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Analysis of Phonocardiograhic Signals as a Function of Age

Gurjit Kaur Maan[1], Randhir Singh[2], Parveen Lehana[3]

PG Student, S.S.C.E.T, Badhani, Pathankot, Punjab, India [1]

Assistant Professor, S.S.C.E.T, Badhani, Pathankot, Punjab, India [2]

Associate Professor, Department of Physics and Electronics, University of Jammu, J&K, India [3]

ABSTRACT: All living organism reflect their physiological and pathological process in term of signals called biomedical signals. These signals extract the useful information from biological system under investigation. Heart is an important part of body and any disorder can affect sounds produced by heart. Auscultation is one of the fundamental and non-invasive tools used for analysis of heart sounds. There are four types of heart sounds are produced due to mechanical activities of heart. Conventionally electrocardiogram is used for analysis of heart activates but due to defect in their signals and cannot detect low frequency signals. Phonocardiogram is provides the detection and analysis of low frequency heart sounds. In this paper, analysis is done on phonocardiographic signal which shows the significant effect as a function of age.

Keywords: Electrocardiogram, Phonocardiogram, Auscultation, Biomedical signals, Heart sounds.

I. INTRODUCTION

Most of the physiological processes are associated with different signals that reflect the nature and activity of signals itself, also called biomedical signals. All living things reflect their activities in term of biological signals i.e. electrical mechanical or chemical. Biomedical signals reflected from different sources such as hearts, brains and nervous system are used to diagnosis of patient diseases and biomedical research. The analysis of biomedical signals is useful for both medical treatment and research [1]. Biomedical signals are mainly observed from the physiological activities of organisms such as genes, cells, tissues etc and play a vital role for extracting useful information from the biological system that is under investigation [2]. The process of extracting information from the biomedical signals called biomedical signal processing. These signals carry information about status and nature of the system under investigation and proper processing of these signals provides useful clinical and physiological information which is important both for medical diagnosis, new biology and research [3]. Biomedical signals are classified according to their source of production, applications or in terms of signal characteristics. These signals are classified into variety of classes dependent on the rate and nature of variation take place. Some types of biomedical signals are explained below.

a) Bio-acoustic signals: The outputs of such biomedical signals are acoustic in nature. These signals provide the information about the phenomenon occur in biological system or function being performed by biological system. For example lub-dub sound produced by pumping of heart, flow of blood in heart trough heart valves and flow of air through trough lungs and upper and lower airways that generate the acoustic signal.
b) Bio-impedance signals: These signals are produced in tissues by injecting low current (<20 mA) sinusoidal signals at frequencies between 50 kHz and 1 MHz and measuring the voltage drop across the tissues. The electrical impedance of tissue provides important information about endocrine activities, composition of tissues and blood volume distribution in tissues. For example the measurement of respiration rate and galvanic cell resistance. It monitors the relationship between current and voltage.
c) Bio-magnetic signals: In various organs such as brain, heart and lungs due to electrical activities extremely weak magnetic field is produced which is turn generate magnetic signal. The measurement of these signals provides information that is not available in bioelectric signal, e.g. magneto-encephalographic signal generated due to activities of brain.
d) Bio-chemical signals: These signals produced due to chemical reaction take place in living tissues or samples analyzed in the laboratory. The chemical reaction alerts the chemical composition of tissues in both gross and

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subtle ways. For example measurement of partial pressure of carbon dioxide, concentration of various ions in the blood, partial pressure of oxygen.

e) Bio-optical signals: As the name indicates these signals are produced due to the optical functioning of the biological system and related to the optical transmission and reflectance of the tissues. These signals are occurring either naturally or induced by measurement process. For example by measuring relationship between the reflectance of IR and visible wavelength blood oxidation level can be estimated.

f) Bio-mechanical signals: These signals are produced due to mechanical function of the biological system. These are mainly produced due to the motion, displacement. Temperature, flow and pressure change in biological system. These signals do not propagate unlike electrical and magnetic signals therefore measured at source. For example phonocardiogram, carotid pulse, etc. [4].

Paper is based on the analysis of the effect of age on the phonocardiographic signals. The next sections of paper describe the structure of heart and heart sound, methodology and result followed by conclusion.

II. STRUCTURE OF HEART AND HEART SOUNDS

Heart is an important part of human body. It is an empty muscle having shape like fist perform the function of pumping of blood to the whole body trough blood vessels. Human heart is made up from two parts right heart and left heart. The right heart pumps the blood into lungs and the left heart provide oxygen and nutrients to whole body and organs. Human heart is consist of four chambers upper chambers are called atrium and lower chambers are called ventricles. Two upper chambers are used to collect the blood entering in the heart and lower chambers are used to supply blood to the whole body. During these processes of contraction and relaxation of atria and ventricles take place which may turn produced sounds called heart sounds. Any abnormalities in heart structure and characteristics mostly affect the sounds produced by heart. Heart sounds are highly non stationary and complex signals and generally developed during opening and closing of valves, blood flow into and out of ventricle and action of myocardial.

