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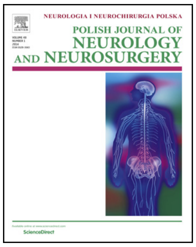

Original research article

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.

Table 1 – Symbols for the light sources used in the study.

Description	Light sources and the method used to supply power
K	Incandescent 60 W light bulb, with power supplied from the mains, at a frequency of 50 Hz, used as a reference.
ELC	3000 K fluorescent tubes with a power rating of 2 × 18 W, powered by a voltage at a frequency of 52 kHz from an electronic ballast.
KLC	3000 K fluorescent tubes with a power rating of 2 × 18 W, powered by a voltage at a frequency of 50 Hz from an electromagnetic ballast.
ELZ	6500 K fluorescent tubes with a power rating of 2 × 18 W, powered by a voltage at a frequency of 52 kHz from an electronic ballast.
KLZ	6500 K fluorescent tubes with a power rating of 2 × 18 W, powered by a voltage at a frequency of 50 Hz from an electromagnetic ballast.
LEDC	3000 K LEDs with a power rating of 115 W, powered by a rectangular PWM voltage at a frequency of $f = 122$ Hz and with a duty cycle $D = 32\%$, where the turn-on time is $t = 2.62$ ms.
LEDZ	6500 K LEDs with a power rating of 115 W, powered by a rectangular PWM voltage at a frequency of $f = 122$ Hz and with a duty cycle $D = 32\%$, where the turn-on time is $t = 2.62$ ms.
LEDCZ	LEDs with a power rating of 2 × 115 W and resultant color temperature of 4200 K, powered by a rectangular PWM voltage at a frequency of $f = 122$ Hz and with a duty cycle $D = 19\%$, where the turn-on time is $t = 1.55$ ms.

The study used LEDs, fluorescent tubes and an incandescent light bulb, with the power supplied respectively through dedicated power supply units, ballasts and directly from the mains. The paper [5] discusses other studies on light pulsation and plasma temperature in discharge lamps for different power supply methods [18]. Table 1 shows the symbols used for the light sources in this study.

2.2.2. *Methods of powering*

2.2.2.1. Methods of powering the incandescent light bulb. The reference light source used in the study was an incandescent light bulb (K) powered from the mains at a frequency of 50 Hz. Fig. 1 shows the instantaneous values of the luminous flux emitted by the light bulb. Despite being powered by a voltage at a frequency of 50 Hz, the light is of a continuous character and offers light emission similar to solar radiation. The results obtained for this light source were treated as a reference for other results.

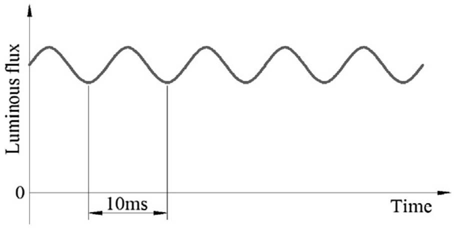

Fig. 1 – Luminous flux of an incandescent 2700 K light bulb powered by a voltage at a frequency of 50 Hz (K).

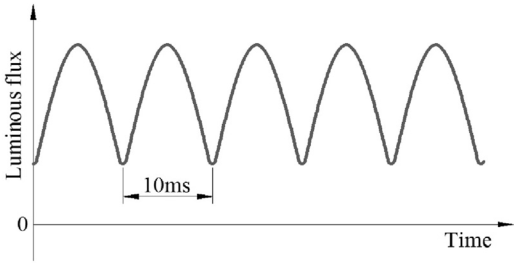

Fig. 2 – Luminous flux of a 3000 K fluorescent tube powered by a voltage at a frequency of 50 Hz (KLC).

