Effects of classical and heavy metal music on the cardiovascular system and brain activity in healthy students. Preliminary report

Wpływ muzyki klasycznej i heavy metal na czynność układu krążenia i mózgu u zdrowych studentów. Doniesienie wstępne

Anna Kalinowska[1], Alina Kułakowska[2], Wojciech Kułak[1], Bożena Okurowska-Zawada[1]

[1] Department of Pediatric Rehabilitation and Center of Early Support for Handicapped Children "Give a Chance"
[2] Department of Neurology, Medical University of Białystok, Poland

STRESZCZENIE

Muzyka jest złożonym zjawiskiem wpływającym na psychikę, emocje i układ krążenia człowieka. Celem pracy było zbadanie potencjalnego wpływu muzyki klasycznej i heavy metalowej na układ krążenia i czynność mózgu u zdrowych studentów. EEG, tętno i ciśnienie krwi analizowano u 33 studentów. EEG mierzono podczas słuchania muzyki klasycznej (sonata Mozarta K. 448) oraz heavy metalowej (Iron Maiden). Tętno i ciśnienie krwi mierzono przed i po słuchaniu obu rodzajów muzyki. Muzyki słuchano przez słuchawki stereo. Czas trwania nagrania z muzyką klasyczną wynosił 8,19 minuty, a czas trwania nagrania z muzyką heavy metal 7,30 minuty. Nie stwierdzono istotnych różnic pomiędzy średnimi wartościami częstości czynności serca oraz ciśnienia tętniczego krwi przed i po słuchaniu obu rodzajów muzyki. Stwierdzono istotną różnicę wartości amplitud rytmu alfa przed i po wysłuchaniu muzyki klasycznej. Nie stwierdzono także istotnych różnic w widmie mocy (fal beta, alfa, theta i SMR) przed i po wysłuchaniu obu rodzajów muzyki. Niniejsze badanie wskazuje, że słuchanie muzyki klasycznej oraz heavy metalowej nie miało istotnego wpływu na czynność serca i ciśnienie krwi u zdrowych studentów. Wykazano natomiast obniżenie amplitudy rytmu alfa po wysłuchaniu muzyki klasycznej.

Słowa kluczowe: muzyka, ciśnienie krwi, częstość akcji serca, elektroencefalogram, studenci

ABSTRACT

Listening to music is a complex phenomenon, involving psychological, emotional, and cardiovascular changes in human. The objective was to examine the potential effects of classical music and heavy-metal music on the cardiovascular system and brain activity in healthy students. EEG, heart rate and blood pressure were recorded from 33 students. EEG was measured during listening to classical (Mozart's sonata K. 448) and heavy metal music (Iron Maiden). Heart rate and blood pressure were measured before and after listening both types of music. The musical stimuli were presented via stereo headphones. Duration of classical music was 8.19 minutes; duration of heavy metal music was 7.30 minutes. No significant differences between mean values of heart rate and blood pressure before and after listening to classical or heavy metal music were found. Significant difference in the amplitudes of alpha rhythm before and after listening to classical music was noted. No significant differences in the power spectra between measurements before, during, and after listening to classical and heavy metal music were found. This report suggests that listening to classical or heavy metal music has no significant effect on heart rate and blood pressure in healthy students. This study demonstrated significant decrease in the amplitude of alpha rhythm after listening to classical music.

Keywords: music, blood pressure, heart rate, electroencephalogram, students

Listening to music affects arousal (degree of physiological activation), mood, and listeners' enjoyment, which in turn influence performance on a variety of cognitive tasks. Music may help facilitate a relaxation response in part because of the integrated ways that it is processed by the brain and body [1]. Music can enhance cognitive functions, such as spatiotemporal reasoning, attention, and memory [2–4]. Listening to classical music provides a helpful mnemonic for verbal learning during early development and in educational settings [5]. College students who had spent 10 minutes listening to Mozart's Sonata (K. 448) had Stanford-Binet spatial subtest IQ scores 8–9 points higher than students who had listened to a relaxation tape or listened to nothing. The IQ effects did not persist beyond the 10–15 min testing session [6]. The "Mozart's effect" music has been extensively studied in recent years [6–9]. It was found that auditory background stimulation can affect visual brain activity. Students who solved a simple visual task while listening to Mozart's music displayed (mainly in the gamma band) more coherent brain activity, whereas a decoupling of brain areas in the gamma band was observed while respondents solved the nardisame task in silence [11]. However, a similar result has been shown to appear not only with the music of Mozart, but also that of Beethoven, and Sibelius [12–14]. It has been shown that cerebral blood flow was significantly lower when listening to 'Va pensiero' from Verdi's 'Nabucco' compared with 'Libiam nei lieti calici' from Verdi's 'La Traviata' or

Bach's Cantata No. 169 'Gott soll allein mein Herze haben' [11]. The greatest benefit to health is evident with classical music and meditation music, whereas heavy metal music or techno are not only ineffective but possibly dangerous and can lead to stress and/or life-threatening arrhythmias.

