

Implementation of MP3 Player for Music Therapy on Hypertension

J. Y. Yu, D. F. Huang, Y. Li and Y. T. Zhang, *Fellow, IEEE*

Abstract—Hypertension is a common clinical disease and a major risk to human health. Many clinical findings indicate that certain types of music can reduce blood pressure (BP), and music therapy is considered as an important part of anti-hypertension treatment. We integrate our former related research achievement into the new MP3 player, which can also detect the current BP value with a cuffless measurement method. According to the current BP value, the MP3 player selects certain types of music for playing in order to alleviate the hypertension of patients.

I. INTRODUCTION

Hypertension is a common clinical disease, which has a very high risk of cardiovascular and kidney diseases, and it becomes a major risk for human health. Until 2002, the percent of adults with hypertension was 18.8% and the total number of people with hypertension was over 160 million in China.

The current patient's rehabilitation treatment of hypertension mainly concentrated in drugs, exercise and diet. The treatment of anti-hypertension is divided into drug treatment and non-drug treatment. For drug treatment, medical experts from WHO, etc. [1] consider anti-hypertensive drugs can just lower blood pressure (BP) temporarily and are not benefit for hypertension. Because of the side effects and cost of anti-hypertensive drug, non-drugs treatments have been more increasingly concerned, especially music therapy.

Music therapy is a treatment method that achieves the medical effects by participating in singing, playing instruments, or listening to music. It is a cross-product combined with medical psychology and music [2]. Music can regulate physiological functions by influencing the central nervous system, which can satisfy the people's self-expression needs and influence their moods. Music therapy has positive effects on many physical illnesses, for example, listening to soft music can lower high blood pressure, skin resistance, heart rate and anxiety level, improve headache, dizziness, chest distress, palpitation, insomnia and other clinical symptoms. Music therapy also

has been widely used for mental illness treatment and rehabilitation medicines, which can improve the patients' physical and mental status, relax sympathetic [3].

There are two kinds of treatment methods on music therapy for hypertension: one method is called active expression or participative method. This method is that patients participate in singing, playing instruments, etc. to heal their illness; the other method is called passive acceptance or feeling method. This method is that patients listen to selected music to achieve therapeutic effects. Passive treatment is a major method of music therapy at present.

In this paper, an MP3 player is implemented for music therapy on hypertension. The player including a cuffless BP measurement method [4] can play selected music according to user's current BP value.

II. RELATED WORK

There are mainly two ways that music could influence body: psychology and physiology. Different music can stimulate different emotions. Human mood is not only related to cerebral cortex, but also related to endocrine system, vegetative nervous system, hypothalamus and limbic system. Through its melody, rhythm, tone, timbre, etc, music can have multiple effects on human body to regulate cardiovascular system, neural system, etc. and improve the functional status of cerebral cortex [5]. With the functional status of cerebral cortex adjusted, patients could clam down their irritable mood, relax their tense nerves and reduce their blood pressure. The modern neurophysiology study shows that marginal brain system and brainstem reticular formation can regulate organs and physical mechanism. Music therapy has a direct impact on those neuromechanism [6], which can indirectly relax muscles, dilate vessels, and reduce blood pressure. The physiological effects made by music are implemented by sound waves. Sound waves of Music spread into human body through hearing and afferent nerve, resonate with the tissues of human body, and are absorbed by the human body, which can stimulate the body's potential [6].

Because drug therapy just reduces blood pressure temporarily, which is not benefit for hypertension and has side effects, non-drug therapy is considered as the maintain treatment method. Especially, music therapy has been considered as an important part of hypertensive rehabilitation. Many Studies have been done on the effects of music on hypertension [7][8][9].

In 2007, a research group led by Prof. Yuan Ting, Zhang [7] studied the effects of certain music on BP of hypertensive patients. The study was carried out at an elderly

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The authors are with the Shenzhen Institute of Advanced Technology Chinese Academy of Sciences, Shenzhen, 518067, China (e-mail: jy.yu, df.huang, ye.li@sub.siat.ac.cn).

