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Original article

Effects of auditory stimulation with music of different intensities on heart period

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ABSTRACT

Various studies have indicated that music therapy with relaxant music improves cardiac function of patients treated with cardiotoxic medication and heavy-metal music acutely reduces heart rate variability (HRV). There is also evidence that white noise auditory stimulation above 50 dB causes cardiac autonomic responses. In this study, we aimed to evaluate the acute effects of musical auditory stimulation with different intensities on cardiac autonomic regulation. This study was performed on 24 healthy women between 18 and 25 years of age. We analyzed HRV in the time [standard deviation of normal-to-normal RR intervals (SDNN), percentage of adjacent RR intervals with a difference of duration >50 ms (pNN50), and root-mean square of differences between adjacent normal RR intervals in a time interval (RMSSD)] and frequency [low frequency (LF), high frequency (HF), and LF/HF ratio] domains. HRV was recorded at rest for 10 minutes. Subsequently, the volunteers were exposed to baroque or heavy-metal music for 5 minutes through an earphone. The volunteers were exposed to three equivalent sound levels (60–70, 70–80, and 80–90 dB). After the first baroque or heavy-metal music, they remained at rest for 5 minutes and then they were exposed to the other music. The sequence of songs was randomized for each individual. Heavy-metal musical auditory stimulation at 80–90 dB reduced the SDNN index compared with control (44.39 ± 14.40 ms vs. 34.88 ± 8.69 ms), and stimulation at 60–70 dB decreased the LF (ms^2) index compared with control (668.83 ± 648.74 ms^2 vs. 392.5 ± 179.94 ms^2). Baroque music at 60–70 dB reduced the LF (ms^2) index (587.75 ± 318.44 ms^2 vs. 376.21 ± 178.85 ms^2). In conclusion, heavy-metal and baroque musical auditory stimulation at lower intensities acutely reduced global modulation of the heart and only heavy-metal music reduced HRV at higher intensities.

1. Introduction

Auditory stimulation with music as a therapy has received attention for treatment and prevention of disorders.[1] Studies on music therapy were performed on patients under pharmacological treatment, immediately after surgery or awaiting surgical procedures.[2] Musical auditory stimulation produces an extensive variety of psychological and hemodynamic effects by influencing the cardiac autonomic modulation.[3,4]

In this regard, heart rate variability (HRV) is a method that analyzes the oscillations of the intervals between consecutive heartbeats (RR intervals). HRV is well accepted in the literature to investigate cardiac autonomic regulation, which is influenced by the sinus node.[5] Reduction in HRV is an indicator of poor cardiovascular function, such as in the case of chronic heart failure, whereas the increase in HRV corresponds to an improvement of cardiovascular function.[6]

Patients with cancer treated with anthracycline, a cardiotoxic medication, had improvements in HRV after music therapy intervention for 10 weeks. However, after the treatment cessation, their HRV levels returned to control values reported before the music therapy intervention, indicating the positive effects of music

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therapy on HRV in that population.[3] Another study suggested that music therapy increased parasympathetic activity and reduced the probability of congestive heart failure development in elderly patients with dementia and cerebrovascular disease.[7]

Although it was already evidenced that acoustic stimulation with white noise above 50 dB caused cardiac sympathetic changes,[8] it is not well understood whether the effects of musical auditory stimulation on HRV are dependent on equivalent sound level. Moreover, knowledge on cardiac autonomic responses elicited by music exposure is important for developing future therapies that might contribute to the prevention of cardiovascular disorders. Therefore, in this study, we evaluated the acute effects of baroque and heavy-metal musical auditory stimulation at different intensities on cardiac autonomic regulation.

2. Methods

2.1. Study population

Volunteers were 28 healthy female college students (all nonsmokers; age, 18–25 years). All volunteers were informed about the procedures and objectives of the study and gave written informed consent. All study procedures were approved by the Ethics Committee in Research of the Faculty of Sciences of the Universidade Estadual Paulista, Campus de Marilia (No. Protocol: 2011-385), and were in accordance with Resolution 196/96 National Health 10/10/1996.

2.2. Noninclusion criteria

Volunteers were excluded if they had cardiopulmonary, auditory, psychological, and neurological disorders, and other impairments that would prevent them from performing the study procedures. We also excluded those undergoing treatment with drugs that influence cardiac autonomic regulation.

