A COMPARATIVE STUDY TO ASSESS THE ACUTE EFFECT OF MUSIC AND NOISE ON HEART RATE VARIABILITY IN YOUNG HEALTHY ADULTS.

Dissertation submitted to

THE TAMILNADU DR.M.G.R MEDICAL UNIVERSITY,

CHENNAI – 600032

In partial fulfillment of the requirement for the degree of

Doctor of Medicine in Physiology (Branch V)

M.D. (PHYSIOLOGY)

APRIL 2017

DEPARTMENT OF PHYSIOLOGY

COIMBATORE MEDICAL COLLEGE

COIMBATORE – 14.

CERTIFICATE

This dissertation entitled **"A COMPARATIVE STUDY TO ASSESS THE ACUTE EFFECT OF MUSIC AND NOISE ON HEART RATE VARIABILITY IN YOUNG HEALTHY ADULTS."** is submitted to The Tamil Nadu Dr. M.G. R Medical University, Chennai, in partial fulfillment of regulations for the award of M.D. Degree in Physiology in the examinations to be held during April 2017.

This dissertation is a record of fresh work done by the candidate **Dr.A.DHAMAYANTHI,** during the course of the study (2014-2017). This work was carried out by the candidate herself under my supervision.

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DECLARATION

I, **Dr.A.DHAMAYANTHI** solemnly declare that the dissertation entitled **"A COMPARATIVE STUDY TO ASSESS THE ACUTE EFFECT OF MUSIC AND NOISE ON HEART RATE VARIABILITY IN YOUNG HEALTHY ADULTS"** was done by me at Coimbatore Medical College, during the period from July 2015 to August 2016 under the guidance and supervision of **Dr.N.Neelambikai.M.D.,** Professor, Department of Physiology, Coimbatore Medical College, Coimbatore.

This dissertation is submitted to The Tamilnadu Dr. M.G.R. Medical University towards the partial fulfillment of the requirement for the award of M.D. Degree (Branch - V) in Physiology. I have not submitted this dissertation on any previous occasion to any University for the award of any degree.

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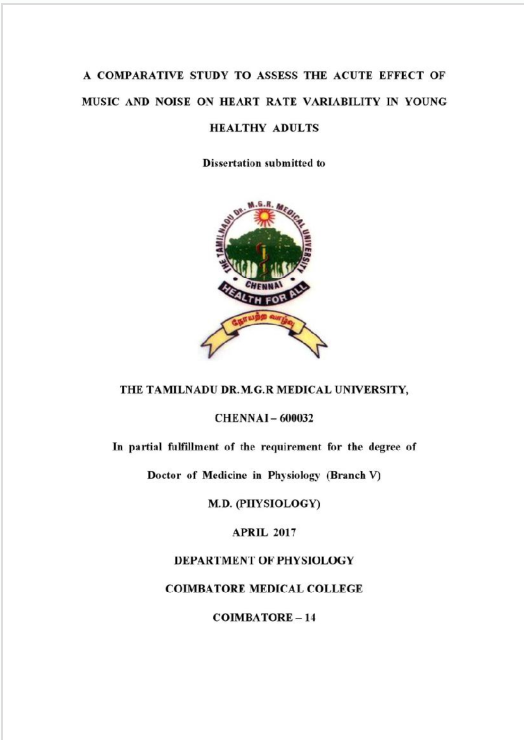

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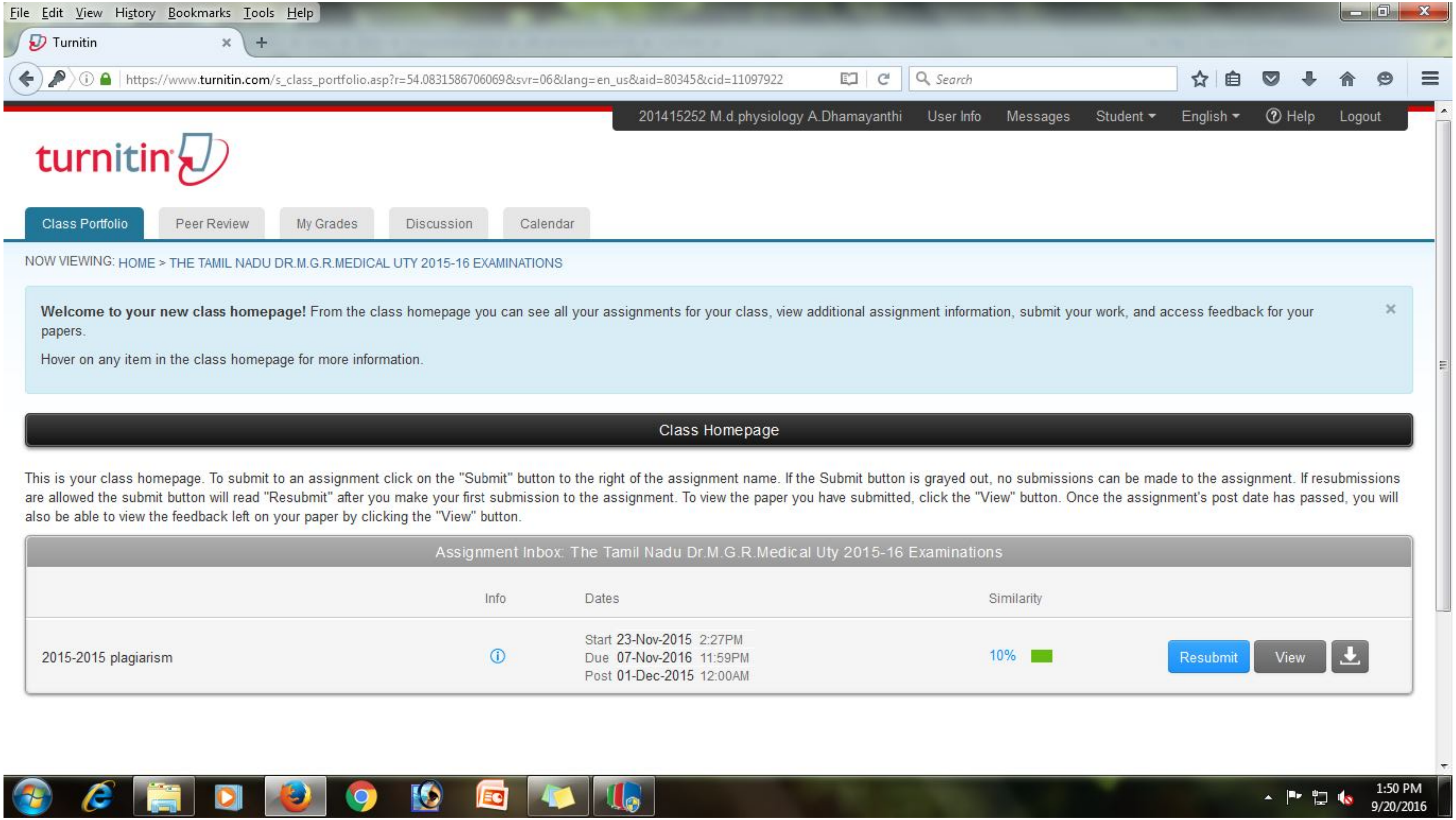
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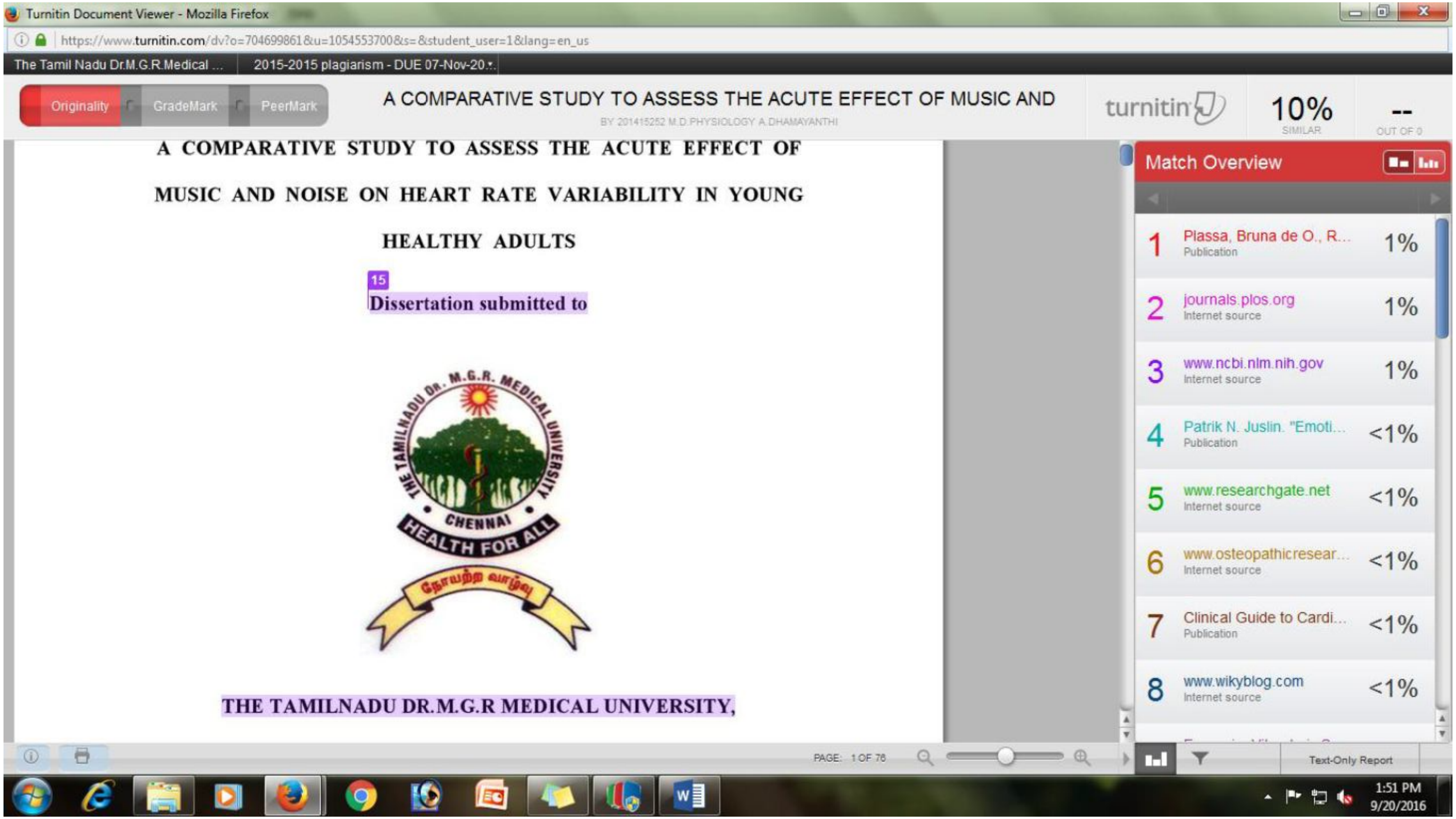
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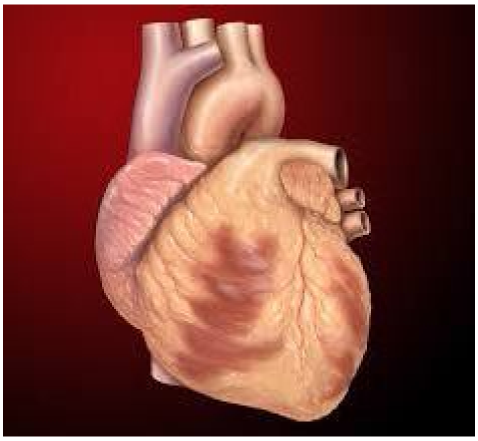


A COMPARATIVE STUDY TO ASSESS THE ACUTE EFFECT OF MUSIC AND NOISE ON HEART RATE VARIABILITY IN YOUNG HEALTHY ADULTS.

CONTENTS

ABBREVIATIONS USED IN THE STUDY

HRV	Heart Rate Variability.
ANS	Autonomic Nervous System.
SNS	Sympathetic Nervous System.
PNS	Parasympathetic Nervous System.
CVS	Cardio Vascular System
ECG	Electro Cardio Gram
IBI	Inter beat interval
FFT	Fast Fourier transformation
VLF	Very Low Frequency.
LF	Low Frequency.
HF	High Frequency
LF nu	Low frequency normalized unit
HF nu	High frequency normalized unit
RMSSD	Root mean square of the sum of successive differences between adjacent RR interval.

INTRODUCTION

INTRODUCTION

Music is a wonderful creation of human being, which plays a major role in each and every activity of human life right from ancient days. 'Music is a mixture of frequency, rhythm , compactness, tone, beat , reverberation, repetition, intensity, and lyrics'[1]. It is labelled as a powerful force which is capable of creating international brotherhood, as well as peace. Music is an appreciated device to understand the human emotion, cognition and fundamental brain mechanisms[2].

Flutes made up of vulture bones were identified in the caves near Southern Germany 40,000 years ago, which are the oldest musical instruments discovered so for. It is presumed that the ability of human to learn musical devices occupied in the language evolution, communication, cooperation, and social cohesion. Parental singing plays an important role in the intellectual, expressive and communal development of kids.[3]

In the modern era, people's desire is unlimited and wanted to live a luxury life. To achieve that they work too hard and ultimately end up in stress. The autonomic functions are not regular even in healthy subjects, because of repetitive stress, which has become an integral part of the modern lifestyle[4].

Autonomic imbalance mainly occurs due to stress[5]. Stress activates the sympathetic system & inhibits the parasympathetic system. This sympathovagal imbalance ends in many non communicable diseases such as hypertension, diabetes and cardiovascular diseases.[6,7]

Exercise and yoga are helpful to improve the parasympathetic system[6,8]. However it needs practice, guidance from experts, regularity and dedication from individual and it is more time consuming. Further, it boils down, Is there any other simple way is present to modulate autonomic nervous system?, Yes, several studies suggest that 'MUSIC' plays an important role in regulating sympathovagal balance.[4,9-15.]

Listening to music is non-invasive, is a greatly acknowledged intervention tool. It is very useful in the management of stress and stress associated health problems.[5]

Music has the intrinsic ability of lessening psycho-biological stress response. However, the surviving literatures is not sufficient to explain about the valuable effect of music over the autonomic nervous system[5]

Noise refers to disagreeable sound. It has become an important environmental pollution in everyday life due to urbanization and industrialization. Migration of more people from rural areas to urban areas results in overcrowding, which ultimately end in noise pollution[16]. The noisy environment causes irritation to loss of hearing .

Numerous studies have validated that the natural environment increases well-being & decreases physiological stress responses as compared with urban environments. Many research has elucidated that natural sounds are observed as pleasant component and industrial sounds are observed as an unpleasant component.[16-19]

Exposure of noise is linked with adverse cardiovascular health effects. More precisely, it is associated with elevated blood pressure, hypertension, ischemic heart disease including myocardial infarction[18].

In the past two decades various studies involving both human beings and animals have revealed a significant association between the sympathovagal imbalance and cardiovascular adverse effects. In modern civilization due to industrialization, sedentary life style and intense stress, one of the primary causes of cardiovascular mortality is autonomic imbalance[19].

Autonomic modulation of Heart Rate, is assessed by Heart Rate Variability[HRV].[20] HRV is considered as a standard, non-invasive tool used to measure autonomic dysfunction.[12]

HRV denotes variability between cardiac beats and is the most sensitive indicator of sympatho vagal balance. This state of sympathovagal balance is used in the prevention, diagnosis and management of several cardio vascular disorders and many autonomic dysfunctional disorders[12,20].

HRV analysis is used to specifically assess the effectiveness of cardiac vagal control of the individual, as it denote the variation that occurs mainly due to sinus arrhythmia. During inspiration vagal inhibition occurs due to central irradiation of impulses from the medullary respiratory center to the cardio vascular center, responsible for the fluctuations in heart rate during respiration - Respiratory sinus arrhythmia.

Herat rate[HR] is mainly regulated by the ANS. Normally, parasympathetic has cardio inhibitory effect and sympathetic has cardio accelerating effect. HRV analysis is a tool of sympathovagal balance. It mirrors the fluctuations in the period in-between heart beat (R waves) over time. R–R interval or inter beat interval (IBI) is the interval between two consecutive R waves which is measured in milliseconds.

Autonomic Nervous System directs the inter beat interval via sympathetic and parasympathetic neural pathways. Under resting conditions in healthy individuals, parasympathetic system plays dominant part in controlling the HR. In stressful and emergency conditions sympathetic plays a main part in regulating the HR. High value of HRV denotes parasympathetic activity, while lower HRV denotes sympathetic activity[21].

Music is a potent stimulus for inducing and modifying emotions[22]. Every person likes music because it evokes many emotional states. These emotional states are connected to the central nervous system and the autonomic nervous system. The habit of using music as a therapeutic tool is a matter of increasing attention, but only little is recognized about how music can modify physiological parameters like heart rate and respiratory rate.

Noise is an undesirable sound. Noise also causes autonomic imbalance, which is known to act as a stressor[23]. The instantaneous autonomic reactions to white noises can be identified using spectral analysis of HRV and the evoked reactions offer a profound way to evaluate the effect of white noise.

The present study is done to assess the changes in cardiac autonomic activity during exposure to classical music, rock music and white noise by using HRV.

Value of the study:

- The present study tries to establish a knowledge regarding, how classical music, rock music & white noise influence the autonomic nervous system.
- How music is used as a stress reliever in day to day life in modern civilization.
- Music related researches are relatively less in our country. This study encourages the upcoming researchers to do music related researches in the future.

AIM & OBJECTIVES

AIM AND OBJECTIVES

AIM:.

To assess the effect of classical music, rock music & white noise on heart rate variability in young healthy adults .

OBJECTIVES:

- To record short term HRV in basal state & during exposure to classical music, rock music and white noise.
- To compare the changes in HRV parameters between basal & classical music.
- To compare the changes in HRV parameters between basal & rock music.
- To compare the changes in HRV parameters between basal & white noise.
- To compare the changes in HRV parameters between classical & rock music.
- To compare the changes in HRV parameters between classical & white noise.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

MUSIC:

Music is one of the most simple and primitive socio-cognitive territories of the human race. Human musical skills played a excelling role in development of language. Music making played an important role in the evolutionary process of communication, collaboration, social cohesion and group coordination.

Ontogenetically, an infant's first steps in language development is based on the musical communication during the initial period of childhood. In the emotional, cognitive and social development of the child music plays a vital role. Since olden days, people played and enjoyed music.[20] Charles Darwin authenticated that auditory stimulation of music could have been a protolanguage in the olden era.[24]

Music is a crucial and important art. From the beginning, the art of music reflects the culture, civilization and humanism of people from different parts of the world.[25] It plays a key role in various social environments, for instance, weddings, funerals and parties.[26]

Music is the medium to extend the religious doctrines, to induce the thirst for independence and to teach the boons and banes of life. It is an element of each moment of human activity and is also used as medicine to alleviate diseases.[25]

Music was present in the form of representational arts during ancient days. When we look back on history, music started as a visual record and it transformed to oral phonation with pronuncation.[27]

Music has been around for as long as people have. In the very early period, people use music in prayers and for hunting. Humans are vocal and musical animals. They flexibly learn new vocalizations and easily observe and move to rhythm [28]

Musical notation emerged on a broad scale in every civilization. The medieval monks who composed the missals for the worship's service started enhancing the normal text into artistic work. Thus entirely narrative phase in artistic musical score design was evolved in the twentieth century.[27]

In Greece, flute music and the kithara was played in the course of the Olympic Games to improve sports performance. Music is also progressively used in neurological diseases, cardio vascular diseases and it also used as sedative in post-operative period[1].

Journal articles describe how doctors, healthcare professionals and musicians use music to treat anxiety, cancer , coronary artery disease, chronic pain and mental illness like Alzheimer's disease. During delivery of baby music can relieve pain and anxiety of the mother, and also helps to release endorphins which dramatically decreases the need for sedation and analgesia.[29]

MUSIC PERCEPTION :[3,20,30,31.]

Music perception start with decoding of acoustic information. This information is transformed into cochlea, and then gradually transformed in the brainstem. Periodicity of sounds, timber, intensity of sound and inter aural disparities are analyzed in the superior olivary nucleus and inferior colliculus. Dorsal cochlear nucleus give projection to reticular formation. Reticular formation is responsible for startle-reactions to sudden loud sounds.

Inferior colliculi can commence flight and self-protective activities in reaction to frightening stimuli, prior to acoustic data reaches the auditory cortex. From the MGB of thalamus neural information are projected into auditory cortex. Amygdala plus medial orbitofrontal cortex also receive projections from the thalamus. These structures accountable for emotional activities.

Acoustic features like pitch height, timbre, intensity and roughness are coded in the primary and secondary auditory cortex. Primary auditory cortex is positioned in HG (Heschl's gyrus) located in the superior temporal lobe. Area accountable for perception of pitch is located at the lateral part of HG. Planum temporale lies posterior to Heschl's gyrus. Planum temporale is an auditory association area involved in the analysis of complex sound sources like spatial location and information in relation to pitch patterns. Superior temporal gyrus is located anterior to Heschl's gyrus which is responsible for the investigation of streams of auditory information, for instance, spoken sentence and musical melody. Areas surrounding the anterior temporal lobe and insula are responsible for recognition of nonverbal sounds. Lateral temporal and parietal lobes connect auditory sensation and other sensations. Working memory in favor of music is coded in parietal and frontal lobes.

