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Research Article

Effects of Quantitative Electroencephalography Based Neurofeedback Training on Autonomous Regulations in Patients with Alcohol Use Disorder

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ABSTRACT

Purpose: The study investigated whether neurofeedback training (NFT) can normalize the excessive high beta and low alpha waves indicative of hyperarousal and subsequently improve autonomous regulation based on the self-determination theory in alcohol use disorders.

Methods: A nonequivalent control group pretest–posttest design was used. Data were collected using self-report questionnaires from 36 Korean inpatients who met the Alcohol Use Disorder Identification Test in Korea criteria. Data were collected from quantitative electroencephalography to assess alpha (8–12 Hz) and high beta (21–30 Hz) waves for hyperarousal. The questionnaires included Basic Psychological Need Satisfaction scales that assessed autonomy, competence, and relatedness, and the Alcohol Abstinence Self-Efficacy Scale and Treatment Self-Regulation Questionnaire. The experimental group underwent 10 sessions of NFT over 4 weeks. Data were analyzed using the Chi-squared, Mann–Whitney U, and Wilcoxon signed-rank tests.

Results: In the experimental group, the alpha wave was increased in 15 of 19 sites and high beta waves were decreased in 15 of 19 sites, but this difference was not significant. However, high beta waves were increased in 15 of 19 sites in the control group, with seven sites (Fz, Cz, Pz, Fp2, F4, C4, and P4) showing significant increases. The experimental group showed a significant increase in basic psychological need satisfaction, alcohol abstinence self-efficacy, and self-regulation compared with the control group.

Conclusion: NFT is recommended for improving autonomous regulation in alcohol use disorder as a nursing intervention. However, for significantly attenuating hyperarousal through brain wave correction, it may be necessary to increase the number of neurofeedback sessions.

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Introduction

Alcohol use disorder (AUD), a mental illness, can devastate the lives of individuals. A survey by the World Health Organization (WHO) in 2014 reported that Korean alcohol consumption ranked 15th among the 188 member countries and 1st among Asian nations [1]. In addition, the 2016 Mental Health Survey conducted by the Ministry of Health and Welfare reported that AUD was the most prevalent mental illness in Korea (12.2%) [2]. In Korea, alcohol consumption is very high because of forced over-drinking, subsequently increasing the prevalence of AUD. It is estimated that

approximately 1.4 million people are affected by AUD every year in Korea [2]. Excessive alcohol consumption has become a serious social problem. In addition to personal physical and mental health problems, it is also associated with family dysfunction, suicide, and violent crime [3,4].

Brain damage because of chronic alcohol consumption increases activity in the autonomic nervous system, causing physical and psychological stress and withdrawal symptoms, such as anxiety or sleep disorders [3,4]. Excessive physical and psychological stress and reaction states are defined as hyperarousal, which can be measured by recording brain waves [5–7]. Studies have reported that high beta waves, indicating anxiety and excitement state, are enhanced, and alpha waves, indicating a calm state, are decreased during hyperarousal [5]. In addition, enhanced high beta waves are clinically important because they are associated with the severity and relapse of AUD [5–8]. AUD patients intake alcohol as a means

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of self-medication to relieve their withdrawal symptoms. Therefore, to prevent recurrence, it is necessary to carefully manage the symptoms of hyperarousal [3,4]. Most intervention programs that treat patients with AUD focus on psychological intervention, with very few programs assessing neurophysiological changes, such as hyperarousal. This shows that there is a need for a neurophysiological approach for relieving hyperarousal that can correct abnormal brain waves.

Neurofeedback training (NFT), also known as brain wave biofeedback training, is a neuromodulation technique based on operational conditioning principles. Patients receive visual and aural feedback on abnormal brain waves in real time and use their own strategies to normalize them, learning and improving their self-regulation. The human brain is characterized by its plasticity, and it has been reported that abnormal brain waves can be corrected through NFT. It has also been used clinically in attention deficit hyperactivity disorder, anxiety, depression, epilepsy, and traumatic brain injury [6,9]. To the best of our knowledge, no NFT studies with AUD have been conducted in Korea. The causes of drinking alcohol in patients with AUD involve a combination of biological, psychological, and social factors. Moreover, they are difficult to be assessed because of the various clinical manifestations caused by alcohol consumption [3,4]. Patients with AUD have a very high relapse rate; abstinence is temporary when it is motivated by external pressure or compensation [10].