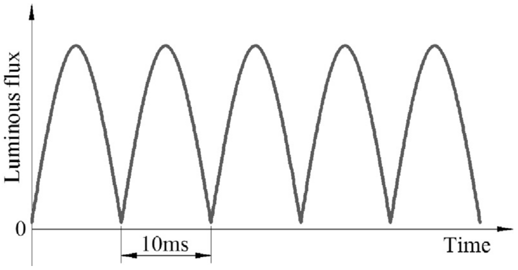

Fig. 3 – Luminous flux of a 6500 K fluorescent tube powered by a voltage at a frequency of 50 Hz (KLZ).

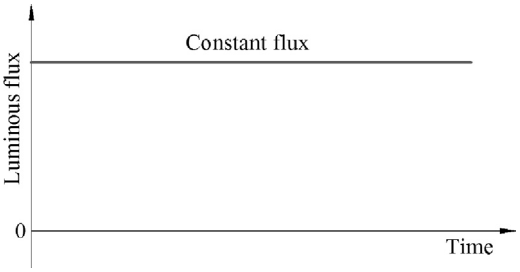

Fig. 4 – Luminous flux of a 3000 K, 6500 K fluorescent tubes powered by a voltage at a frequency of 52 kHz (ELC, ELZ).

2.2.2.2. Methods used for power supply power of linear fluorescent tubes. Figs. 2 and 3 illustrate the luminous flux for 3000 K and 6500 K fluorescent tubes powered from the mains at a frequency of 50 Hz using an electromagnetic ballast.

Fig. 4 shows the luminous flux for 3000 K and 6500 K fluorescent tubes, with power supplied from an electronic ballast with a full-bridge topology with voltage at a frequency of 52 kHz, with SiC diodes [19]. The luminous fluxes recorded by means of a fast photodetector reveal that the respective methods of light emission differ significantly.

When the fluorescent tubes were powered with a voltage at a frequency of 50 Hz, the light pulsed twice as fast (once for the positive and once for the negative half of the sinusoid of the supply voltage), i.e. at a frequency of 100 Hz. The value of the luminous flux changes from zero (which corresponds to

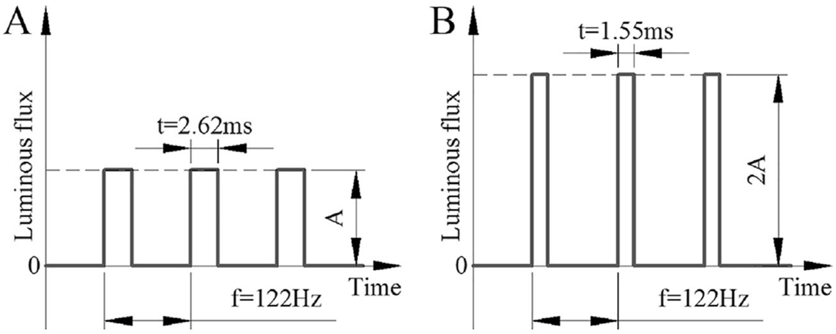

Fig. 5 – Luminous flux time waveform: (A) 3000 K (LEDC) and 6500 K (LEDZ). (B) 4200 K (LEDCZ).

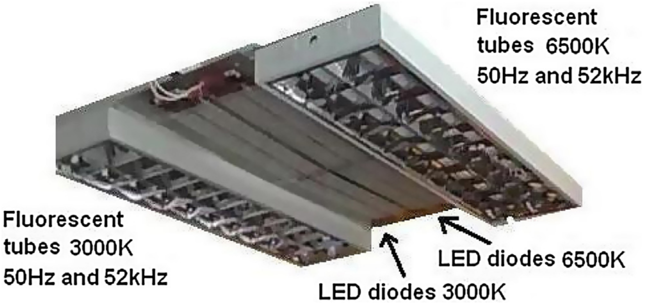

Fig. 6 – View of the lighting part of the station.

the transition of the sinusoid through zero) to the maximum value obtained every 10 ms (which corresponds to the amplitude of the supply voltage). Voltage at a frequency of 52 kHz causes the fluorescent tube to emit continuous luminous flux. Apart from differences in the radiation spectrum the radiation spectrum, this method of producing light is similar to solar light emission.

