After the experiment of the senior citizens participating in yoga according to the color lighting environment, the Sense of Control ($\beta = 0.694$), which is a sub-factor of the exercise flow, turned out to have an effect, yet the Clear Goals ($\beta = -0.374$), Loss of Self-Consciousness ($\beta = -0.091$), Transformation of Time ($\beta = -0.258$), and Autotelic Experience ($\beta = -0.005$), turned out to have no significant effect on the Alpha waves statistically. Furthermore, after the experiment, the ratio of the exercise flow following the color lighting environment of the senior citizens participating in yoga, explaining the identity of the Alpha waves turned out to represent approximately 9.4% ($R^2 = 0.094$) of the explanatory power of the total variance.

Table 4. The Effect of the Yoga Participating Senior Citizens' Exercise Flow Following the Lighting Environment on the Theta Wave

		Before experiment		After experiment	
		Beta	t	Beta	t
White lighting	Constant		3.529		2.141
	Clear Goals	0.059	0.164	-0.530	-1.478
	Sense of Control	-0.300	-0.724	-0.292	-0.706
	Loss of Self-Consciousness	0.173	0.341	0.470	0.929
	Transformation of Time	-0.379	-1.313	-0.005	-0.017
	Autotelic Experience	-0.386	-1.100	-0.061	-0.175
Explanatory ratio		R Square = 0.261 Adjusted R Square = -0.024		R Square = 0.261 Adjusted R Square = -0.023	
		Before experiment		After experiment	
		Beta	t	Beta	t
Color lighting	Constant		0.959		1.984
	Clear Goals	-0.489	-1.816	-0.382	-1.374
	Sense of Control	0.482	1.759	0.706	2.489**
	Loss of Self-Consciousness	-0.292	-0.940	-0.267	-0.829
	Transformation of Time	-0.266	-1.084	-0.371	-1.458
	Autotelic Experience	0.569	2.000	0.222	0.756
Explanatory ratio		R Square = 0.455 Adjusted R Square = 0.246		R Square = 0.417 Adjusted R Square = 0.193	

**p < 0.01

Table 5. The Effect of the Yoga Participating Senior Citizens' Exercise Flow Following the Lighting Environment on the Alpha Wave

		Before experiment		After experiment	
		Beta	t	Beta	t
White lighting	Constant		3.585		2.584
	Clear Goals	-0.023	-0.062	-0.234	-0.645
	Sense of Control	-0.185	-0.440	-0.577	-1.380
	Loss of Self-Consciousness	0.324	0.629	0.514	1.005
	Transformation of Time	-0.372	-1.271	0.037	0.127
	Autotelic Experience	-0.472	-1.324	-0.224	-0.633
Explanatory ratio		R Square = 0.237 Adjusted R Square = -0.056		R Square = 0.246 Adjusted R Square = -0.045	
		Before experiment		After experiment	
		Beta	t	Beta	t
Color lighting	Constant		2.155		2.621
	Clear Goals	-0.504	-1.780	-0.374	-1.269
	Sense of Control	0.391	1.357	0.694	2.309**
	Loss of Self-Consciousness	0.099	0.304	-0.091	-0.267
	Transformation of Time	-0.297	-1.150	-0.258	-0.956
	Autotelic Experience	0.180	0.602	-0.005	-0.014
Explanatory ratio		R Square = 0.397 Adjusted R Square = 0.166		R Square = 0.346 Adjusted R Square = 0.094	

**p < 0.01

3.3 The effect of the yoga participating senior citizens' exercise flow following the lighting environment on the low beta wave

The third research hypothesis established in this study was whether the exercise flow following the lighting environment of the senior citizens participating in yoga has a significant effect on the Low-Beta wave. To address such an issue, the results of the multiple regression analysis on the effect of the exercise flow following the lighting environment of the senior citizens participating in yoga on Low-Beta wave are as illustrated in Table 6. Table 6 was prepared for the contents of the white lighting and color lighting to be compared together according to the lighting environment.

According to Table 6, prior to the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = 0.133$), Sense of Control ($\beta = -0.363$), Loss of Self-Consciousness ($\beta = 0.438$), Transformation of Time ($\beta = -0.325$), and Autotelic Experience ($\beta = -0.490$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Low-Beta waves statistically.