MUSIC AND BRAIN [32]

Right hemisphere is usually termed as the place for appreciation of music. Many studies explained that people who have injury in right and left hemisphere are also able to understand the music. For instance, the pitch recognizing area in the brain is also concerned with perception of speech. Music which enters the ears passes on to the auditory cortex. The right hemisphere is necessary for distinguishing pitch along with certain aspects of tune, timbre, rhythm and synchronization. Left hemisphere is responsible for dealing with changes in frequency and intensity in music [33,34]. Both hemispheres are required for total rhythm perception and frontal cortex is involved in rhythm and melody perception. Remaining parts of the brain are involved in emotion and pleasure[1].

Music has been revealed to evoke emotional response and stimulate the central nervous system. The brain is a flexible organ and music has the influence to shape its development. Physical organization of the human brain can be modulated by music exposure. Also, music causes long-term modifications even after complete maturation of brain. For instance people playing musical instrument habitually, may not develop dementia. It implies that music also helps in the protection of cognitive function.

Learning And Development[32]

Exposure to music brings about modifications of the brain, improving development of language and cognition particularly among the kids affected with learning disabilities. Music is able to improve the performance of a child in the classroom. It can improve language and literacy skills.

Clinical Application of Music:[32]

Music is acknowledged as an influential force in rehabilitative treatment. It can be used in brain injuries to modulate the motor dysfunction, impairment in cognition, language plus emotional disturbances. It is used for patients suffering from cerebral palsy, parkinson’s disease, stroke and traumatic brain injury to improve cognition.

In Parkinson disease, Music therapy is used to improve the mood and quality of life, to overcome bradykinesia and it is also helpful to improve body posture, swinging of arm, initiation of motor function and gait.

Music is useful in improving mood, memory, emotional state, attitude, self-awareness and also environmental awareness in people suffering from Alzheimer disease. Those people who have resistance to other treatment modalities have also got benefits from music therapy[83].

Children affected with autism also get benefits from music. It aids in the improvement of communicative and developmental skills in kids. Music helps in shaping the central nervous system and to incorporate various sensory inputs[32]. Individual affected with diseases have pain, stress, and anxiety. Music is helpful to decrease the effect of stress and pain. It can also improve the attitude of patients in pre and perioperative periods.

Music is used in the oncology department to reduce anxiety, pain and nausea. Also in the preventive, recovery plus palliative stages of malignancy. In neonatal intensive care unit, lullabies and classical music are used to improve weight gain in premature infants. It decreases the episodes of respiratory distress and oxygen desaturation. While hearing music babies become quiet and go to sleep which is helpful in painful interventions for babies like heel prick and circumcision.

NOISE:

Even though, both noise and music are sound-vibrations, they are perceived in different ways[35]. Noise is labelled as an "unwanted sound" which is subjective. Since one man's sound becoming noise to another man and vice versa. Noise is also defined as 'wrong sound at the wrong time in wrong place '[36]. Jean-Jaques Nattiez has stated that 'the border among musical auditory stimulation and noise is always culturally defined — which implies that, even within a single society, this border does not always pass through the same place'[24].

One more definition of noise is any perceptible acoustic energy that results in many functional or psychological adverse effects. Acoustic waves of haphazard intensities and frequencies which are disagreeable and unpleasant is known as noise[36,37].

Noise causes irritation, disturbing sleep and interferes with communication. Noise causes cardio vascular disorders. "One day man will have to fight against noise as cholera and pest"[38] (Robert Koch-1910).

According to the Occupational Health Safety and Health Act 1970, 90 dB is the most permissible noise intensity of exposure to a worker, without ear protectors for 8 hours a day[36].

Spankovich.C[39] studied the influence of diet on hearing status. This study result suggested that adverse effects induced by noise are more among people with poor dietary quality than those with better dietary quality.

The observation of Munzel.T et al[38] studying the relation between the noise exposure during night time and the cardiovascular adverse effect was that nocturnal noise disturbed sleep. Sleep disturbances resulted in impaired cognition, irritation, anxiety, stress and also associated with increased sympathetic tone and venous endothelial dysfunction, decreased insulin sensitivity which ultimately ends cardio vascular side effects.

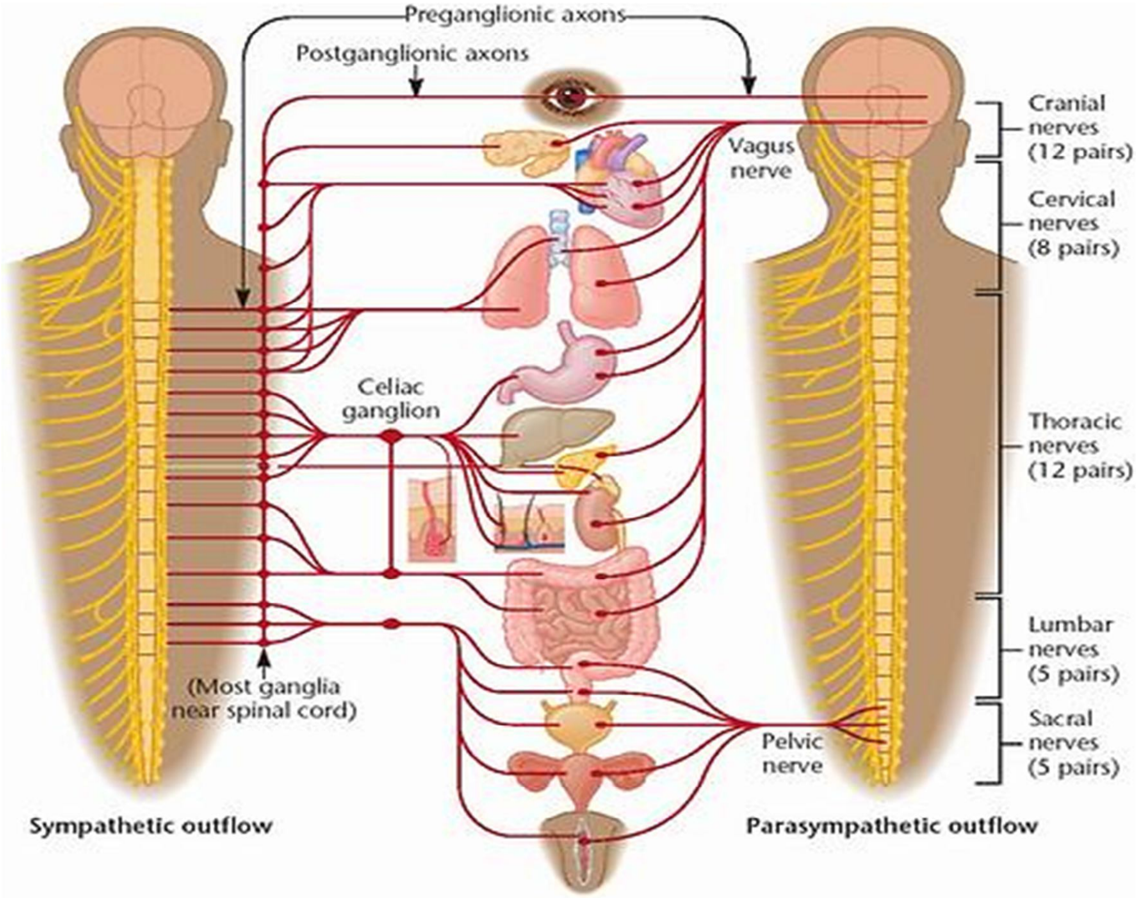
AUTONOMIC NERVOUS SYSTEM : [ANS]

"Autonomic nervous system" is a neurovisceral integerative system[12]. ANS is a part of the central nervous system, which is mainly involved in homeostasis. ANS is otherwise called as vegetative or visceral nervous system[40].

The word 'autonomous' is derived from Greek, auto means 'self', nomos means 'control'. This system was defined by Langley in 1898. Autonomic nervous system works whether we are awake and attentive, preoccupied with other activities, or asleep.[41,42]

ANS monitors autonomic afferents from the viscera and the rest of the body, compares this input with current and predicted needs, and regulates the output to the body's organ systems. [42]

Generalized Organisation of Autonomic Nervous System



General Organization of the ANS[40-45]

ANS is divided into sympathetic system, parasympathetic system and enteric nervous system based on their functional, anatomical and neurochemical properties[42]. The vegetative system is stimulated primarily by centers situated in the spinal cord, brain stem, and hypothalamus. ANS operates by visceral reflexes[40].

Cortical organization: Limbic system and prefrontal cortex are main cortical areas controlling ANS. Emotional effect of sympathetic system is mainly contributed by these areas.

Hypothalamic organization: The hypothalamus, especially the paraventricular nucleus, is the most important brain region for coordinating autonomic output. The hypothalamus projects to the parabrachial nucleus, medullary raphe, Nucleus Tractus Solitorius, central gray matter, locus coeruleus, dorsal motor nucleus of the vagus, nucleus ambiguus, and intermedio lateral column of spinal cord. Thus, hypothalamus can initiate and coordinate an integrated response to the needs of the body including modulation of autonomic output[42]. Hence Sherrington pointed out that hypothalamus is a head ganglion of the ANS.

Brainstem organization: Parasympathetic pre ganglionic neurons are found in cranial nerve nuclei of oculomotor, facial, glossopharyngeal and vagus nerve. Nucleus tractus solitorius[NTS] located in medulla gets information regarding visceral sensation via glossopharyngeal and vagus nerve. NTS closely connected with reticular formation containing cardio vascular centres and respiratory centres. ANS mediate cardio vascular and respiratory responses via NTS. Sympathetic fibre originate from vasomotor centre in the medulla and project to spinal cord through bulbospinal pathway. Stimulation of NTS increase the vagal activity and inhibits the sympathetic activity.

Sympathetic distribution of viscera is determined mainly by the locus in the embryo from which viscera originated. For example, heart obtains several sympathetic nerve fibres from the neck portion of the sympathetic chain because it is originated in the neck of the embryo before trans locating into the thorax[40].

The efferent pathway of ANS has 2 neuron. One is pre ganglionic neuron and other one is post ganglionic neuron. Sympathetic pre ganglionic neuron situated in thoracolumbar region so it is labelled as thoracolumbar outflow. Parasympathetic pre ganglionic neurons are found in some cranial nerve nuclei and sacral region of spinal cord, So it is labelled as craniosacral division. Sympathetic post ganglionic neuron located in the para vertebral sympathetic chain on either side of vertebral column or parallel to vertebral column. Parasympathetic post ganglionic neuron located near the target organ.

Neurotransmitters: Preganglionic nerve terminals of the both division of ANS are cholinergic. Parasympathetic post ganglionic neurons are cholinergic. Sympathetic Postganglionic neurons are adrenergic. Except sweat glands, piloerector muscles of the hairs and few blood vessels supplied by postganglionic sympathetic nerve fibres are cholinergic.

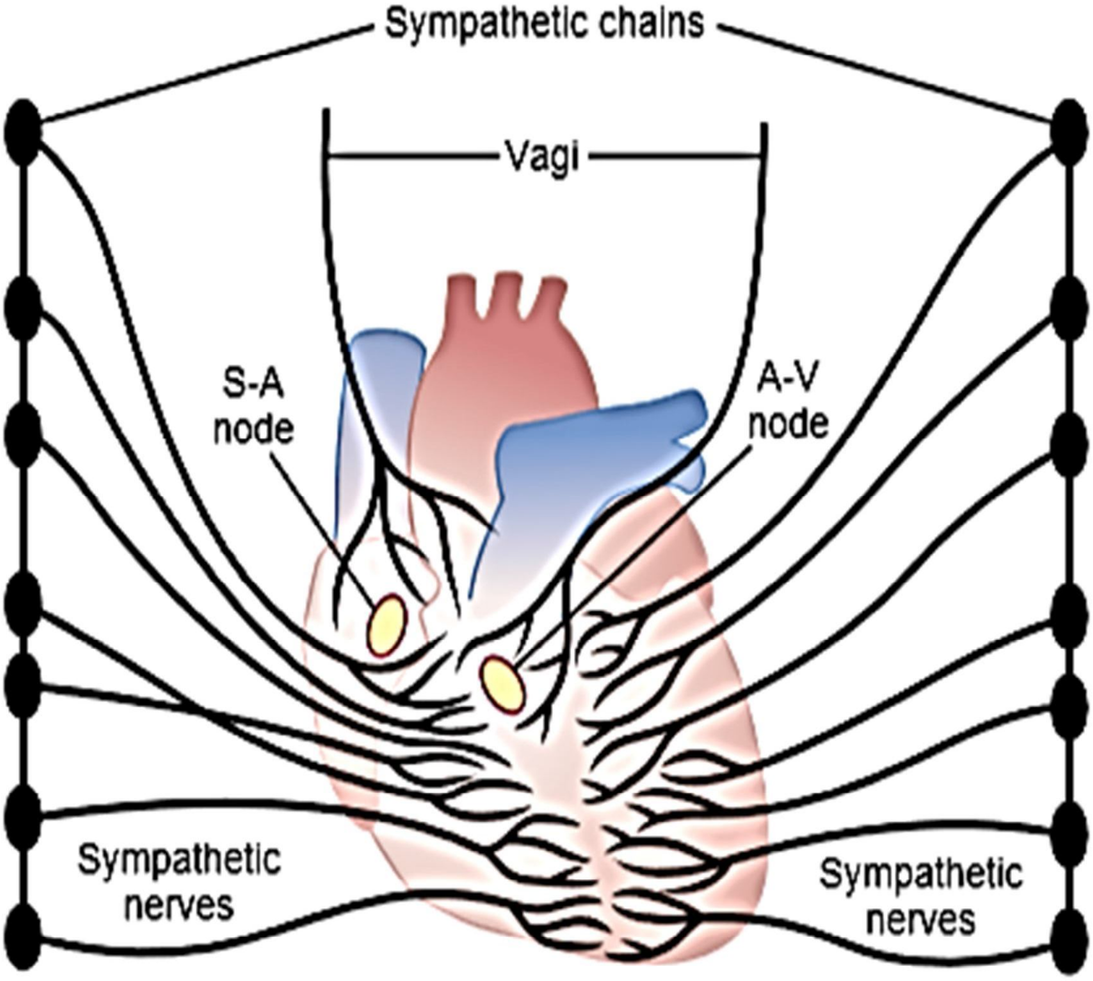
SYMPATHETIC AND PARASYMPATHETIC INTERACTION OVER HEART: [40-47]

Neural control of the heart is very complicated, due to dual innervation. Parasympathetic and sympathetic interaction occurs in the CNS and also happen within cardiac tissues[46]

The axons of sympathetic fibres supplying the heart are positioned in the the upper 4-5 thoracic segments. The preganglionic fibres are myelinated by B fibres [47]. Some of the sympathetic nerves supplying the heart are derived from cervical ganglion.

The parasympathetic fibers of heart are passed in the vagi. Pre ganglionic fibre of vagus synopses with postganglionic neurons existing in the cardiac plexus. Synaptic relays present inside the viscera is a distinguishing feature of parasympathetic system. Because of this, parasympathetic actions are limited to a small area. However sympathetic system has widespread actions.

SYMPATHETIC AND PARASYMPATHETIC INTERACTION OVER HEART



Vagus nerve arises from dorsal motor nucleus and nucleus ambiguous is located in the medulla oblongata. The right and left vagal postganglionic nerves go to the right atrium, supply SA node and AV node. Right vagus mostly supplies the SA node. AV node is mainly supplied by the Left vagus. Among the right and left vagus, right vagus dominates the pacemaker cells of heart in defining changes in the heart rate.

Left sympathetic fibres are dispersed to left side of the heart having major role in myocardial contractility and right sympathetic distribution accountable for change in heart rate. Vagal innervation has a cardio inhibitory effect. sympathetic innervation has a cardio acceleratory effect[47].

Average resting heart rate is about 70 beats per minute. Heart rate is decreased by parasympathetic activity, and it is increased by sympathetic activity. The rate that occur after complete ANS blockade is known as intrinsic heart rate. Many physiological and pathological conditions may alter these two branches of autonomic supply to result in changes in cardiovascular function.

Two divisions of the visceral nervous system provoke antagonistic effects on numerous function of the heart which is mainly due to two types interactions between sympathetic and para sympathetic system. One is Accentuated Antagonism and the second type is recognized as Reciprocal Excitation.

ACCENTUATED ANTAGONISM [46]

Effect of vagal stimulation was markedly greater when the heart is under the influence of tonic sympathetic stimulation which is labelled as an Accentuated Antagonism.

Influence of Acetyl Choline [ACh] were exaggerated in the presence of norepinephrine. An experiment done in dogs explained that Acetyl choline injected into a coronary artery had only a slight cardio inhibitory effect. But, if the same infusion was administered in the presence of increased sympathetic activity or during a continuous infusion of Norepinephrine, inhibitory effect produced by ACh was more prominent. This interactions are peculiar to ANS.

RECIPROCAL EXCITATION

Effects of the heart brought about by parasympathetic division may mimic those ordinarily evoked by sympathetic division and vice versa. The common instances include positive chronotropic effect and positive inotropic effects which can be caused by parasympathetic system. Sympathetic system can also cause cardio inhibitory effect. Reciprocal Excitation may be due to existence of sympathetic fibres in parasympathetic nerve trunk, cholinergic motivation of the heart intervened by adrenergic mechanisms.

Postganglionic axons of parasympathetic and sympathetic nerve fibres are enclosed by abundant muscle cells which form a closed system. Neurotransmitters released by the nerve ending of one division can freely diffuse to nerve endings of the other division.

Vagal Activity on Heart [40-44]

Acetylcholine released at the vagal nerve endings. These neurotransmitters has two special effects on cardio vascular system. It reduces the rate of discharge of impulse arising from sinoatrial node and also it decreases the AV nodal conduction. Weak to moderate motivation of vagus diminishes heart rate mainly, It has minute effect over the force of contraction. Strong stimulation of parasympathetic system is able to stop the rhythmical excitation of sinus node or block A-V nodal conduction. Ventricles stop temporarily for 5 to 20 seconds, after that Purkinje fibres produce a rhythm which causes contraction of ventricles. The rate of ventricular contraction is about 15 to 40 beats per minute. Which is known as ventricular escape.

Mechanism

Acetylcholine upsurges the penetrability of cell membranes to potassium ions,. Which permit more potassium efflux. So hyperpolarization occurs due to increased negativity inside the membrane. Hyperpolarization declines the resting membrane potential of SA node. As a result, threshold potential for excitation is increased. This significantly slow down the rate of rhythmicity of SA node.

Sympathetic effect over heart rate

Stimulation of sympathetic system causes contradictory CVS effects as to those produced by parasympathetic stimulation. Sympathetic system accentuate the rate of discharge of SA node. It also increases excitability, conduction rate and also strength of contraction of the heart. Resulting in increased cardiac activity as a whole.

Mechanism

Norepinephrine is released at sympathetic nerve terminals. It increases the permeability of sodium and calcium ions, Which produces further positive resting potential in SA node. "An Increase of NA^{2+}, Ca^{2+} permeability also increases the rate of upward drift of the diastolic membrane potential toward the threshold level for self excitation, thus accelerating self-excitation and, therefore increasing the heart rate". Sympathetic stimulation also decreases AV nodal conduction. Increased permeability of calcium ions may be the reason for the increased force of contraction.

HRV

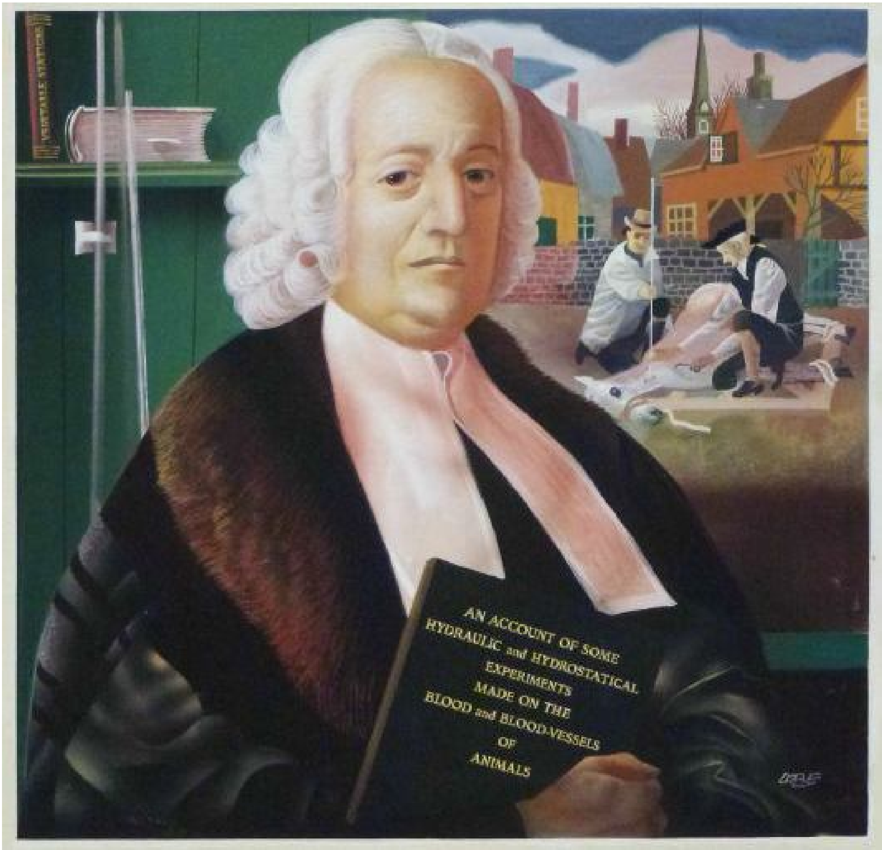
HISTORICAL OVERVIEW OF HRV[48]

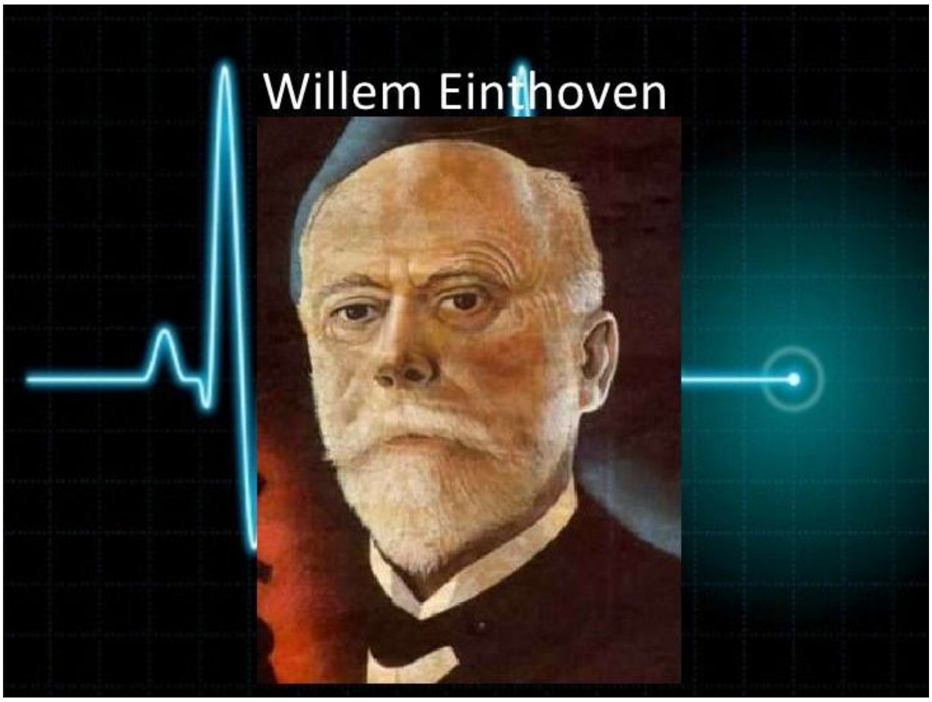
First written reports of heart rate are established in literatures of Greek scientist Herophilos. Archigenes describe about pulse and its characteristic features such as rate, rhythm, volume and he explained that pulse is caused by contraction occurs during systole and relaxation occurs in diastole.