2.2.2.3. *Methods used for power supply of LEDs*. Fig. 5A shows time profiles for the luminous flux emitted by the warm and cold diodes. The electrical power needed to excite LED radiation emission was supplied by means of a dedicated power supply unit controlled by a pulse width modulation (PWM) algorithm. The method consists of the cyclical switching on and off of the light source with the voltage kept at a constant frequency and using an adjustable turn-on time. With this method, the diodes emit maximum luminous flux for a very short time.

The human eye reacts slowly enough not to perceive such fast changes in light intensity. The pupil of the eye adjusts to the light intensity's mean value, whereas the interior of the eye responds to the amplitude i.e. the maximum luminous flux emitted by the diodes. Changing the duty cycle allows for adjustments to be made to the light intensity's mean value.

Fig. 5B illustrates time profiles for the luminous flux emitted by warm and cool diodes simultaneously. In this case, twice as many diodes are needed to produce the light. Therefore, the flux amplitude "A" is also twice as high "2A". In order to maintain the same mean value of light intensity, the duty cycle was reduced for the voltage that powered the LEDs.

Fig. 7 – EEG registration during the test.

The stand developed for the needs of the researches included the described light sources, the working plane, and the EEG apparatus. Fig. 6 shows the view of the lighting part with the light sources installed. Fig. 7 shows the view of the test stand during testing.

2.2.3. *EEG*

The EEG examination was performed according to the standardized procedure. The signals from the cap were recorded using a *System Flex 30 Holter* (*Deymed*) EEG with *TruScan* software installed on a PC. The amplification of the measurement channels was 100 μV/10 mm, with measurement signal filtering. A low-pass filter at a frequency of 0.5 Hz and a high-pass filter at a frequency of 40 Hz were used to reduce the number of disturbances during recording [20].

These measurements consist of recording the voltage on the scalp using electrodes attached to an EEG cap which contained twenty electrodes arranged at the standard measurement points in the 10-20 system. The electrodes were filled with medical gel to reduce impedance between the electrodes and the skin. Before each examination, the cap and the electrodes were washed and disinfected. The skin on the head was degreased in order for electrode impedance to be maintained at a level of under 5 kOhm.

Bioelectrical activity of individual areas of the cerebral cortex consists of the generation of internal electrical signals with specific frequencies and amplitudes, which form the signal recorded by the EEG apparatus. The fast Fourier transform (FFT) is used to decompose this signal, allowing for the computation of the frequency and amplitude of each signal separately. An electroencephalogram for a healthy adult person at rest is composed of frequencies ranging from 0.5 Hz to 45 Hz, which are divided into five ranges and allotted consecutive letters of the Greek alphabet: DELTA, THETA, ALPHA, BETA, GAMMA

2.2.4. *Experimental procedure*

The examinations of bioelectrical brain activity were started after the completion of the recruitment procedure. Examinations were performed during two sessions with different light conditions. The light source has changed four times during a single session. The light intensity for the working surface for each light source was 500 lx (regardless of the light source). The order of examinations is shown in Table 2 (Table 1 shows the symbols used for the light sources in this study).

During each session, examinations were performed for four consecutive light sources; these sessions from here on termed "work", taking 10 min for each light source. During each 10-min exposure the participants performed the task (attention test). After completion of the "work", a "rest" period of 6 min was administered, when the study participants remained in darkness. Bioelectrical brain activity was also recorded during the "rest".

2.2.5. *Description of the task performed during the examinations*

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. The task consisted of the addition, as fast as possible, of the digits in the columns and writing the results in the next column.

2.2.6. *Analysis of the measurement results*

One 5-s disturbance-free section of the EEG signal was chosen for each participant and each type of lighting, and the sections were processed in the Matlab environment using the *bandpower* function. Signal samples for the measurement sessions defined as "work" were chosen at around the 8th minute of the measurement, whereas for the "rest" they were taken at around the 5.5 min mark.