After the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = -0.069$), Sense of Control ($\beta = -0.661$), Loss of Self-Consciousness ($\beta = 0.837$), Transformation of Time ($\beta = 0.010$), and Autotelic Experience ($\beta = -0.513$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Low-Beta waves statistically.

Before the experiment of the senior citizens participating in yoga according to the color lighting environment, Clear Goals ($\beta = -0.107$), Sense of Control ($\beta = 0.219$), Loss of Self-Consciousness ($\beta = 0.310$), Transformation of Time ($\beta = -0.287$), and Autotelic Experience ($\beta = 0.110$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Low-Beta waves statistically.

After the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = -0.257$), Sense of Control ($\beta = 0.403$), Loss of Self-Consciousness ($\beta = -0.086$), Transformation of Time ($\beta = 0.071$), and Autotelic Experience ($\beta = -0.062$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Low-Beta waves statistically.

3.4 The effect of the yoga participating senior citizens' exercise flow following the lighting environment on the middle beta wave

The fourth research hypothesis established in this study was whether the exercise flow following the lighting environment of the senior citizens participating in yoga has a significant effect on the Middle-Beta wave. To address such an issue, the results of the multiple regression analysis on the effect of the exercise flow following the lighting environment of the senior citizens participating in yoga on Middle-Beta wave are as illustrated in Table 7. Table 7 was prepared for the contents of the white lighting and color lighting to be compared together according to the lighting environment.

According to Table 7, prior to the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = 0.022$), Sense of Control ($\beta = -0.296$), Loss of Self-Consciousness ($\beta = 0.519$), Transformation of Time ($\beta = -0.263$), and Autotelic Experience ($\beta = -0.535$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Middle-Beta waves statistically.

After the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = -0.091$), Sense of Control ($\beta = -0.625$), Loss of Self-Consciousness ($\beta = 0.899$), Transformation of Time ($\beta = 0.007$), and Autotelic Experience ($\beta = -0.549$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Middle-Beta waves statistically.

Before the experiment of the senior citizens participating in yoga according to the color lighting environment, Clear Goals ($\beta = -0.118$), Sense of Control ($\beta = 0.200$), Loss of Self-Consciousness ($\beta = 0.161$), Transformation of Time ($\beta = -0.251$), and Autotelic Experience ($\beta = 0.255$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Middle-Beta waves statistically.

After the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = -0.298$), Sense of Control ($\beta = 0.379$), Loss of Self-Consciousness ($\beta = -0.200$), Transformation of Time ($\beta = 0.101$), and Autotelic Experience ($\beta = -0.020$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Middle-Beta waves statistically.

3.5 The effect of the yoga participating senior citizens' exercise flow following the lighting environment on the high beta wave

The fifth research hypothesis established in this study was whether the exercise flow following the lighting environment of the senior citizens participating in yoga has a significant effect on the High-Beta wave. To address such an issue, the results of the multiple regression analysis on the effect of the exercise flow following the lighting environment of the senior citizens participating in yoga on High-Beta wave are as illustrated in Table 8. Table 8 was prepared for the contents of the white lighting and color lighting to be compared together according to the lighting environment.

According to Table 8, prior to the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = -0.014$), Sense of Control ($\beta = -0.142$), Loss of Self-Consciousness ($\beta = 0.378$), Transformation of Time ($\beta = -0.202$), and Autotelic Experience ($\beta = -0.487$), which are sub-factors of the exercise flow, turned out to have no significant effect on the High-Beta waves statistically.

After the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = -0.101$), Sense of Control ($\beta = -0.616$), Loss of Self-Consciousness ($\beta = 0.900$), Transformation of Time ($\beta = 0.039$), and Autotelic Experience ($\beta = -0.579$), which are sub-factors of the exercise flow, turned out to have no significant effect on the High-Beta waves statistically.

Before the experiment of the senior citizens participating in yoga according to the color lighting environment, Clear Goals ($\beta = -0.127$), Sense of Control ($\beta = 0.178$), Loss of Self-Consciousness ($\beta = 0.043$), Transformation of Time ($\beta = -0.243$), and Autotelic Experience ($\beta = 0.348$), which are sub-factors of the exercise flow, turned out to have no significant effect on the High-Beta waves statistically.