Carl Lugwig (1816–1895).

Herophilos (335–280 BC).

Rev. Stephen Hales (1677–1761).





In 1733, Rev. Stephen Hales was the first person to report that the cardiac beat-to-beat variation and arterial pressure variation occurs during respiration.

In 1847, Carl Ludwig discovered the smoked drum - kymograph which is helpful to measure the mechanical activity. He did an experiment in dogs and he found that during expiration pulse rate is diminished and in inspiration pulse rate is amplified . Which is the first recognized document regarding Respiratory Sinus Arrhythmias [RSA].

Ludwig Traube (1818–76) suggested that arterial waves occurs due to irradiation from medullary respiratory centres to cardiac centres. In 1871 Karl Ewald Hering established that these episodic fluctuations are due to reflex stimulation of afferent fibres placed in the lungs.

Francis Bainbridge (1874–1921) anticipated that RSA is not due to the involvement of nervous system but it is due to variations in the thoracic pressure which occurs during each respiratory cycle that will result in the mechanical distortion of atria.[48-50]

Willem Einthoven (1860–1927), quantitated the accurate ups and downs in electrical events of the heart, with the help of galvanometers, which is the first constant recordings of electrical events of the heart.[50]

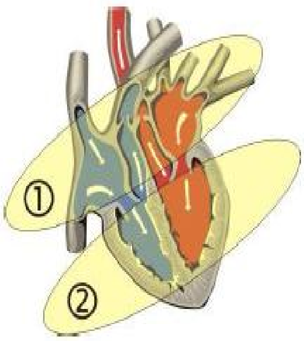
In 1960s, ambulatory ECG was recorded for 24hours by means of a small transportable recorder discovered by Jeff Holter, which is helpful to understand the cardiac beat-to-beat variation.

In 1970s power spectral analysis comes to analyse the foundation for beat to beat fluctuations in heart. Subsequently the field has quickly extended. Time domain and frequency domain methods were used to quantity HRV.

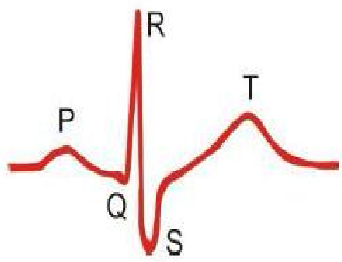
Cerulli in 1991 introduced spectral analysis of HRV in rats and in 1992 Zieglac introduced HRV spectral analysis in humans. Later in 1996 Task Force of European society published Standards of measurement for HRV

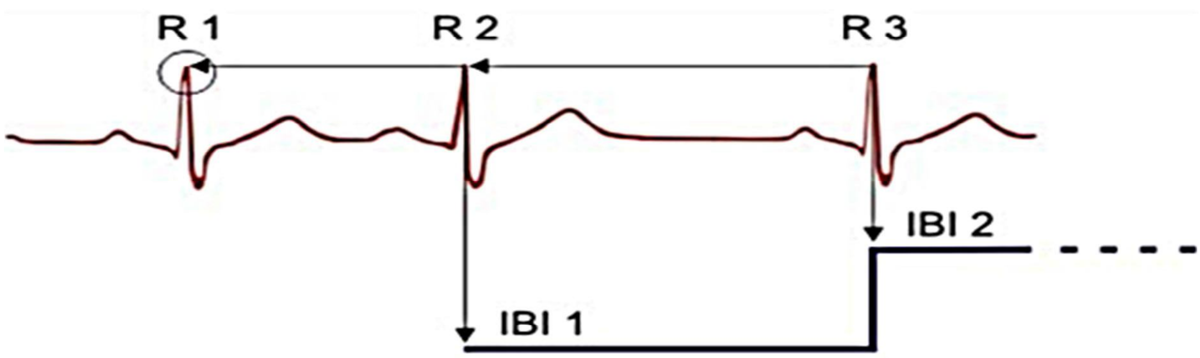
BASIS OF HRV [26,44,51-54]

Cardiac beat to beat variation is a physiological phenomenon. This variation is measured by HRV. It measures the degree of fluctuations in the inter beat interval or otherwise called as RR interval. This interval can obtained from ECG or Plethysmogram. HRV reflects autonomic regulation of heart rate. When autonomic regulation of the heart rate is good it produce high value of HRV, this value denote parasympathetic activity. Any alteration in autonomic balance produce low value of HRV. Sympathetic activity denoted by low level of total power of HRV.



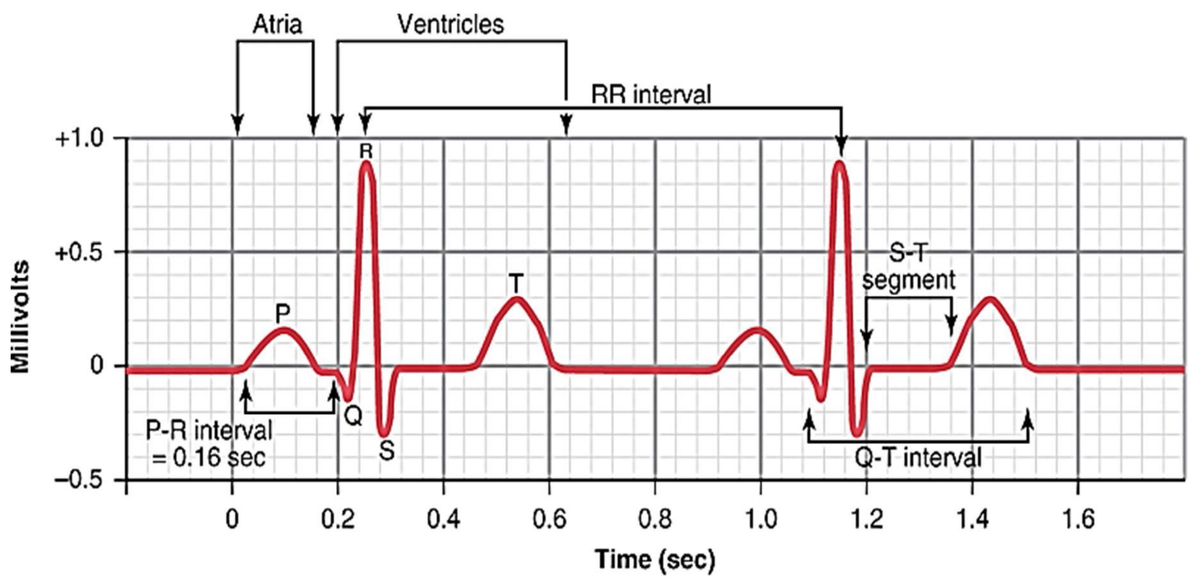
P	**Depolarization of the atria**
QRS	**Depolarization of the ventricles (& repolarization of the atria)**
T	**Repolarization of the ventricles**





Other terms of HRV include cycle length variability, heart period variability and RR variability (R corresponds to the peak of QRS complex of ECG and RR is the interval between successive Heart beat).

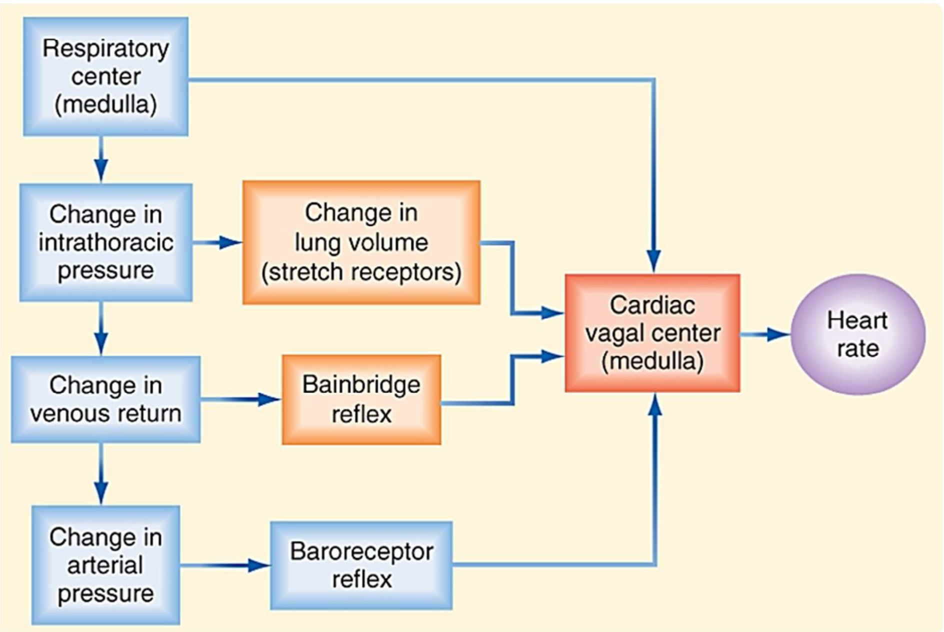
ECG is the most suitable device to analyse short term HRV because it give clear idea regarding electrical events of the heart. ECG is composed of many waves, segments and intervals. Waves are named as P , QRS and T. The QRS complex is often labelled as three separate waves namely Q,R,S. Depolarization of Atrium causes P wave. Depolarization of ventricles causes QRS complex. So P wave and QRS complex are labelled as depolarization waves. All the electrical events of the heart occurs before the mechanical events . T wave is produced by ventricular repolarisation. T wave is recognized as a repolarization wave. Thus, the electrocardiogram is composed of both depolarization and repolarization waves [40,44].



Physiology Behind HRV[24,26,44,51-56]

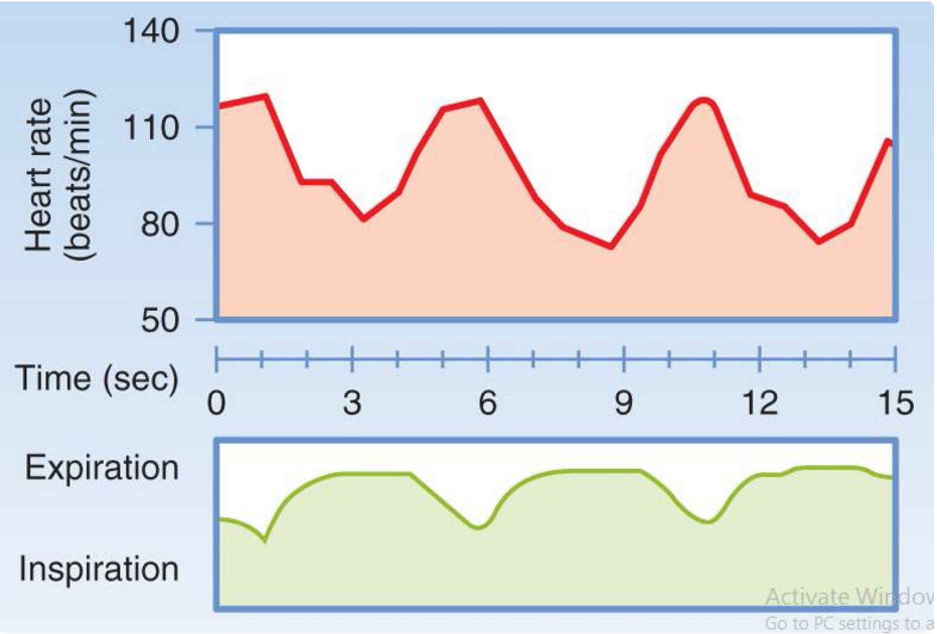
HRV is a physiological phenomenon occurs due to beat-to-beat variation in heart rate during respiratory cycle. Inter beat interval that is length between two R waves are determined by the balance between the decelerating effect of parasympathetic and the accelerating effect of the sympathetic innervation, and also by humeral mechanisms, and the intrinsic rhythmicity of the cardiac pacemaker tissue.

Physiological variations of the heart rate occurs during respiration called as respiratory sinus arrhythmia[55]. Cardiac rate variation also occurs with modifications associated with blood pressure fluctuations and baroreflex mechanisms, hormonal changes and thermoregulation which is mainly due to renin-angiotensin system and also very slow variations in response to day and night.[56]



Modulation of respiratory sinus arrhythmia by the Bainbridge and baroreceptor reflexes[57,41]

- During inspiration there occurs tachycardia and during expiration there occurs bradycardia. This is responsible for Respiratory sinus arrhythmia.
- During inspiration venous return is increased, which causes tachycardia via the Bainbridge reflex that uphold respiratory sinus arrhythmia.
- Initial length of cardiac muscle is increased due to increased venous return occurs in inspiration. As per frank starling principle increased initial length of cardiac muscle increases force of contraction that will result in increased strike volume which activates baroreflex mechanism that antagonize the effect caused by the Bainbridge reflex that is tachycardia. Thus, the baroreceptor reflex controls the respiratory sinus arrhythmia[57].
- The strength of respiratory sinus arrhythmia is depends on balance of the Bainbridge reflex and the baroreceptor reflex.



Autonomic modulation of the heart assessed by Heart rate variability, which is a simple, non expensive , non invasive, reproducible, recordable specific tool to assess autonomic function.

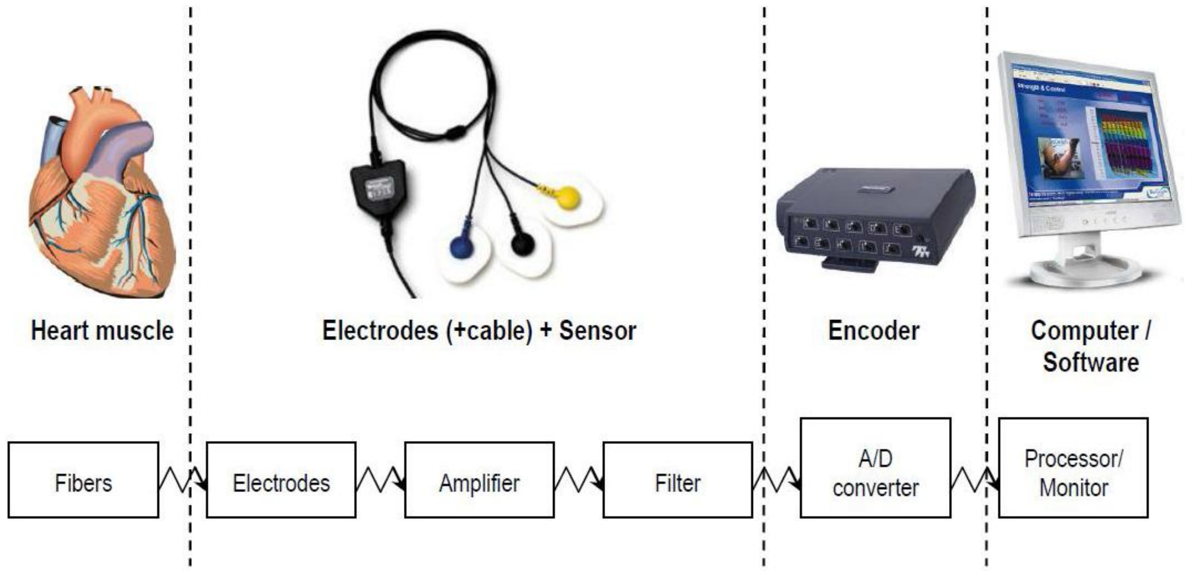
Recognition of Heartbeat Signals[58]

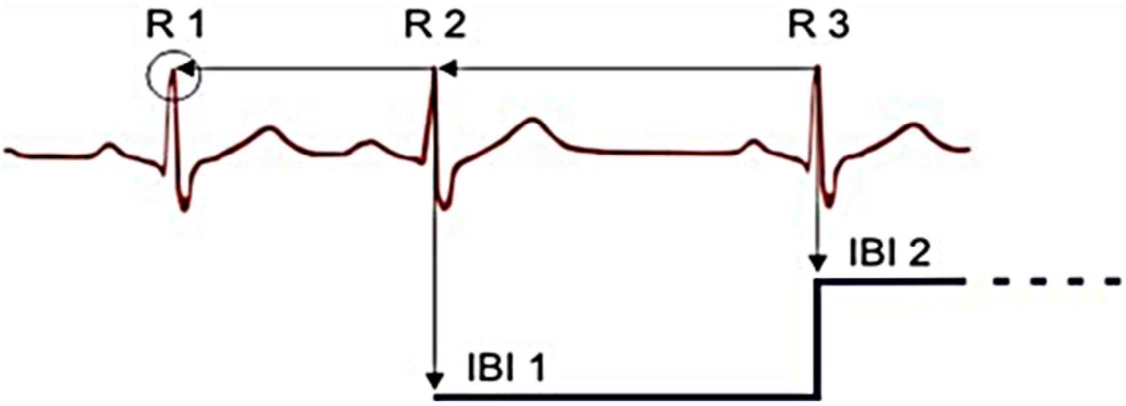
HRV biofeedback has the ability to sense heartbeats regularly and precisely. Electrocardiography is used as a sensor. It is a non invasive tool, it sense changes related to activity of the heart. The output of sensor shows a measurable beat pattern that is used to estimate the time among consecutive beats. From a sequence of such Inter Beat Interval values, a number of statistical process can be applied to take out the standard metrics used for HRV biofeedback.

Signal processing

By using the ECG signals, computer system with primarily designed software algorithms detect cardiac beats. Important point regarding the ECG signal, which permit more accuracy in the recognition of beats. The moment the first beat is detected, the program starts counting . The minute the second beat is sensed, the inter beat interval is calculated.

Detection of Heartbeat Signals





In this figure R 1 is the first spike. R2 is the second spike. Interval between R1 and R2 is labelled as inter beat interval. HRV computations is based on IBI data .

TERMINOLOGY:

In 1996 a Task Force of the European Society of Cardiology (ESC) and the North American Society of Pacing a Electrophysiology (NASPE) defined and established the clinical use, physiological explanation and standards of measurement of HRV. Frequency domain plus Time domain analysis are the standard clinically used parameters[49,50,58-60].

Heart rate variability is a indicator of autonomic modulation of the heart[61]. HRV is evaluated as time Domain and frequency domain analysis. In both methods, the time period between each consecutive QRS complex are first determined[62].

These two methods has its own advantages and disadvantages. The time domain methods are easy to estimate but do not offer a means to quantify autonomic balance. So, the main benefits of the frequency domain measures is that it contributes information regarding sympatho vagal balance.

HRV analysis can be performed on short ECG recordings lasting for 5 minutes which is labelled as short term HRV. It can be performed on 24 hour ECG recordings which is called as long term HRV. Statistical methods are used in time domain measures to compute the variation of standard deviation of succeeding RR intervals.

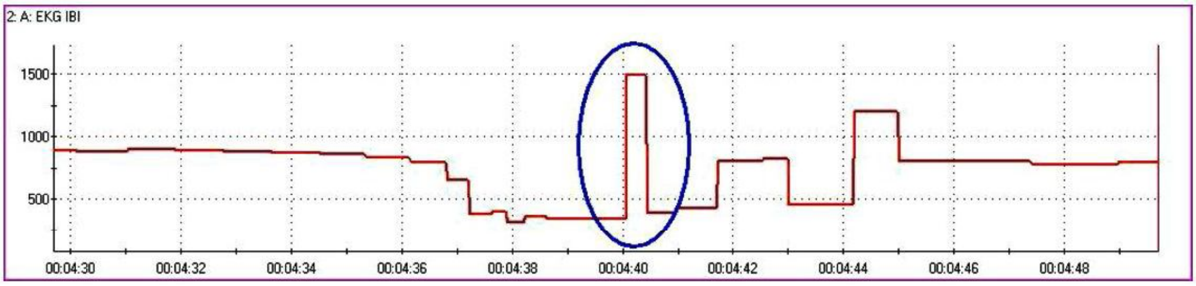
The frequency domain analysis of HRV calculate the respiratory dependent high frequency[HF] and the low frequency [LF] power. HF power is intervened by vagal activity[63], LF signifies mainly sympathetic modulations [61,64].