Y. T. Zhang is both with the Shenzhen Institute of Advanced Technology Chinese Academy of Sciences, Shenzhen, 518067, China, and with Biomedical Engineering at the Chinese University of Hong Kong, Hong Kong, China (e-mail: ytzhang@ee.cuhk.edu.hk).

home. Fifteen old people were enrolled in the study as subjects, 4 male and 11 female. Among them, 8 subjects had initial systolic blood pressure (SBP) higher than 140 mmHg. Those subjects listen to the selected music in a quiet room, 25 min per day for 4 weeks. The BP was measured twice a week by a registered nurse with a sphygmomanometer at brachial arteries. During the experiment period, 3 subjects including one with initial SBP higher than 140 mmHg dropped due to some reasons, 12 subjects completed the whole experiment.

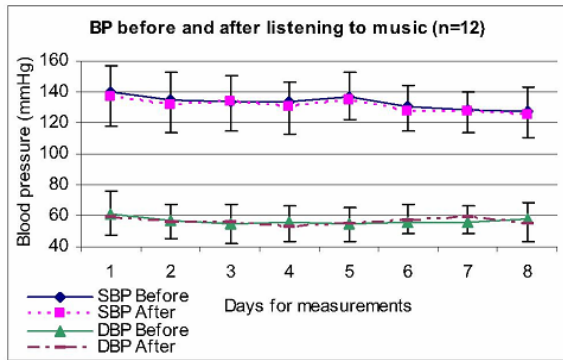


Fig. 1 The average BP values of the entire group obtained before and after listening to music (n=12)

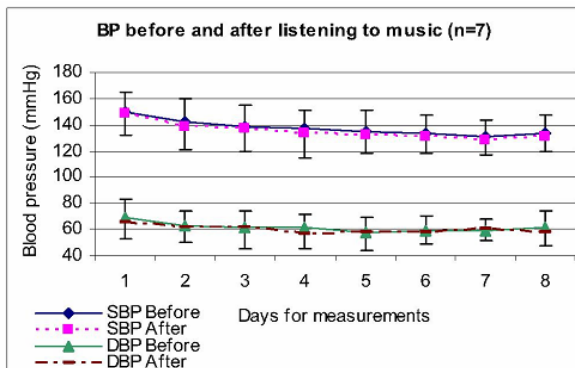


Fig. 2 The average BP values of the subgroup of subjects with initial SBP higher than 140 mmHg (n=7) obtained before and after listening to music

Fig. 1 shows the curves of the average BP values of the entire group, and fig. 2 shows the curves of the average BP values of the subgroup of subjects with initial SBP higher than 140 mmHg. According to the two figures, the decreasing trend in DBP is not as pronounced as in SBP. It can be seen that the decreasing trend in BP of the subgroup was more pronounced. The study results indicate that listening to selected music would significantly reduce SBP of hypertensive patients.

III. SYSTEM IMPLEMENTATION

Based on former researches, we implemented a kind of MP3 player for music therapy with cuffless BP measurement module, which can easily measure user's current BP value. According to the current BP value, the player can choose certain music to play in order to reduce the user's high BP.

The implemented MP3 player consists of four parts: BP measurement, signal processing and controlling, music playing, and data storage. Fig. 3 shows the system architecture of the player. The physiological signals collected by bio-sensors, such as electrocardiogram (ECG) and photo-plethysmograph (PPG), are weak and contain noise, which must be amplified and filtered. Based on proper algorithm, signal processor calculates user's BP value. Controller selects certain music to play according to the measured BP value and the rules of music therapy prescription.