Little is known about the impact of heavy metal music on the cardiovascular system and brain activity [15]. Critics argue that heavy metal music has negative impacts on the health and well-being of people who listen to it, especially on young fans. Defenders counter that metal music is a form of entertainment similar to horror films and does not have harmful consequences [16].

We hypothesized that listening to classical music by healthy individuals reduces heart rate and blood pressure and positively affects brain activity (increase spectral power of the beta, alpha, and SMR bands, and decrease of the theta). In contrast, the listening to heavy metal music by healthy participants increases heart rate and blood pressure and negatively affects brain activity (decrease spectral power of the beta, alpha, and SMR bands, and increase of the theta).

Furthermore, to our knowledge, no comparative studies (the Mozart music and heavy metal music) were conducted in healthy students. This study examines the potential effects of classical and heavy metal music on the cardiovascular system and brain activity in healthy students.

MATERIALS AND METHODS

Participants

Thirty-three volunteer physiotherapy students (25 females, 8 males) with normal hearing and no history of heart disease, kidney disease, diabetes, neurological or psychiatric conditions took part in the experiments. All participants were drug-free, and all were non-smokers. All the individuals were in a good condition in terms of having enough sleep and food and were asked not to drink tea, coffee, or alcohol for 12 hours before the experiment. The mean age of the entire sample was 21.72 (S.D. = 0.839; range, 21–25 years). Structured interviews verified musical preferences. The study was approved by the Ethical Committee of the Medical University of Białystok. Informed consent was obtained from all participants.

Musical stimuli

On the first day, the students listened to classical music – Mozart's Sonata for two pianos Allegro Con Brio, part I KV. 448. On the second day, they listened to heavy metal music – "Fear of The Dark" by Iron Maiden.

The Sonata for Two Pianos in D major, K 375a, (K. 448) is a piano work composed in 1781 by Wolfgang Amadeus Mozart. It has a high degree of long-term periodicity, especially within the 10–60s range. The sonata is written in three movements. The first movement *Allegro con spirito* begins in D major, and sets the tonal center with a strong introduction. *Andante* is played, in a very relaxed pace. *Molto Allegro* begins with a galloping theme. There are different tempos (65–120 beat per minute-bpm).

"Fear of The Dark" is the ninth studio album by British heavy metal band Iron Maiden, released on 11 May 1992. There are different tempos (80–200 bpm, average 105.89)

The musical stimuli were presented via stereo headphones plugged into the notebook. Duration of classical music was 8.19 minutes and duration of heavy metal music was 7.30 minutes. The volume level of the music recordings was kept at approximately 60 dB throughout the study. Throughout the whole experiment the participants were lying down. During baseline and stimulus presentation, the participants were told to close their eyes and concentrate on the music. The experiments were conducted in complete silence, and there were no other sounds interfering with the experiment.

Physiological and EEG measurements

The silence duration was adjusted to 4 minutes. Silence was used as a reference to discover the changes in each participant. Before two minutes and after they listened to music two minutes, the students' non-invasive beat to beat blood pressure at the radial artery and heart rate were recorded by an OMRON wrist manometer worn on the right wrist.

EEG recordings were performed while the volunteers were in a resting state with eyes closed and lying down. EEG was recorded two minutes before listening to music, during listening, and two minutes afterwards. EEG signals were recorded via scalp electrodes (according to the International 10–20 systems), all correlated with the earlobes reference (A_1). We only recorded signals using a set of nine (C_3, C_4, C_z, P_z, P_z, T_3, T_4, A_1, A_2) scalp electrodes, and amplified and filtered by a Neurobit Optima (Poland). This apparatus has only nine channels. Electrode impedance was maintained below 5 kΩ. Due to technical limitations of the EEG apparatus for the statistical evaluation of the EEG phenomena, absolute power spectrum and amplitude values were calculated within four frequency bands: theta (4–7.99 Hz) at C4, alpha (8–12.99 Hz) at Pz, Sensory Motor Rhythm – SMR (12–15 Hz) at C3, and beta (13–28 Hz) at Cz. To maximize the detection of alpha activity the both central and occipital placements are recommended the central derivations. The temporal lobes are suggested to be the best regions of the EEG signals recordings of theta rhythm. Spectral power and amplitude values before, during and after listening to music were recorded. The EEG analysis was performed using version 1.4 of the program BioExplorer (CyberEvolution, USA). All EEG signals were continuously obtained on a personal computer.