One essential factor to analysing Inter Beat Interval in HRV analysis is that the data should be artefact free.

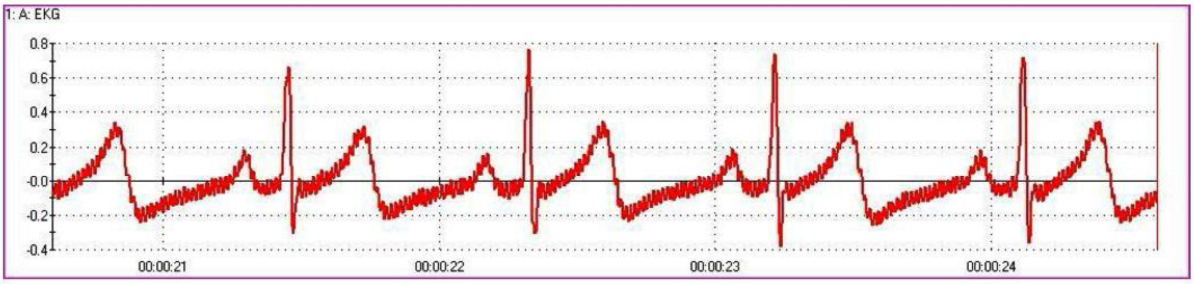
HRV artefacts [58,65]

There are two kinds of HRV artefacts one is missed beats and another one is extra beats. Both are commonly produced by signal distortion. This artefact causes very high rises of waves or very low drops of waves on a graph so it is easily seen. Proper editing help to eliminate this type of artefact.

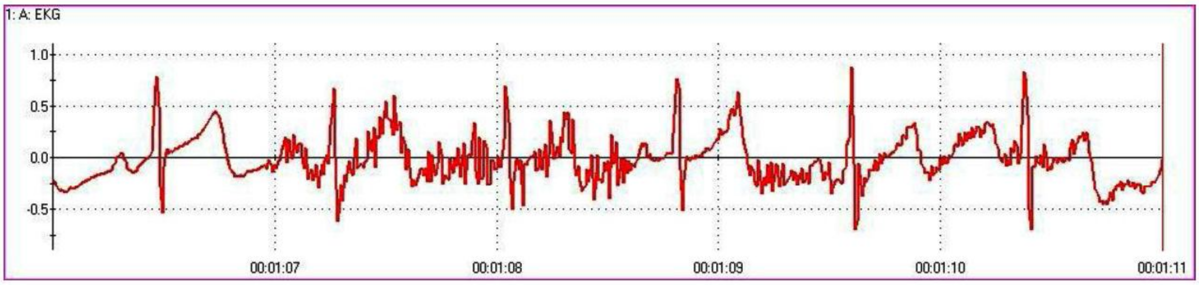
HRV Artefacts



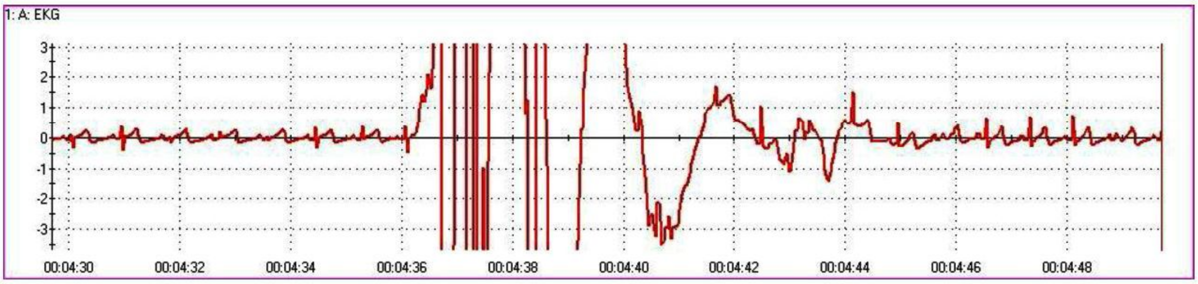
ECG Artefacts



Muscle Contraction Artefacts



Electrode Movement Artefacts



ECG artefacts

Line interference is the most common artefact. It is mainly due to electrical devices present near the data acquisition system. Unused sensors are disconnected to prevent this type of artefact.

Muscle contraction artefacts

Heart being a muscle the electrical activity of the heart is not very much altered from that of the other muscles. ECG get signal from nearby muscle mainly from chest plus arm muscles. This artefact produce many extra beats. So subject is asked to relax their chest and arm muscles as much as possible.

Electrode movement artefacts:

When subject moves enough to pull the cable and one of the electrodes off the skin, which can generate extensive deviations. ECG Wrist straps give some freedom of movement and increase the contact of electrodes. By using ECG Wrist straps this type of artefacts are avoided.

MEASUREMENTS OF HEART RATE VARIABILITY [6,49,58, 62,64,66,67]

The main categories of HRV parameters are,

1. Time domain analysis
2. Frequency domain analysis.

Time Domain Parameters

It is the simplest technique to find out the heart rate fluctuations. Commonly used parameters are:

SDNN:

The standard deviation of all NN intervals. It is conveyed in terms of square root of variance. Which mirrors the complete cyclic component of cardiac beat variability.

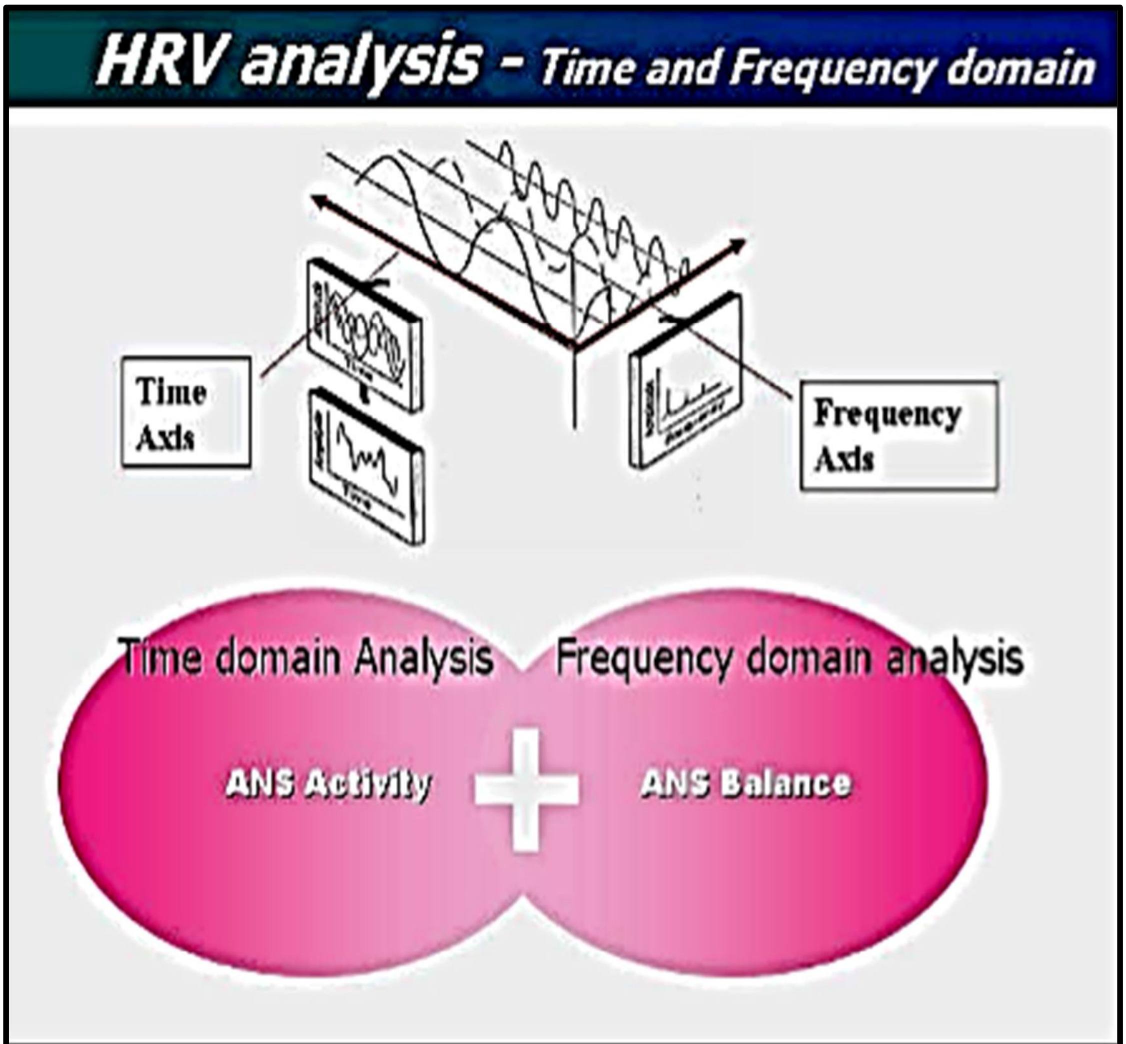
Since the value of SDNN replicates the length of recording, longer the length of recording gives higher value of SDNN and shorter recording gives the lowest value of SDNN. Millisecond is the unit of measuring SDNN. 24 hours ECG recording can reflect SDNN value better than short term recording of HRV. So, analysis of SDNN measured only in long term recording.

PNN50

It is the percentage of NN50 count divided by Over-all quantity of NN intervals

RMSSD

The square root of the mean of the sum of the squares of the differences between adjacent NN intervals. Even though RMSSD is a time domain parameter it can answer well to short term recording of HRV. It is the good interpreter of parasympathetic regulation of heart rate.



Time domain analysis and Frequency domain analysis

SDNN Index

It is the mean of the standard deviation of all NN intervals from the total recordings of 5 minutes ECG. It normally reflects the autonomic balance of cardiac rate variability .

Frequency Domain Parameters

Power Spectral Analysis: Variation in heart rate is evaluated spectrally by two methods one is fast- fourier transformation algorithm and autoregressive modelling. These two methods used to study the short term HRV. The oscillations of heart rate in a periodic manner can be determined by the power spectral density analysis which gives information about the intensity of sinus rhythm of heart, decomposition of different amplitude and frequency of heart rate.

Fast Fourier transformation also called as non parametric method where the frequencies with distinct peaks may be seen. Autoregressive model of parametric method which detects the spectral activity in a continuous smooth manner. The advantage of FFT is that it is simple to perform, very rapid and stored RR interval can be transformed in to bands of several frequencies in a different manner. The entire results are converted to hertz by dividing length of mean RR interval.

Very Low Frequency

0.0033 to 0.04 Hz is the power spectral range of VLF. It indicates the sympathetic function. Unit of measurement is millisecond square (ms^2). This component is responsible for beat variation linked with thermoregulation and hormonal regulation especially, rennin-angiotensin mechanism and local factors.

Total Power

0 and 0.4 Hz is the power spectral range of total power. Even though it reflects the autonomic activity in overall way but main contributing thing is for sympathetic activity. Millisecond square (ms^2) is the unit for total power.

Low Frequency

0.04 to 0.15 Hz is the power spectral frequency range of LF. Sympathetic and parasympathetic component, both are reflected by LF. Overall LF is the predictor of sympathetic activity. Unit of measuring LF is millisecond square (ms^2)

High Frequency Power

0.15 to 0.4 is the spectral range of high frequency and it is one of the predictor of parasympathetic activity. This was proved in several experimental studies such as blockage of muscarinic receptor, stimulation of vagus nerve, and denervation of vagus. It is otherwise known as the respiratory band as it undergoes changes in respiration. It is measured in millisecond squared (ms^2).

LF/HF Ratio:

LF/HF Ratio is higher in sympathetic dominance and lowered values represents parasympathetic dominance. Thus it represents the overall activity of autonomic balance among parasympathetic and sympathetic nervous system .

Normalized Low Frequency (LF nu)

Unit of calculating normalized LF is percentile. It reflects ratio among absolute values of LF power and difference between very low frequency and total power.

Normalized High Frequency Norm (HF Norm)

Unit of calculating normalized HF is percentile. It reflects ratio between absolute values of HF and difference between VLF and total power. Both these normalized forms minimize the effect of changes of VLF and ensure the changes in the sympathetic and parasympathetic components.

HRV - GEOMETRIC METHODS [9,68.]

RR intervals transform into geometric patterns by Triangular index (RRtri), triangular interpolation of NN interval histogram (TINN) and Poincare plot. This method has its own advantages and disadvantages. Comparative insensitivity to methodical quality of the sequence of N-N intervals is the advantage of geometric methods. Sensible number of N-N intervals needed to construct the geometric pattern is the disadvantage of this method.

PHYSIOLOGICAL FACTORS AFFECTING HRV[52]

1. Respiration
2. Posture
3. Diet
4. Exercise, yoga
5. Sleep
6. Circadian Rhythm

Heart Rate Variation Occurs During Deep Breathing[51]

As mentioned previously during deep respiration R-R intervals vary in a sinusoidal shape that prolong during inspiration and reduce during expiration. This variation is maximum at around 6 breaths per minute and is primarily mediated by parasympathetic cardiac nerves. This response lessens with age.

Effect of Standing on Heart Rate

Heart rate variation occurs during standing comprises of an instantaneous and rapid increase. This is followed by a relative slowing to a level, that is usually more rapid than the supine heart rate. In normal healthy subjects heart rate is maximal at around the 15th beat after starting to stand up, and the relative bradycardia is occur around the 30th beat. Parasympathetic pathways are mainly involved, sympathetic to a lesser extent. The extent of the response diminishes with age.

Effect of Valsalva Maneuver on Heart Rate [44,51.]

Four phases of the normal cardiovascular responses are noted during the Valsalva maneuver (blowing against resistance for 10±20s). Phase I is the instantaneous onset of strain. This brings a sudden increase in intra thoracic pressure, which is reflected by a transitory rise in BP[blood pressure] and often a reflex drop in HR.

As strain continues (phase II), venous return is reduced, and this produces a progressive fall in cardiac output and blood pressure. This blood pressure fall results in a steadily increasing heart rate and peripheral vasoconstriction.

Phase III is the period immediately following release of strain. The release of intra thoracic pressure and subsequent increase in pulmonary venous capacitance leads to additional fall in cardiac output, decrease in BP, and a reflex increase in HR.

Phase IV consists of rebound hypertension caused by the increased cardiac output, systemic vascular resistance is still elevated in reaction to the falling BP of phase II. This, in turn, produces a reflex bradycardia and peripheral vasodilatation to restore the circulatory hemodynamics to normal. The reflex pathways elaborate in the Valsalva response are multifaceted. The modifications in heart rate are mainly mediated by parasympathetic nerves. This type of test only helpful to assess the parasympathetic component of ANS.

Diet And Hrv

Diet contain high saturated fat are linked with increased activity of sympathetic nervous system[69]. High Frequency heart rate variability decreased after meals, that indicates the decrease in cardiac parasympathetic tone.

Exercise & Hrv [64,70-72]

Study exhibited that the HFnu component augmented pointedly with the exercise load, parasympathetic influences reflected by HF nu.

LF/HF ratio is an index of sympathetic activation, and the LF component diminished noticeably with the exercise load. Also, ventilation had a main effect on HRV indices during exercise.

Yoga & Hrv

In yoga, sympathetic discharge is inhibited and parasympathetic discharge is facilitated. Thus, relaxation therapies in yoga ensure sympatho vagal homeostasis.[6,71]

In normal respiration, inspiration is longer and duration of expiration is less than the half of inspiration. During inspiration, HR is more owing to less vagal tone and during expiration HR is less owing to more vagal tone. Taking benefit of this physiological phenomenon of sinus arrhythmia, our ancient spiritual visionaries, rishis and yogis had practiced pranayama as part of their natural living and lived healthily for centuries, and attained a kind of immortality.

Sleep & Hrv [73]

The interaction between ANS and sleep is multifaceted, bidirectional. According to the stages of sleep HRV parameters fluctuate. Parasympathetic activity dominates during non REM sleep, it is called quite sleep and sympathetic activity dominate during REM sleep is called paradoxical sleep.

Circadian Variation & Hrv [56]

High value of HRV is observed during non REM sleep which indicates parasympathetic activity. Circadian Variation occurs in cardiac beat variability and it is not dependent on vagal innervation. It may be due to oscillations in sympathetic activity.

CLINICAL APPLICATIONS OF HRV

The clinical importance of HRV was first distinguished in 1965, when Hon and Lee distinguished that fetal distress was preceded by modifications in inter beat intervals before any noticeable changes happened in the heart rate itself[49].

Huikuri and stein , their studies defines HRV analysis an increasing important diagnostic tool in cardiology. For example HRV is a tool to assess the risk in patients recovering from myocardial infarction.[19,49,74,75.]

Reduced or altered HRV linked to arrhythmic events as well as sudden cardiac death. HRV can also be used as a predictor of non sudden cardiac death[74]

In Motta et al study, The sympathetic nervous system has a vital role in the pathogenesis of arterial hypertension. Higher parasympathetic nervous system activity helps to reduce the cardio vascular mortality.[76]

Mathy I et al study explains, Obesity is one of the important autonomic dysfunctional disorder. Obesity associated with insulin resistance, diabetes, hypertension and dyslipidemia. Sympathovagal imbalance has been reported in obesity.[77]

Autonomic assessment in insomniac patients revealed notable results. Increased Low frequency component and decreased High frequency component of HRV are noted in insomniacs compared to healthy subjects during sleep. Insomnia is associated with sympathetic activation which leads to cardiovascular diseases.[73]

Bravi et al, terms that Physiological stress like exercise and pathological stress like infection disturbing the cardiovascular system have both been documented to be linked with a reduction in overall heart rate variability. [70]

Absolutely regular sinus rhythm is too a sign of cardio vascular dysfunction. Reduced variability in cardiac rhythm and rate is a alerting sign in patients who are alive after the critical stage of myocardial infarction[MI].[75]

At the moment of the transplantation the heart is entirely denervated. So it is not affected by ANS. Studies recommended that, increase in HRV is a indication of re-innervation of transplanted heart. [49,75]

Recording of heart rate over long periods using ambulatory ECG monitoring reveals that the heart rate varies continuously, mainly influenced by the cardiac sympathetic and parasympathetic innervation. Therefore, analysis of heart rate variation provides techniques for the investigation of cardiac autonomic innervation. The R-R intervals yield detailed beat-to-beat information and its variation is the most useful non-invasive index of cardiac autonomic neuropathy. [51]

MUSIC, ANS , HRV[12,78]

Autonomic nervous system is linked with the central nervous system, endocrine and immune system. Music exerts its therapeutic effect through ANS.

Nakamura.T et al study was done to measure the influence of auditory stimulation over vagal activity in rats anesthetized with urethane. Rats under the effect of anesthesia were exposed to a pleasant music resulted in an increase in gastric vagal activity, this was the first study to demonstrate the parasympathetic response to auditory motivation with music. A study done in rats showed that musical stimulation reduces the sympathetic activity of renal system and BP via histaminergic neurons [9,79,80]

The relation of music to emotion has been studied for decades and the literature is abundant. There exist a lot of psychological models between music and emotion, but the physiological models between music and emotion are limited. HRV is regulated by the ANS, is tightly connected with emotions.[81]

MUSIC, EMOTION, STRESS[: 82-90.]

According to a "communicative" theory of emotions, emotions are help to convey the messages from one individual to others. For instance smile is considered as a sign of happiness and weeping is recognized as sign of sadness. This nonverbal signals are universals among people even those who living in different cultures.

Music elicit emotions in a mimetic way. For instance while people are sad, they speak slowly, walk slowly and hear soft music. While people are joyful they speak loudly and move on to fast music.

Music creates some fundamental emotions of cheerfulness, depression, nervousness, and anger [85]. Music induces emotion by Brain stem reflexes[88,89]. Music can also influence our state of arousal, and excitement. 'Music energizes, surprises, soothes, delights, and otherwise shapes our emotional states'.[82]

Music listening is used as a simple, non-invasive, and acknowledged intervention tool has interest in the treatment of stress. Music is considered as the best sedative in modern days of stress and anxiety[25]. Music influences the human health by causing modulation in the autonomic nervous system[15].

Limbic system and hypothalamus play a major role in stress induced emotions. Hypothalamus is the important area regulate the autonomic nervous system.

Heart rate and music [22]

Heart rate is synchronized by brainstem structures and ganglion present in the heart and thorax, which are under the influence of cortical structures involved in emotion like hypothalamus, insular cortex, amygdale and orbitofrontal cortex. Music is able to modulate these forebrain structures by elicit many emotions.

Literature reported that music can decrease the anxiety. This effect is responsible for Blood Pressure reductions and regular breathing caused by music. Music helpful in treatment of hypertension. Studies stated that pleasant music produce dopamine release in mesolimbic areas that will help to manage depression[22,91]

Studies have reported that autonomic effect over the CVS depends on the time at which point music is heard[9]. Watanabe K[92] studies have publicized the effect of music its tempo on the ANS and respiratory system. In view of the fact that there is the communication between the ANS and the respiratory system, It is probable that the influence of musical tempo on the ANS is altered by the respiratory system. For that reason, they study the effects of the relationship among musical tempo and respiratory rhythm on the ANS.