According to the self-determination theory, personal volition and active engagement are essential to change and maintain healthy behavior [10–12]. To understand the motivation of humans to change, innate psychological needs such as autonomy, competence, and relatedness should be considered [11]. Autonomy involves the desire of an individual to self-decisively choose to start, maintain, or stop an action; that is, the ability of self-control [13]. Competence is the ability to act efficiently, and it involves the internalization of autonomy [11]. Relatedness is the tendency to maintain stable interpersonal relationships [10]. Therefore, treatment improving autonomy and competence can improve patient compliance and the acquisition of positive results. Relatedness is also important for treatment because patients accept and internalize the values of the actions of people they trust. Individuals with self-determinant regulation do not use addictive substances, such as alcohol, because they tend to overcome negative feelings, such as hopelessness and helplessness, in a flexible manner. They will consider negative experiences to be meaningful and as opportunities to achieve goals, even when they involve the chance of failure [11,14]. The types of self-regulation can be divided into nonregulation, controlled regulation, and autonomous regulation depending on the value and integration of the individual's motivation to change. Patients can acquire regulation by satisfying basic human needs and integrate regulation by enhancing self-regulation and alcohol abstinence self-efficacy through exploring and evaluating resistance factors [10,11,15].

NFT can improve the autonomy, competence, and relatedness of patients of AUD. Through neurofeedback, patients increase autonomy by identifying and controlling their own brain waves. The competence of the patient is enhanced by gradually regulating the regulatory task. It increases through learning the ability to control brain waves and adapting to increasing difficulty. Moreover, there is always interaction between the patient and the nurse in NFT, which increases reliable relatedness [10,15]. Many nurses are already working as biofeedback experts, and NFT is also likely to be used as a nursing intervention.

Therefore, in this study, NFT for inpatients with AUD was performed in combination with other intervention programs in hospital according to recommend of previous study [5]. The range of NFT was determined based on the results of individual quantitative

electroencephalography (QEEG) considering that different brain hyperarousal state in AUD. The participants' brain function was evaluated objectively through assessment using QEEG [9]. The purpose of this study was to examine effect of the 10 sessions of NFT on autonomous regulation for alcohol abstinence.

Study hypotheses

Hypothesis 1. Hyperarousal would decrease in the experimental group but would not change in the control group.

Hypothesis 1-1. Alpha waves would increase in the experimental group but would not change in the control group.

Hypothesis 1-2. High beta waves would decrease in the experimental group but would not change in the control group.

Hypothesis 2. Autonomous regulation would be higher in the experimental group than in the control group.

Hypothesis 2-1. Basic psychological need satisfaction (BPNS) would be higher in the experimental group than in the control group.

Hypothesis 2-2. Alcohol abstinence self-efficacy would be higher in the experimental group than in the control group.

Hypothesis 2-3. Self-regulation would be higher in the experimental group than in the control group.

Methods

Study design

This study was a nonequivalent control group pretest–posttest quasi-experiment that assessed the effect of NFT in inpatients with AUD based on the self-determination theory [11].

The conceptual framework of this study is shown in Figure 1. Inpatients with AUD are asymptomatic with no motivation or ability to control alcohol consumption. They are admitted to the hospital and are maintained in an alcohol abstinence state, regardless of their personal wishes. This can be regarded as controlled regulation including external and introjected regulation. NFT was applied to improve autonomous regulation.

Setting and sample

The study participants were 36 adult patients diagnosed with and hospitalized for AUD in D city, South Korea. Patients were recruited from four psychiatric hospitals. The number of participants was calculated using G* power, version 3.1.9. The minimum sample size required for a one-sided test of the effect of NFT with $\alpha = .05$, power $\beta = 80\%$, and effect size 0.68 [16] was 16 patients in both two groups. Considering a dropout, we recruited 22 patients in each group. After explaining the study to potential participants and obtaining their consent, we used the self-report version of the AUD Identification Test in Korea (AUDIT-K) [17] to identify adult patients with a score of ≥ 20 (men) and ≥ 10 (women), according to the Korean Psychiatric Association criteria [18]. Exclusion criteria included patients with visual and auditory sensory impairments, those with artificial substances or devices in the body, and those using stimulants or sedatives. Patients with diseases that may affect brain waves such as mental retardation, brain disease, epilepsy, seizures, delirium, dementia, and cognitive impairment were also excluded.

The experimental group consisted of 22 patients admitted in two hospitals. We excluded two patients because of an excessive artifact during the QEEG measurement at the pretest phase. The remaining 20 patients underwent 10 sessions of NFT. At the fifth training session, two men refused because of fight with each other. At the eight training session, one woman became ill with the flu

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