

The effects on mental fatigue and the cognitive function of mechanical massage and binaural beats (brain massage) provided by massage chairs



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ABSTRACT

Objective: To verify whether the mechanical massage using massage chairs and binaural beats (brain massage) affect the mental fatigue recovery and cognitive enhancements.

Methods: 25 healthy adults used massage chairs that could provide mechanical massage and binaural beats (brain massage) for 20 min. Mental fatigue and cognitive function were assessed before and after receiving brain massage using electroencephalogram (EEG) and 5 prolonged cognitive tests.

Results: When a person received a brain massage on the massage chair, the decrease in mental fatigue was statistically significant compared to taking a rest or receiving a mechanical massage only on the massage chair. In addition, sustained attention, verbal short-term and long-term memory and non-verbal long-term memory were statistically significantly increased after using brain massage.

Conclusion: Brain massage (mechanical massage and binaural beats) are effective in reducing mental fatigue and improving the cognitive function.

1. Introduction

As times change, mental labor has been increasingly required in modern society. Accordingly, mental fatigue can be more easily experienced in everyday life [1]. Mental fatigue refers to the feeling of fatigue and exhaustion, which can be experienced during or after prolonged cognitive activity and is known to be associated with sympathetic hyperactivity [2]. The accumulation of mental fatigue causes a decrease in individual cognitive functions, and Van der Linden et al. (2003a, 2003b, 2006) have reported that planning and eventual strategic modification are difficult because of mental fatigue [3–5]. In addition, Boksem et al. (2005) reported that mental fatigue made it difficult to ignore irrelevant information to the task currently being performed [6]. This decline in cognitive functions affects both individuals and society. According to the research conducted by Ricci et al., approximately 66% of the workforce declines in productivity in the comparison between those who are tired and those who are not tired, which caused an annual social cost of more than \$100 billion in the United States alone [7]. Thus, it is notably important to improve the cognitive functions through recovering mental fatigue.

Massage is one of the commonly used alternative treatments for fatigue recovery purposes, which tap or knead the body's muscles and joints by hands or tools [8–10]. According to previous studies, the stimulus to skin and muscles through massage activates the sensory,

temperature, vibration, and pain receptors, is transferred to the autonomic and central nervous system and triggers neuro-chemical reactions [11,12]. As a result, the hyper-activated nervous system is stabilized, and the parasympathetic nervous system is activated, which reduces the blood pressure, pulses and cortisol levels, relaxes one's mind and body, and helps recovering from fatigue [11,12]. Massage also affects the cognitive functions: 15 min of massage improve math calculations [13], and massage using a stream of water improves the working memory, which is related to restoring, planning and execution of information [14]. The effect of massage on the mental fatigue recovery appears to improve the cognitive functions.

The public interest in massage chairs is rapidly increasing with the efficacy of these massages and the healing trends of modern people seeking comfort, healing and mental health [15]. A massage chair is a chair-type massager that uses mechanical tools such as massage balls, rollers and airbags to automatically massage the user's full body. With the advances in technology, recent massage chairs can implement a professional's feeling of massage such as tapping, kneading and acupressure [15]. Thus, the effectiveness of massage chairs are expected to be similar to the effectiveness of the massage itself. However, there are few studies except for massage chair's effects on inducing muscle's relaxation [16] and sleep [17], so further studies of the clinical effectiveness of massage chairs are necessary.

In addition, the modern massage chairs offer music therapy such as

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instrumental music, natural sounds and binaural beats for relaxation and refresh. The binaural beats refer to the third sound heard when two different frequencies of pure tones are provided in each ear [18]. For example, when a pure tone of 295 Hz is heard through the left ear and a pure tone of 305 Hz is heard through the right ear, the beat sound of 10 Hz can be heard, which entrains the 10-Hz brainwaves and regulates the autonomic nervous system [18]. According to previous studies, the binaural beats have a positive effect on the blood pressure, pulse rate, body temperature, emotion, relaxation, and cognitive functions [16,19–24]. Thus, mechanical massage and binaural beats have different mechanisms but seem to have similar positive effects. However, there is no evidence that these effects of mechanical massage and binaural beats have relieved mental fatigue and improved cognitive functions such as concentration and memory.

Therefore, this study intends to verify whether the mechanical massage using massage chairs and the binaural beats (brain massage) are effective for mental fatigue recovery and cognitive functions enhancement. For this purpose, prolonged cognitive tests were conducted for healthy adults, which induced mental fatigue, and the massage chairs that could provide mechanical massage and binaural beats were used. Furthermore, by quantitatively analyzing the electroencephalogram (EEG) and cognitive tests results, we objectively verified the decrease in mental fatigue and improvement in cognitive function.