One study explained the HRV in professional singers and amateur singers. Effect of singing like relief of tension, improved mood and happiness are more in professional singers than amateur singers[12].

2-minute silence in the middle point of music progression has a bigger impact in decreasing HR and BP. “The silence had a totally different effect on heart rate and other parameters when it came after music than it did at baseline,” Bernardi recalls. “Silence in-between music had the greatest relaxing effect. [93,94]
Bernardi says, “We discovered that controls and musicians all behaved the same way when listening to music.

The faster the tempo, faster the respiration, heart rate, blood pressure, and so on. When the music was slower, it had a slowing effect.” Music is a strong mood regulator that can encourage relaxation and diminish anxiety in altered situations. Music also have a anxiolytic effect.

HRV In Singers

Vickhoff B et al study suggest that song phrases can guides respiration, Singing causes slow, regular and deep respiration which consecutively triggers Respiratory Sinus Arrhythmia. [11,95]

NOISE, ANS, HRV

ANS is influenced by many factors like noise, mental stress, temperature, smoking, and exercise. One of the important factor is Noise. Noise induce sympathetic activity and it act as a stressor. Surveys conducted to assess the effect of noise reported that noise produces annoyance, sleep disorders and so many cardio vascular problems[23].

Noise may result in an impairment of hearing , disturbance of speech , performance issues, mental problems, and annoyance. These are considered as direct noise related health problems. While indirect effects includes autonomic dysfunction and cardiovascular dysfunction.[23,96]

Exposure of noise serves as a stressor that accentuates the sympathetic tone via hormone release[37]. Activation of fight-flight reactions induces changes in hypothalamus which control ANS and endocrine system and limbic areas. Hypothalamus is involved in various homeostatic functions like regulation of heart rate, blood pressure ,temperature, appetite and circadian rhythm. All physiological functions are disturbed by the loud noise[17].

Exposure to noise during night time has a more adverse effect than day-time noise exposure. Influence of noise on ANS was assessed by time and frequency domain analysis of HRV. Low level of HRV is taken as a risk factor for unfavorable cardiovascular events.[18]

Alvarsson JJ et al[17] research studied the comparison between a natural pleasant sound environment with unpleasant urban environments dominated by loud noise. Skin conductance level assess the sympathetic activity, HF values assess the parasympathetic activity. The key idea of this study was to found out whether recovery of stress is earlier during exposure to pleasurable sounds than to loud noise. The study concluded that recovery was quicker in the natural sound compared to noise. The mechanisms responsible for faster recovery is due to positive emotions elicited by nature sound.

The intensity of auditory stimulation is a significant issue. White noise exposure above 50 dB influences the sympatho vagal balance. Sympatho-vagal balance assessed by the LF/HF ratio. Loud noise has a strong relation with LF/HF ratio. Kraus U et al[18] studied the effect of daytime noise exposure on heart rate variability. Result suggested that noise exposure is closely associated with cardiovascular risk.

Short AE et al [97] studied the effect high noise levels in the patient admitted in emergency department . All participants are enquired by the questioner to assess the noise induced stress effect and music induced pleasant effect. Study concluded that music is a wonderful stress reliever in patients admitted in emergency department.

Human expose to music and noise unintentionally in everyday life. Music appreciation in day to day life is used for pleasure[64]. Music has a unique capacity to influence both the mind and the body. It can both convey and elicit emotions, and emotions, in turn, influence human physiology and behavior. Auditory system conduct sound signal to the nerve centre, then signal transform to cerebral cortex. Music causes changes in brain structures such as the hypothalamus, amygdala, insular cortex, and orbitofrontal cortex. These structures involved in regulation of cardiac autonomic activity. music-induced emotions has the effect on cardiac autonomic activity.

Autonomic nervous system also affected by noise. Average heart rate is an simple measure of the complex interchange that occurs between the cardiovascular system and the autonomic nervous system. Heart rate is controlled by both divisions of the ANS. HRV is a statistical measure of the level of variation in time between inter beat intervals and provides a more complete picture of an individual’s ANS functioning. It helps to provides a clear idea regarding the effects of music and noise on ANS.

In this study, the following music are selected, 1.classical baroque music 2. Rock music 3.white noise.

Hence, this study is intended to evaluate the influence of music and noise over heart rate variability. Also give an idea about changes that occur in autonomic balance during exposure to classical baroque, universal rock and white noise.

MATERIALS & METHODS

MATERIALS & METHODS

STUDY DESIGN:

It is a cross-sectional study.

STUDY PLACE:

The study was conducted in the research laboratory of Department of Physiology at Coimbatore Medical College, Coimbatore.

STUDY PERIOD:

This study was conducted during the period of July 2015 to June 2016.

SAMPLING METHOD:

Non Probability-Purposive Method

STUDY SUBJECTS:

- A total of 100 healthy young adolescents of both 50 males & 50 females in the age group of 19-22 years were included in the study.

Exclusion criteria:

1. Subject with previous experience with musical instruments
2. Who enjoyed rock music styles, classical music styles was excluded from study, because preferences of music may effect cardiac autonomic changes [13,68].
3. Subjects with history of following were excluded from the study

Diabetes mellitus, Hypertension, Dyslipidemia, known Smoker, Known alcoholics, Obesity, H/O taking medications that alter autonomic function, H/O Cardiovascular disease, Clinically hypothyroid / hyperthyroid, H/O sleep deprivation, Illiterates , Auditory abnormality

PRECAUTIONS TAKEN BEFORE STUDY:

Environmental Requirement [62]

1. Appropriate environment maintained by avoiding too bright light or noise
2. Proper room temperature maintained
3. Soundproof measures were taken to counter the sound of noise.

Before Measurement:

1. Subjects were asked not to take heavy meals, coffee, alcohol four hour before the test.
2. Subjects were asked not to exercise four hour before the test.
3. Unwanted electrical equipments were removed from test surroundings. to avoid unnecessary electrical signals that may cause artefacts in recordings.

During measurement

1. Advised to sit comfortably.
2. Advised to avoid move or talk.
3. Advised not to close the eyes or fall asleep.
4. Advised to maintain normal breathing. And not to control the breathing intentionally.

MATERIALS USED FOR THE STUDY:

1. **Proforma** : To collect the detailed history and to record the vital signs of an individual.
2. **Portable weighing machine**:

   To record the body weight in kilograms
3. **Stadiometer**:

   To measure the standing height in centimeters
4. **Standardized Mercury Sphygmomanometer**: To record the Blood pressure
5. **Tuning fork [512hz]** - to screen hearing impairment by doing Rinne's test, Weber'test
6. **Sound level meter** - To record decibel in classical, rock, white noise
7. **Head phone** to hear music
8. **Silver silver electrodes** were attached with wrist strap to conduct electrical signals.
9. **Electrode gel** to improve the conduction of electrical signals.
10. **NEUROPERFECT EMG 2000 SYSTEM** WITH INSTALLED HRV SOFTWARE. To record HRV measurement.

SOUND LEVEL METER

NEURO PERFECT EMG 2000 SYSTEM

METHODOLOGY:

ETHICS:

After getting permission from ethical committee of Coimbatore Medical College, Coimbatore, the subjects were selected. The procedure was explained in detail to the subjects and informed consent was obtained.

The Study Protocol Consists Of,

1. **History taking and Clinical Examination:**

   Recording of a detailed history including family history to

   rule out Diabetes mellitus, secondary hypertension, cardiovascular abnormality.

2. **Measurement of Anthropometric Indices:**

Weight of Subject:

The Subjects were instructed to wear light clothing and to stand erect with their arms relaxed at their side, with both feet close together. By using a portable standard weighing machine, weight in kilograms was recorded. Weight was measured to the nearest 0.5 kg.

Height of Subject:

Height of the subject in centimetres was measured by using a stadiometer, to the nearest 0.5cm, with the subjects were asked to standing in erect posture .

BMI:

Body mass index was calculated by Quetelet's Index.

BMI = Weight in Kg / Height in m^2.

3) Measurement Of Blood Pressure:

First, the subjects were asked to sit and relax for 15 minutes in a quiet room with comfortable room temperature. Then blood pressure was recorded in all subjects by using a standard sphygmomanometer having a cuff size of 25 x 12.5cms.

4) Hearing test:

Hearing loss was screened by using Rinne's & Weber's test.

5) PROCEDURE:

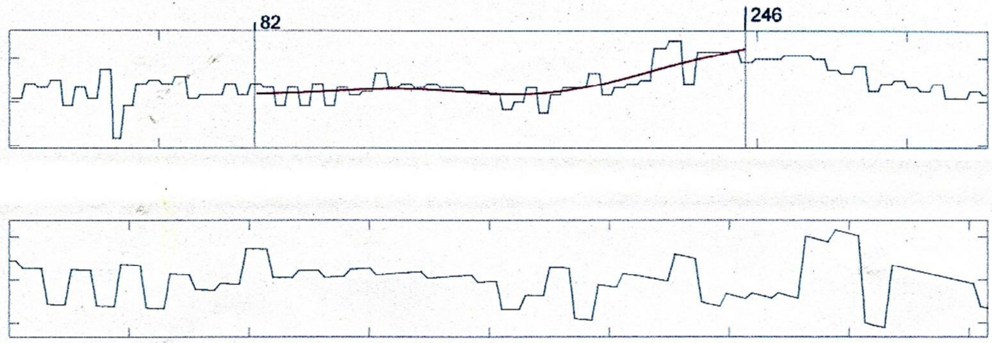
Subjects were asked to sit comfortably in quiet and relaxed environment for 15 minutes, following which electrode gel applied on both palmar aspect of wrist and both legs. Electrodes were tied with the help of using straps. Five minutes lead II ECG was acquired and digitized at rate of 1000 samples per second. Which is considered as basal HRV. After digital filtering accompanied with manual filtering to eliminate premature ectopic beats and artefacts, at least 256 R–R intervals were used for the data analysis. Only data series with more than 95% sinus rhythm were used.[63,9,14] HRV analysis was performed by Medicaide software installed in system.

HRV RECORDING

Now subjects were exposed to relaxant classical baroque- Pachelbel's "Canon in D Major'' music[13], after 15 minutes of rest again subjects were exposed to excitatory heavy metal - Gamma Ray's ''Heavy Metal Universe'' music[13], then after 15 minutes of rest again subject exposed to white noise. The volume of sound for exposure was set at 70dB±5dB using a sound-level meter[98]. All subjects were exposed to same music with same decibel in same environment during particular time period, all women were studied during their follicular phase of menstrual cycle. All these precautions were taken to avoid technical bias.

While exposed to classical & rock music and white noise 5 minutes lead II ECG was acquired and digitized at rate of 1000 samples per second. According to "Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology", Frequency domain methods preferred over time-domain methods while studying short term recordings. In time domain methods RMSSD has good statistical properties. Time domain methods gives idea about autonomic activity only but frequency domain methods completely assess the autonomic activity and sympathovagal balance.

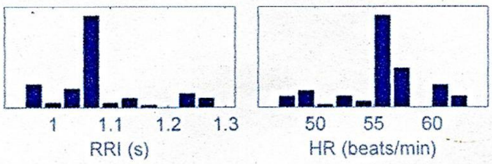
HRV analysis in Basal State



Time Domain Results

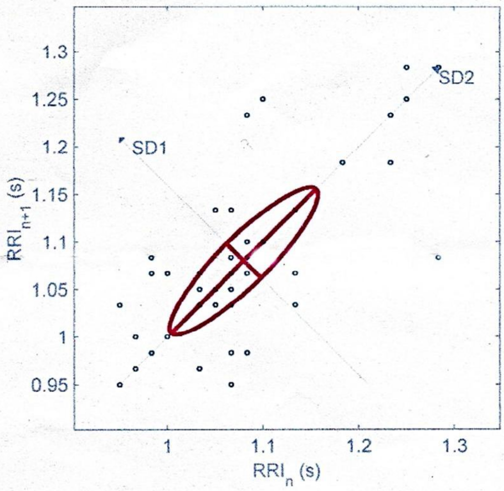
Variable	Units	Value
Statistical Measures		
Mean RR*	(s)	1.080
STD	(s)	0.047
Mean HR*	(1/min)	55.84
STD	(1/min)	2.79
RMSSD	(ms)	35.9
NN50	(count)	18
pNN50	(%)	11.9
Geometric Measures		
RR triangular index		0.060
TINN	(ms)	180.0

Distributions*

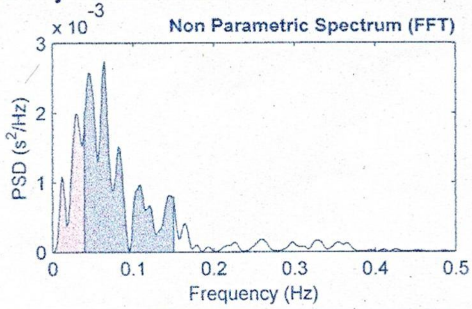


Poincare Plot*

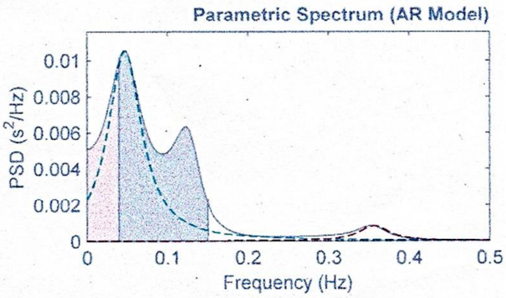
SD1 = 25.7 ms ↔ (Short-term HRV)
SD2 = 107.3 ms ↔ (Long-term HRV)



Frequency Domain Results

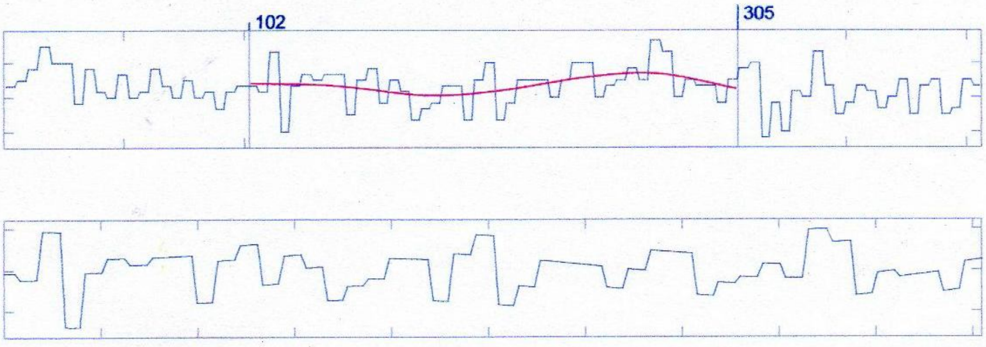


Frequency Band	Peak (Hz)	Power (ms^2)	Power (%)	Power (n.u.)
VLF	0.0293	41	22.1	
LF	0.0645	120	65.2	83.8
HF	0.1504	23	12.6	16.2
LF/HF			5.162	



Frequency Band	Peak (Hz)	Power (ms^2)	Power (%)	Power (n.u.)
VLF	0.0000	0	0.0	
LF	0.0469	684	92.4	63.0
HF	0.3574	56	7.6	5.1
LF/HF			12.244	

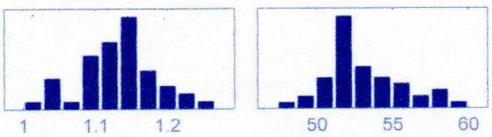
HRV analysis during exposure to classical music



Time Domain Results

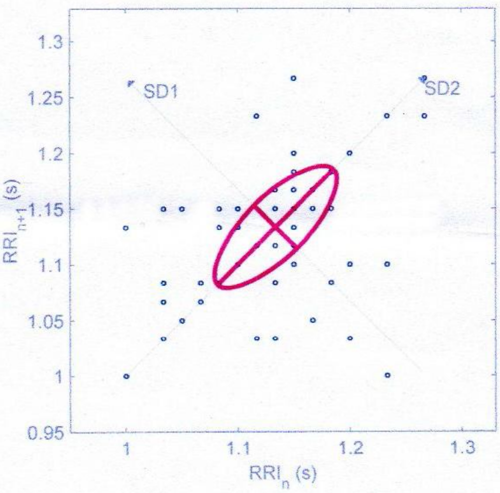
Variable	Units	Value
Statistical Measures		
Mean RR*	(s)	1.134
STD	(s)	0.050
Mean HR*	(1/min)	53.05
STD	(1/min)	2.51
RMSSD	(ms)	38.1
NN50	(count)	18
pNN50	(%)	10.1
Geometric Measures		
RR triangular index		0.066
TINN	(ms)	190.0

Distributions*



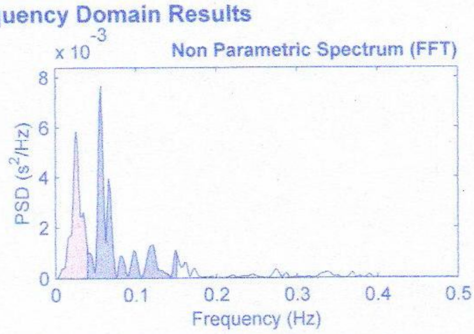
Poincare Plot*

SD1 = 27.3 ms ↔ (Short-term HRV)
SD2 = 73.4 ms ↔ (Long-term HRV)



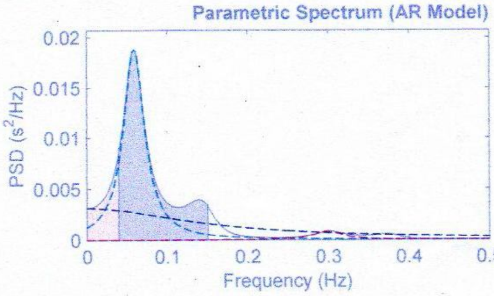
Frequency Domain Results

Non Parametric Spectrum (FFT)



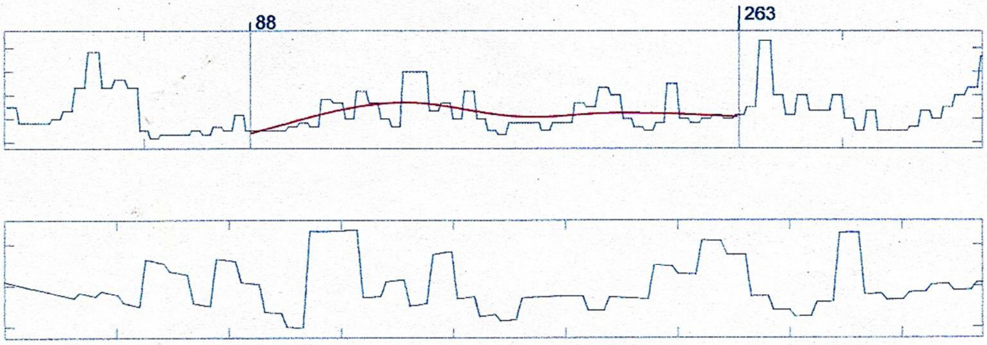
Frequency Band	Peak (Hz)	Power (ms^2)	Power (%)	Power (n.u.)
VLF	0.0254	79	33.8	
LF	0.0566	109	55.1	83.2
HF	0.1504	26	11.1	16.8
LF/HF			4.191	

Parametric Spectrum (AR Model)



Frequency Band	Peak (Hz)	Power (ms^2)	Power (%)	Power (n.u.)
VLF	0.0000	1	0.1	
LF	0.0586	875	94.4	75.7
HF	0.2988	51	5.5	4.4
LF/HF			17.012	

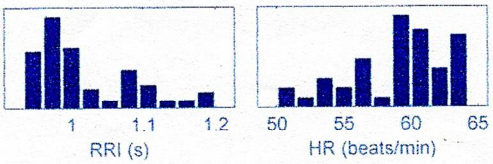
HRV analysis during exposure to rock music



Time Domain Results

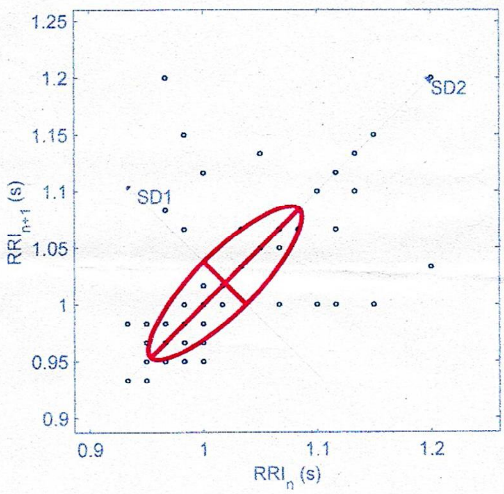
Variable	Units	Value
Statistical Measures		
Mean RR*	(s)	1.019
STD	(s)	0.058
Mean HR*	(1/min)	59.13
STD	(1/min)	3.52
RMSSD	(ms)	37.2
NN50	(count)	16
pNN50	(%)	9.4
Geometric Measures		
RR triangular index		0.041
TINN	(ms)	180.0

Distributions*

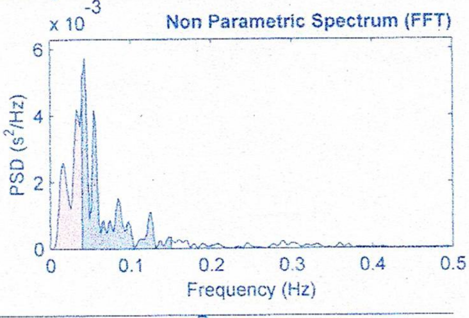


Poincare Plot*

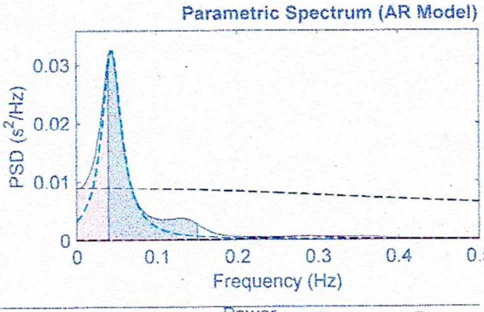
SD1 = 26.7 ms ↔ (Short-term HRV)
SD2 = 92.6 ms ↔ (Long-term HRV)