After the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = -0.340$), Sense of Control ($\beta = 0.370$), Loss of Self-Consciousness ($\beta = -0.323$), Transformation of Time ($\beta = 0.118$), and Autotelic Experience ($\beta = -0.002$), which are sub-factors of the exercise flow, turned out to have no significant effect on the High-Beta waves statistically.

Table 6. The Effect of the Yoga Participating Senior Citizens' Exercise Flow Following the Lighting Environment on the Low Beta Wave

		Before experiment		After experiment	
		Beta	t	Beta	t
White lighting	Constant		4.094		3.417
	Clear Goals	0.133	0.355	-0.069	-0.191
	Sense of Control	-0.363	-0.836	-0.661	-1.601
	Loss of Self-Consciousness	0.438	0.825	0.837	1.656
	Transformation of Time	-0.325	-1.075	0.010	0.035
	Autotelic Experience	-0.490	-1.333	-0.513	-1.467
Explanatory ratio		R Square = 0.187 Adjusted R Square = -0.125		R Square = 0.263 Adjusted R Square = -0.020	
		Before experiment		After experiment	
		Beta	t	Beta	t
color lighting	Constant		1.904		2.553
	Clear Goals	-0.107	-0.339	-0.257	-0.747
	Sense of Control	0.219	0.685	0.403	1.151
	Loss of Self-Consciousness	0.310	0.855	-0.086	-0.217
	Transformation of Time	-0.287	-1.000	0.071	0.227
	Autotelic Experience	0.110	0.332	-0.062	-0.171
Explanatory ratio		R Square = 0.258 Adjusted R Square = -0.027		R Square = 0.111 Adjusted R Square = -0.231	

**P< 0.01

Table 7. The Effect of the Yoga Participating Senior Citizens' Exercise Flow Following the Lighting Environment on the Middle Beta Wave

		Before experiment		After experiment	
		Beta	t	Beta	t
White lighting	Constant		4.242		3.168
	Clear Goals	0.022	0.059	-0.091	-0.254
	Sense of Control	-0.296	-0.680	-0.625	-1.510
	Loss of Self-Consciousness	0.519	0.974	0.899	1.774
	Transformation of Time	-0.263	-0.869	0.007	0.025
	Autotelic Experience	-0.535	-1.453	-0.549	-1.564
Explanatory ratio		R Square = 0.184 Adjusted R Square = -0.130		R Square = 0.260 Adjusted R Square = -0.025	
		Before experiment		After experiment	
		Beta	t	Beta	t
color lighting	Constant		1.896		2.549
	Clear Goals	-0.118	-0.368	-0.298	-0.866
	Sense of Control	0.200	0.614	0.379	1.081
	Loss of Self-Consciousness	0.161	0.436	-0.200	-0.503
	Transformation of Time	-0.251	-0.857	0.101	0.321
	Autotelic Experience	0.255	0.753	-0.020	-0.055
Explanatory ratio		R Square = 0.228 Adjusted R Square = -0.069		R Square = 0.107 Adjusted R Square = -0.236	

**P< 0.01

Table 8. The Effect of the Yoga Participating Senior Citizens' Exercise Flow Following the Lighting Environment on the High Beta Wave

		Before experiment		After experiment	
		Beta	t	Beta	t
White lighting	Constant		4.303		3.352
	Clear Goals	-0.014	-0.035	-0.101	-0.285
	Sense of Control	-0.142	-0.319	-0.616	-1.506
	Loss of Self-Consciousness	0.378	0.692	0.900	1.797
	Transformation of Time	-0.202	-0.649	0.039	0.139
	Autotelic Experience	-0.487	-1.286	-0.579	-1.670
Explanatory ratio		R Square = 0.140 Adjusted R Square = -0.191		R Square = 0.278 Adjusted R Square = 0.000	
		Before experiment		After experiment	
		Beta	t	Beta	t
color lighting	Constant		2.374		2.764
	Clear Goals	-0.127	-0.393	-0.340	-1.008
	Sense of Control	0.178	0.539	0.370	1.074
	Loss of Self-Consciousness	0.043	0.115	-0.323	-0.829
	Transformation of Time	-0.243	-0.823	0.118	0.381
	Autotelic Experience	0.348	1.016	-0.002	-0.007
Explanatory ratio		R Square = 0.212 Adjusted R Square = 0.091		R Square = 0.142 Adjusted R Square = -0.188	

