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Spectrogram Analysis of Phonocardiographic Signals as a Function of Weight

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Abstract**—** In human body different types of systems reflect their activities in term of biomedical signals. The processing of these signals extracting information from many sources such as heart, brain, and nervous system. These systems perform the physiological and pathological process which control different action of human body. As heart is an important part of human part therefore diagnosis of heart is important for human health. Auscultation is fundamental tool for analysis of heart sounds. There are four types of sounds produced in human heart. The signal reflected from heart is analyzed by using electrocardiogram and phonocardiogram technique. But as electrocardiogram technique has some defects in their signals and cannot detect low frequency signals. Therefore phonocardiogram technique is used. In this paper frequency spectrum of heart sounds as a function of weight is analyzed using phonocardiogram technique. The effect of weight on log spectral distance and spectrogram is studies by grouping data into three different age groups having different weights which gives that in childrenôs log spectral distance increase with weight while in adultôs its effect is reverse.

Keywords**—** Biomedical Signals, Auscultation, Heart sounds, Electrocardiogram, Phonocardiogram.

I. INTRODUCTION

Biomedical signal processing is extracting the information from many sources such as heart, brain, and endocrine systems in order to improve medical diagnosis. In human body different types of system reflect their activities in term of signals called biomedical signals such as electrical, mechanical and biochemical signals. These systems perform the physiological and pathological process both and control the different actions of human body. The pathological process is occurred when any diseases effects the human body. Biomedical signals are originated from different sources e.g. electrical signal is due to current and potential, mechanical signal is due to pressure and temperature, and biochemical is due to neurotransmitter and hormones. The main purpose of processing of biomedical signals is to extract the relevant parameter from noisy signal and reduced the redundant data stream. The analysis of these signals is important for both medical treatment and scientific research. Some commonly used biomedical Signals are given as:-

Action Potential: It is mother of biomedical signals and generated by single cell. It is mechanism by which electrical signal propagate between cell, tissues and organs.

Electrocardiogram: It is commonly used signal in medical provide graphical representation of electrical activity of heart and monitor the heart rate.

Electrogastogram: It is used for the graphical representation of electrical activity of stomach.

Electromyogram: It represent the electrical activities occurred in muscle cells.

Phonocardiogram: It is a physiological signal which is used to record the sounds produced by heart. It is representation of heart sound signal in time- frequency domain [1].

All systems of human body are important for performing an appropriate function, but heart is one of the most important systems of human body. It performs function of pumping of oxidized blood to the body and collects the blood from body for oxidation. During processes of oxidation and de-oxidation some sounds are produced in heart called heart sounds. These are biomedical signals which provide the valuable information about the structural abnormality associated with heart valves and great vessels [2]. The Signals reflected from heart is analyzed by using electrocardiogram and phonocardiogram techniques which provides relevant information about the function of heart.

Electrocardiogram is non invasive technique used for graphical representations of the electrical activates carried out in the heart. It is a popular method used to analysis anything wrong with the functioning of heart such that structural abnormalities and characterization by heart murmurs. It is mainly measured the rate and regularity of heartbeats in order to detect any irregularity to the heart. It is nonïinvasive technique therefore by using these signals can be measured without entering the body by using electrodes [3]. But it has some defects in their signals and cannot use for detection of low frequency and small heart defects. As electrodes are used to measures the electric potential produced in heart therefore it an expensive technique and need experts for their analysis which make its usage limited. As heart defects almost led to change among the sounds produced by heart therefore listing of heart sound with auscultation method is valuable diagnosis tool used for analysis of such defects [4]

Auscultation is a fundamental tool used for the analysis of heart sounds that are produced due to mechanical vibration generated in the organs. These mechanical vibrations are produced due to tremendous acceleration and retardations of

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blood in heart chambers during opening and closing of heart valves and propagate to the surface through body tissues. Auscultation is the process of listing these sounds produced in heart using a stethoscope in order to make diagnosis of heart defects. There are four positions on heart from which auscultation detected shown in Fig. 1.

