

## Heart Rate Variability and Acute Musical Auditory Stimulation

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### INTRODUCTION

Music has been used as therapy in diseases and disorders such as depression, schizophrenia, Alzheimer's disease, autism, attention deficit, hyperactivity, eating disorders, for musician therapists or not, in order to analyze and discuss neurophysiological effects and cardiovascular parameters elicited by this stimulation<sup>[1,2]</sup>.

Changes in heart rate, respiratory rate<sup>[3,4]</sup> and blood pressure<sup>[5]</sup> are observed in response to music therapy, possibly influenced by the autonomic nervous system due to changes in the sympathetic and parasympathetic components<sup>[6]</sup>.

Autonomic nervous system behavior can be assessed through heart rate variability (HRV), a simple and noninvasive method that describes fluctuations in intervals between consecutive heart beats (RR intervals) and can be analyzed by linear methods, time and frequency domain and nonlinear methods<sup>[7]</sup>.

HRV is a strong predictor of cardiovascular mortality, it is modulated through the sympathetic and parasympathetic (vagal) components of the autonomic nervous system. Vagal stimulation decreases heart rate whereas sympathetic stimulation increases heart rate<sup>[8,9]</sup>. Autonomic imbalance, i.e., lower parasympathetic activity, is associated with increased morbidity, greater predisposition to arrhythmias and heart failure<sup>[9,10]</sup>.

Previous studies used music as an alternative therapy through analysis of cardiovascular and psychological parameters<sup>[11-13]</sup>. The exploitation of studies correlating the autonomic nervous system and the music is important for the development of complementary and alternative therapies for protocols involving autonomic disturbances. Thus, in this review we described studies related to the effects of musical auditory stimulation on heart rate variability.

### ABSTRACT

**AIM:** It was observed that auditory stimulation with music influences the cardiovascular system. In this study, we described the relationship between musical auditory stimulation and heart rate variability (HR).

**METHOD:** Searches were performed with the Medline, SciELO, Lilacs and Cochrane databases using the following keywords: "Music," "autonomic nervous system", "sympathetic nervous system", "parasympathetic nervous system", "heart rate" and "ECG".

**RESULTS:** Some studies showed that relaxant music acutely increase HRV through spectral analysis, while others reported that exciting music reduces global HRV.",

**CONCLUSION:** Music present acute responses that may be different depending on the style.

**Key words:** Autonomic nervous system; Cardiovascular physiology; Hearing

### METHODS

Articles used in this study were obtained through research in databases Medical Literature Analysis and Retrieval Online System (Medline/PubMed) and Virtual Health Library (Bireme) containing

the electronic databases of the Scientific Library Online (SciELO), Latin Literature -American and Caribbean Health Sciences (Lilacs), The Cochrane Library (Cochrane). We considered articles published from January 2005 to January 2015.

The keywords that have been used were: "music", "autonomic nervous system", "sympathetic nervous system", "parasympathetic nervous system", "heart rate" and "ECG". The terms in Portuguese were defined based on the Descriptors in Health Sciences (DeCS) and their counterparts in the English language, the Medical Subject Headings (MeSH). The term "heart rate variability" was used for the search, however, we did not consider it as a descriptor.

With the keywords the following crosses were made: "Music and autonomic nervous system", "music and sympathetic nervous system", "music and parasympathetic nervous system", "music and heart rate", "music and heart rate variability" and "music and electrocardiogram".

The inclusion criteria considered articles published from January 2005 to January 2015 in Portuguese, English and Spanish, and covered all types of study design that analyzed the influence of music on the autonomic nervous system evaluated through HRV in otherwise healthy people. We deleted dissertations, theses, reviews, editorials, conference papers and studies that used interventions combined with the musical auditory stimulus.

We firstly excluded repeated titles. The titles and abstracts selected addressed as main idea the influence of music on the autonomic nervous system through HRV and the changes that the music performed in sympathetic and parasympathetic components of the autonomic nervous system, excluding articles that did not cover the subject proposed or were part of the exclusion criteria.

After this exclusion, the texts were read in full and analyzed if they really met the inclusion criteria. The remaining articles had their data divided according to the characteristics of authors and year of publication, objectives, HRV indices analyzed and conclusions.

## RESULTS

In the search strategy and electronic selection we located 826 titles. Among the articles we eliminated 480 repeated titles. After reading the remaining 347 articles we excluded 338 articles that met the exclusion criteria based on their titles and abstracts. At the end of seven articles they had their texts read full, excluding one article that did not present intervention, totaling 6 final articles.

Table 1 shows the 6 final articles resulting from the search and selection, describing the studies on the musical auditory stimulation on HRV, according to authors/year, population, analyzed variability indices and conclusions.