Table 2 – Experimental procedure order of examinations in different lighting conditions.

Session I		Session II	
Dark	6 min, rest	Dark	6 min, rest
K	10 min, attention test	ELZ	10 min, attention test
Dark	6 min, rest	Dark	6 min, rest
ELC	10 min, attention test	KLZ	10 min, attention test
Dark	6 min, rest	Dark	6 min, rest
KLC	10 min, attention test	LEDZ	10 min, attention test
Dark	6 min, rest	Dark	6 min, rest
LEDC	10 min, attention test	LEDCZ	10 min, attention test
Dark	6 min, rest	Dark	6 min, rest

Analysis of the results consisted of averaging the recorded EEG signals from all the electrodes in the cap, and calculation of the mean power in band frequency range by applying a Hamming window and using a periodogram power spectral density estimate. In all computations standard discrete Fourier transform is used with the number of points equal to the length of analyzed sections. The values obtained were analyzed using a repeated measures ANOVA, whereas the Tukey–Kramer method was used for post hoc pairwise tests [21].

3. Results

Analysis of the results of the EEG measurements in the 0.5–40 Hz range revealed that changes in the activity of brain waves occur within the 20–30 Hz range, identified as the BETA band. Therefore, further analysis was confined to this frequency range.

3.1. *Fourier analysis of the EEG signal*

Fig. 8 shows the fast Fourier transform (FFT) for the power spectral densities of the EEG signal in the 20–30 Hz BETA range during "work" at the research stand when illuminated by the incandescent light bulb K followed by fluorescent tubes KLC, KLZ, ELC, ELZ.

Fig. 9 shows the fast Fourier transform (FFT) for the power spectral densities of the EEG signal in the 20–30 Hz BETA range during "rest" at the research stand when illuminated by the incandescent light bulb K followed by fluorescent tubes KLC, KLZ, ELC, ELZ.

Fig. 10 shows the fast Fourier transform (FFT) for the power spectral densities of the EEG signal in the 20–30 Hz BETA range during "work" at the research stand when illuminated by the incandescent light bulb K followed by diodes LEDC, LEDZ and LEDCZ.

Fig. 11 shows the fast Fourier transform (FFT) for the power spectral densities of the EEG signal in the 20–30 Hz BETA range during "rest" at the research stand when illuminated by the incandescent light bulb K followed by diodes LEDC, LEDZ and LEDCZ.

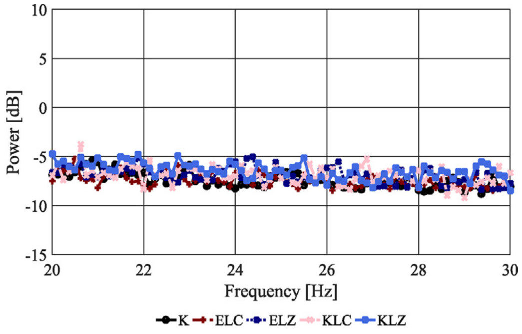

Fig. 8 – Diagrams of the periodogram power spectral density estimate (in decibels) during "work" for the incandescent light bulb and fluorescent tubes.

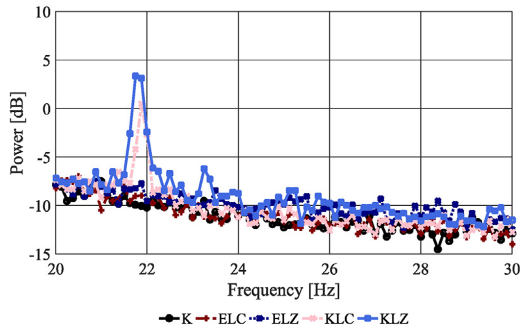

Fig. 9 – Diagrams of the periodogram power spectral density estimate (in decibels) during "rest" for the conventional light bulb and fluorescent tubes.