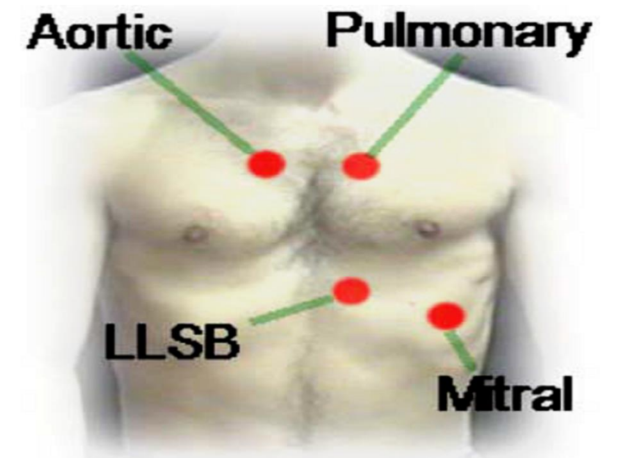

Fig. 1. Ausculation Sites on Chest to place stethoscope [12].

Stethoscope is a device which is used to transmitted sound energy from surface of body to ear of physician or doctor. The stethoscope was firstly invented in franc by Dr. Laennecôs in 1816 at the Necker-Enfants Malades Hospital. It is used for more than 180 years in order to listing the heat and lungs sounds. But conventional stethoscope could not provide amplification and not able to store the information for further analysis. Therefore in order to overcome these disadvantages a modern technology provided more powerful tools like electronic stethoscope to record and analyses the heart sounds. It converts the acoustic sounds into Digital signals called phonocardiogram and amplified signals for analysis. Electronic stethoscope is prevalent in market and very few companies manufactured it. Some of popular companies are Think lab, Littman Wetch-Allayn [6]. The process of recording and representing heart sounds by using auscultation process is called phonocardiogram. The phonocardiogram is firstly developed in 1894. It overcomes the drawback of traditional auscultation and provides valuable information about the integrity functioning of heart. The analysis of frequency and time spectrum of phonocardiogram signals by using digital signal processing extracting an important feature from heart sounds which are not detected by human hear. It can also analyze the characteristics of heart sounds such as frequency content, timing relationship etc [7].

This paper provides the spectrogram analysis of phonocardiographic signals as a function of weight. In next section of paper explain mechanism for production of heart sounds, methodology, results and conclusion.

II. Production Of Heart Sounds

The Heart sounds are mainly non- stationary sounds produced due to mechanical movement of heart and indicate the health status of individual. These sounds are having low frequency range approximately between 10 to 750 Hz and contain both physiological ant pathological information about various parts of body and heart.

Heart pumps the oxidized blood to the body and collect blood from body for oxidation. During the process of oxidation and de-oxidation the contraction and relaxation of heart valves take place which turn produced sounds called heart sounds. Therefore heart sounds are generated due to flow of blood into and out of heart blood vessels [8]. The schematic for human heart is shown in Fig. 2. Heart sounds are mainly consist of two main parts first sound S_1 has duration of 70 to 150 ms, produced due to closure of the tricuspid and mitral valves and S_2 has duration of 60 to 120 ms, produced by closure of aortic and pulmonary valves [9]. The sound S_1 has frequency range of 20 Hz to 150 Hz and sound S_2 having frequency range of 50 to 250 Hz [4]. Therefore the heart sound S_2 is has high pitch and shorter duration than S_1.

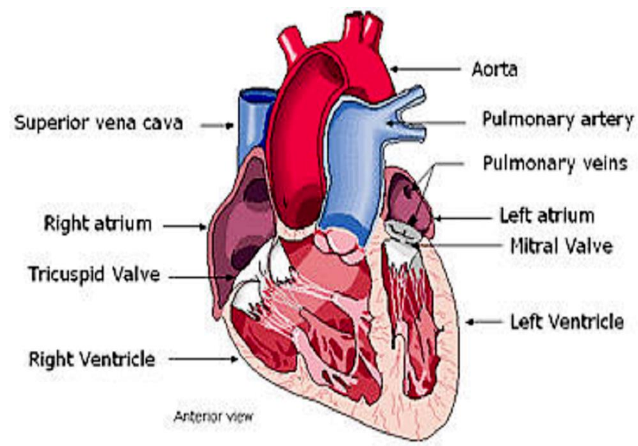

Fig. 2. Human Heart [6].

