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Original Article

The effect of traditional Persian music on the cardiac functioning of young Iranian women

Behzad Abedi[b], Ataollah Abbasi[a,*], Atefeh Goshvarpour[c], Hamid Tayebi Khosroshai[d], Elnaz Javanshir[e]

[a] Computational Neuroscience Laboratory, Department of Biomedical Engineering, Faculty of Electrical Engineering, Sahand University of Technology, Tabriz, Iran
[b] School of Advanced Medical Sciences, Tabriz University of Medical Sciences, Tabriz, Iran
[c] Computational Neuroscience Laboratory, Department of Biomedical Engineering, Faculty of Electrical Engineering, Sahand University of Technology, Tabriz, Iran
[d] Division of Internal Medicine, Imam Reza Hospital, Tabriz University of Medical Sciences, Tabriz, Iran
[e] Department of Cardiology, Cardiovascular Research Center, Tabriz University of Medical Sciences, Tabriz, Iran

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ABSTRACT

In the past few decades, several studies have reported the physiological effects of listening to music. The physiological effects of different music types on different people are not similar. Therefore, in the present study, we have sought to examine the effects of traditional Persian music on the cardiac function in young women. Twenty-two healthy females participated in this study. ECG signals were recorded in two conditions: rest and music. For each of the 21 ECG signals (15 morphological and six wavelet based feature) features were extracted. SVM classifier was used for the classification of ECG signals during and before the music. The results showed that the mean of heart rate, the mean amplitude of R-wave, T-wave, and P-wave decreased in response to music. Time-frequency analysis revealed that the mean of the absolute values of the detail coefficients at higher scales increased during rest. The overall accuracy of 91.6% was achieved using polynomial kernel and RBF kernel. Using linear kernel, the best result (with the accuracy rate of 100%) was attained.

1. Introduction

The ECG is a biometric signal, which reflects the electrical activity of the heart muscle. An analysis of the ECG signal provides useful information about the heart's performance. The heart's electrical activity during normal heartbeat is characterized by five basic waves P, Q, R, S, and T waves and sometimes U wave. The P wave and T wave represent atrial depolarization and ventricle repolarization, respectively. In addition, the QRS wave represents ventricular depolarization.[1] The intervals and amplitudes defined by ECG features provide useful clinical information.

It has been previously established that ECG signals can be affected by different factors such as age, cardiovascular diseases, and mental stress.[2] In addition, in the past few decades, several studies in music, psychology, and medicine have reported the physiological effect of listening to music.[3,4] Loomba et al. claimed that music could decrease systolic blood pressure, diastolic blood pressure, and heart rate, significantly.[5] This may be attributed to brain and autonomic nervous system (ANS) activity, but the relationship between music features and ANS activity is not completely understood.[6,7]

These effects have been examined in response to different kinds of music, such as sedative music and excitative music.[2] Since the 1918s, studies were started in which the quantitative differences of cardiac autonomic function during music and rest were extracted.[8] However, the effect of music on cardiac function have varied from research to research. Rickard et al. [9] studied the physiological responses of sedative music. They showed that heart rate was reduced by sedative music. In other studies by Davis et al. [10] and Vanderark et al. [11] it has been shown that music made no changes to the heart rate. Therefore, it can be concluded that the physiological effect of different music types on different people

* Corresponding author.
E-mail address: ata.abbasi@gmail.com (A. Abbasi).

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are not similar. These different effects can be related to method, findings, music types, and gender.[12]

Dousty et al. [2] investigated the relationship between music types and cardiovascular function. They focused on two types of music, namely, sedative and arousal music. They claimed that the heart responded differently when different kinds of music were played. Khazaei et al. represented that music can be used as a powerful method for reducing stress and anxiety in generalized anxiety disorder patients.[13] Other physiological effects of music have been summarized in Table 1.