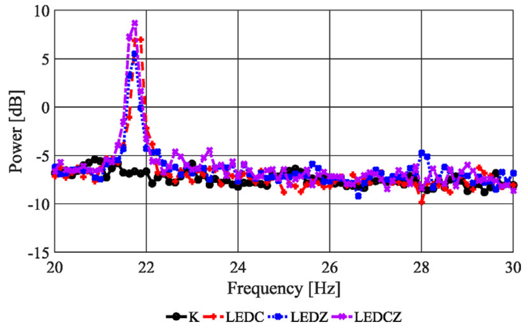

Fig. 10 – Diagrams of the periodogram power spectral density estimate (in decibels) during "work" for the incandescent light bulb and LEDs.

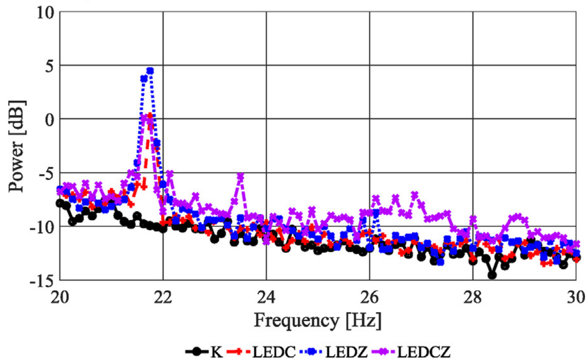

Fig. 11 – Diagrams of the periodogram power spectral density estimate (in decibels) during "rest" for the incandescent light bulb and LEDs.

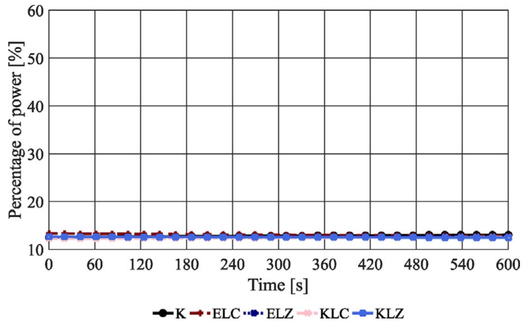

Fig. 12 – Linear regression of the ratio of the average power in the 21–22 Hz range to the average power over the whole 20–30 Hz BETA range for the incandescent light bulb and fluorescent lamps during "work".

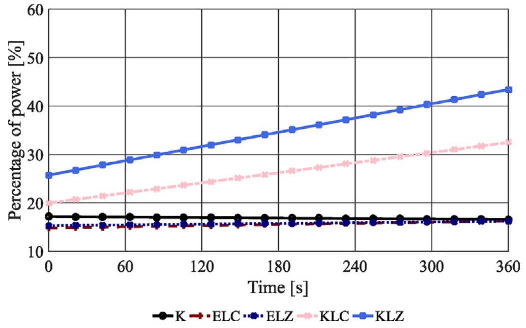

Fig. 13 – Linear regression of the ratio of the average power in the 21–22 Hz range to the average power over the whole 20–30 Hz BETA range for the incandescent light bulb and fluorescent lamps during "rest".

3.2. *Variability of EEG signal power during the examination*

N-depth analysis of the results of the fast Fourier transform in the 20–30 Hz BETA range showed that the highest variability of power spectral density for the EEG signal is observed for the range of frequencies from 21 to 22 Hz.

Fig. 12 illustrates the percentage relationships between the power spectral density of the EEG signal measured in the 20–30 Hz BETA range and the power spectral density of the signal measured in the 21–22 Hz range, during "work" at the research stand when illuminated by the incandescent light bulb K followed by fluorescent tubes KLC, KLZ, ELC, ELZ.

Fig. 13 illustrates the percentage relationships between the power spectral density of the EEG signal measured in the 20–30 Hz BETA range and the power spectral density of the signal measured in the 21–22 Hz range, during "rest" at the research stand when illuminated by the incandescent light bulb K followed by fluorescent tubes KLC, KLZ, ELC, ELZ.