Frequency Domain Results

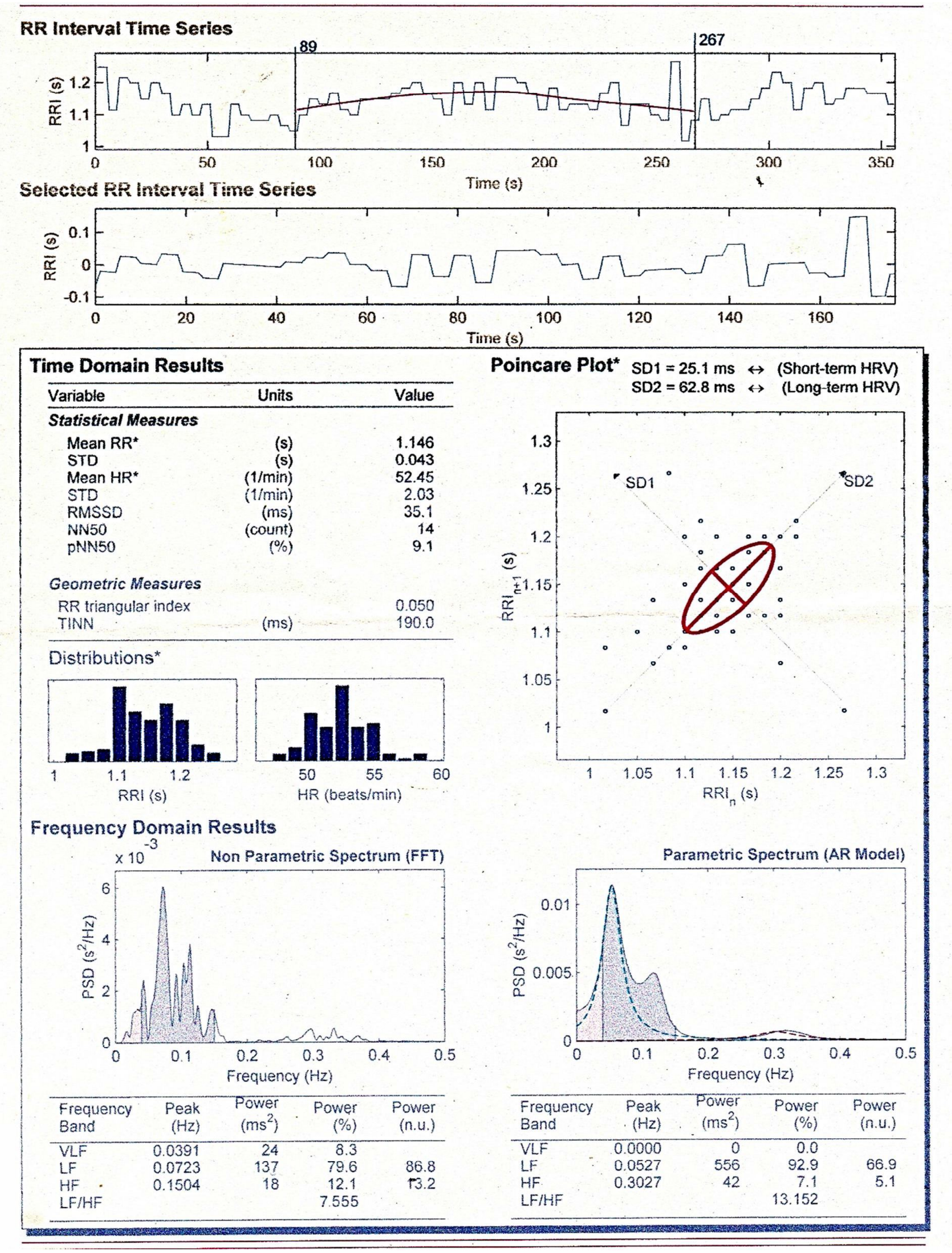


Frequency Band	Peak (Hz)	Power (ms^2)	Power (%)	Power (n.u.)
VLF	0.0332	79	37.4	
LF	0.0430	124	53.7	85.7
HF	0.1504	19	8.9	14.3
LF/HF			6.526	



Frequency Band	Peak (Hz)	Power (ms^2)	Power (%)	Power (n.u.)
VLF	0.0000	0	0.0	
LF	0.0449	1422	96.3	81.4
HF	0.2832	54	3.7	3.1
LF/HF			26.229	

HRV ANALYSIS DURING EXPOSURE TO WHITE NOISE



Time Domain Results

Variable	Units	Value
Statistical Measures		
Mean RR*	(s)	1.146
STD	(s)	0.043
Mean HR*	(1/min)	52.45
STD	(1/min)	2.03
RMSSD	(ms)	35.1
NN50	(count)	14
pNN50	(%)	9.1
Geometric Measures		
RR triangular index		0.050
TINN	(ms)	190.0

Frequency Domain Results

Non Parametric Spectrum (FFT)

Frequency Band	Peak (Hz)	Power (ms^2)	Power (%)	Power (n.u.)
VLF	0.0391	24	8.3	
LF	0.0723	137	79.6	86.8
HF	0.1504	18	12.1	13.2
LF/HF			7.555	

Parametric Spectrum (AR Model)

Frequency Band	Peak (Hz)	Power (ms^2)	Power (%)	Power (n.u.)
VLF	0.0000	0	0.0	
LF	0.0527	556	92.9	66.9
HF	0.3027	42	7.1	5.1
LF/HF			13.152	

RESULTS

RESULTS

STATISTICAL ANALYSIS

Required data collected from all the cases and data were recorded in a Master Chart. Data analysis was done by using **Statistical Packaging of Social Science 16 (SPSS 16) Version.** Statistical methods were used to calculate the means and standard deviations. ANOVA test was applied to analyses the statistical significance in HRV parameters during basal state and during exposure to classical, rock music and white noise. If ANOVA was statistically significant, then Bonferroni post-Hoc test were used for inter-group comparisons. Microsoft word and excel has been used for making tables, charts and graphs.

TABLE 1

Descriptive statistics of various anthropometric measurements in the study population (n=100)

Parameter	Height	Weight	Body Mass Index (BMI)
Mean	152.24	57.42	24.721
Std. Deviation	4.839	6.634	2.111
Minimum	146	48	21.096
Maximum	169	71	31.005

TABLE 2

Descriptive statistics of various clinical measurements in the study population (n=100)

	Pulse Rate/min	Respiratory Rate/min	Systolic Blood Pressure	Diastolic blood pressure
Mean	70.94	12.98	109.40	72.10
Std. Deviation	4.784	1.073	7.762	7.823
Minimum	60	12	90	60
Maximum	85	16	120	80

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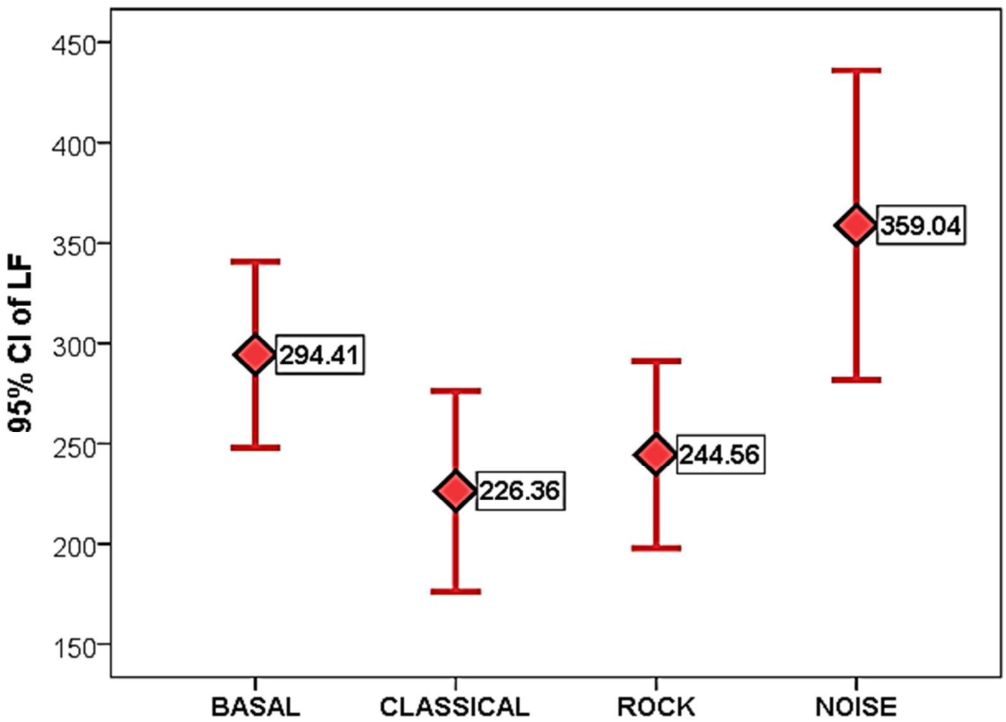
TABLE 3

Descriptive statistics of low frequency values in the study population (n=100)

LF (ms^2)	Mean	Std. Deviation	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Basal	294.41	234.779	247.82	341.00
Classical	226.36	252.622	176.23	276.49
Rock	244.56	234.937	197.94	291.18
Noise	359.04	388.789	281.89	436.18

Fig. 1: Box plot showing distribution of low frequency levels (LF exposure) and type of music (n=100)



Types of Music

Table 4:

Inter group comparison

Dependent Variable (LF levels)	**Mean Difference (A - B)**	**P value**	**95% Confidence Interval**	
			Lower Bound	**Upper Bound**
Basal Vs Classical	68.050	0.554	-38.89	174.99
Basal Vs Rock	49.850	1.000	-57.09	156.79
Basal Vs Noise	-64.626	0.659	-171.56	42.31
Classical Vs Rock	-18.200	1.000	-125.14	88.74
Classical Vs Noise	-132.676	***0.007****	-239.61	-25.74
Rock Vs Noise	-114.47	***0.029*****	-221.41	-7.54

*Statistic test showed that mean LF between classical music Vs white noise was statistically significant (p value: 0.007).

** Mean LF levels between rock music Vs white noise was statistically significant (p value: 0.029).

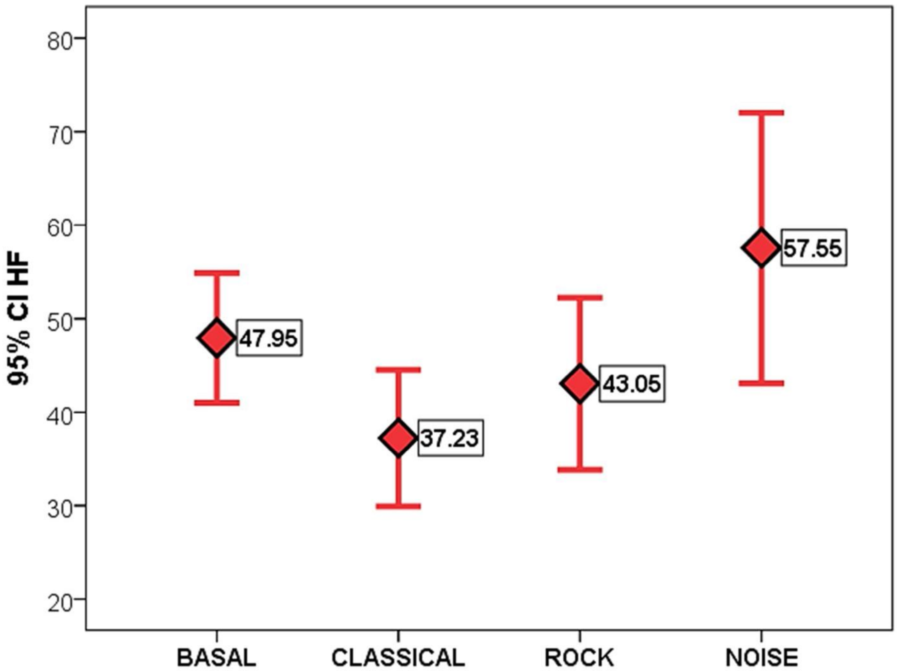
TABLE 5

Descriptive statistics of High frequency levels in the study population (n=100)

HF (ms^2)	Mean	Std. Deviation	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Basal	47.95	34.932	41.02	54.88
Classical	37.23	36.811	29.93	44.53
Rock	43.05	46.458	33.83	52.27
Noise	57.55	72.904	43.08	72.02

FIGURE 2

Box plot showing distribution of high frequency levels (LF exposure) and type of music (n=100)



Types of Music

TABLE 6

Inter group comparison

Dependent Variable (HF levels)	**Mean Difference (A - B)**	**P value**	**95% Confidence Interval**	
			Lower Bound	**Upper Bound**
Basal Vs Classical	10.720	0.787	-8.08	29.52
Basal Vs Rock	4.900	1.000	-13.90	23.70
Basal Vs Noise	-9.600	1.000	-28.40	9.20
Classical Vs Rock	-5.820	1.000	-24.62	12.98
Classical Vs Noise	-20.320	***0.026****	-39.12	-1.52
Rock Vs Noise	-14.50	0.249	-33.30	4.30

*Bonferroni test showed that the difference in mean HF levels between classical music vs white noise was statistically significant (p value: 0.026).

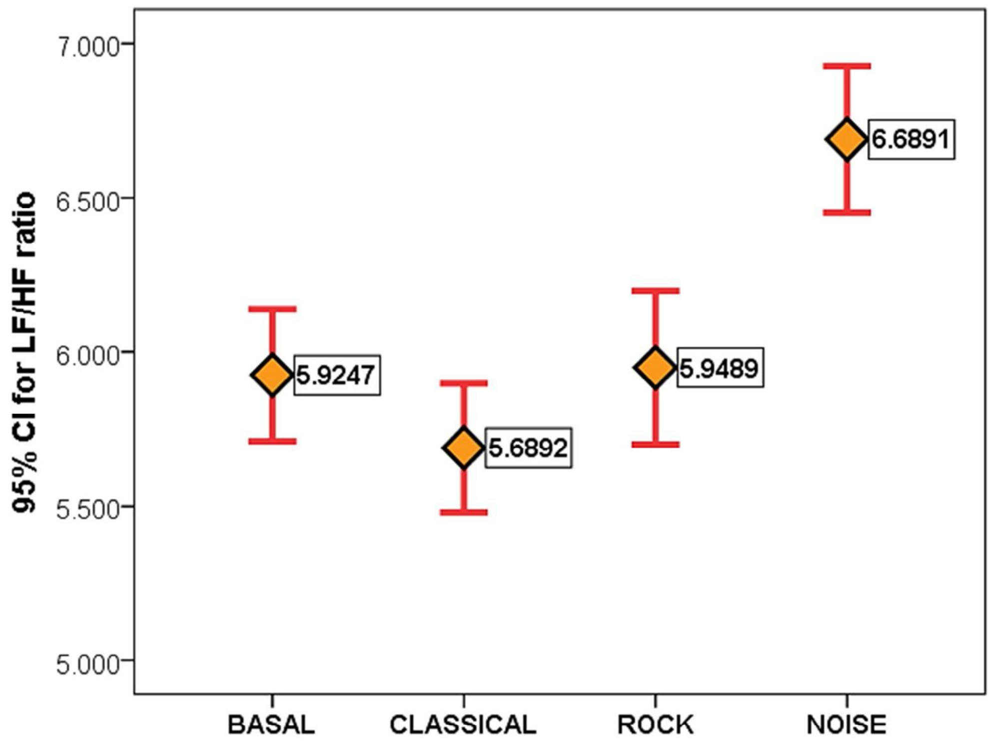
TABLE 7

Descriptive statistics of LF/HF ratio in the study population (n=100)

LF/HF ratio	Mean	Std. Deviation	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Basal	5.92474	1.080084	5.71043	6.13905
Classical	5.68916	1.050894	5.48064	5.89768
Rock	5.94893	1.254043	5.70010	6.19776
Noise	6.68914	1.199671	6.45110	6.92718

FIGURE 3

Box plot showing distribution of LF/HF ratio and type of music (n=100)



Types of Music

TABLE 8

Inter group comparison

Dependent Variable (LF/HF ratio) (A Vs B)	**Mean Difference (A - B)**	**P value**	**95% Confidence Interval**	
			Lower Bound	**Upper Bound**
Basal Vs Classical	0.235580	0.888	-0.19536	0.66652
Basal Vs Rock	-0.024190	1.000	-0.45513	0.40675
Basal Vs Noise	-0.764400	***<0.001****	-1.19534	-0.33346
Classical Vs Rock	-0.259770	0.665	-0.69071	0.17117
Classical Vs Noise	-0.999980	***<0.001****	-1.43092	-0.56904
Rock Vs Noise	-0.740210	***<0.001****	-1.17115	-0.30927

* Stastistical test showed that the difference in mean LF/HF ratio levels between basal levels Vs white noise, rock music Vs white noise and classical music Vs white noise was statistically significant (p value: <0.05).

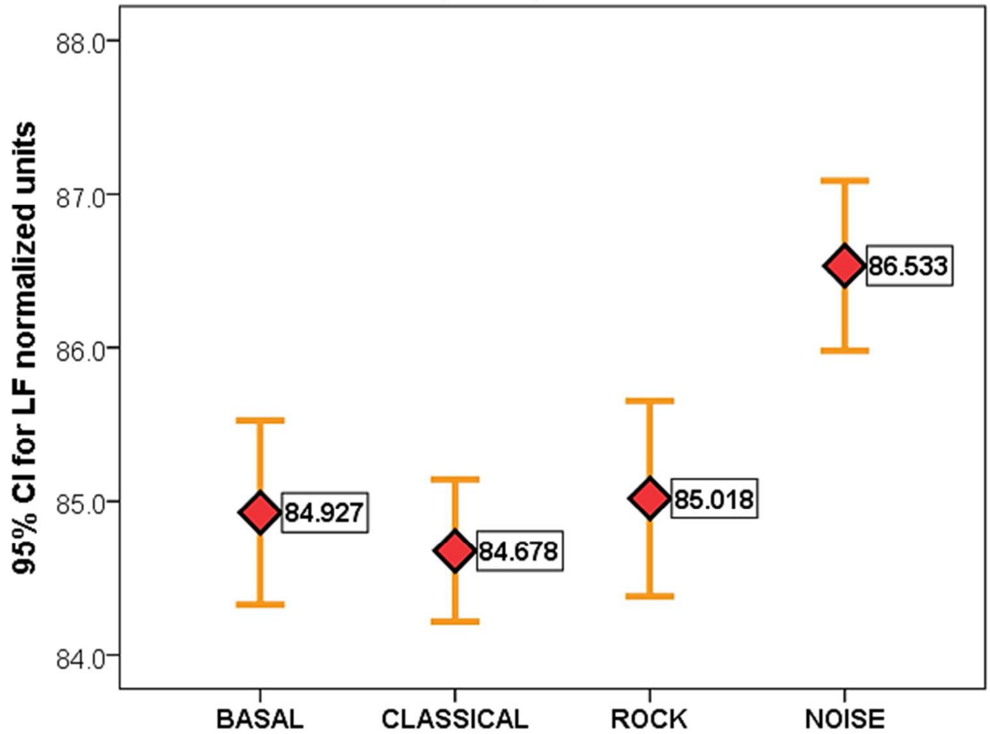
TABLE 9

Descriptive statistics of LF normalized units in the study population (n=100)

LF normalized units	Mean	Std. Deviation	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Basal	84.927	3.0164	84.328	85.526
Classical	84.678	2.3361	84.214	85.142
Rock	85.018	3.2131	84.380	85.656
Noise	86.533	2.7837	85.981	87.085

FIGURE 4

Box plot showing distribution of LF normalized units and type of music (n=100)



Types of Music

TABLE 10

Inter group comparison

Dependent Variable (LF normalized units) (A Vs B)	Mean Difference (A - B)	P value	95% Confidence Interval	
			Lower Bound	Upper Bound
Basal Vs Classical	0.2490	1.000	-0.822	1.320
Basal Vs Rock	-0.0910	1.000	-1.162	0.980
Basal Vs Noise	-1.6060	***<0.001****	-2.677	-0.535
Classical Vs Rock	-0.3400	1.000	-1.411	0.731
Classical Vs Noise	-1.8550	***<0.001****	-2.926	-0.784
Rock Vs Noise	-1.5150	***0.001****	-2.586	-0.444

*Bonferroni test showed that the difference in mean LF normalized unit between basal levels Vs white noise, rock music Vs white noise and classical music Vs white noise was statistically significant (p value: <0.05).