Statistical analysis

We performed analysis of variance for repeated measures ANOVA with post hoc tests to calculate the statistical significance of differences of variables (heart rate, blood pressure, power spectra and amplitude value values) before and after listening to the music for all participants. Statistical significance was defined as $P < 0.05$. Statistics were obtained using the Statistica 7.1.

RESULTS

Most students reported listening to many types of music. More than half of students (51.5%) listened to classical music. Following classical music was pop – 32%; jazz – 18%; Hip-hop – 15%, soul – 14%, techno – 11%, and others – 10%.

Mean values of heart rate (beats/min) were 63.87 ± 9.74 before and 65.93 ± 9.04 after listening to classical music; and 69.09 ± 11.49 before and 70.12 ± 11.00 after listening to heavy metal music (table I). No significant differences between mean values of heart rate before and after listening to classical or heavy metal music were found.

No significant difference was noted in blood pressure before and after listening to classical music (mean 125.00 ± 12.47 mmHg) before; mean 125.09 ± 11.99 mmHg after. Similarly, no significant difference was found in systolic blood pressure before and after listening to heavy metal music (mean 123.6 ± 11.74 mmHg) before; mean 124.7 ± 13.81 mmHg after. No significant difference was noted in diastolic blood pressure before and after listening to classical music (mean 78.57 ± 8.44 mmHg) before; mean 77.57 ± 8.83 mmHg after. No significant difference was found in diastolic blood pressure before and after listening to heavy metal music (mean 77.42 ± 10.41 mmHg before; mean 77.06 ± 8.35 mmHg after.

The results of amplitude and power spectra analysis are presented in table II.

We only found a significant decrease in the amplitude of alpha rhythm after listening to classical music $F(2,62) = 4.1650$, $p = 0.020$. No significant differences in the amplitudes and power spectra between measurements before, during, and after listening to classical and heavy metal music were found (table III).

Table I. Heart rate and blood pressure before and after listening to classical or heavy metal music *Czynność serca i ciśnienie tętnicze przed i po wysłuchaniu muzyki klasycznej oraz muzyki heavy metalowej*

Variable *Zmienna*	**Silence** *Cisza* **Mean** *Średnia* **SD** *Odchylenie standardowe*	**After music** *Po muzyce* **Mean** *Średnia* **SD** *Odchylenie standardowe*	**Cohen's d value** *Wskaźnik Cohena* **Silence-After** *Cisza-Po*	**P value** *Wartość P*
		Classical music *Muzyka klasyczna*		
Heart rate (bpm) *Częstość serca (bpm)*	63.87 9.73	65.93 9.04	–0.21	0.618
Systolic BP (mmHg) *Ciśnienie skurczowe (mm Hg)*	124.27 10.70	124.48 10.94	–0.01	0.253
Diastolic BP (mmHg) *Ciśnienie rozkurczowe (mmHg)*	78.75 8.44	77.57 8.83	0.13	0.193
MAP (mm Hg) *Średnie ciśnienie tętnicze (mmHg)*	101.51 9.57	101.02 9.88	0.05	0.517
		Heavy metal *Muzyka heavy metal*		
Heart rate (bpm) *Częstość serca (bpm)*	69.06 11.49	70.12 11.00	–0.09	0.833
Systolic BP (mmHg) *Ciśnienie skurczowe (mm Hg)*	123.0 10.22	123.96 11.31	–0.08	0.994
Diastolic BP (mmHg) *Ciśnienie rozkurczowe (mmHg)*	77.42 10.41	77.06 8.35	0.03	0.865
MAP (mmHg) *Średnie ciśnienie tętnicze (mmHg)*	100.21 10.31	100.51 9.83	–0.02	0.968

Values are average (SD). The *P*-value was obtained by variance for repeated measures ANOVA. BP – blood pressure; MAP – mean arterial pressure. *Wartości przedstawione jako średnie (odchylenie standardowe). Wartość P uzyskano w analizie analizy wariancji wielokrotnych porównań. BP – ciśnienie tętnicze; MAP – średnie ciśnienie tętnicze.*