Except these normal sounds some extra sounds are also produced in heart i.e. S_3, S_4 and murmur. These sounds specified heart pathology condition. The sound S_3 is of low pitch and can listen best at apex. It is normal variant in childrenôs and sometimes in adults and sign of left ventricle failure. The heart sound S_4 is pre-systolic low pitch sound which is mainly occurs just before S_1. It is not present in healthy persons and occurred when there is decreased ventricular compliance such as hypertension, coronary artery disease, and cardio-myopathy. The heart sound S_3 and S_4 are also called as gallop sounds [10].

Heart murmur also produced due to pathology condition of heart. Heart murmurs are unusual sound heard in between two heart beats. Murmurs are occurs due to defects in valve such as mitral regurgitation, blood leaks backward and narrowed valve. It ranges from very faint to very loud sometime like a swishing noise or whooshing. These are ñpuffò type sounds that are stretches from start of heart sound for few seconds or during entire cardiac cycle. Murmurs are three types depend upon at which position they occur in cardiac cycle [11].

III. Methodology

The investigation is carried out in order to analyze the effect of weight on spectrogram of phonocardiogram signals. The data was collected from 12 subjects having different weights from 4.5 to 75 Kg. The data was recorded from four positions of heart P_1, P_2, P_3 and P_4 by using electronic stethoscope or laptop based phonocardiograph recording system. The electronic stethoscope has ability to record heart sounds with excellent quality and produced Phonocardiogram signal. In order to record heart sounds with excellent quality environment was kept silent.

The recorded data was affected by noise during recording because electronic stethoscope is sensible to noise. Therefore pre-amplification of recorded sounds are take place to get the desired level of sound and filtering action is also take place to filter the noise component in recorded heart sounds. The heart sounds were recorded at sampling frequency of 16 KHz. Then spectrogram for each heart sound is drawn using praat software package for duration of 4 seconds and analyze the effect of weight on spectrogram of phonocardiogram signals. Data is then divided into four age groups range from 1 month to 60 month, 72 month and 156 month and 276 month to 372 month having different weights. Then we analyzed the spectrogram of phonocardiogram signals for different weights in each age group.

IV. Results

Table 1 shows the log spectral distance for heart sounds S_1, S_2, S_3 and S_4 for different age groups as a function of weight.

Table I. Log spectral distance for heart sounds S_1, S_2, S_3 and S_4 for different age groups as a function of weight.

Age Group (1 to 60 months)				
Weight	S_1	S_2	S_3	S_4
4.5	9.5	9.0	8.2	8.2
9.5	11.2	10.4	9.1	9.2
12	11.4	11.4	9.5	9.6
24	11.9	11.5	9.0	10.3
Age Group (72 to 156 months)				
Weight	S_1	S_2	S_3	S_4
28	10.2	10.4	9.5	8.9
33	9.7	9.5	8.2	8.5
34	10.7	9.8	8.8	8.8
36	10.8	10.8	8.9	9.0
Age Group (276 to 372 months)				
Weight	S_1	S_2	S_3	S_4
43.5	20.9	21.2	19.9	18.7
57.5	20.8	20.7	19.4	18.4
59.5	20.4	22.2	19.2	18.2
75	19.9	21.2	19,0	18.1

The log spectral distance of phonocardiograph signals at position P_1 of heart are shown in Fig. 3 to Fig. 5 to analyze the effect of weight on spectrograms of phonocardiogram signals and their corresponding spectrograms are shown in Fig. 6 to Fig. 8.

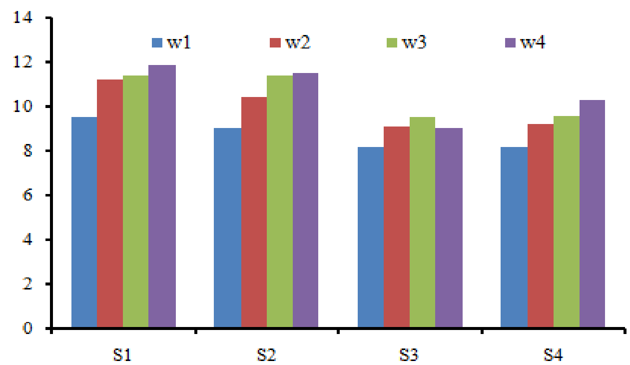

Fig. 3. Log spectral distance for heart sounds S_1, S_2, S_3, S_4 for weights range from 4.5 to 24 Kg.