2.3. Initial evaluation

Baseline criteria for initial evaluation were age, sex, weight, height, and body mass index (BMI). Weight was determined using a digital scale (W 200/5; Welmy Ind Com Ltda, São Paulo, Brazil) with a precision of 0.1 kg. Height was determined using a stadiometer (ES 2020; Sanny, São Paulo, Brazil) with a precision of 0.1 cm and extension of 2.20 m. BMI was calculated as weight/height,[2] with weight in kilograms and height in meters.

2.4. Measurement of the auditory stimulation

Measurements of the equivalent sound levels were conducted in a soundproof room using an SV 102 audio dosimeter (Svantek, Warsaw, Poland). This device was programmed to take measurements in the "A" weighting circuit with a slow response.

Measurements were taken when participants relaxed for 10 minutes by listening to classical baroque music. An insert-type microphone (microphone in real ear) was placed inside the auditory canal of the volunteer, just below the speaker, which was connected to a personal stereo.

Before each measurement, the microphone was calibrated with an acoustic CR:514 model calibrator (Cirrus Research).

For the analysis, we used Leq (A), which is defined as the equivalent sound pressure level and which corresponds to the constant sound level in the same time interval. It contains the same total energy as the sound. We also analyzed the frequency spectrum of the sound stimulation (octave band).[9]

2.5. HRV analysis

The RR intervals recorded by the portable RS800CX HR monitor (sampling rate, 1000 Hz) were downloaded to the Polar Precision Performance program (version 3.0; Polar Electro, Kempele, Finland). This software enabled the visualization of HR and the extraction of a cardiac period (RR interval) file in ".txt" format. Following digital filtering complemented with manual filtering for the elimination of premature ectopic beats and artifacts, at least 256 RR intervals were used for the data analysis. Only those series with more than 95% sinus rhythm were included in the study.[5] For calculation of the linear indices, we used the HRV analysis software (Kubios HRV version 1.1 for Windows; Biomedical Signal Analysis Group, Department of Applied Physics, University of Kuopio, Kuopio, Finland).

2.6. Linear indices of HRV

To analyze HRV in the frequency domain, the low frequency (LF = 0.04–0.15 Hz) and high frequency (HF = 0.15–0.40 Hz) spectral components were measured in m/s and normalized units, representing a value relative to each spectral component in relation to the total power minus the very-low-frequency components, and the ratio between these components (LF/HF). The spectral analysis was performed using the fast Fourier transform algorithm.[10]

The time domain analysis was performed in terms of standard deviation of normal-to-normal RR intervals (SDNN), percentage of adjacent RR intervals with a difference of duration > 50 ms (pNN50), and root-mean square of differences between adjacent normal RR intervals in a time interval (RMSSD).

We used Kubios HRV version 2.0 software to analyze these indices.[11]

2.7. Protocol

Data collection was carried out in the same soundproof room for all volunteers with the temperature between 21°C and 25°C and relative humidity between 50% and 60%. All volunteers were instructed not to drink alcohol and caffeine for 24 hours before evaluation. Data were collected on an individual basis, between 8 and 12 AM to standardize the protocol. All procedures necessary for data collection were explained to every volunteer individually. The volunteers were instructed to remain at rest and avoid talking during the data collection.

After the initial evaluation, the heart monitor belt was placed over the thorax, aligned with the distal third of the sternum, and the Polar RS800CX HR receiver (Polar Electro) was placed on the wrist. The volunteers (eyes opened) wore headphones and avoided tapping with a finger or a foot (to avoid art factual entrainment), which was confirmed by continuous visual monitoring.

The women variables were compared between the following: (1) rest control; (2) music at 60–70 dB; (3) music at 70–80 dB; and (4) music at 80–90 dB. The musical auditory stimulation was performed using an excitatory heavy metal (Gamma Ray: "Heavy Metal Universe") and a relaxant baroque (Pachelbel: "Canon" in D Major; an example of the first nine measures in shown in Fig. 1). The sequence of intensity of songs was randomized for each individual.

2.8. Statistical analysis

Standard statistical methods were used to calculate the means and standard deviations. The normal Gaussian distribution of the data was verified by the Shapiro–Wilk goodness-of-fit test ($z > 1.0$). For parametric distributions, we applied analysis of variance for repeated measures followed by the Bonferroni post-test. For