Fig. 14 illustrates the percentage relationships between the power spectral density of the EEG signal measured in the 20–30 Hz BETA range and the power spectral density of the signal measured in the 21–22 Hz range, during "work" at the research stand when illuminated by the incandescent light bulb K followed by the LEDC, LEDZ, LEDCZ diodes.

Fig. 15 illustrates the percentage relationships between the power spectral density of the EEG signal measured in the 20–30 Hz BETA range and the power spectral density of the signal measured in the 21–22 Hz range, during "rest" at the research stand when illuminated by the incandescent light bulb K followed by the LEDC, LEDZ, LEDCZ diodes.

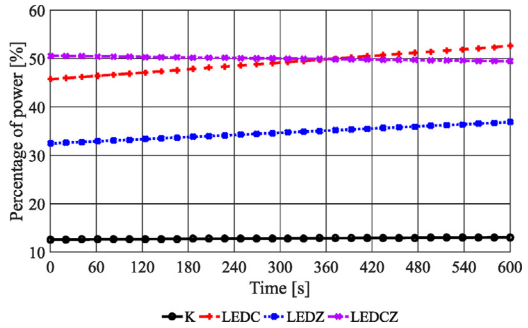

Fig. 14 – Linear regression of the ratio of the average power in the 21–22 Hz range to the average power over the whole 20–30 Hz BETA range for the incandescent light bulb and LED's during "work".

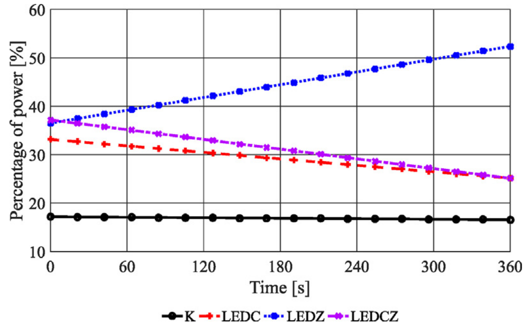

Fig. 15 – Linear regression of the ratio of the average power in the 21–22 Hz range to the average power over the whole 20–30 Hz BETA range for the incandescent light bulb and LED's during "rest".

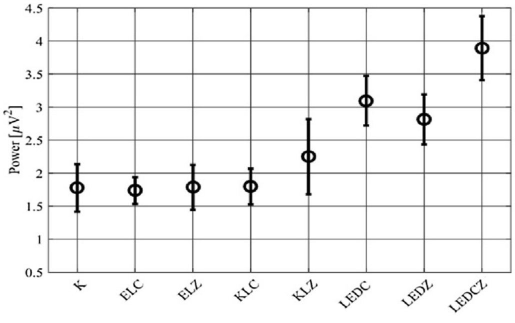

Fig. 16 – Diagrams of the power density of "work" measured for BETA band in frequency interval 20–30 Hz.

3.3. *Measurements of the EEG signal power*

Fig. 16 shows the values of the power spectral density for the EEG signal measured in the 20–30 Hz Beta range during "work" for each light source.

Fig. 17 illustrates the values of the power spectral density for the EEG signal during "rest" following "work" at the research stand when illuminated by the various light sources.

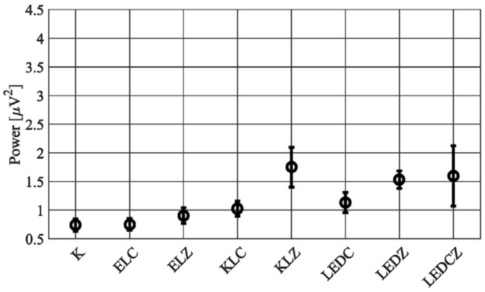

Fig. 17 – Diagrams of the power spectral density of the 20–30 Hz BETA band during "rest".