Table II. The mean amplitudes (uV) of bands in 33 students silence, during and after listening to classical or heavy metal music *Średnie wartości amplitud (uV) fal u 33 studentów przed, w trakcie i po wysłuchaniu muzyki klasycznej lub heavy metalowej*

Bands *Fale*	**Silence** *Cisza* **Mean SD**	**During** *W trakcie* **Mean** *Średnia* **SD** *Odchylenie standardowe*	**After** *Po* **Mean** *Średnia* **SD** *Odchylenie standardowe*	**Cohen's d value Wskaźnik Cohena Silence-After** *Cisza-Po*	**P value** *Wartość P*
		Classical music *Muzyka klasyczna*			
Beta	7.79 2.54	7.21 2.30	7.12 2.23	0.28	0.157
Alpha	12.75 5.68	11.50 5.46	11.47 5.93	0.22	0.020
Theta	6.70 3.11	6.00 2.99	5.80 3.04	0.29	0.351
SMR	5.79 2.45	5.50 2.12	5.53 2.15	0.11	0.229
		Heavy metal *Muzyka heavy metal*			
Beta	7.64 2.46	7.21 2.24	7.04 2.26	0.25	0.107
Alpha	12.63 5.77	11.66 5.43	11.53 5.57	0.19	0.283
Theta	10.76 3.07	10.67 2.95	10.35 3.01	0.13	0.429
SMR	5.49 2.13	5.43 2.02	5.30 2.01	0.09	0.266

Values are average (SD). The *P*-value was obtained by variance for repeated measures ANOVA. *Wartości przedstawione jako średnie (odchylenie standardowe). Wartość P uzyskano w analizie analizy wariancji wielokrotnych porównań.*

Table III. Total spectral power of the bands (beta, alpha, theta, SMR) in 33 students silence, during and after listening to classical or heavy metal music *Całkowita moc fal (beta, alfa, theta, SMR) u 33 studentów przed, w trakcie i wysłuchaniu muzyki klasycznej lub heavy metalowej*

Bands *Fale*	**Silence** *Cisza* **Mean SD**	**During** *W trakcie* **Mean** *Średnia* **SD** *Odchylenie standardowe*	**After** *Po* **Mean SD**	**Cohen's d value Wskaźnik Cohena Silence-After** *Cisza-Po*	**P value** *Wartość P*
		Classical music *Muzyka klasyczna*			
Beta	19.31 0.37	19.40 0.33	19.40 0.31	–0.26	0.606
Alpha	9.88 0.33	9.93 0.32	9.94 0.29	–0.19	0.980
Theta	5.73 0.12	5.69 0.09	5.70 0.10	0.27	0.429
SMR	13.30 0.09	13.30 0.10	13.28 0.09	0.22	0.417
		Heavy metal music *Muzyka heavy metal*			
Beta	19.29 0.40	19.36 0.34	19.43 0.32	–0.38	0.373
Alpha	9.86 0.35	9.92 0.33	9.91 0.32	–0.14	0.973
Theta	5.71 0.10	5.72 0.09	5.69 0.11	0.19	0.140
SMR	13.32 0.09	13.29 0.09	13.29 0.09	0.33	0.697

Values are average (SD). The *P*-value was obtained by variance for repeated measures ANOVA *Wartości przedstawione jako średnie (odchylenie standardowe). Wartość P uzyskano w analizie analizy wariancji wielokrotnych porównań.*

DISCUSSION

In the present study we found that neither the classical music of Mozart nor the heavy metal music of Iron Maiden had the significant effect on the cardiovascular system. We found the only significant decrease in the amplitude of alpha rhythm after listening to classical music. Our findings are not in accordance with previous reports [12, 15, 18, 19].

Actually, Fear of the Dark has a medium-slow tempo (75), which, according to previous studies, could be predicted to have little cardiovascular effects. Conversely, Mozart is much faster (120–125) though the general "atmosphere" of this music might suggest a slower tempo than the actual one. In any case, this faster tempo could have induced some blood pressure response, but this should have been measured during the music, whereas the lack of change after the music is not very surprising.

