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Effects of Taking a Hot Spring Bath on Relaxation

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Abstract

The purpose of this study is to clarify the effects of taking a hot spring bath on relaxation. Ten healthy male college students volunteered to be subjects in this study. This experiment was done in a laboratory to get rid of influences from the background environment, since it has been suggested that the effects of taking a hot spring bath on the post-stress phenomenon are brought from not only taking a hot spring bath but also the pleasant surroundings of the hot spring resort. The subject took a household style bath where hot spring water was provided in a laboratory setting. The electroencephalograph (EEG) Biofeedback System was used in this study. The EEG was determined prior to, during and after taking a hot spring bath.

As results of this study, it was found that a difference between the θ waves prior to and during the taking of a hot spring bath was significant. The θ wave decreased significantly due to taking the bath, which means that taking a hot spring bath can have a positive effect on relaxation.

Introduction

Although sleeping, rest, sports and drinking are suggested as ways of getting rid of mental stress[1~3], these are also supposed to play a part in not only getting rid of the stress but also preventing it. In other words, sleeping, rest and sports should be properly adopted in daily life and relaxation should be maintained. Relaxation also eases an individual's muscle fiber[4]. It has been suggested that if a strain of

muscle can be released, the brain will be relaxed by decreasing the impulse, since 40 % of body weight is muscle in a human being[5].

Taking a hot spring bath is effective for getting rid of mental stress. Besides that, taking a hot spring bath is effective in the recovery from fatigue, the prevention of illness and the treatment of chronic disease, and it preserves and improves health[6,7]. The effects of a hot spring bath on improving health have been applied in Japanese since early times to recover the individual's health[8]. Because of that, there is a research study to indicate that a death rate of cerebral apoplexy is lower in municipalities which have a hot spring as compared to municipalities without[9].

Taking a hot spring bath also releases the state of mind and removes mental fatigue[10]. The effects are usually caused by physical actions of heat, hydraulic pressure and buoyancy[8,10~13]. Immersion in lukewarm water stimulates the parasympathetic nerve system, brings anodyne and mentally composes individuals[14]. The effects of taking a hot spring bath on relaxation are remarkable since taking a hot spring bath is significantly more effective in keeping a body warm as compared with taking an ordinary hot water[15].

Relaxation can be determined in EEG and the EEG is classified in α, β, θ and δ waves[16]. An α wave (8～13Hz) is obtained when a normal individual awakes, rests and closes eyes and a β wave (14～30Hz) is seen when the individual feels anxiety and strain[16]. A light sleep seen in hypnagogic period shows a θ wave (4～7Hz), and a deep sleep indicates a δ wave (0.5～3Hz)[17]. Generally relaxation can be judged from the α wave appearing during mental rest.

Research using EEG concerning the effects of taking a hot spring bath on relaxation is little seen, although physical and mental responses by relaxation have been often reported. The purpose of this study is, therefore, to clarify the effects of taking a hot spring bath on relaxation.

Materials and Methods

Since the effects of taking a hot spring bath on the post-stress phenomenon are brought about not only from taking a hot spring bath but also from the natural environment of the hot spring resort[18], a study of this sort needs to eliminate ambient influences. The experiment of this study was, therefore, done in a laboratory.

Ten healthy male college students volunteered to be subjects in this study. Informed consent was obtained from all of the subjects by explaining the purpose and the methods of this study. The EEG Biofeedback System FM 515 (Fewtech

Electronics, Inc.) was used in this study. During the 15 minutes before taking a hot spring bath, a superior EEG was measured by attaching a sensor belt to the forehead. In the EEG biofeedback instrument used in this study, an electrode attached to the sensor belt was placed in Fp_1 and Fp_2 of the frontal lobe, 3 or 4 cm above the eyebrow and approximately 3 cm outside from the midline. The EEG was detected on the forehead and the ground wire was attached to an ear. The subject took a household bath where a hot spring supplied in the laboratory. The superior EEG was determined for 15 minutes prior to, during and after taking the bath.

The hot spring, 47.7℃, pH 8.7, colorless, transparent, weak acidity and odorless in the source of hot spring, used in this study was the source of the Kanai Educational Institution. The subject soaked with a lower part of the body in the bath. Since peripheral blood vessel became extended, blood pressure decreased and the load on the heart was reduced due to taking a hot spring bath while the heart rate and the load on the heart also increased due to taking a very hot bath, taking a lukewarm bath, 38～40℃ for 15～20 minutes, is encouraged[10]. The lukewarm bath, 38℃, was, therefore, used in this study. As the study Ueda[11] showed, the experiment was done in the laboratory maintained 25℃ of temperature and 75% of humidity. In the study Ueda[11] showed, the lukewarm bath, 38℃ was also used.

Results

The mean values and the results of testing a normal distribution are illustrated in Table 1. The result of the α_3 wave was excluded, since the measurement value was concluded to be unable to statistically compare the changes. The variables besides the α_2 wave after taking a hot spring bath, the β wave after taking it and the θ wave prior to taking it did not show a normal distribution, and the Smirnov test for extreme value was applied. As a result, the β wave prior to taking it and the θ wave during and after taking it show a normal distribution according to Table 1 on the next page.