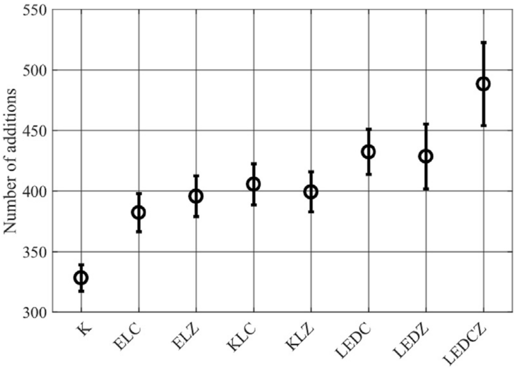

Fig. 18 – Number of performed additions for light sources used in researches.

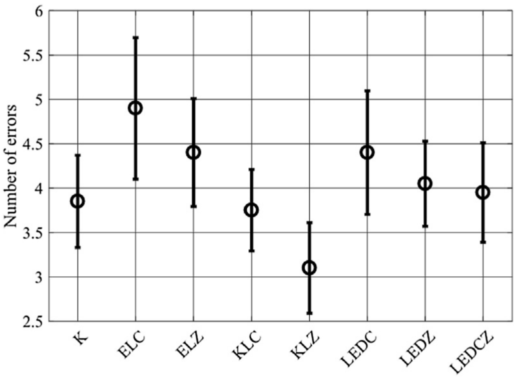

Fig. 19 – Number of errors during additions for light sources used in researches.

3.4. *Number of performed additions and number of errors*

Section 2.2.5 describes the test performed during the examinations. Various work speeds and numbers of errors are obtained by lighting the test stand with various sources of the artificial light.

Figs. 18 and 19 present the results for the number of addition operations performed in the test and the number of errors in the same time range the person has for performing the test.

4. Discussion

Rhythmical brain activities in the beta frequency range are considered as a cortex excitation indicator. Their location can concern the frontal, central and anterior regions of the brain. This activity may be involved in synchronization of different brain areas, but this problem has not been sufficiently explored to date [22].

The results of the study demonstrate that the use of different light emission types and different light color temperatures has an effect on bioelectrical brain activity.

The highest excitation values were found for LEDC, LEDZ, LEDCZ powered by a rectangular voltage with a constant frequency and duty cycle. Different results were obtained for the BETA and 21–22 Hz ranges. The value of the EEG signal during "work" (Fig. 10) ranged from −6 dB with the incandescent light bulb K to +9 dB with LEDCZ. Therefore, the difference in the signal levels was 15 dB, whereas during "rest" (Fig. 11), the difference in the EEG signal levels was 14 dB.

Assuming that a difference of 3 dB corresponds to a doubling in the supplied signal's power, the bioelectrical brain activity during "work" and "rest" changed by a factor of 5. The relationship between the color temperature of office lighting and its effect on the mood and efficiency of office workers is presented in the paper byMills et al. [7]. Our study is also consistent with a study that found a greater effect of color temperature of 7500 K (6500 K in our study) compared to color temperature 3000 K on the CNS activation [4].

No differences were found between the levels of the EEG signal power during "work" at the research stand when illuminated by the incandescent light bulb K and by the fluorescent tubes KLC, KLZ, ELC, ELZ (Fig. 8). However, differences were found for "rest" at the research stand when illuminated by fluorescent light bulbs KLZ, KLC (Fig. 9). In this case the differences in the EEG signal level compared to the incandescent light bulb K were 14 dB for KLZ and 11 dB for KLC.

As mentioned before, the highest variability of the spectral power density was obtained in the 21–22 Hz range. Thus one important challenge for this research was to determine the variability of this parameter measured during the experiment.

In addition to the effect on vision, light also plays significant non-visual functions. The mechanisms that lead to these positive light effects remain unclear but they are likely to be linked to a new photoreceptor, melanopsin [23]. Only an insignificant percent of information from human visual organ is received consciously. However, little is known about the attention and concentration connected with vision and participation of beta activities in this process [24].

Our initial report supports this cognitive process yet further research is needed.