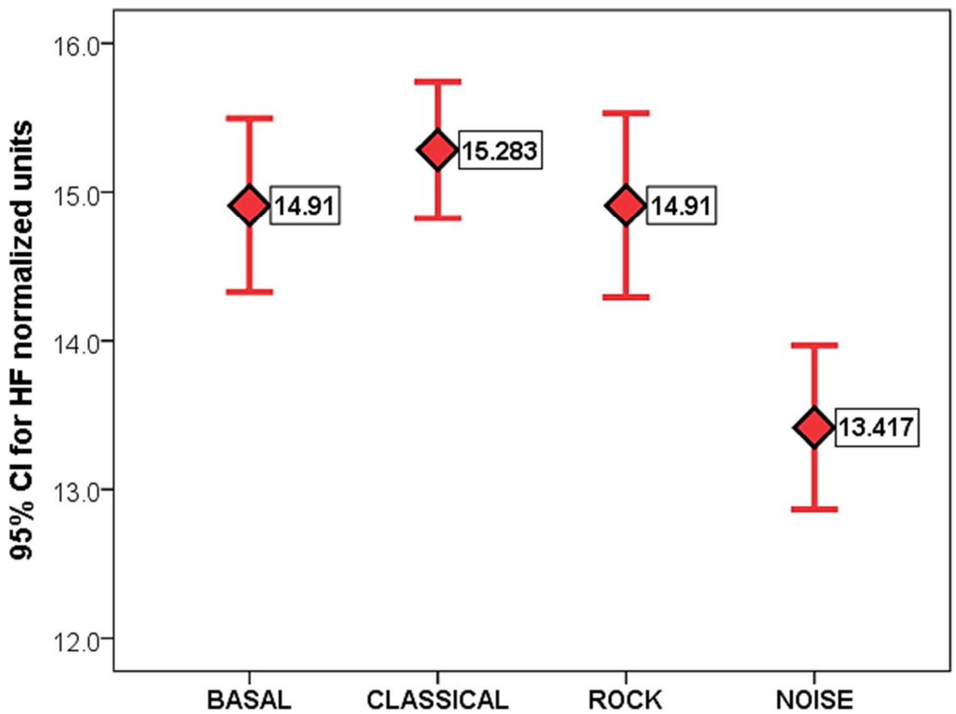
TABLE 11

Descriptive statistics of HF normalized units in the study population (n=100)

HF normalized units	Mean	Std. Deviation	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Basal	14.910	2.9371	14.327	15.493
Classical	15.283	2.3149	14.824	15.742
Rock	14.910	3.1115	14.293	15.527
Noise	13.417	2.7852	12.864	13.970

FIGURE 5

Box plot showing distribution of HF normalized units and type of music (n=100)



Types of Music

TABLE 12

Inter group comparison

Dependent Variable (HF normalized units) (A Vs B)	Mean Difference (A - B)	P value	95% Confidence Interval	
			Lower Bound	Upper Bound
Basal Vs Classical	-0.3730	1.000	-1.424	0.678
Basal Vs Rock	0.0000	1.000	-1.051	1.051
Basal Vs Noise	1.4930	***0.001****	0.442	2.544
Classical Vs Rock	0.3730	1.000	-0.678	1.424
Classical Vs Noise	1.8660	***<0.001****	0.815	2.917
Rock Vs Noise	1.4930	***0.001****	0.442	2.544

*Statistic test showed that the difference in mean HF normalized unit levels between basal levels Vs white noise, rock music Vs white noise and classical music Vs white noise was statistically significant (p value: <0.05).

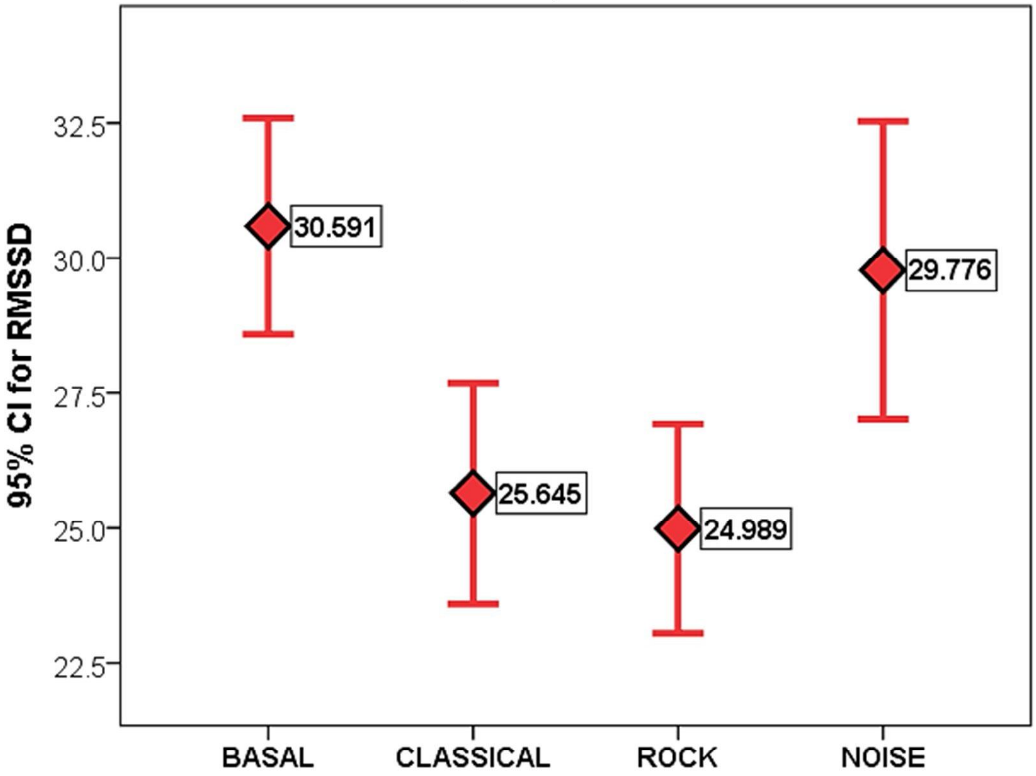
TABLE 13

Descriptive statistics of RMSSD values in the study population (n=100)

RMSSD (ms)	Mean	Std. Deviation	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Basal	30.591	10.1030	28.586	32.596
Classical	25.645	10.3055	23.600	27.690
Rock	24.989	9.7839	23.048	26.930
Noise	29.776	13.8979	27.019	32.534

FIGURE 6

Box plot showing distribution of Root mean square sum of successive difference between adjacent RR interval (RMSSD) and type of music (n=100)



Types of Music

Table 14

Inter group comparison

Dependent Variable (RMSSD) (A Vs B)	**Mean Difference (A - B)**	**P value**	**95% Confidence Interval**	
			Lower Bound	**Upper Bound**
Basal Vs Classical	4.9460	***0.011****	0.765	9.127
Basal Vs Rock	5.6020	***0.003****	1.421	9.783
Basal Vs Noise	0.8146	1.000	-3.366	4.995
Classical Vs Rock	.6560	1.000	-3.525	4.837
Classical Vs Noise	-4.1314	0.055	-8.312	0.049
Rock Vs Noise	-4.7874	***0.015****	-8.968	-0.607

*Statistic test showed that the difference in mean RMSSD levels between basal Vs Classical music, Basal Vs Rock music and white noise Vs Rock music was statistically significant (p value: <0.05).

DISCUSSION

DISCUSSION

In this study 100 healthy young adolescents of both 50 males & 50 females were included. Subjects were exposed to classical music, heavy metal universe music and white noise for five minutes duration. During exposure to music and noise heart rate variability were recorded. Data collected and statistically analysed. Effect of music and noise on heart rate variability were assessed.

The highest mean Low Frequency(LF) levels were absorbed after exposure to white noise but there was fall in LF levels after exposure to rock music and classical music. LF levels between classical music Vs white noise was statistically significant. LF values reflects both sympathetic and para-sympathetic activity. In general it indicates activity of sympathetic system.

The highest mean LF/HF ratio levels were absorbed after exposure to white noise and there was a marginal rise after exposure to rock music but there was fall in LF/HF ratio levels after exposure to classical music. This ratio can be used to assess the balance between the sympathetic plus parasympathetic systems. Sympathetic system activity reflected by higher values of LF/HF, while parasympathetic activity reflected by lower value of LF/HF. Mean LF/HF ratio levels between basal levels versus white noise, rock music versus white noise and classical music versus white noise was statistically significant.

The highest mean LF normalized unit levels were noted after exposure to white noise and there was a marginal rise after exposure to rock music but there was fall in LF normalized unit levels after exposure to classical music. LFnu values reflect changes in sympathetic regulation. Mean LF normalized unit levels between basal levels versus white noise, rock music versus white noise and classical music versus white noise was statistically significant.

The highest mean HF normalized unit levels were absorbed after exposure to classical music and there was no change after exposure to rock music but there was fall in HF normalized unit levels after exposure to white noise. HFnu values indicate changes in parasympathetic regulation. Mean HF normalized unit levels between basal levels versus white noise, rock music versus white noise and classical music versus white noise was statistically significant.

The highest mean RMSSD levels was absorbed at basal level and there was marginal fall in RMSSD levels after exposure to white noise. Mean RMSSD levels between basal versus Classical music, Basal versus Rock music and white noise versus Rock music was statistically significant. It reflects parasympathetic regulation of the heart.

Study result shows that lower levels of LF values, LFnu values and LF/HF values and higher values of HF nu value after exposure to classical music, this reflect decreased sympathetic activity. Exposure to rock music causes moderate rise in LFnu, LF/HF reflect increased activity of sympathetic system. Exposure to white noise markedly increases sympathetic activity which is reflected by marked rise in LFnu, LF/HF values.

Study favorable to my results are

The effect of music on frequency domain measures of HRV and the stress level in medical students was assessed by Latha R et al [4] and the results showed that music group demonstrated a significant decrease in HR, mean arterial pressure and rate pressure product compared with non music group. Stress level in music group was reduced significantly after listening to music. The study concluded that classical music may have a beneficial effect on HRV and reduces the stress level in medical students, as the autonomic balance shifts towards the improvement of parasympathetic tone.

Umemura M, Honda K[98] studied the influence of music on HRV and comfort while subjects hear music and white noise. They used pieces of classical music, rock music, and white noise and found that while subjects listened to white noise or rock music, RSA component declines compared with when they are at rest. This variation is especially great with noise. Classical music does not induce stress as noise does, thus classical music helps to decrease the sympathetic activity. They found that classical music cause comfort and rock music and white noise cause discomfort.

The observation of Silva SA et al [99] on the acute effects of classical plus heavy metal music on HRV in healthy men was that LF index (ms^2 and nu) was diminished during heavy metal plus classical music stimulation , the HF index (ms^2) was shortened with heavy metal music and LF/HF ratio declined with classical music and noted that acute auditory stimulation of heavy metal music decreases the autonomic modulation on the heart, while exposure to classical music lessened the sympathetic regulation on the heart.

Plassa OB et al[14] evaluated the influence of musical stimulation over cardiac autonomic activity in subjects who liked and who did not like music and came to a conclusion that women who enjoyed the music existing with reduction in heart rate variability. Those who did not like the music offered no such response. Sim CS et al[23] noted the impact of noise over HRV in men and found that noise higher than background noise, affects the ANS.

After scrutinizing the effect of music on the heart rate variability with Electrocardiogram recorded in silence and music attending modes Dehghanpour P, Moharrer S[15] stated that music helps to decrease the sympathetic activity. Proverbio AM et al [100] studied the effect of background music on cognition. Vital parameters like HR and BP were recorded during an explicit face study this is followed by memory test. The study results suggested that faster recall of faces occurred during silence and during exposed to pleasant music correlating that music helps to improve the memory.

The relationship between cardiac autonomic activity and exposure to short duration of white noises with different intensities was investigated by Lee GS et al [101]. Cardiac autonomic modulations representing the low-frequency power (LF) and the cardiac sympathetic modulations reflecting LF/HF ratio. This ratio were significantly greater with increase in the noise intensity.

Study unfavorable to my results are,

Roque Al et al study[9] analysed 40 healthy female subjects, they observed no changes regarding LF, LFnu, HF, HF nu. LF/HF ratio increased during exposure to white noise but result is not statistically significant in this study. They concluded that, classical and rock music has trivial effects over the global HRV. Parasympathetic activity on CVS reduced during white noise.

Amaral J.T et al [13] exposed 16 healthy male students to classical and heavy metal music . Time domain indices and frequency domain indices were measured during and after exposure to music . The conclusion of the study was that, auditory stimulation with classical and heavy metal music intensities did not affect cardiac autonomic activity in men.

Probable mechanism explained are,

The cardiac autonomic responses observed in the present study during exposure to musical auditory stimulation may be explained by physiological mechanisms associated with the brain. One hypothesis for this mechanism is that it is related with the enhancement of emotions. The peaks of autonomic nervous system activity, which reflect the experience of the most intense emotional moments due to the combined psychophysiological, neurochemical and hemodynamic procedure are associated with dopamine release.

The emotional spectrum triggered include expectations, stress, its resolution, bliss, surprise and yearning. The intense pleasure experienced when listening to music is related to dopamine activity in the mesolimbic reward system, including both the dorsal and ventral striatum.

The dopamine release in the mesolimbic reward system, specifically the nucleus accumbens, was proposed to be involved in emotional stimulation when listening to music. It has been suggested that this area is activated in the euphoric component of psychostimulants, such as cocaine, and is intensely connected with limbic regions that regulate emotional reaction, such as the hippocampus, amygdala, ventromedial prefrontal cortex and cingulate. Conversely, there is support for moderately higher dopamine activity in the caudate immediately before the climax of emotional responses. This sub region of the striatum is connected with the motor, associative and sensory regions of the brain and has typically been implicated in the learning of stimulus-response associations.

A temporal dissociation between distinct regions of the Striatum while listening to pleasurable music has been reported. The emotions elicited by music are evoked by temporal phenomena, such as expectations, delay, tension, resolution, prediction, surprise and anticipation[9,14,79,102].

Music induces emotion by Brain stem reflex. Sudden loud auditory signal and fast tempo music stimulate arousal and a feeling of irritation. The mechanism behind this is not clearly understood. Some evidence suggested that there is a close association between reticular formation and intra laminar nuclei of the thalamus.

Brain stem is responsible for many sensory and motor functions like perception of sound, control of attention, emotion, arousal, respiratory rate and HR. The reticular system quickly induce arousal during exposure to loud sounds. The system puts forth widespread effect on sensory and motor functions through neurotransmitters like norepinephrine, serotonin. Brain stem reflexes to music depends on the early stages of auditory processing.

Brainstem reflexes are rapid and involuntary. 'Brain stem reflexes to music may function even prior to birth, as indicated by findings of heart rate accelerations and increased motor responses on playing loud music to fetuses. Whereas soft music causes moderate heart rate decelerations and decreased motor responses'[89,90]

The levels of heart rate, noradrenaline, cortisol, and adrenocorticotropic hormone were significantly increased while listening to heavy metal music. Scientific literature has many such examples of psychological arousal and stress induction associated with listening to heavy metal music.[13, 79,92,103.]

A fast paced music stimulates the sympathetic nervous system. Cardiac activity is controlled by the Rostral Ventral Lateral Medulla [RVLM], one of the principal regulator of the sympathetic nervous system. Auditory system is indirectly connected to the RVLM via the amygdala. Neurons that respond regularly to repeated auditory stimuli are situated not only on medial geniculate body (MGB) but also located on lateral amygdala (LA), signifying that there are neuronal connections involving the MGB and LA. Additionally, the auditory cortex (AC) has neuronal projections to the LA.

The Lateral amygdala projects to the central nucleus of the amygdala, and then nucleus tractus solitarius (NTS) receive the inhibitory input, and the caudal ventro lateral medulla (CVLM) receives the excitatory input from the Central nucleus of Amygdala. This inhibition of the NTS reduces the inhibitory inputs from the CVLM to the RVLM, which then activates neurons in the RVLM, leading to an increase in sympathetic outflow. Therefore, the change in auditory stimuli indirectly affects the RVLM through the amygdala. Listening to sounds with a fast paced tempo increases the RVLM trigger rate, in turn enhancing the sympathetic activity[92].

Raised sympathetic activity is observed on exposure to 50 dB white noise. Thus, the noise intensity (higher decibels) is seen influencing heart rate variability. Through many pathways cardiovascular responses to sound may be conducted . One instance is the startle reflex mediated by a brainstem. Abrupt increase in heart rate and blood pressure after hearing sudden loud sounds is due to acoustic startle reflex.

An intensity higher than the background environmental noise level, for example 110 dB or higher is used to elicit the startle reflux. However, heightened cardiovascular responses that were witnessed over trials were also observed in subjects exposed to repeated 60 dB and 110 dB white-noise stimuli. Hence our findings of increased heart rate and blood pressure secondary to a startle stimulus indicates the autonomic response to acoustic stimuli.

Musical stimulation influences memory and emotions while white noise has no major influence on cognitive functions. It is generally accepted that noise exposure enhances sympathetic nerve activity. We can also be assume that white noise and rock music elicit stress, discomfort and tension while classical music provides comfort and satisfaction.[13,23,103].

SUMMARY

SUMMARY

- Music and noise have effects on sympathovagal balance. Heart rate variability is the best tool to assess the sympathovagal balance.

- Effect of classical and rock music and white noise over heart rate variability was assessed.

- Classical baroque music reduces the sympathetic activity and improves the parasympathetic activity.

- Rock music and white noise activates sympathetic activity, and reduces parasympathetic activity.

CONCLUSION

CONCLUSION

When the person is exposed to some sound stimulations, various physiological changes can be noted. Sound is inherently a temporal and sequential signal[102]. Sound stimulations not only influence the auditory system, but also influence the endocrine, circulatory, respiratory and autonomic nervous system. Music and noise can cause changes in the body because it is also noted as one of the sound stimulations[98].

Different types of music and noise causes different type of effects. Some type of music cause comfort and other can cause discomfort. The present study shows that classical music gives comfort to individual and it reduces sympathetic activity, and helps to improve the parasympathetic activity. Rock music and white noise gives discomfort to individual. They activate sympathetic nervous system, and reduces the activity of parasympathetic nervous system.

"Music is the medicine of future" said by Edgar Cayce [29]. In twenty first century, stress is considered as a priceless poison. Music is helpful in managing stress, express emotions, enhances memory, gives pleasure and lighten the pain. Music is considered as the best tranquillizer in modern days of anxiety and tension[100]. Music can affect the body and mind in many health-promoting ways, which is the foundation for a growing field well-known as music therapy.

Music is used more and more as a therapeutic tool, because all subjects, whether musically trained or not, respond in a similar manner. Music can be used as a best stress reliever in noisy environment. Music may be viewed as an alternative technique of relaxation or meditation, without involving the active participation of the subject. Music doesn't take time from our busy schedule it can be used in background to improve our working performance. The present study suggest that cardiac autonomic changes caused by music can be best assessed by heart rate variability and Classical music is a best tool to improve parasympathetic activity.

LIMITATION OF THE PRESENT STUDY

In this present study, sample size is small. A large sample size and longitudinal study will be of great value. Short term effect of music only assessed. Effect of music and noise on sympathovagal balance assessed only by HRV and not by means of other autonomic function test such as coldpressor test, Tilt table test, Sympathetic skin response test. Measurement of biochemical markers of sympathetic nervous system like salivary cortisol level and salivary alpha amylase level[100] not measured.

FUTURE SCOPE OF THE STUDY

The study can be extended as a prospective study and subject exposed to music for one or two months then heart rate variability measured to find out the long term effect of music. Many kinds of music and noise with different intensities can be used to extend the knowledge about music and noise.

Finally, the study did not present a sympathetic challenge test such as a tilt table test. Sympathetic challenge allowed the researcher to study the autonomic response in resting conditions and also in a stressful conditions. This would have provided a more sensitive and complete picture of how young, healthy adults respond to music in different situations. Biochemical markers of sympathetic activity like salivary cortisol level and salivary alpha amylase level[100] measured to confirm the effect of music and noise over sympathovagal balance

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ANNEXURES

ஒப்புதல் படிவம்

பெயர்.. வயது .... முகவரி ....

.... ஆகிய நான் உடலியங்கியல் துறை கோவை மருத்துவக் கல்லூரி பட்ட மேற்படிப்பு மாணவி மரு.ஆ.தமயந்தி அவர்கள் "இசை மற்றும் சத்தத்தினால் இதயத்துடிப்பில் ஏற்படும் மாற்றங்கள் அறிதல்" என்ற தலைப்பில் செய்யும் ஆய்வில் கலந்து கொண்டு ஒத்துழைக்க சம்மதிக்கிறேன்.

இந்த ஆய்வின் செய்முறை மற்றும் இது தொடர்பான அனைத்து விளக்கங்களையும் கேட்டு கொண்டு, எனது சந்தேகங்களையும் தெளிவுபடுத்திக் கொண்டேன் என்பதனையும் தெரிவித்துக் கொள்கிறேன்.

நான் இந்த ஆய்வில் முழுமனதாக சுயசிந்தனையுடன் கலந்துகொள்வதுடன், எந்த நேரத்திலும் இந்த ஆய்விலிருந்து விலகிட எனக்கு உரிமை உண்டு என்பதையும் அறிவேன்.

இந்த ஆய்வில் எனது விவரங்கள் பாதுகாக்கப்படுவதுடன் இதன் முடிவுகள் ஆய்விதழில் வெளியிடப்படுவதில் ஆட்சேபனை இல்லை / விருப்பம் இல்லை என்பதை தெரிவித்துக்கொள்கிறேன்.

இடம்

தேதி கையொப்பம்

STATEMENT OF CONSENT

I, ______________________, do hereby volunteer and consent to participate in this study being conducted by Dr.A.Dhamayanthi, I have read and understood the consent form (or) it has been read and explained to me thoroughly. I am fully aware of the study details as well as aware that I may ask questions to her at any time.