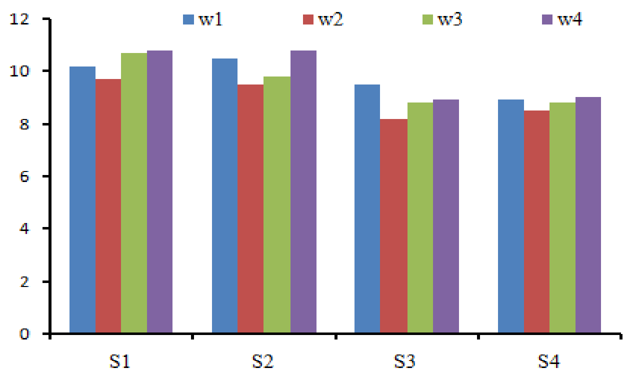

Fig. 4. Log Spectral Distance for heart sounds S_1, S_2, S_3, S_4 for weights range from 28 to 36 Kg.

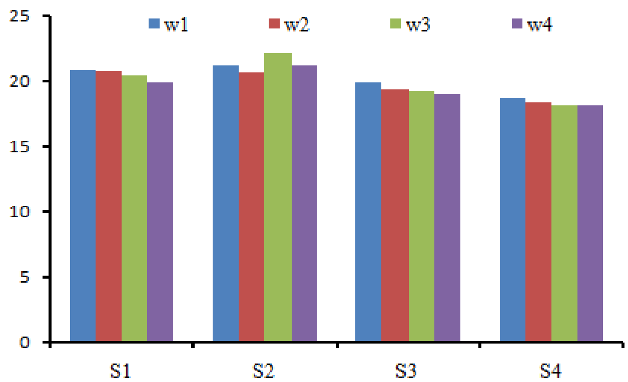

Fig. 5. Log Spectral Distance for heart sounds S_1, S_2, S_3, S_4 for weights range from 43.5 to 75 Kg.

This investigation is carried out on both childrenðs and adults by dividing them into three age groups 1 to 60 months, 72 to 156 months, 276 to 372 months in increasing order of weight. The effect of weight on log spectral distance between the adjacent sounds S_1, S_2, S_3 and S_4 are found.

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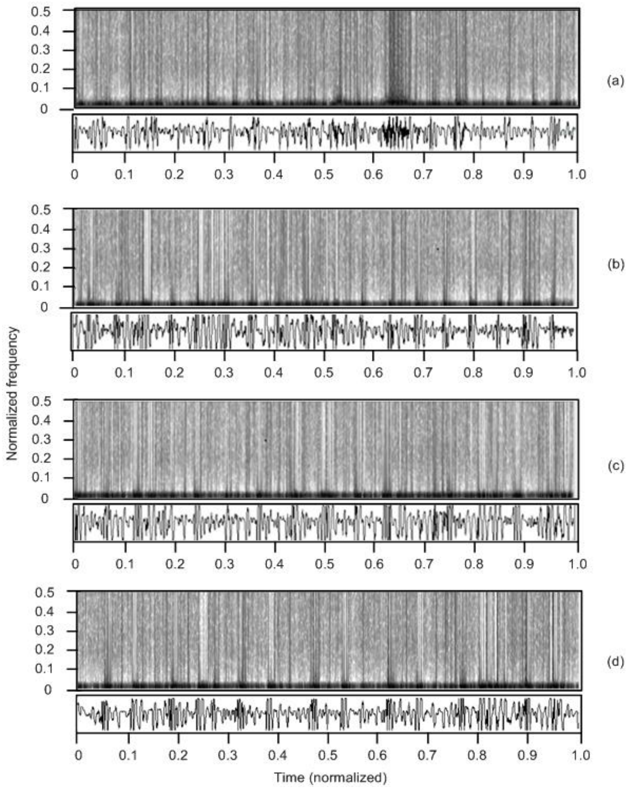

Fig. 6. Spectrogram of heart sounds in increasing order of weight.