The highest level of variability of power spectral density for the EEG signal during "work" was recorded for diodes LEDC, LEDZ, LEDCZ (Fig. 14). The values varied over a range of 32–36% for LEDZ, 46–52% for LEDC and 51–49% for LEDCZ. During "rest" (Fig. 15), the power spectral density declined over a range of 37–25% for LEDCZ and 32–25% for LEDC, whereas it rose over a range of 36–52% for LEDZ.

The smallest power spectral density values of the EEG signal were found for "work" for fluorescent tubes regardless of the color temperature and the method used to supply their power (Fig. 12). The results in this case are nearly identical with the results recorded for the incandescent light bulb K.

The variability of power spectral density during "rest" (Fig. 13) varied over a range of 26–43% for KLZ and 20–32% for KLC, whereas for ELC and ELZ, the results are nearly identical with those obtained for the incandescent light bulb K.

In conclusion, the results shown in Figs. 16 and 17 should also be emphasized. They show that the highest bioelectrical brain activity during "work" was recorded for diodes LEDC, LEDZ, LEDCZ powered with a PWM method, with a constant frequency and duty cycle, whereas the lowest activity was found for the fluorescent tubes, regardless of the powering method.

During the "rest" following "work" at the illuminated research stand, the highest power spectral density values were recorded for the fluorescent tube KLZ and the LEDC, LEDZ and LEDCZ diodes. The lowest power values were obtained with the incandescent light bulb K and ELC fluorescent tube.

Light was found to be a strong modulator of cognitive brain functions and improved work performance [25]. Work performance is assessed in particular by the measurement of speed and accuracy. Similar criteria were used to evaluate ability to work at the beginning of the 20th century. Kraepelin [26], who attempted to find the causes of individual differences in work performance, created "the work curve" and analyzed several positive (motivation) and negative (fatigue) factors which affected the activity. However, it is unclear how light affects speed of work connected with visual attention and whether it is directly related to improvements in solving behavioral tests [15]. The results presented in Figs. 18 and 19 show that the speed of work i.e. number of performed addition operations and the number of mistakes depend on the type of lighting.

The use of certain methods of artificial light emission leads to additional stimulation of bioelectrical brain activity and is one of the many factors that have an impact on human excitation [1,2]. The results of the present study may have many practical implications which should be taken into consideration during the choice of light source for a specific application.

Pulsating light may be employed in rooms for used in the daytime, such as offices [6] or care centers for older people [11] since this type of light stimulates additional bioelectrical activity. A similarly important role is played by the use of cool light (6500 K), which also has a stimulating effect [13]. Conversely, neither pulsating nor cool light are suitable for places designed for rest, where warm light, which emits a continuous luminous flux, should be used.

As demonstrated in the study, the power supply methods for these types of light source do not cause increased brain activity but rather is an important factor affecting the quality of sleep [3]. It is also one of the many factors that affect the human circadian rhythm [12,14], seasonal well-being [10] and mood [9].

5. Conclusion

- The study demonstrated that, regardless of the type of light source used (LED, fluorescent tubes), the highest brain wave activity is found between the 21 and 22 Hz frequencies in the BETA range.

- The methods used to power supply and the color temperature of fluorescent lights do not significantly affect bioelectrical brain activity during ''work'', although ''work'' with KLC and KLZ lighting has a noticeable effect on bioelectrical brain activity during the subsequent ''rest''.
- Regardless of the color temperature, LED lighting with a PWM power supply leads to the highest bioelectrical activity (mainly over the range of 21–22 Hz) in the brain during work and rest, which might suggest the usefulness of this method of supplying power for everyday work. (This conclusion still needs to be confirmed by further research).
- Incandescent light did not affect bioelectrical brain activity during work or rest.
- The highest speed was obtained for LEDCZ, whereas the smallest was found for the conventional K light bulb.
- The highest number of mistakes was obtained for ELC, whereas the smallest – for KLZ.

Conflict of interest

None declared.

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