**p < 0.01

3.6 The effect of the yoga participating senior citizens' exercise flow following the lighting environment on the gamma wave

The sixth research hypothesis established in this study was whether the exercise flow following the lighting environment of the senior citizens participating in yoga has a significant effect on the Gamma wave. To address such an issue, the results of the multiple regression analysis on the effect of the exercise flow following the lighting environment of the senior citizens participating in yoga on High-Beta wave are as illustrated in Table 9. Table 9 was prepared for the contents of the white lighting and color lighting to be compared together according to the lighting environment.

According to Table 9, prior to the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = 0.001$), Sense of Control ($\beta = 0.062$), Loss of Self-Consciousness ($\beta = 0.057$), Transformation of Time ($\beta = -0.371$), and Autotelic Experience ($\beta = -0.257$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Gamma waves statistically.

After the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = -0.204$), Sense of Control ($\beta = -0.677$), Loss of Self-Consciousness ($\beta = 0.568$), Transformation of Time ($\beta = 0.121$), and Autotelic Experience ($\beta = 0.121$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Gamma waves statistically. Furthermore, it turned out that the ratio of exercise flow according to the color lighting environment of the senior citizens participating in yoga before the experiment, which explains the

identity of Gamma wave represents approximately 19.8% ($R^2=0.198$) of the total variance.

After the experiment of the senior citizens participating in yoga according to the white lighting environment, Clear Goals ($\beta = -0.294$), Sense of Control ($\beta = 0.507$), Loss of Self-Consciousness ($\beta = -0.237$), Transformation of Time ($\beta = -0.325$), and Autotelic Experience ($\beta = 0.099$), which are sub-factors of the exercise flow, turned out to have no significant effect on the Gamma waves statistically.

Table 9. The Effect of the Yoga Participating Senior Citizens' Exercise Flow Following the Lighting Environment on the Gamma Wave

		Before experiment		After experiment	
		Beta	t	Beta	t
White lighting	Constant		3.100		2.134
	Clear Goals	0.001	0.002	-0.204	-0.570
	Sense of Control	0.062	0.141	-0.677	-1.637
	Loss of Self-Consciousness	0.057	0.105	0.568	1.122
	Transformation of Time	-0.371	-1.207	0.121	0.420
	Autotelic Experience	-0.257	-0.688	-0.128	-0.364
Explanatory ratio		R Square = 0.161 Adjusted R Square = -0.162		R Square = 0.262 Adjusted R Square = -0.022	
		Before experiment		After experiment	
		Beta	t	Beta	t
Color lighting	Constant		1.174		2.311
	Clear Goals	-0.393	-1.416	-0.294	-0.931
	Sense of Control	0.385	1.362	0.507	1.578
	Loss of Self-Consciousness	-0.323	-1.008	-0.237	-0.650
	Transformation of Time	-0.279	-1.101	-0.325	-1.130
	Autotelic Experience	0.627	2.139**	0.099	0.298
Explanatory ratio		R Square = 0.421 Adjusted R Square = 0.198		R Square = 0.252 Adjusted R Square = -0.035	

**P < 0.01

4. Discussion

The purpose of this study was to examine and validate the positive effect of the exercise flow following the color lighting environment of the senior citizens participating in yoga. To this end, the effect of the exercise flow according to the color lighting environment on the EEG was examined.

In general, the Theta wave emerges predominantly when attention is paid to the inner self in the state of ecstasy or meditation (Lee, 2015), and the Alpha wave emerges predominantly in a comfortable state such as relaxation (Kim & Ryu, 2011). Alpha waves are generated when the body and mind are harmonized in a state of high consciousness (Jee & Kim, 2014), which are also called meditation waves when and as the muscles are relaxed and the mind is relaxed while

the consciousness is concentrated (Byun et al., 2013). People in a state of health and free of stress tend to have a lot of the Alpha waves activated (An, 2006). In this study, as a result of conducting the EEG test before and after the yoga exercise program in the color lighting environment, significant results were found in the Theta wave's and Alpha wave's areas. Such results are consistent with the research results of Naesook Pyo and Jeongdoek Ahn (2002) which provided that the emergence of the Theta and Alpha waves among the middle-aged women after the exercise therapy was significantly activated.