The mean values after the Smirnov test for extreme value are indicated in Table 2. Only the θ wave was of possible use to test the difference of the mean using parametric methods to statistically compare the measurement values due to the environmental changes in all variables. All of the variables besides the θ wave were tested by Wilcoxon T values using nonparametric methods.

Table 1. The mean values and the results of testing a normal distribution.

	prior	during	after taking the bath
α_1 wave	35.3±35.6	38.3±39.7	34.5±33.2
χ^2	4.165*	4.246*	6.511**
Smirnov test	non-rejection	non-rejection	non-rejection
α_2 wave	14.3±18.3	33.2±31.5	23.5±27.0
χ^2	4.246*	9.691**	1.988
Smirnov test	non-rejection	non-rejection	
α_3 wave	0.2±0.7	0.0±0.0	0.0±0.0
χ^2	14.383**	19.326**	impossible determination
Smirnov test	non-rejection	non-rejection	non-rejection
β wave	8.6±12.0	10.2±10.9	8.9±13.9
χ^2	6.171*	4.246*	3.825
Smirnov test (χ^2)	3.245	non-rejection	
θ wave	31.0±27.5	16.1±25.3	24.9±35.4
χ^2	0.897	9.691**	11.284**
Smirnov test (χ^2)		0.359	1.222

(Mean ± S.D.) (* $p<0.05$, ** $p<0.01$)

Table 2. Mean values after the Smirnov test.

	prior	during	after taking the bath
α_1 wave	35.3 (N=10)	38.3 (N=10)	34.5 (N=10)
α_2 wave	14.3 (N=10)	33.2 (N=10)	23.5 (N=10)
α_3 wave	0.2 (N=10)	0.0 (N=10)	0.0 (N=10)
β wave	5.3 (N=9)	10.2 (N=10)	8.9 (N=10)
θ wave	31.0 (N=10)	8.3 (N=9)	8.3 (N=8)

(Mean)

The results of testing the difference between any two variables are shown in Table 3 on the next page. According to Table 3, a difference between the θ waves prior to and while taking a bath was found to be significant. It is, therefore, to clarify that the θ wave decreases significantly due to taking it. There was a tendency for the α_2 wave to increase all through, prior to, and while taking the bath. It was, however, not significant.

Discussion

It was clarified that the θ wave decreases significantly all through, prior to, and while taking the bath. Since the physiological interpretation of the θ wave is

Table 3. The results of testing the difference between any two variables.

	prior vs. during	prior vs. after	during vs. after takine the bath
α_1 wave	6.0	9.0	8.0
α_2 wave	25.0	23.0	24.0
β wave	13.0	13.0	10.0
θ wave	2.606*	2.114	0.508

(t value in θ wave, T value of Wilcoxon besides the θ wave) (* $p<0.05$)

mental strain[20], the significant decrease of the θ wave due to taking a hot spring bath means a reduction of mental strain. The reduction of mental strain can be understood, since a tendency to increase the α_2 wave was shown.

It is effective to reduce strain by stimulating the parasympathetic nervous system through taking a lukewarm water[11], and the lukewarm water brings generally about subsidence in the human body[21]. It seems that the lukewarm water used in this study brought about subsidence. It is valid to determine a concentration of acetylcholine in blood as a direct index of the parasympathetic nervous system[21]. It is necessary to determine a concentration of acetylcholine in blood in order to clarify the detailed effects of taking a hot spring bath on relaxation in future research.

As a relaxation effect, the quality of a hot spring seems to be a factor. The hot spring used in this study contained 58.94% of Na^+ and 40.36% of Ca^{2+} in the total cation and 31.66% of Cl^- and 66.25% of SO_4^{2-} in the total anion, as investigated in the Fukui Research Institute of Hygiene. The hot spring was a bitter, chloride spring and a low tensive and high alkaline spring as also investigated by the institute. It seems that the quality of a hot spring hastens extension of the blood vessels. The degree of the extending of blood vessels depends on particular properties of a hot spring[23]. A carbonate and hydrogen sulfide spring and a sulfur spring bring about remarkable extension of the blood vessels and a salt spring also improves the circulation of blood by stimulating the blood vessels[23]. It can be thought that improvement of the circulation of blood promotes relaxation effects.

Although one of the effects of taking a hot spring bath is invigoration, the effects are usually caused by the physical actions of heat, hydraulic pressure and buoyancy[6),10~13]. In soaking a body in lukewarm water, the blood of the skin becomes warmer and the blood flow promotes the extension of the blood vessels[6),13]. The observed relaxation effects might have been caused by the heat action promoting the extension of the blood vessels. If metabolism is promoted by heat action, a

fatiguing substance, such as lactic acid, decreases, and the pain and fatigue of muscles are released while recovery of fatigue is also promoted.

It is also possible that soaking the lower part of the body in a bath as administered in this study promotes relaxation. Since soaking the lower part of the body in a bath has little effect on the heart and the lungs due to lower hydrostatic pressure[10], subjects in this study seem to feel light stress to the heart and lungs. The buoyancy caused by taking a bath might possibly promote the relaxation.

Relaxation is important in the stressful society of the present age. Taking a hot spring bath should be applied for relaxation.

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