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# Real-Time Physiological Signal Feedback for Anxiety Intervention Music System for Postpartum Women

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**Abstract.** Objective: To identify postpartum anxiety in real time and construct a music playback system that can provide music therapy in time, so as to achieve the purpose of better reducing postpartum anxiety. Methods: The real-time emotion algorithm system identified that the maternal anxiety had lasted for 5 minutes through the EDA and BVP signals collected by the wrist wearable device, and then sent random music instructions. After 30 minutes, the music stopped if the patient was not anxious, and continued until the patient was not anxious. The system also takes sleep-wake into account. Experiment: Twenty-six parturients assessed as having present anxiety participated in a 4-week comparative effectiveness trial of music therapy. In the control group (N=13), in addition to routine rehabilitation, music was played twice a day. The study group (N=13) received music therapy through the system in addition to conventional rehabilitation. Anxiety was assessed again after 1 and 4 weeks of intervention. Results: Both groups showed significant anxiety before and after intervention（$p<0.05$，$p<0.01$）, the study group was more significant, and the performance was more prominent in continuous treatment. Conclusion: The system can identify maternal anxiety in real time and take synchronous and timely treatment, which has a positive effect on reducing postpartum anxiety. The convenience of wrist bracelet can also be applied to other aspects of life.

**Keywords.** physiological signals, emotion recognition, real-time system, music therapy, postpartum anxiety

## 1. Introduction

Postpartum anxiety and depression are common social and psychological health disorders and illnesses among postpartum mothers, but due to their frequent lack of timely detection - including the mother herself, or her unwillingness to voluntarily provide information about her symptoms [1], [2]. In addition, due to its lactation period, medication treatment is often assessed as risky and cautious[3], [4], which leads to a

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lack of timely and effective treatment for various reasons, which has serious adverse effects on mothers, children, and families. Music therapy, as a complementary non-pharmacological intervention [5], has been used to reduce postpartum anxiety and depression [6]. The proposed system in this study collects physiological data related to Electrodermal Activity (EDA) and Blood Volume Pulse (BVP) through a smart bracelet, so as to judge whether the wearer is in an anxious state or a non-anxious state. After the anxiety state is identified, the system will timely sent instruction to the music player to turn on the music. The music library is composed of 53 pieces of selected music, which based on relevant research and the advice of music experts. In the experiment of 26 participants, the Hamilton Anxiety Scale (HAMA) score of the control group changed from 27.15±7.62 to 22.23±6.94 after one week, and 19.92±5.86 after four weeks (p=0.032*). In the study group, the score changed from 27.19±7.19 to 19.85±7.07 after one week and 14.15±5.10 after four weeks (p=0.000**). The proposed music intervention system is superior to the currently existing music therapy modalities, especially for those requiring longer intervention dates. This is consistent with the characteristics that postpartum anxiety is indirect and lasts for a long time, and the music intervention therapy carried out by this system has a significant effect on reducing postpartum anxiety.

## 2. Background and Related Work

Postpartum anxiety is the most common psychological disorder after childbirth. Bourin mentions that about 80% of postpartum women experience postpartum anxiety (or "baby blues") from the third day after childbirth[7]. Women are also twice as likely to develop depression during the postpartum period [8]. In a study of the prevalence of postpartum depression among women worldwide [9], the average number reached to 17.22%. Listening to music can reduce anxiety and depression [10]. In recent years, music therapy has been shown to play a good role in reducing anxiety and depression in multiple fields of population research and application [11], [12]. Examples include Alzheimer's patients [13], Covid-19 patients [14], cancer patients [15], and people who are undergoing surgery [6], [16], [17], postpartum women as well suffer from anxiety. In terms of the choice of music therapy, music with slow rhythm, stable melody and low notes is more beneficial to reduce anxiety, such as Mozart's classical music [18], some natural sounds [19], and pleasant but not exciting ambient music - especially for women [20].