Such results indicate that the green and yellow (Lee & Lee, 2012) lighting environments, which cause a visually relaxing effect, might have influenced the activation of the Alpha waves related to stability. Furthermore, in this exercise, being exposed to the green (Kwon, 2018) lighting environment which activates the parasympathy such as maintaining a calm and peaceful state of mind and body by achieving the physical and mental balance, and stabilizing the pulse and blood pressure, may be deemed to have induced the exercise flow. After the exercise flow, it is considered that the Theta wave and the Alpha wave are activated by entering into a meditative state with a sense of control and a feeling of being completely in harmony with the meditation.

The Gamma waves are among the fastest waves during the brain activities, and also are mainly generated in the frontal and parietal lobes in a state of excitement, complex information processing, extreme concentration, excessive arousal, or stress (Cho et al., 2017). In this study, it turned out that the Gamma waves, which demonstrated a significant value before the yoga exercise program in the color lighting environment, were not significant on an ex post basis. It may be considered that the yoga exercise program in the color lighting environment reduced the activities of the Gamma waves. Such results are considered to have been influenced by the color lighting environment which activates the parasympathy together with the visual relaxation effects as with the Theta and the Alpha waves.

Lastly, the study of Hyejeong Lee, Wonjae Lee, and Sojeong Lee (2014), reported on the results that, after 8 weeks of the Hata yoga practice, the Alpha waves' F8-F7 levels increased, resulting in a positive change in the decreased sympathetic nervous system's tensions and the increased parasympathetic nervous system's tensions, along with which, the study (Chong et al., 2004) which reported that the color lighting affects the physiological signals and emotional changes in the human, both support the results of this study. That is, in tandem with the study results (Ko et al., 2014) providing that the characteristics of the yoga exercise present the stress relief effect of the 10-week Hata and Raja complex yoga programs (Ko et al., 2014), the color lighting of this study would have influenced the effect of the exercise flow (Jeon et al., 2018) inspiring the senior citizens to feel positively.

Through the limitations of this study manifested, recommendations may be made for the follow-up studies. Since this study was conducted with such a small number of people, there were limitations in analyzing the effect of the yoga exercise according to the color lighting environment. Furthermore, since it was conducted as a one-time event, significant changes could not be verified for all of the EEGs. Therefore, it is considered that in the follow-up studies, it would be necessary to study the differences in the EEG changes via the yoga participation in the color lighting environment for over a long period of time with a large number of people.

5. Conclusion

The purpose of this study was to articulate the effect of the exercise flow following the color lighting environment of the senior citizens participating in yoga on the EEG, and also present the basic data on the physiological responses of the yoga research for which the color lighting is applied in the future. To this end, the exercise flow measure was selected, and the basic EEG was collected through the EEG test. The multiple regression analysis was performed for the exercise flow scores and the basic EEG according to the lighting environment, and the results are as follows.

First, the exercise flow according to the white light environment does not have a significant effect on the EEG. Second, the exercise flow according to the color lighting environment turns out to have a significant effect in part on the EEG. Examining specifically, the Sense of Control, which is a sub-factor of the exercise flow, turns out to influence the Theta and Alpha waves, and the Autotelic Experience turns out to have an effect on the Gamma waves. Other Low-Beta waves, Middle-Beta waves, and High-Beta waves are not influenced by the exercise flow. Gathering the research results, it turned out that the exercise flow according to the color lighting environment has a positive effect on the Theta, Alpha, and the Gamma waves.

In Korea, studies of the color lighting and the yoga exercise are very inadequately conducted, and hence, various studies are needed. This study is meaningful in that it has verified the effect of the exercise flow on the EEG according to the color lighting environment of the senior citizens participating in yoga. Therefore, this study may lead to the further facilitation of the studies to articulate the effects of the yoga exercise across various color lighting environments in the future.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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