It is a widely held belief that music aids relaxation, and Fernell [19] evaluated the effects of music on anxiety in the perioperative period. Patients in the music group were given stereo headphones, a cassette player, and a choice of 22 types of music (including soft hits, classical guitar, chamber music, and folk music). Patients in the music group had lower heart rate and blood pressure levels than patients in the no-music group in the preoperative period, during surgery, and after surgery. Furthermore, patients in the music group reported lower levels of perceived stress and higher levels of ability to cope after surgery than the no-music group. On the other hand, our participants (students) were free of serious illness and did not wait for surgery.

A growing body of research has confirmed links between music and a variety of cognitive functions, including temporal order learning, spatiotemporal reasoning, attention, and auditory verbal memory [20].

Bernardi et al. [14] assessed changes in the cardiovascular and respiratory systems induced by music, specifically tempo, rhythm, melodic structure, pause, and individual preference. Passive listening to music accelerated breathing rate and increased blood pressure, heart rate (thus suggesting sympathetic activation), proportional to the tempo and perhaps to the complexity of the rhythm. The music style or a person's music preference seemed less important. These findings may partially explain lack negative effects of heavy metal music on the cardiovascular system in our study.

The efficacy of music therapy as a non-pharmacological intervention for the reduction of anxiety has been demonstrated in patients in the perioperative period [19]. Patients who listened to music (including soft hits, classical guitar, chamber music, and folk music) had lower heart rate and blood pressure levels than patients who did not listen to music. On the other hand, our participants (students) were free of serious illness and did not wait for surgery.

The effects of listening to different types of music on perceived and physiological indicators of relaxation were evaluated in 56 students by Burns et al. [15]. They were randomly assigned to listen to classical, hard rock, self-selected relaxing music, or no music. Participants' relaxation levels, skin temperature, muscle tension, and heart rate were evaluated before and after exposure to a music condition. Skin temperature was decreased for all conditions, and the classical, self-selected relaxing music and no-music groups reported significant increases in feelings of relaxation. Furthermore, no differences were found between the different types of music on physiological indicators of arousal, which is in accordance with our findings.

Music's effects on the brain's electrophysiology have also been reported in a number of studies [10, 21]. White noise and violoncello music induced decreases in the amplitude of all wave components, compared with silence. Jaušovec and Habe [10] described the differences in brain activity provoked by increased cognitive workload caused by listening to Mozart's Sonata K. 448. In the present study, we found a decrease of amplitude in the alpha rhythm in students listened to classical music.

The role of the gamma band in cognitive processing is a matter of intense interest within the conceptual framework of temporal coding theory and the binding hypothesis [22]. Increases in gamma coherence while listening to music have been reported by Bhattacharya et al. [11]. In our study, we did not evaluate gamma rhythm (range 25–100 Hz).

Listening to the Mozart sonata was also accompanied by increased power of the beta spectrum of the EEG in the right temporal, left temporal and right frontal regions [4]. However, in the present study, we did not find the above-mentioned differences.

The other features of the "Mozart Effect" include increased EEG coherence, changes in the amplitude of the alpha rhythm, and changes in epileptiform patterns [22]. It is suggested that music with a high degree of long-term periodicity, whether of Mozart or other composers, would resonate within the brain to decrease seizure activity and to enhance spatial-temporal performance.

The architecture of Mozart's music is brilliantly complex but also highly organized. The superorganization of the cerebral cortex would seem to resonate with the superior architecture of Mozart's music, normalizing any suboptimal functioning of the cortex [15]. Unlike Mozart's classical music, Iron Maiden's heavy metal radicalized blues and rock 'n roll by incorporating distortion, hard beats, and explosive sounds into music and dark images into lyrics. Furthermore, we also did not find that heavy metal music affected physiological parameters and EEG measurements.

Faster music is perceived to be more complex and takes up more attention that should be focused on the relevant task. Generally, most suitable background music falls in the range of 60 and 120 bpm, with a favored range of between 70–110 bpm.

A few limitations and issues in this study should be highlighted. First, our students sample has a small number of participants. Second, there is no the control group. Third, we used only several derivations in EEG.

CONCLUSIONS

This report suggests that listening to classical or heavy metal music has no significant effect on the heart rate and blood pressure. This study demonstrated significant decrease in the amplitude of alpha rhythm after listening to classical music.

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Adres do korespondencji:
Wojciech Kułak, Klinika Rehabilitacji Dziecięcej z Ośrodkiem Wczesnej Pomocy Dzieciom Upośledzonym „Dać Szansę, ul. Waszyngtona 17, 15–274 Białystok, Poland, tel. +48 85 7450601, e-mail: kneur2@wp.pl