Signature / Left Thumb Impression of the patient

Station: Coimbatore

Date:

PROFORMA

1.I.D NO:

2.ADDRESS:

3.AGE IN COMPLETED YEARS;

4.SEX;

5.EDUCATION :

6.OCCUPATION:

7.PHYSICAL STATUS: HEIGHT : WEIGHT:

BMI:

8.HISTORY OF DISEASES ; HYPERTENSION/ DIABETES/ STROKE/SEIZURE

DISORDER/NEUROPATHY/PSYCHIATRIC PROBLEMS/ ANY OTHERS(SPECIFY)

9.HISTORY OF ANY DRUG INTAKE : YES/NO ,

IF YES WHAT DRUG? DURATION:

10.PERSONAL HABITS :

SMOKING /ALCOHOL/TOBACCO CHEWING/PAN,GUTHKA,HANS/

OTHERS (SPECIFY)

IF YES DURATION OF USAGE : NO.OF TIMES PER

DAY:

GENERAL EXAMINATION:

PULSE :

BLOOD PRESSURE :

RESPIRATORY RATE:

SYSTEMIC EXAMINATION:

CARDIO VASCULAR SYSTEM:

RESPIRATORY SYSTEM:

ABDOMINAL SYSTEM:

PRE TEST QUESTIONS:

HAVE YOU LEARN ANY FORM OF MUSIC?

if yes specify what type it is?

HAVE YOU USE MUSIC AS STRESS RELEIVER IN DAY TO DAY LIFE?

if yes specify what type of music you used?

Do you use Walkman,cellphone,   to enjoy music?

If yes – how many hours per day

What type of music you used frequently

POST TEST QUESTIONS;

Were you previously hear this particular music?

Were you emotionally disturbed during exposure to this music :

If yes specify , it occur during classical / rock music

Were you comfortable with hearing classical music : yes/no

Were you comfortable with hearing rock music : yes/no

Were you comfortable with hearing white noise : yes/no

MASTER CHART

MASTER CHART : HRV ANALYSIS

	basal state							classical music							rock music							white noise					
ID NO	LF	HF	LF/HF	Lfnu	HF nu	RMSSD		LF	HF	LF/HF	Lfnu	HF nu	RMSSD		LF	HF	LF/HF	Lfnu	HF nu	RMSSD		LF	HF	LF/HF	Lfnu	HF nu	RMSSD
1	210	34	6.173	86.1	13.9	32.8		98	14	6.827	87.2	12.8	22.6		277	45	6.214	86.1	13.9	24.6		574	104	5.508	84.6	15.4	39.9
2	277	42	6.604	86.8	13.2	25.3		64	13	4.839	82.9	17.1	13.8		138	19	7.342	88	12	16		338	47	7.163	87.7	12.3	23.8
3	347	56	6.188	86.1	13.9	30.3		242	41	5.883	85.5	14.5	24.9		173	42	4.104	80.4	19.6	23.4		94	14	6.936	87.4	12.6	20.8
4	174	46	3.771	79	21	51.2		144	28	5.198	83.9	16.1	37.4		403	67	5.974	85.7	14.3	47.8		58	14	4.3	81.1	18.9	34.4
5	1050	170	6.166	86	14	49.2		971	114	8.526	89.5	10.5	50.9		1057	214	4.943	83.2	16.8	45.85		1375	315	4.36	81.3	18.7	69.7
6	347	56	6.188	86.1	13.9	30.3		242	41	5.883	85.5	14.5	24.9		171	42	4.104	80.4	19.5	23		93	14	6.936	87.1	12.6	20.1
7	326	45	7.313	88	12	24		104	16	6.311	86.3	13.7	21.5		152	19	8.015	88.9	11.1	18.8		262	31	8.57	89.6	10.4	22.8
8	56	9	6.519	86.7	13.3	16.1		86	12	7.436	88.1	11.9	14.6		68	9	7.87	88.7	11.3	14.3		120	17	6.962	87.4	12.6	17.4
9	59	9	6.472	86.6	13.4	20.6		52	7	7.519	88.3	11.7	12.5		382	62	6.159	86	14	22.3		698	124	5.621	84.9	15.1	34.9
10	307	55	5.572	84.8	15.2	28		83	17	4.976	83.3	16.7	26.8		138	22	6.303	86.3	13.7	18.8		495	65	7.595	88.4	11.6	35.5
11	271	40	6.6	85.7	12.9	24.9		64	13	4.839	82.9	17.1	13.8		138	19	7.34	88	12	16		337	46	7.163	87.7	12.3	23.8
12	347	56	6.188	86.1	13.9	30.3		242	41	5.883	85.5	14.5	24.9		171	42	4.104	80.4	19.5	23		93	14	6.936	87.1	12.6	20.1
13	173	46	3.771	77	21	51		142	28	5.198	83.2	16.1	37		401	67	5.793	85.7	14.3	47.4		58	14	4.3	81.1	18.9	34.4
14	1080	170	6.166	86	14	49		970	114	8.526	88.9	10.5	50.9		1057	214	4.943	83.2	16.8	45.85		1371	312	4.36	81.3	18.7	67.1
15	45	9	4.876	83	17	13.9		40	9	4.346	81.3	18.7	17.4		87	22	3.99	79	19.2	21.5		218	33	6.516	85.9	13.3	21.7
16	344	55	6.316	82	18.9	33.9		98	14	6.827	87.2	12.8	22.6		98	14	6.827	87.2	12.8	22.6		574	104	5.508	84.6	15.4	39.9
17	597	75	7.938	88.8	11.2	41.5		922	153	6.026	85.8	14.2	41.7		408	66	6.207	86.1	13.9	35.1		627	94	6.678	87	13	51.8
18	73	14	5.209	83.9	16.1	36.3		530	78	6.787	87.2	12.8	36.2		132	25	5.235	84	16	30.3		240	33	7.35	88	12	24.2
19	296	50	5.967	85.6	14.4	36.4		179	30	5.897	85.5	14.5	22.8		236	36	6.58	86.8	13.2	23		180	23	7.936	88.8	11.2	21.92
20	385	66	5.879	85.5	14.5	28.9		278	43	6.514	86.7	13.3	25.8		158	29	5.481	84.6	15.4	25.6		152	22	6.988	87.5	12.5	23.2
21	210	34	6.173	86.1	13.9	32.8		98	14	6.827	87.2	12.8	22.6		277	45	6.214	86.1	13.9	24.6		574	104	5.508	84.6	15.4	39.9
22	277	42	6.604	86.8	13.2	25.3		64	13	4.839	82.9	17.1	13.8		138	19	7.342	88	12	16		338	47	7.163	87.7	12.3	23.8
23	347	56	6.188	86.1	13.9	30.3		242	41	5.883	85.5	14.5	24.9		173	42	4.104	80.4	19.6	23.4		94	14	6.936	87.4	12.6	20.8
24	72	11	6.849	87.3	12.7	14.4		69	13	5.481	84.6	15.4	15.2		175	36	4.85	82.9	17.1	22.5		76	15	4.932	83.1	16.9	15.8
25	487	67	7.262	87.9	12.1	28.2		149	23	6.467	86.6	13.4	21.6		46	15	3.002	75	25	18.2		254	35	7.323	88	12	27.6
26	307	55	5.572	84.8	15.2	28		83	17	4.976	83.3	16.7	26.8		138	22	6.303	86.3	13.7	18.8		495	65	7.595	88.4	11.6	35.5
27	271	40	6.6	85.7	12.9	24.9		64	13	4.839	82.9	17.1	13.8		138	19	7.34	88	12	16		337	46	7.163	87.7	12.3	23.8
28	326	45	7.313	88	12	24		104	16	6.311	86.3	13.7	21.5		152	19	8.015	88.9	11.1	18.8		262	31	8.57	89.6	10.4	22.8
29	73	14	5.209	83.9	16.1	36.3		530	78	6.787	87.2	12.8	36.2		132	25	5.235	84	16	30.3		240	33	7.35	88	12	24.2
30	296	50	5.967	85.6	14.4	36.4		179	30	5.897	85.5	14.5	22.8		236	36	6.58	86.8	13.2	23		180	23	7.936	88.8	11.2	21.92
31	307	55	5.572	84.8	15.2	28		83	17	4.976	83.3	16.7	26.8		138	22	6.303	86.3	13.7	18.8		495	65	7.595	88.4	11.6	35.5
32	271	40	6.6	85.7	12.9	24.9		64	13	4.839	82.9	17.1	13.8		138	19	7.34	88	12	16		337	46	7.163	87.7	12.3	23.8
33	487	67	7.262	87.9	12.1	28.2		149	23	6.467	86.6	13.4	21.6		46	15	3.002	75	25	18.2		254	35	7.323	88	12	27.6
34	307	55	5.572	84.8	15.2	28		83	17	4.976	83.3	16.7	26.8		138	22	6.303	86.3	13.7	18.8		495	65	7.595	88.4	11.6	35.5
35	296	50	5.967	85.6	14.4	36.4		179	30	5.897	85.5	14.5	22.8		236	36	6.58	86.8	13.2	23		180	23	7.936	88.8	11.2	21.92
36	307	55	5.572	84.8	15.2	28		83	17	4.976	83.3	16.7	26.8		138	22	6.303	86.3	13.7	18.8		495	65	7.595	88.4	11.6	35.5
37	271	40	6.6	85.7	12.9	24.9		64	13	4.839	82.9	17.1	13.8		138	19	7.34	88	12	16		337	46	7.163	87.7	12.3	23.8
38	45	15	2.924	74.5	25.5	17.8		109	24	4.514	81.9	18.1	17.9		93	25	3.646	78.5	21.5	21.5		45	11	4.164	80.6	19.4	20.5

MASTER CHART : HRV ANALYSIS

39	58	22	2.681	72.8	27.2	18.5		75	11	6.909	87.4	12.6	16.4		83	11	7.458	88.2	11.8	13.5		89	36	2.505	71.5	28.5	18.5
40	249	41	6.002	85.7	14.3	30.2		8	2	3.251	76.5	23.5	11.6		169	37	4.562	82	18	23.5		64	14	4.581	82.1	17.9	17.7
41	174	46	3.771	79	21	51.2		144	28	5.198	83.9	16.1	37.4		403	67	5.974	85.7	14.3	47.8		58	14	4.3	81.1	18.9	34.4
42	296	50	5.967	85.6	14.4	36.4		179	30	5.897	85.5	14.5	22.8		236	36	6.58	86.8	13.2	23		180	23	7.936	88.8	11.2	21.92
43	17	3	5.227	83.9	16.1	12.9		81	17	4.875	83	17	12.7		27	5	5.451	84.5	15.5	12.9		161	28	5.643	84.9	15.1	19.9
44	75	12	6.266	86.2	13.8	17.8		63	8	7.817	88.7	11.3	12.4		126	20	6.432	86.5	13.5	21.3		82	13	6.437	86.6	13.4	15.7
45	277	42	6.604	86.8	13.2	25.3		64	13	4.839	82.9	17.1	13.8		138	19	7.342	88	12	16		338	47	7.163	87.7	12.3	23.8
46	347	56	6.188	86.1	13.9	30.3		242	41	5.883	85.5	14.5	24.9		173	42	4.104	80.4	19.6	23.4		94	14	6.936	87.4	12.6	20.8
47	326	45	7.313	88	12	24		104	16	6.311	86.3	13.7	21.5		152	19	8.015	88.9	11.1	18.8		262	31	8.57	89.6	10.4	22.8
48	347	56	6.188	86.1	13.9	30.3		242	41	5.883	85.5	14.5	24.9		173	42	4.104	80.4	19.6	23.4		94	14	6.936	87.4	12.6	20.8
49	174	46	3.771	79	21	51.2		144	28	5.198	83.9	16.1	37.4		403	67	5.974	85.7	14.3	47.8		58	14	4.3	81.1	18.9	34.4
50	1050	170	6.166	86	14	49.2		971	114	8.526	89.5	10.5	50.9		1057	214	4.943	83.2	16.8	45.85		1375	315	4.36	81.3	18.7	69.7
51	307	55	5.572	84.8	15.2	28		83	17	4.976	83.3	16.7	26.8		138	22	6.303	86.3	13.7	18.8		495	65	7.595	88.4	11.6	35.5
52	271	40	6.6	85.7	12.9	24.9		64	13	4.839	82.9	17.1	13.8		138	19	7.34	88	12	16		337	46	7.163	87.7	12.3	23.8
53	347	56	6.188	86.1	13.9	30.3		242	41	5.883	85.5	14.5	24.9		171	42	4.104	80.4	19.5	23		93	14	6.936	87.1	12.6	20.1
54	45	9	4.876	83	17	13.9		40	9	4.346	81.3	18.7	17.4		87	22	3.99	79	19.2	21.5		218	33	6.516	85.9	13.3	21.7
55	597	75	7.938	88.8	11.2	41.5		922	153	6.026	85.8	14.2	41.7		408	66	6.207	86.1	13.9	35.1		627	94	6.678	87	13	51.8
56	73	14	5.209	83.9	16.1	36.3		530	78	6.787	87.2	12.8	36.2		132	25	5.235	84	16	30.3		240	33	7.35	88	12	24.2
57	296	50	5.967	85.6	14.4	36.4		179	30	5.897	85.5	14.5	22.8		236	36	6.58	86.8	13.2	23		180	23	7.936	88.8	11.2	21.92
58	241	39	6.208	86.1	13.9	34.5		251	49	5.138	83.7	16.3	32.5		260	52	4.958	83.2	16.8	29.3		1019	168	6.079	85.9	14.1	49.2
59	141	29	4.788	82.7	17.3	31.3		101	20	5.115	83.6	16.4	29.2		581	86	6.771	87.1	12.9	37.6		1089	157	6.941	87.4	12.6	54
60	1005	146	6.868	87.3	12.7	42.8		293	45	6.458	86.6	13.4	29.5		476	66	7.217	87.8	12.2	32.5		328	43	7.649	88.4	11.6	26.6
61	29	5	6.244	86.2	13.8	17.1		20	5	4.287	81.1	18.9	13.5		74	14	5.263	84	16	17.9		26	5	5.027	83.4	16.6	14.8
62	65	15	4.246	80.9	19.1	28.8		54	8	6.659	86.9	13.1	17		147	21	6.994	87.5	12.5	17.3		68.6	9	7.598	88.4	11.6	31.1
63	207	30	6.99	87.5	12.5	20.6		42	6	6.915	87.4	12.6	11.6		89	11	7.953	88.8	11.2	17.9		86	11	7.516	88.3	11.7	19.9
64	385	66	5.879	85.5	14.5	28.9		158	29	5.481	84.6	15.4	25.6		278	43	6.514	86.7	13.3	25.8		152	22	6.988	87.5	12.5	23.2
65	210	34	6.173	86.1	13.9	32.8		574	104	5.508	84.6	15.4	39.9		277	45	6.214	86.1	13.9	24.6		98	14	6.827	87.2	12.8	22.6
66	277	42	6.604	86.8	13.2	25.3		64	13	4.839	82.9	17.1	13.8		138	19	7.342	88	12	16		338	47	7.163	87.7	12.3	23.8
67	326	45	7.313	88	12	24		104	16	6.311	86.3	13.7	21.5		152	19	8.015	88.9	11.1	18.8		262	31	8.57	89.6	10.4	22.8
68	56	9	6.519	86.7	13.3	16.1		120	17	6.962	87.4	12.6	17.4		86	12	7.436	88.1	11.9	14.6		120	17	6.962	87.4	12.6	17.4
69	59	9	6.472	86.6	13.4	20.6		698	124	5.621	84.9	15.1	34.9		382	62	6.159	86	14	22.3		52	7	7.519	88.3	11.7	12.5
70	307	55	5.572	84.8	15.2	28		83	17	4.976	83.3	16.7	26.8		138	22	6.303	86.3	13.7	18.8		495	65	7.595	88.4	11.6	35.5
71	271	40	6.6	85.7	12.9	24.9		64	13	4.839	82.9	17.1	13.8		138	19	7.34	88	12	16		337	46	7.163	87.7	12.3	23.8
72	347	56	6.188	86.1	13.9	30.3		171	42	4.104	80.4	19.5	23		242	41	5.883	85.5	14.5	24.9		93	14	6.936	87.1	12.6	20.1
73	173	46	3.771	77	21	51		58	14	4.3	81.1	18.9	34.4		142	28	5.198	83.2	16.1	37		401	67	5.793	85.7	14.3	47.4
74	1080	170	6.166	86	14	49		970	114	8.526	88.9	10.5	50.9		1057	214	4.943	83.2	16.8	45.85		1371	312	4.36	81.3	18.7	67.1
75	45	9	4.876	83	17	13.9		87	22	3.99	79	19.2	21.5		40	9	4.346	81.3	18.7	17.4		218	33	6.516	85.9	13.3	21.7
76	307	55	5.572	84.8	15.2	28		83	17	4.976	83.3	16.7	26.8		138	22	6.303	86.3	13.7	18.8		495	65	7.595	88.4	11.6	35.5
77	271	40	6.6	85.7	12.9	24.9		64	13	4.839	82.9	17.1	13.8		138	19	7.34	88	12	16		337	46	7.163	87.7	12.3	23.8
78	347	56	6.188	86.1	13.9	30.3		242	41	5.883	85.5	14.5	24.9		171	42	4.104	80.4	19.5	23		93	14	6.936	87.1	12.6	20.1

MASTER CHART : HRV ANALYSIS

79	45	9	4.876	83	17	13.9		40	9	4.346	81.3	18.7	17.4		87	22	3.99	79	19.2	21.5		218	33	6.516	85.9	13.3	21.7
80	597	75	7.938	88.8	11.2	41.5		922	153	6.026	85.8	14.2	41.7		408	66	6.207	86.1	13.9	35.1		627	94	6.678	87	13	51.8
81	73	14	5.209	83.9	16.1	36.3		530	78	6.787	87.2	12.8	36.2		132	25	5.235	84	16	30.3		240	33	7.35	88	12	24.2
82	296	50	5.967	85.6	14.4	36.4		179	30	5.897	85.5	14.5	22.8		236	36	6.58	86.8	13.2	23		180	23	7.936	88.8	11.2	21.92
83	597	75	7.938	88.8	11.2	41.5		922	153	6.026	85.8	14.2	41.7		408	66	6.207	86.1	13.9	35.1		627	94	6.678	87	13	51.8
84	73	14	5.209	83.9	16.1	36.3		132	25	5.235	84	16	30.3		530	78	6.787	87.2	12.8	36.2		240	33	7.35	88	12	24.2
85	296	50	5.967	85.6	14.4	36.4		179	30	5.897	85.5	14.5	22.8		236	36	6.58	86.8	13.2	23		180	23	7.936	88.8	11.2	21.92
86	383	81	4.734	82.6	17.4	37.4		581	102	5.704	85.1	14.9	44.5		227	38	5.914	85.5	14.5	26		2128	325	6.548	86.8	13.2	73.7
87	141	29	4.788	82.7	17.3	31.3		101	20	5.115	83.6	16.4	29.2		581	86	6.771	87.1	12.9	37.6		1089	157	6.941	87.4	12.6	54
88	1005	146	6.868	87.3	12.7	42.8		293	45	6.458	86.6	13.4	29.5		476	66	7.217	87.8	12.2	32.5		448	58	7.672	88.5	11.5	33.7
89	249	35	7.044	87.6	12.4	33.1		298	57	5.263	84	16	29.5		119	18	6.596	86.8	13.2	20.2		328	43	7.649	88.4	11.6	26.6
90	385	66	5.879	85.5	14.5	28.9		158	29	5.481	84.6	15.4	25.6		278	43	6.514	86.7	13.3	25.8		152	22	6.988	87.5	12.5	23.2
91	347	56	6.188	86.1	13.9	30.3		242	41	5.883	85.5	14.5	24.9		173	42	4.104	80.4	19.6	23.4		94	14	6.936	87.4	12.6	20.8
92	72	11	6.849	87.3	12.7	14.4		175	36	4.85	82.9	17.1	22.5		69	13	5.481	84.6	15.4	15.2		76	15	4.932	83.1	16.9	15.8
93	487	67	7.262	87.9	12.1	28.2		149	23	6.467	86.6	13.4	21.6		46	15	3.002	75	25	18.2		254	35	7.323	88	12	27.6
94	142	36	3.922	79.7	20.3	39.9		466	101	4.633	82.2	17.8	56.6		1307	272	4.801	82.8	17.2	56.3		1941	303	6.396	86.5	13.5	66.7
95	174	46	3.771	79	21	51.2		144	28	5.198	83.9	16.1	37.4		403	67	5.974	85.7	14.3	47.8		58	14	4.3	81.1	18.9	34.4
96	17	3	5.227	83.9	16.1	12.9		81	17	4.875	83	17	12.7		27	5	5.451	84.5	15.5	12.9		161	28	5.643	84.9	15.1	19.9
97	75	12	6.266	86.2	13.8	17.8		126	20	6.432	86.5	13.5	21.3		82	13	6.437	86.6	13.4	15.7		63	8	7.817	88.7	11.3	12.4
98	271	40	6.6	85.7	12.9	24.9		64	13	4.839	82.9	17.1	13.8		138	19	7.34	88	12	16		337	46	7.163	87.7	12.3	23.8
99	347	56	6.188	86.1	13.9	30.3		171	42	4.104	80.4	19.5	23		242	41	5.883	85.5	14.5	24.9		93	14	6.936	87.1	12.6	20.1
100	173	46	3.771	77	21	51		58	14	4.3	81.1	18.9	34.4		142	28	5.198	83.2	16.1	37		401	67	5.793	85.7	14.3	47.4

LF-low-frequency-ms2
HF-high-frequency-ms2

LF/HF-low frequency,high frequency raito
LFnu-low-frequency-normalized-unit

Hfnu-high-frequency-normalized-unit
RMSSD-Root-mean-squre-of-sum-of-successive-difference-between-adjacent RR interval