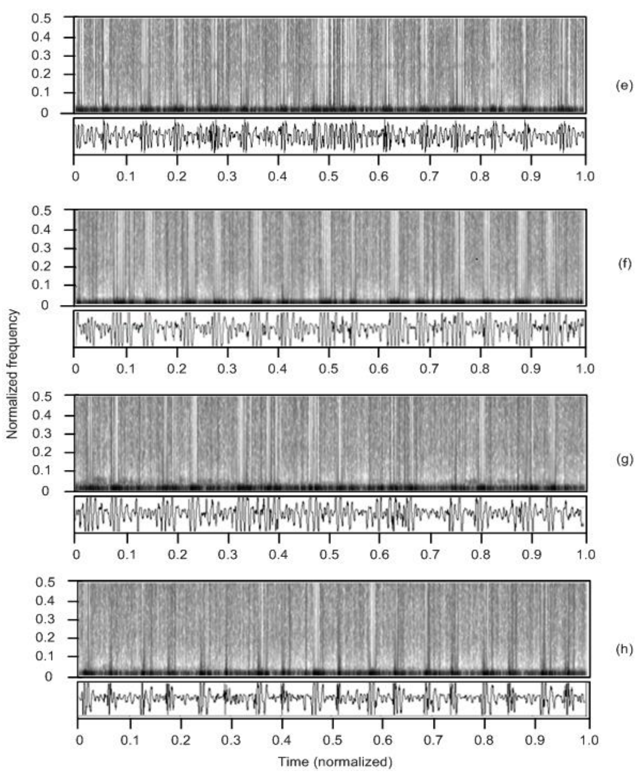

Fig. 7. Spectrogram of heart sounds in increasing order of weight.

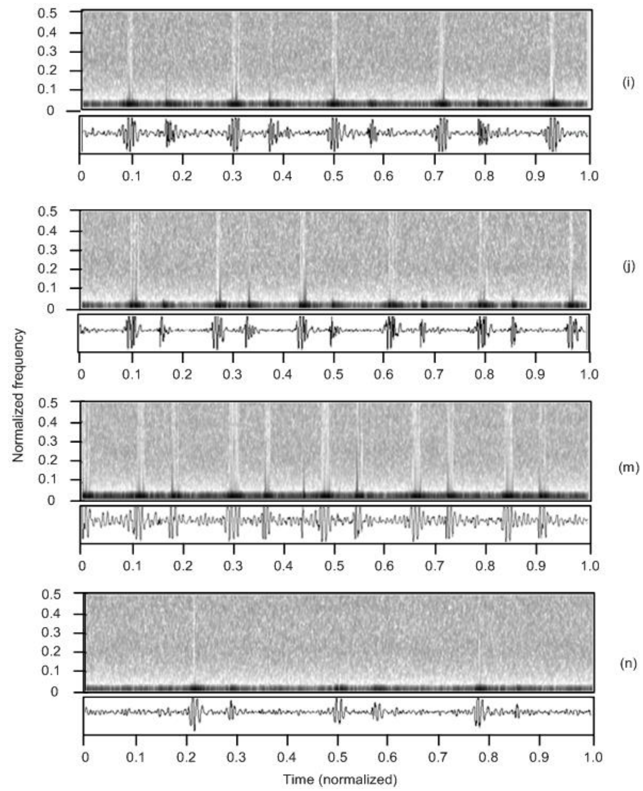

Fig. 8. Spectrogram of heart sounds in increasing order of weight.

In these spectrograms normalized time is represented along X- axis and the normalized frequency is represented along Y-axis. In first group it seems that as the weight of subject increases the Log spectral distance between adjacent sounds of subjectôs increases for all four sounds of heart and sound S_1 has maximum significant log spectral distance as compared to all three sounds. In second group same effect is seen that log spectral distance increases with weight and sound S_1 also has maximum significant log spectral distance than all three sounds. But in third group the effect is reversed and log spectral distance decreases with weight and heart sound S_2 has maximum significant log spectral distance than all three types of heart sounds. Also the frequency components for different heart sounds are more in childrenôs than adults.

V. Conclusion

Data was recorded using an electronic stethoscope having ability to replay the recorded sounds. Investigation is carried on heart sounds obtained from childrenôs and adults. The recorded data is divided into three age groups having different weights. It may be concluded that frequency components in childrenôs is more than adults and as the weight increases log spectral distance in childrenôs increases and in adults shows reverse result and log spectral distance decreases.

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