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Original research article

Examinations of the methods used to power supply of different light sources and their effect on bioelectrical brain activity

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ABSTRACT

Objective: The article represents the preliminary study, with the aim of the experiment being to examine whether different types of light sources used commonly in building interiors combined with various color temperature have an effect on EEG activity. The effect of frequency pulsation and color temperature on brain activity in EEG examinations in the beta 2 band was assumed.
Material/participants: Twenty healthy men aged 19–25 years participated in the experiment.
Methods: The research stand was lit by: LED diodes with color temperatures of 3000 K, 4200 K, 6500 K, with the power supplied using the pulse width modulation (PWM) method with the current frequency of 122 Hz, linear fluorescent tubes (3000 K, 6500 K), with the power supplied with the frequency of 50 Hz and 52 kHz from the electromagnetic and electronic ballasts, and the conventional light bulb, with the power supplied directly from the mains electricity, used as a reference light. System Flex 30 apparatus with TrueScan software was used to record the EEG signal. The examination used two factors (speed and accuracy) of the Kraepelin's work curve to describe changes in work performance for various types of lighting.
Results: The results demonstrate that the use of different types of emission of light and color temperature of the light have an effect on bioelectrical brain activity and work performance.
Conclusions: The highest activity of brain waves concerns the beta band in the frequency range of 21–22 Hz, regardless of the type of the light source (LED, fluorescent tube). The methods used to supply power and color temperature of fluorescent tubes do not significantly affect bioelectrical brain activity during "work", but previous lighting with fluorescent tubes during work has an essential effect on bioelectrical brain activity during rest. Regardless of the color temperature, LED lighting with PWM power supply leads to the highest bioelectrical activity (mainly in the range of 21–22 Hz) in the brain during work and rest, which might suggests the usefulness of this method of supplying power for everyday work. Incandescent light does not affect the bioelectrical brain activity during work and rest.

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1. Introduction

The light is one of the most important factors influencing to the human activity. Its parameters affecting various areas of life, including: medicine, stimulation, physiology and many more. One of the most important parameters which determines the quality of light is its color temperature and pulsation. According to the scientific assumptions taken during the implementation of this research, there is a relationship between these two parameters and the level of bioelectric activity of the human brain affecting physical and emotional activity.

A problem that has not received the attention it deserves in contemporary research is the optimal lighting conditions for areas in which people are working, learning or otherwise engaged. Light has a biological effect as well as a visual effect on the human body. The non-image forming (NIF) effect of light is enabled by melanopsin, which is found in photosensitive retinal ganglion cells. Recent studies have found that the NIF system detects the variability of the light in the environment and produces changes in the circadian rhythm, hormone levels, heart activity, the ability to fall asleep, excitation level, and body temperature, and it is a strong modulator of brain activity during the performance of cognitive tasks [1–4].

Nowadays, there are a number of light sources available on the market. These sources produce visible light in many ways, e.g. through the generation of high temperature (incandescent lamps), as a result of electrical discharge (gas–discharge lamps) or through the recombination of electric charge carriers (LEDs). Due to significant differences in design, these light sources also differ in the properties of the light stream they produce. Depending on the frequency of the power supply, the pulsation of the light stream emitted varies significantly and may have different effects on our neurophysiological reactions [4,5].

The light emitted by fluorescent tubes may have a harmful effect on people working in their vicinity. The conventional (electromagnetic) method of supplying power to gas-discharge lamps leads to the occurrence of migraines, which may reach a frequency of several times a week, whereas after the installation of electronic ballasts, this number is reduced to an average of 1.3 times a week [6]. When choosing the light source, apart from paying attention to its basic functional parameters, such as luminous flux, stability or power supply type, one should also take into consideration the color temperature. The mood and efficiency of workers was demonstrated to have improved in an environment illuminated by light with a high color temperature (7000 K) compared to the incandescent 2900 K [7,8].

The biostimulatory effect of the visible spectrum has been used in clinical practice for the treatment of mood disorders, especially seasonal affective disorder [9,10] and sleeping disorders [11]. Attempts have also been made to use phototherapy for the treatment and prevention of depression and sleeping disorders in older adults who suffer from dementia complexes [12]. Blue light helps improve cognitive function in older people undergoing long-term treatment programs [13] for dementia. Finally, it was demonstrated that phototherapy involving the use of white light administered in 30-min morning sessions for women undergoing chemotherapy for breast cancer may prevent the occurrence of circadian rhythm disorders commonly induced by this treatment [14]. Thus establishing the principles of biologically optimal lighting conditions and how to implement them is a valid research aim.

The aim of this study is to answer to the question whether the power supply method has an effect on EEG activity combined with different color temperature and type of light source.

Numerous authors have emphasized the importance of alpha, beta and gamma bands due to their supposed functional importance [15–17].

The effect of frequency pulsation and color temperature on brain activity in EEG examinations in the beta 2 band was assumed in our preliminary research.

2. Materials and methods

2.1. Subjects

The study examined 20 healthy adults aged from 19 to 25 years, who were students from the University of Physical Education and were not paid for their participation in the examinations. The mean age was 20.4 years, and the standard deviation for the group was 1.53. Before the examinations, a recruitment procedure was used to select the people to participate in the study. The following exclusion criteria were used when selecting the study participants:

- Diseases of the central nervous system,
- Taking drugs or substances with sedative or stimulant effects on the central nervous system,
- Visual impairments and other vision problems,
- Incorrect results during photosensitivity examinations.

The participants were advised to sleep regularly and well and refrain from using substances that can have an effect on the central nervous system before the examinations (i.e. alcohol was prohibited for 2 days, and caffeine and nicotine for at least 4 h, prior to the examinations).

Conducted research is at an early stage where it is important to check general scientific assumptions. At this stage, the study was attended only by students who expressed their willingness to participate in the research and were positively qualified for them.

2.2. Methods

2.2.1. Light sources and power supply methods

In the tests were used 8 (eight) the most popular methods of light emission, were one of them is certainly used in room requiring illumination. Each of the light source and power supply device implementing one emission method and was purchased in a lighting shop. The luminaries, light sources and power supply devices used in tests have been accepted by certified laboratories to sale on the market.

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