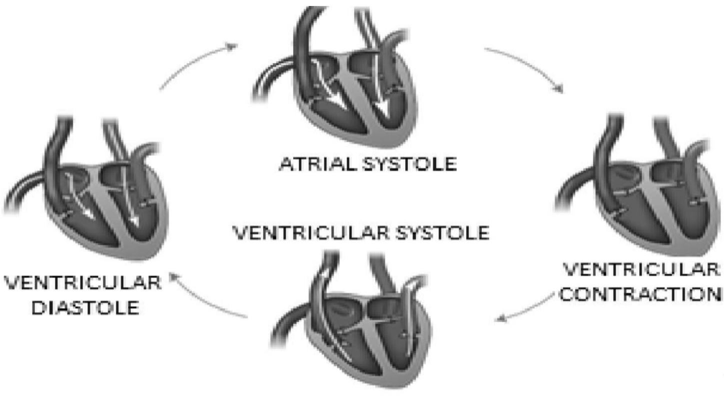

Fig. 1 Heart sound production mechanism [8]

Heart is mainly considered to be analogous to electromechanical system and its health is characterized by both of its electrical and mechanical behavior. The mechanical functioning of heart produced sounds which are detected by using stethoscope [5]. Due to the mechanical functioning of heart four types of sounds are generally produced during one cardiac cycle. Heart sounds are short lived bursts of vibration having transient characteristics. From these sounds typically two sounds S1 and S2 are mainly produced for healthy subject and easily heard by using normal stethoscope. The first sound S1 produced at beginning of ventricular in systole due to closer of atria-ventricular valves and second heart sound S2 are produced at the beginning of diastole and end of systole. The sounds S1 is made up of two main components mitral component (M1) due to closure of mitral valve and Tricuspid component (T1) due to closing of tricuspid valve, sound S2 is also having two components the aortic component (A2) produced due to closing of aortic valve and pulmonary component (P2) corresponding to the closure of pulmonary valve. The frequency range of S1 is between 20 Hz -150 Hz and S2 is between 50 Hz -250 Hz [6]. The third and fourth sound are produced when any structural defect in heart and any abnormality in heart. The heart sound S3 and S4 having lower amplitude than S1 and S2 and occurs by effect of diseases or age.

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These sounds are audible and mainly occur in children's but sometimes in adults also. The third sound occurs during rapid filling period of diastole due to rush of inflow of blood which generate the pressure difference between atria and ventricle. The sound S4 occurs before occurrence of S1 and after the diastole. This is produced due to vibration occurs due to expansion of ventricle in abnormal heart [7]. The production mechanism for heart sounds are shown in Fig. 1.But some pathological processes in heart valves affect the phonocardiogram signal which produced heart murmur. Heart murmurs are vibration caused due to turbulent blood flow through the blood vessels due to damage of valves. It is one of the abnormal phenomenon's that can be detected with stethoscope. The murmurs occurs in systolic or diastole and its type depends upon pre-systolic murmur, diastolic murmur, continuous murmur and early systolic. The frequency of heart murmur is greater than 2 KHz and difficult to distinguish it from heart sounds and only depends upon human hearing ability. Murmurs are mainly of three types systolic murmur occurs temporary between S1 and S2 due to interference to flow of blood, innocent murmurs are mainly occurs in young age patients during systole and diastole murmur generated at middle to end of the diastole and restrict the laminar flow of blood [9].

III. METHODOLOGY

The investigation was carried out in order to analyze the effect of age on corresponding heart sounds using log spectral distance. The data was collected from 17 subjects having different ages from 1 to 360 months. The data was recorded by using laptop based phonocardiograph recording system at position p1 of heart. The recording of heart sounds are done by using an electronic stethoscope which has capability to record and replay the recorded heart sounds with excellent quality and produced phonocardiogram signal. Environment was kept silent in order to a high quality recording of heart sounds.

As the stethoscope sensors are very sensible therefore due to noise, recorded data get affected. Therefore signals were feed into the pre-amplifier for amplification to a desired level and also filtering was done to filter the noise component in recorded heart sounds. The heart signals were recorded at sampling frequency of 16 KHz. As heart signals consists of four sound waves.

In order to analyze the effect of age using log spectral distance the signals were segmented into four sounds. Then the log spectral distance was obtained between corresponding heart sounds of all subjects in increasing order of age by taking a least age as reference.

Fig. 2 Jabes electronics stethoscope with laptop based phonocardiogram

IV. RESULT AND DISCUSSION

The readings taken for subjects are of different ages in increasing order at position p1 of heart listed in Table I and plotted in Fig. 3 to Fig. 6. Here age is represented along x-axis and log spectral distance is represented along y-axis. Investigation showed that as the age increases the log spectral distance also increases with different values of standard deviation. Table shows the effect of age on log spectral distance for four heart sounds S1, S2, S3, and S4. It also found that sound S1 has maximum significant log spectral distance. It is seen that the curve is best fitted for polynomial of degree 5.