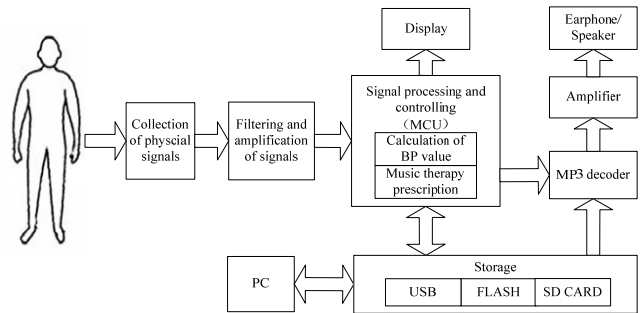


Fig. 3 The block diagram of the player system

Blood pressure measurement methods are divided into invasive and non-invasive type. The invasive method can obtain BP continuously and accurately, but it is difficult to operate and may cause infection. Therefore, the medical staffs and patients prefer the non-invasive method. The common non-invasive methods are Korotkoff and oscillometric [10]. Both methods are easy to obtain BP value, but need to use a cuff. In this paper, we use an indirectly method to obtain BP value by using cuffless measurement.

A. Cuffless Blood Pressure Measurement

Blood pressure can be indirectly obtained by measuring pulse wave velocity (PWV), which is related to both electrocardiogram (ECG) and photo-plethysmograph (PPG). However, it is very difficult to measure PWV. Another physical parameter — pulse wave transition time (PWTT) is used to describe the relationship between PWV and BP. Usually, PWTT is defined as the time interval between two characteristic points — the R peak of ECG and the minimum point of pulse on finger [11], which is illustrated in Fig. 4.

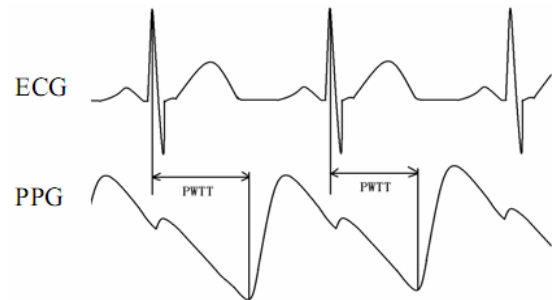


Fig. 4 The definition of PWTT

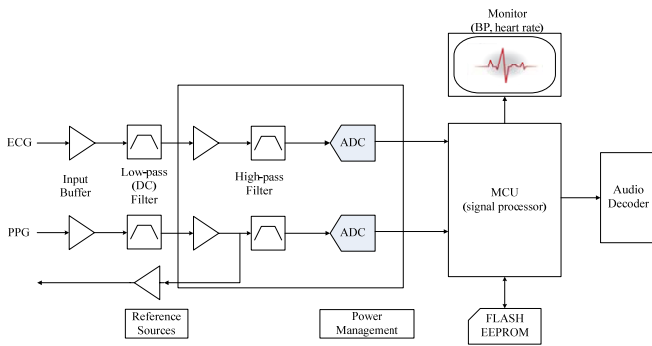


Fig. 5 The block diagram of BP measurement module

PPG is a non-invasive method to detect cardio-vascular pulse wave by a light source and a detector. PPG signal indicates the volume changes in blood vessels which includes two components — direct current (DC) and alternating current (AC). PPG sensor is put on finger-tip to detect the stable PPG signal from people[4].

The BP measurement block diagram which includes ECG and PPG signal detection is showed in Fig.5. The measured PPG and ECG signals are inevitably containing kinds of noise because they are weak and always in variation. These weakened signals firstly are amplified and filtered by the measurement circuit. For ECG, it contains common-mode signal comprised of 50- or 60-Hz interference and DC electrode offset potential. These noises can be filtered by notch-filter (50Hz) and high-pass filter (about 40 Hz). Other noises within biophysical bandwidth come from the movement of artifacts that changes skin-electrode interface, muscle contraction, respiration, electromagnetic interference (EMI), etc., can be filtered by a high-input-impedance instrumentation amplifier (INA).