Iwanaga *et al.*<sup>[11]</sup> analyzed the effects of repeated exposure to music on HRV in 13 healthy subjects between 19 and 27 years. Each participant was subjected to three conditions: sedative music, and a music excitatory condition without music on different days, and the procedure consisted in the adaptation period, then no music or music sessions for 300 seconds for 2 times. Electrodes were attached to the chest of each individual to measure heart rate and LF indices, HF and LF/HF ratio were analyzed. Based on the results of HRV, there was difference between both types of music and no change observed in the LF component and the LF/HF ratio, whereas the two types of music differ in their effects on the HF component. These results indicate that HRV is a critical index for evaluating the effects of music on cardiac autonomic regulation.

Bernardi *et al.*<sup>[12]</sup> investigated responses to six kinds of music (with

different rhythmic structures, harmonic and melodic) in 24 healthy individuals (musicians versus non-musicians). After five minutes of baseline they applied the six styles of music in random order (first 2 minutes after in 4 minutes with a 2 minutes pause between them). HR was analyzed through ECG and the fastest time induced a progressive increase of the LH/HF ratio. Music induces an irritant effect, which was predominantly related to the pace. The slow or meditative music induced a relaxing effect, and this effect is particularly evident during a break. The music can generate concentration during the first faster rhythms then induce relaxation during pauses or slower rates, especially in musicians.

Orini *Et al.*<sup>[13]</sup> presented a method to characterize the effects induced by music on the dynamic modulation of heart rate. The study was composed of three steps: (1) the distribution analyzed "pseudo - Wigner Ville" which is performed to obtain a time-frequency representation of HRV; (2) A parametric decomposition used to robustly estimate the time course of spectral parameters; and (3) statistical analysis of the population to assess whether different dynamic stimuli elicit different responses. 75 healthy subjects were exposed to "nice" music, the Shepard sequences with the same time as the pleasant music has been applied and the songs considered "unpleasant" overlapped with the same sequences of Shepard tones. The results showed that the modification of HRV parameters are characterized by a rapid onset of transient phase (15-20 s), followed by an almost stationary phase. All types of stimuli caused significant changes in comparison with the rest condition, whereas during "pleasant" music heart and respiratory rate was higher (for more than 80% of the duration of the stimuli,  $p < 0.05$ ), and the power of the HF modulation was low (for more than 70% of the duration of the stimuli,  $p < 0.05$ ) compared with the unpleasant auditory stimulation.

Roque *et al.*<sup>[14]</sup> evaluated the acute effects of baroque and heavy metal music on HRV in women. Healthy female students ( $n = 21$ , age:  $25.2 \pm 3$  years) were exposed to auditory stimulation for 5 minutes for each style (baroque music and heavy metal). As inclusion criteria the volunteers could not present: cardiopulmonary, auditory, neurological and psychological changes; use medications that influence cardiac autonomic regulation; smoking and drinking. The authors found that the low frequency (LF) component ( $\text{ms}^2$ ) was significantly reduced during heavy metal music in comparison with the control condition. On the other hand, no significant changes with regard to LF in normalized units (NU). Therefore, auditory stimulation with Baroque music did not influence the HRV in short term exposure; however, the acute exposure to heavy metal music affected the sympathetic modulation in healthy women.

Roque *et al.*<sup>[15]</sup> evaluated the acute effects of different styles of music (baroque relaxing music versus heavy metal) in the geometric indices of the HRV. 21 healthy women aged 18-35 years old were divided into two groups: Group 1 ( $n = 21$ ) who were exposed to heavy metal and classical baroque music; and Group 2 ( $n = 19$ ) which were exposed to both styles of music and to white noise. Using headphones, the volunteers were exposed to every kind of music for five minutes (70-80 dB), and the interval between each exposure was 5 minutes. The triangular index and the standard deviation of the long-term indices of RR intervals reduced during exposure to both musical styles of the first group and tended to decrease in the second group, while the white noise decreased the high-frequency index. No change in the triangular interpolation, standard deviation of the instantaneous variability beat to beat and standard deviation in the RR interval ratio was observed. The authors suggested that Baroque and heavy metal music slightly decreases HRV due to the equivalent sound level.

Perez-Lloret *et al*<sup>[16]</sup> evaluated the effects on heart rate variability of exposure to different styles of relaxing music. 25 healthy subjects were exposed to silence or to different types of music as “new age” or romantic melodies in a random fashion. At the end of the study, the subjects were asked to select the melody that they would use to relax. The LH/HF ratio was significantly higher when the subjects were exposed to “new age” music when compared to the silence ( $3.4 \pm 0.3$  vs  $2.6 \pm 0.3$ , respectively,  $p < 0.02$ ), while no differences were found with romantic “classic” or melodies” songs ( $2.1 \pm 0.4$  and  $2.2 \pm 0.3$ ). These results were correlated with a reduction of the high frequency (HF) band to the music ‘new age’ as compared to the silence ( $17.4 \pm 1.9$  vs  $23.1 \pm 1.1$ , respectively;  $p < 0.004$ ). The authors found that the preferences of the participants by the type of music do not correlate with autonomic responses. The results suggested that “new age” music induced a change in HRV regardless of musical preference.