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Table I shows log spectral distance and standard deviation at position p1 for four sounds of heart as a function of age

S. No	Age (Months)	Mean				S.D			
		S1	S2	S3	S4	S1	S2	S3	S4
1	9	10.5	10	8.7	8.7	2.9	3.1	1.1	1.3
2	19	11.9	11.4	9.8	10.3	5.3	4.2	2.7	2.2
3	25	11.2	11.4	9.5	9.5	4.0	3.6	1.8	1.9
4	48	9.7	10.5	9.2	9.0	2.8	3.7	2.0	1.5
5	60	11.1	10.4	9.0	9.6	3.5	4.1	1.5	1.9
6	71	13.7	11.1	9.9	9.7	6.2	5.0	2.4	2.5
7	96	10.2	10.4	9.5	8.9	3.5	3.8	2.1	1.3
8	134	10.7	10.8	8.8	9.0	3.4	3.6	1.6	1.5
9	144	10.7	9.5	9.2	9.0	4.2	2.4	1.6	1.4
10	146	12.2	12.1	9.5	9.0	6.4	5.3	2.4	1.6
11	156	10.8	9.8	8.8	8.8	3.3	2.3	1.5	1.5
12	276	20.9	21.2	19.2	18.4	5.2	5.0	2.2	2.2
13	300	20.8	20.8	19.4	18.2	4.5	4.8	2.3	2.1
14	324	20.4	22.2	19.2	18.1	4.7	4.9	2.3	2.3
15	324	20.8	20.7	19.9	19.7	4.5	5.1	2.3	2.2
16	360	19.9	21.2	19.4	19.4	4.7	4.6	2.5	2.2

V. Conclusion

Data was recorded by using electronic stethoscope. The investigation was carried out on heart sounds, obtained from different individuals. It may be concluded that the log spectral distance of corresponding heart sound is increased as the age of different individual increases.

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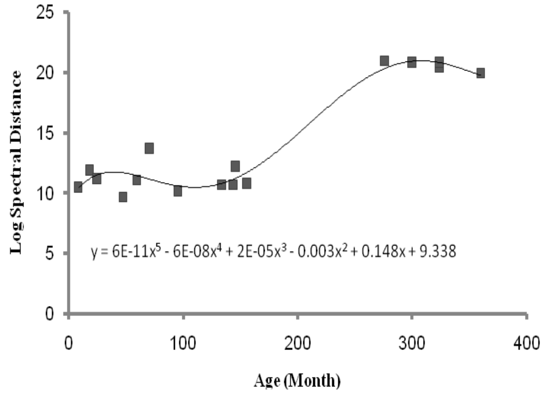

Fig. 3 Log spectral distance of heart sound S1 at position p1 as a function of heart

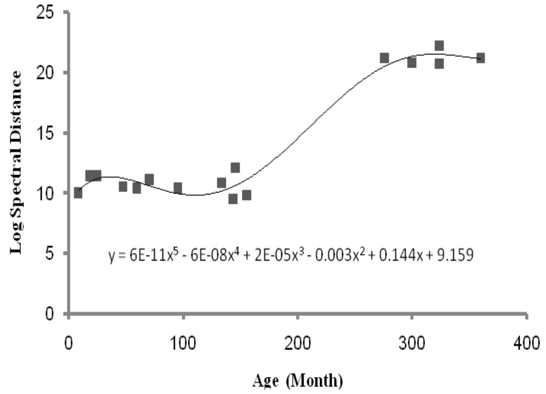

Fig. 4 Log spectral distance of heart sound S2 at position p1 as a function of heart

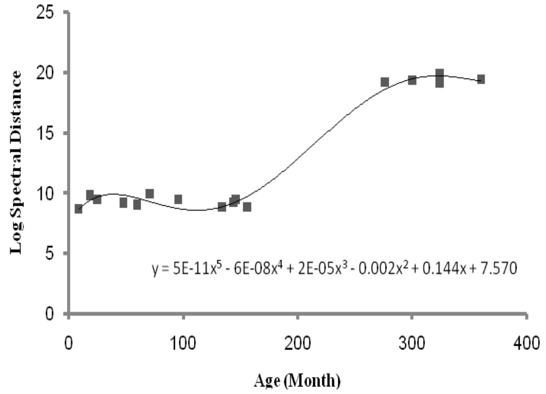

Fig. 5 Log spectral distance of heart sound S3 at position p1 as a function of heart

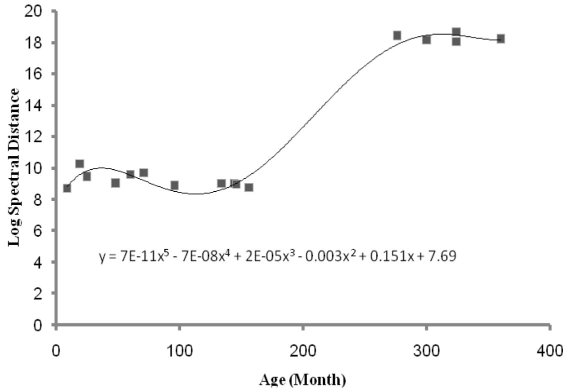

Fig. 6 Log spectral distance of heart sound S4 at position p1 as a function of heart

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