Currently, commonly used signals for emotion recognition include behavioral signals such as gestures, speech, and facial expressions [21]–[23], and physiological signals. Behavioral signals can be consciously controlled by people or influenced by the environment [24], while the objectivity of physiological signals makes it more reliable in emotion recognition [25]. Electrocardiogram (ECG), electroencephalogram (EEG), electrocutaneous response (GSR), and skin temperature are physiological signals that are often used to identify anxiety [26]–[28]. Zheng et al. proposed a wearable headset and glasses to collect EEG and photoplethysmography (PPG) derived features to assess anxiety levels [29]. The emotion recognition system designed by Udovičić et al. through the Shimmer3 device to collect GSR and PPG is used to identify surprise, disgust, joy, fear, sadness and anger [30]. An H2SEC framework was constructed to predict calmness, anxiety, and depression [31]. Mai et al. designed an

ear-electroencephalogram to identify negative emotions and alert users on their phones [32].

The application of music list recommendation based on the user's preferences has become the norm. Research on music recommendation based on the current mood has also begun, but most of them recommend the corresponding music by facial recognition of emotion [33]–[36]. The feasibility of playing emotional music has been confirmed, but its role in health and practical utility in daily life due to device limitations have not been explored.

Current treatments for postpartum anxiety and depression are based on planned music playing [6], [37]. Compared to previous music intervention therapy methods, this article will study the identification of postpartum women's anxiety emotions through physiological signals and explore the effectiveness of real-time music intervention therapy for anxiety.

## 3. System Design

The system involved in this study (Figure 1) consists of two parts, one is anxiety emotion recognition and the other is a real-time controlled music playback system.

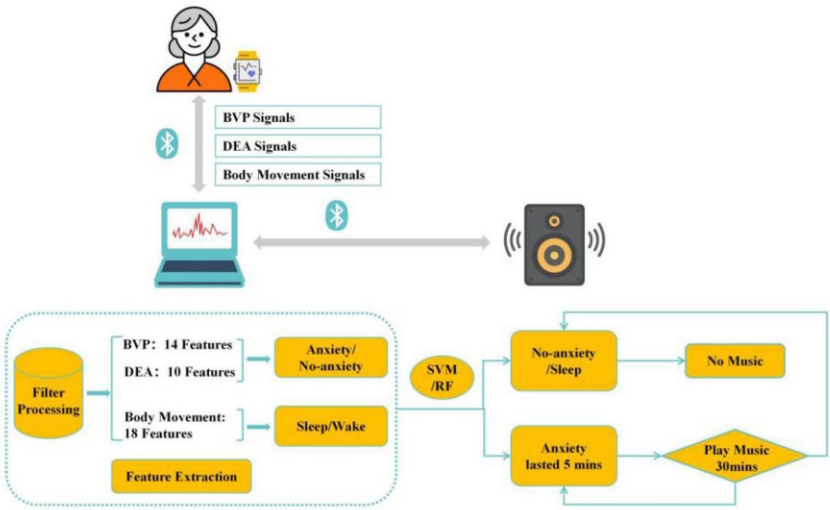


**Figure 1.** Overall architecture diagram of system design.

### *3.1. Emotion Recognition*

In order to better fit the actual use scenario of mothers, so as not to cause trouble to other daily lives in subsequent use of mothers, we have made a simple wrist smart bracelet, which uses sensor modules by Analog Devices, Inc. The ADPD142RI optical module acts as a PPG sensor for BVP signals. The AD8232 is used as a module to

monitor EDA signals. ADXL362 three-axis accelerometer (ACC) is used to detect periodic movement signals of the body to identify sleep or wake, in order to avoid false positives of dream-induced anxiety, resulting in alarm and disturbance caused by music. The sensor module is connected to the ADuCM350 mixed-signal on-chip meter and is responsible for running the necessary software and storing, displaying or transmitting the results. After pre-processing and feature selection algorithm, 14 significantly related EDA features and 10 BVP features (Table 1) are selected from the signals collected by the smart bracelet to identify anxiety or no-anxiety states. The computational model of support vector machine (SVM) classifier is used to complete the calculation of emotional states. For the recognition of sleep or wake, 6 features (Table 1) of body movement signals on ACC are selected on xyz axis, and the calculation model used is Random forests (RF).