## DISCUSSION

In general, analyzes of selected texts have shown controversial results. Some of the articles have shown that classical, baroque or slow pace music, increased relaxation, while heavy metal music with fast pace increased the excitement. Other products decreased HF with nice music, especially regarding the silence and decreased global HRV, due to the same noise presented by the music.

Iwanaga *et al*<sup>[11]</sup> and Bernardi *et al*<sup>[12]</sup> showed results that corroborate each other. The authors suggested that the slow pace and sedative music present relaxing effects on individuals, activating the parasympathetic component, but have the same effect with respect to

any music. On the other hand, Roque *et al*<sup>[14]</sup> did not find influences of Baroque music on HRV in short period of exposure. However, acute exposure to heavy metal music affected the cardiac sympathetic regulation as well as the study of Iwanaga *et al*<sup>[11]</sup> and Bernardi *et al*<sup>[12]</sup>.

Orini *et al*<sup>[13]</sup> found in their study that all styles of auditory stimulation modified the HRV parameters compared to the rest condition, while during the “nice” song the power of HF band was lower compared with the unpleasant auditory stimuli. Supporting the study of Orini *et al*<sup>[13]</sup> and Perez-Lloret *et al*<sup>[16]</sup> the LH/HF ration was significantly higher when the subjects were exposed to relaxing music, along with a reduction of HF component compared to the silence.

In the study of Roque *et al*<sup>[15]</sup>, women were exposed to Baroque and relaxing music, as a result authors suggested that Baroque music and heavy metal slightly decreased HRV due to the noise levels equivalent. In another study, Amaral *et al*<sup>[17]</sup> used different intensities of the same musical styles of Roque *et al*, but found no significant differences in HRV.

An important point to be addressed is that no study showed that music repaired possible damage in the brain or in the heart.

In summary, it was shown that musical auditory stimulation induce controversial changes in autonomic modulation characterized by both increases, decreases of the indexes presented in relation to different musical styles and patterns. Others showed no difference in HRV. Finally, further studies needed it to become possible to use the musical auditory stimulation as a complementary therapy and alternative.

**Table 1** Description of the studies on the musical auditory stimulation in the autonomic nervous system, according to authors year goals, population indices analyzed and conclusions.

Author and year	Objective	HRV indices	Conclusion
Iwanaga <i>et al</i> 2005[11]	To analyze the effects of repeated exposure to music on HRV.	LF HF LF/HF	The high frequency component of HRV during sedative music was higher than during excitatory music. These results suggest that the music decreased excitatory activation of the parasympathetic nervous system.
Bernardi <i>et al</i> 2006[12]	To investigate the reponses to six kinds of music (with different rhythms, harmony, melody and structure) in musicians versus non-musicians.	LF HF LF/HF	Music induces an irritant effect, predominantly related to the rhythm. Slow music or meditation can induce a relaxing effect; relaxation is particularly evident during a break. Music, especially in trained subjects can focus attention during the first faster rhythms then induce relaxation during pauses or slower rhythms.
Orini <i>et al</i> 2010[13]	To present a method to characterize the effects induced by music on the dynamics of HR and HRV.	HF, LF, LF/HF	All stimuli caused significant changes in comparison with the rest condition, whereas during listening to pleasant music heart rate and respiratory rate were higher and HF was lower. Baroque music did not influence HRV in short period of exposure. However, acute exposure to heavy metal affected the sympathetic component in healthy women. It was suggested that this style of music presents more significant acute effects compared to relaxing baroque music.
Roque <i>et al</i> 2013[14]	To assess the acute effects of Baroque and heavy metal music in HRV in women.	HF, LF, LF/HF	
Roque <i>et al</i> 2013[15]	To assess the acute effects of baroque style and heavy metal on the geometric indexes of HRV in women.	RRTri TINN SD1 SD2 SD1/SD2 SDNN (ms) RMSSD (ms) pNN50 (%) LF (ms <sup>2</sup> ) LF (nu) HF (ms <sup>2</sup> ) HF (nu) LF/HF	Baroque (relaxing) and heavy metal (excitatory) slightly decrease the variability of the global heart rate due to the equivalent noise level.
Pérez-Llore <i>et al</i> 2014[16]	To evaluate the effects on HRV (HRV) of exposure to different styles of “relaxing” music.	SDNN, VLF, LF, HF, LF/HF	The results suggested that “new age” music induced a change in HRV from high to low frequencies, regardless of musical preference or listener. The “new era” style reduced HF compared with silence.

## CONFLICT OF INTERESTS

There are no conflicts of interest with regard to the present study.

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