For PPG, DC component which changes slowly and AC component which synchronizes with heart rate. AC component which contains the information about pulse wave and the situation of light absorption of arterial blood, is superimposed on DC component, its amplitude value is about 1~2% of DC's. The frequencies of pulse wave are mostly less than 20Hz. Thus a 40Hz low-pass filter is adopted to remove the high frequencies interference. The high-pass filter (about 0.1Hz) can remove DC component and the notch-filter (50Hz) can suppress power noises. After amplified and filtered, ECG and PPG signals are sampled by a 12-bits analog-to-digital converter (ADC), and processed by signal processor. The physiologic signal processing is implemented in two steps: baseline wander and significant point detection. The precision of PWTT is related to significant point detection, which finally reflects the precision of BP value.

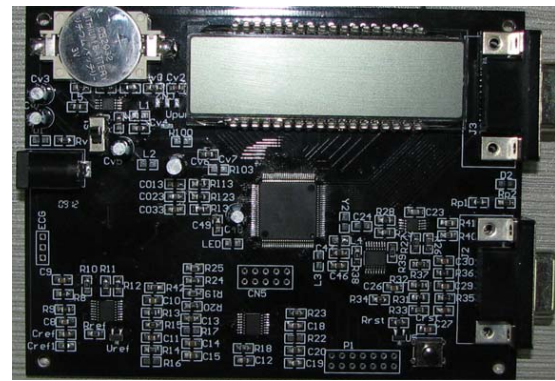


Fig. 6 The PCB of BP measurement module

Fig. 6 shows the implemented PCB of BP measurement, a micro-controller as signal processor is used MSP430449 from Texas Instruments, in which an ADC is located [12]. The ADC is 12 bits which meets the precision requirements of ECG and PPG sampling. The 16 bits micro-controller is designed for low power device. Physiological data sampled by the 12bits ADC are processed by the micro-controller which calculates BP value. After processing, the calculated BP value is displayed on LCD.

B. MP3 Playing Module

There are a lot of mature solutions for MP3 play module. In this paper, miniC-A101FS voice module provided by Shenzhen Minicreate Company is used for MP3 play module [13]. This voice module provides a serial interface for control, which is easy to use and flexible to extend. There are abundant serial commands used to control MP3 playing. The MP3 module consists of four parts: controller, decoder, amplifier and storage. The work flow of this player is as follows: controller in the player sends out certain command based on BP values and rules of music therapy prescription, and then MP3 module receives the command, and reads corresponding music file from mass storage. The file bit stream becomes pulse code modulation (PCM) bit stream after decoded by decoder. Sound can be heard from earphone or speaker after PCM bit stream is converted by digital-to-analog converter (DAC) and amplified by audio amplifier.

Flash, memory card (such as SD card, CF card), etc are common mass storage, micro hard disk is also used in some high-end MP3 players. This player uses memory card (SD card) as mass storage to store mp3 files, and it also supports USB protocol. Thus, mp3 files can be easily copied to SD card from PC.

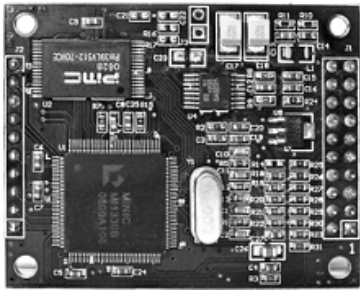


Fig. 7 miniC-A101FS voice module

MiniC-A101FS voice module supports universal asynchronous Receiver/Transmitter (UART). With UART interface, the voice module receives commands from host controller, and does corresponding operations according to those commands.

IV. CONCLUSION

Music therapy is considered as a low-risk, low-cost and alternative treatment for hypertensive patients. This paper mainly implements an mp3 player which has a function of music therapy on hypertension. The implemented MP3 player can be used to reduce BP and as adjuvant therapy in rehabilitation treatment of hypertensive patients. As a part of rehabilitation treatment, it can be used in patients' daily life in order to cumulate effects on reducing high BP which is significant in long-term treatment. The player is modular design and adopts a cuffless BP measurement method, which can measure user's BP conveniently. The value of BP determines the type of music.

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