Most of the previous studies focused on statistical measures, such as mean and variances and tried to assess the physiological effects of music. It has been previously established that frequency domain measures of ECG signals can be significantly affected by music. One appropriate tool for studying of these differences is Discrete Fourier Transform (DFT) and extraction of features from ECG signal power spectrum. An important drawback in the Fourier analysis is that the technique does not provide any information regarding the exact location of frequency components in time.[20] Short Time Fourier (STF) analysis has been proposed for overcoming this limitation by windowing the area of interest. However, the main weakness of this technique is that its time frequency precision is not optimal.[21] Among the different time-frequency transformations, Discrete Wavelet Transform (DWT) is used in the current study in order to investigate the physiological effect of listening to music. DWT is an effective tool for analysis of non-stationary signals like ECG.[21] Furthermore, it has been established that applying DWT to ECG signals can be helpful in detecting clinically significant features that may be missed by other analysis techniques.[22–24] In our previous study,[12] we studied the effect of gender differences on electrical function of the heart in response to traditional Persian music. It has been shown that the mean heart rate signals in men increased during music; however, it decreased in the same protocol in the women's group. We also reported that the heart rate signals of women's group represented maximum power spectrum, twice more than that of the men's group. In addition, it seemed the physiological effect of Persian music was higher in the women's group than the men's group. Therefore, the present study focused on other techniques for studying the ECGs of the female group during music and rest. The present work is organized as follows: In the second part, the ECG dataset, which was collected from a group of young female students before and during listening music, are briefly described. In the third part, the wavelet co-efficient based features and morphological features were developed. Next, the results and comparison between participants' heart rate during music and rest is presented. Finally, discussion and conclusion are presented. A block diagram of the proposed method is shown in Fig. 1.

2. Methods

2.1. Data collection

Twenty two healthy females participated in this study. The age range of the subjects was 20–24 years. All the participants were students of Sahand University of Technology and had no previous history of neurological diseases. ECG signals were recorded under two different conditions from each subject. Initially, the participants were asked to lie in a supine position comfortably and close their eyes for five minutes. Then, five minutes of traditional Persian music was played for participants at a comfortable volume. The ECGs – lead II – were recorded by 16-channel PowerLab (ADInstruments, UK) at a sampling rate of 400 Hz. A digital notch filter was used to remove the 50 Hz Power-Line Interference from the ECG signal. The signals were recorded in MAT, which is a common MATLAB file type.

2.2. Discrete Wavelet Transform

DWT [25,26] is a powerful technique, which can be used to analyse different kinds of biomedical signals like ECG. DWT uses a low pass filter (LPF) and a high pass filter (HPF) to decompose the signal into a number of scales related to frequency components and analyses each scale with a certain resolution. The output coefficients of the LPF and HPF are called approximations and details, respectively. Amplitude of the wavelet coefficients represents the energy density of the signal at particular frequencies and moments. The original signal can be reconstructed by using complementary filters. DWT can be defined as follows:

$$\phi_{m,n} = \frac{1}{\sqrt{a^m}}\phi\left(\frac{t - nba^m}{a^m}\right)dt \quad (1)$$

where φ represents the mother wavelet, which is dilated by integers m and translated by integers n. DWT can be used to provide salient information about the local features of the ECG signals because it has good localization abilities in both time and frequency domain. Choosing a wavelet family, which closely matches the signal to be processed, plays an important role in wavelet applications.[27] As shown in Fig. 2, the Daubechies wavelet family is similar in shape to the QRS complex.[28]

Table 1
Physiologic effects of music.

Study	Number of participants	Music type	Result(s)
Salimpoor et al. [14]	26	1.Self-selected intensely pleasurable music 2.Neutral music	There is a strong positive correlation between ratings of pleasure and emotional arousal.
Orini et al. [6]	75	1.Pleasant music 2.Sequences of Shepard tones 3.Unpleasant sounds	Pleasant music increased the heart and respiratory rates.
Nakahara et al. [15]	13	1.Performance of Music 2.Perception of Music	Musical performance would lead to a greater effect of emotion-related modulation in cardiac autonomic nerve activity than musical perception.
Kemper et al. [16]	81	Designed music	The HRV parasympathetic parameter was significantly lower with music than rest.
Uggla et al. [17]	24		Music significantly lowered the HRV and stress levels of children undergoing haematopoietic stem cell transplants.
Archana and Mukilan [18]	30	Preferential music	Listening to pleasant music could be an effective method of relaxation, and it can shift the autonomic balance towards the parasympathetic activity.
Oh et al. [19]	60		Listening to pleasant music could be an effective nursing intervention for alleviating anxiety during non-stress test.

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