**Table 1.** Features used in this study that were significantly associated with anxiety state recognition

| Signal | Features | Numbers | Details |
|---|---|---|---|
| EDA | Peak amplitudes | 6 | Mean, median, root mean square, standard deviation, minimum, maximum |
| | Peak widths | 3 | Standard deviation, minimum, maximum, |
| | peak prominence | 5 | Mean, median, root mean square, standard deviation, maximum |
| BVP | No. of peaks per minute | 1 | |
| | Peak amplitudes | 5 | Mean, median, root mean square, standard deviation, minimum, maximum |
| | Peak widths | 4 | Mean, root mean square, standard deviation, range |
| Body Movement | Vector amplitude (x, y,z) | 18 | Mean, median, standard deviation, mean amplitude deviation, minimum, maximum |

Based on the above computational model, we carried out an evaluation experiment on the accuracy of emotional state recognition of 37 people. The results showed that the accuracy of recognition of anxiety was 95.7%, the accuracy of recognition of no-anxiety was 96.4%, and the accuracy of recognition of sleep state was 98.4%.

### *3.2. Music Player*

In this study, we designed a simple music player that stores 53 pieces of music that can alleviate anxiety, remains powered on, and continuously connects to the computer through Bluetooth. When the emotion calculation shows that the bracelet wearer has been anxious for 5 minutes, the system will send instructions to start the music to play randomly, and the music will continue to play for 30 minutes. Lee et al. showed that a single music therapy period of 30 to 60 minutes is better for relieving anxiety [17]. After 30 minutes, if the emotion state changed to non-anxiety or sleep, the music was paused. If the people are still anxious, continue to play for another 30 minutes to cycle through.

## 4. Experiment

### *4.1. Participants*

Women (N=26) with definite anxiety (score 14) assessed by the HAMA and undergoing postpartum rehabilitation in a postpartum care center were recruited as participants. They were between 24 and 35 years of age, had 4 to 6 week convalescence cycles in postnatal care centres, had normal hearing and physical health, had no mental disorders or other related mental health problems, and had no intellectual disability or cognitive impairment. The mode of delivery included natural delivery and caesarean section, and there were no serious postpartum complications such as uterine bleeding, infection, or other serious diseases. Medications to reduce postpartum anxiety were excluded from this study. The period of intervention and observation in this study was 4 weeks. Participants were divided into control group (N=13) and study groups (N=13), after grouping, initial mean anxiety levels were similar between the groups. The purpose and procedure of the experiment were explained to the parturients before the experiment, and their informed consent was obtained.

### *4.2. Methods*

Control group: In addition to routine postpartum rehabilitation treatments such as physical examination, nutrition guidance and postpartum recovery gymnastics, they received music therapy twice a day for 30 minutes.

Study group: On the basis of routine rehabilitation nursing in the control group, puerpera were treated with real-time music therapy through the proposed system.

Measurements: At the beginning of the intervention, all participants were assessed twice using the HAMA, after one week and four weeks of the music therapy.

## 5. Results

As can be seen from Table 2, there were significant differences between the control group and the study group before and after the music therapy ($p<0.05$), control group ($F=3.783$, $p=0.032$), study group ($F=13.064$, $p=0.000$). The specific comparison showed that after the music therapy, the anxiety scores of the control group and the study group were lower, which indicated that the anxiety was alleviated.

**Table 2.** The effectiveness of two kinds of music therapy on postpartum women's anxiety.

| Phase of intervention | Control group (x±s) | Study group (x±s) |
|---|---|---|
| Before intervention | 27.15±7.62 | 27.19±7.19 |
| Intervention for 1 week | 22.23±6.94 | 19.85±7.07 |
| Intervention for 4week | 19.92±5.86 | 14.15±5.10 |
| *p* | 0.032* | 0.000** |

* $p<0.05$ ** $p<0.01$

At the same time, the HAMA score of the study group decreased more than that of the control group, which can be seen Figure 2. In addition, the trend curves of the reference group and the study group after 1 week and 4 weeks of intervention in Figure 2 also reflect that the proposed system in this study has more advantages in this respect for the relatively long-term music intervention therapy treatment.