2. Material and methods

2.1. Participants and overall experimental paradigm

This study was conducted on 25 healthy volunteers of 20–50 years old, who agreed to voluntarily participate in the experiment. All subjects had no neurological or psychiatric history and previously confirmed that they did not have any disease that could affect the results of the experiment. Each subject was fully informed of the details of the experimental procedure, and all participants were given written consent to participate in the experiment. The study was reviewed and approved by the Public Institutional Review Board (IRB) committee designated by the Ministry of Health and Welfare, Korea (IRB approval number: P01-201706-11-001).

The overall experimental procedure is shown in Fig. 1. To verify the effects of receiving a mechanical massage and listening to the binaural beats using the massage chair (Treatment C) on the mental fatigue recovery and cognitive improvement, two treatments were selected as the control: having a rest while sitting on a massage chair (Treatment A) and receiving a mechanical massage with a massage chair (Treatment

B). The experiment was performed according to a single-group cross-over design, so all 25 participants received treatment A, B and C once. In order to minimize the effect of each treatment order, only one type of treatment was given per day, and the order of the treatments was determined by 6-block randomization. Each treatment lasted for 20 min, and the participants took at least 3 weeks to receive all the treatments because the time interval between each treatment was at least one week. Electroencephalogram (EEG) recording and cognitive tests were performed once before and after each treatment.

2.2. Description of each treatment

In this study, we used a massage chair (Bodyfriend Inc., Seoul, Korea) with 2 massage arms, 40 airbags and 4 rollers, which could massage the entire body including the neck, shoulders, arms, hands, waist, hip, calf, and sole. The massage chair has a built-in automatic mode that massages the entire body of the user in a specific pattern. It mainly uses 19–33 kneadings, 298–530 tappings per minute, and soft acupressure patterns. The basic angle of the backrest of the massage chair and the ground is 135° and is adjustable. Two separate stereo speakers are located on both sides of the user's ear to play various sound sources such as binaural beats.

Table 1 shows the detailed parameters such as the massage method, massage area, and massage chair angle for each treatment. In Treatment A, the backrest angle of the massage chair was laid down at approximately 160°, which enabled the subject to rest in a relaxed posture for 20 min without mechanical massage. In Treatment B, the “Concentration” massage mode was used to massage the subject's body for 20 min in a specific pattern. First, the backrest angle of the massage chair was laid down at approximately 150°, and the whole-body acupressure and kneading were repeated for 5 min. Then, the massage chair was laid down at 170°, the legs were positioned higher than the head, and the neck and waist were slowly kneaded or received acupressure for 10 min. In the last 5 min, the massage chair was raised again to 135°, and the subject was awoken by acupressure, kneading, and tapping to the entire body. In Treatment C, the massage pattern was identical to that in treatment B, while piano music, natural sounds such as valley water, and binaural beats (brain massage) were provided for 20 min. The beat frequency of the binaural beats was changed to 10, 7, 4, and 10 Hz at 5-min intervals.

2.3. EEG data acquisition and analysis

In this study, electroencephalogram (EEG) signals were measured using a multi-channel EEG (QEEG-64FX, Laxtha Inc., Daejeon, Korea) to

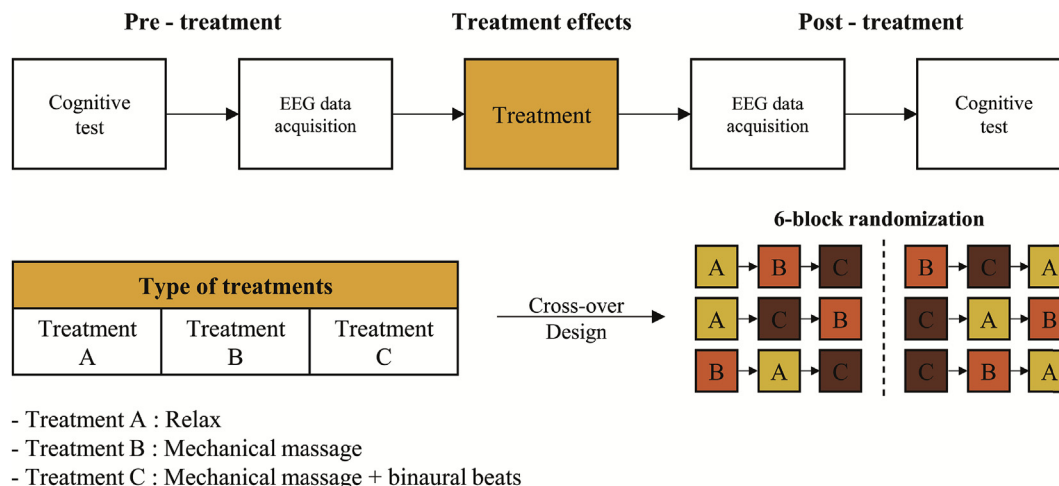


Fig. 1. Overall experimental procedure. The experiment was performed according to the cross-over design, and the treatment order was determined by 6-block randomization. EEG recording and cognitive tests were performed once before and after each treatment.

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