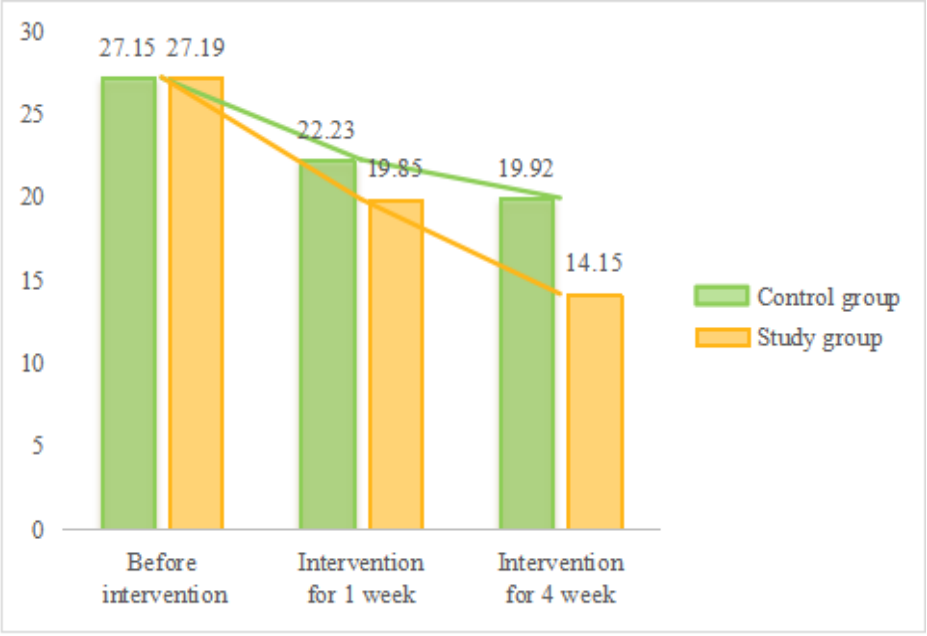


**Figure 2.** The trend chart comparing the effectiveness of the two types of music therapy.

## 6. Discussion

Music therapy can be used to intervene in anxiety, which is consistent with numerous studies. More importantly, for postpartum anxiety symptoms, the proposed system in this study plays a better role in real-time detection, timely intervention, and long-term treatment. Depression may begin to appear around 3 weeks postpartum, which will last longer [7], making this music therapy system is meaningful for postpartum anxiety patients. It's also worth noting that, Postpartum anxiety or depression is not specific to postpartum mothers, and a significant proportion of men may also suffer from it [38]. In fact, appropriate music is also beneficial for sleep [39], and one of the characteristics of postpartum anxiety is insomnia, and future research will focus more on this.

At present, postpartum anxiety and depression, including those of other populations, are still insufficiently detected and valued. In our study, although the accuracy of anxiety recognition in the emotional state recognition process can reach more than 95%, the participants reported some errors, and the accuracy in the use environment is lower, because individual specific factors such as sweat gland density and skin thickness lead to individual differences in EDA. Emotion recognition based on multimodal physiological signals is considered to be a more reliable and accurate way, but the equipment used in these multimodal recognition methods is basically not suitable for daily life. In addition, the 53 pieces of music used in the study were selected by music experts based on the types of music that have been shown to relieve stress in other studies. In this study, each participant used the same music library. Hu et al. conducted a study on computer algorithms to recommend music according to personal preferences and anxiety efficacy [40]. Their experiments showed that the recommended music was useful for relieving anxiety, but it did not involve the recognition of anxiety. Liao et al. has developed a Music Playback Algorithm for joggers to realize the playback sequence considering the current physiology and music emotions during exercise [41]. The study shows that it is superior to other emotion classification models in music emotion classification. But the study did not mention the effectiveness of the system on real-time physiological signal processing and the specific effects on joggers. Nevertheless, more precise emotion recognition based on physiological signals and more personalized, mobile forms of real-time processing and intervention in music playback will be the inevitable direction.

## 7. Conclusions

The proposed system in this study is significant in the direction of intervention for postpartum maternal anxiety. Compared with the currently used music therapy, the real-time identification and intervention of anxiety is more effective in the ongoing treatment. The proposed system in this study is based on mothers with postpartum anxiety, but in fact it can be applied to all aspects of people's daily life, such as people with high work pressure, to create a comfortable living environment and improve health.

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