

A Dissertation On

**IMMEDIATE EFFECT OF PLANTAIN LEAF BATH ON CARDIOVASCULAR
AND AUTONOMIC PARAMETERS IN HEALTHY VOLUNTEERS**

Submitted by

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LIST OF ABBREVIATIONS USED

BP	Blood pressure
DBP	Diastolic blood pressure
HR	Heart rate
HRV	Heart rate variability
PR	Pulse rate
PLB	Plantain Leaf Bath
SBP	Systolic blood pressure
UV	Ultra violet
UVA	Ultra violet A rays
UVB	Ultra violet B rays
UVR	Ultra violet rays
Vit D	Vitamin D

ABSTRACT

Objective: The research work aims at evaluating the immediate effects of ‘Plantain leaf bath’(PLB) on the improvement of cardiovascular and autonomic functions by monitoring parameters such as blood pressure, pulse rate and heart rate variability (HRV). The previously available literature sources, reported the benefits of incorporating plantain leaf bath, aids in improving the autonomic and cardiovascular functioning. The current study intended towards monitoring the immediate effects, with the exposure of PLB, by determining the cardiovascular and autonomic parameters of the study participants.

Study Design: The current research work employed pre-post intervention study.

Method: 30 healthy volunteers belonging within the age group of 18-35 participated in the study. The cardiovascular parameters and short term HRV were assessed during the pre and post intervention of PLB. The collected data were subjected to data analysis and interpretation, for determining the effectiveness and immediate therapeutic effects of the plantain leaf bath among the study participants.

Result: The study showed significant improvement in the Heart Rate Variability values of the study participants. The post intervention data showed significant improvement of HRV and cardiovascular parameters, comparatively to that of the pre intervention data.

Conclusion:The incorporation of Naturopathy mediated therapy involving PLB significantly improving the cardiovascular and autonomic functioning, which was clearly exhibited from the observed cardiovascular parameters and HRV values.

Keywords: Plantain Leaf bath.Heart Rate Variability, Naturopathy, Blood pressure, Pulse rate.

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1. INTRODUCTION

‘Nature is the Healer of Disease’

-Hippocrates

In recent trend, the people are adopting complementary/alternative medicine, instead of Western medicine. Naturopathy became one of the growing trends in today’s health care domain. The discipline is one of the primary intervention approach, regarded by the Ministry of health - AYUSH (Government Of India)¹ and is considered as one of the complementary medicine by the global community. Even when there are numerous forms of alternative medicine, the focal point of health care research is naturopathy.

Naturopathy is defined as the system, concerning on the whole person, rather than just the problems that afflicted on organs and systems. The practitioners prefer natural remedies rather than synthetic drugs/surgeries. The practices of naturopathic medicine involve manual therapy, hydrotherapy, acupuncture, herbalism, environmental medicine, aroma therapy, counseling, and other holistic approaches.²

Complementary therapies involving naturopathy and healing practices aids in reducing the stress levels, anxiety and modify the entire lifestyle patterns that are contributing for cardiovascular diseases. Naturopathy is one among the promising intervention therapies that facilitates in improving the cardiovascular functions much more effectively^{3 4}.

Cardiovascular diseases became one of the growing concerns in recent times. Due to poor dietary habit, mental stress and inadequate physical activity, becoming major factors contributing significantly towards pathogenesis of cardiovascular diseases and other autonomic disorder. For overcoming, managing and prevention of such issues, requires the patients towards seeking healthier lifestyle modifications for preventing and managing the abnormal cardiovascular conditions⁵.

For exploring, an ideal approach has led the society to turn back and investigate the ancient practices such as Yoga and Naturopathy to counteracting pathological conditions. Furthermore, the emergence of psychoneuroimmunology has strengthened the scientific foundations of mind–body medicine ⁶.

There are enough evidences to support on traditional ailments aiding in the treatment of CAD (Coronary artery disease), hypertension, incontinence, chronic pain, headache, stress-related symptoms in cancer, premenstrual syndrome and anxiety disorders ^{7 8}. The efficacies concerning with incorporating lifestyle interventions has been reported to aid in treating Cardio vascular disease(CVD) ^{9 10 11}.

Modern science has just begun investigating on the impacts of plantain leaf, which has a long history of medicinal properties and traditional value in India. The German Commission E, similar to FDA in US, have approved the medicinal uses of plantain leaves, which was found to be helpful in easing coughs, irritation of the mucous membranes, upper respiratory tract infections and also in cardiovascular issues ¹².

Through incorporating sunbaths with plantain leaves covering the body has been one of the approaches in naturopathy treatments helps in keeping the body and head cool and well protected. The sun naturally endowed with the healing power and its usage in medical treatment could be dated back to ancient times. Modern days treatment of sun bath has been referred to as heliotherapy ¹³.

In association with the air bath, in itself a real tonic at an altitude, the general sun bath, that is, the direct action of the sun on the total surface of the integuments, constitutes the most energetic of reconstituents. Further, the sun cure realizes the perfect local treatment by virtue of the analgesic, bactericidal, alterative and sclerogenic action of the solar radiations.

Heliotherapy is given in various forms, among them Plantain/Banana leaf bath is one of the best type of heliotherapy. It is an age old treatment employed in Naturopathic medicine, using naturally available plantain leaves. It is used in most of the Naturopathic treatment centers as a detoxification therapy through profuse sweating to treat skin diseases especially psoriasis, obesity etc.,

Due to the elongated nature of plantain leaf, it is used as a wrap in plantain leaf bath . Banana leaf wrap is used to treat burns. Banana leaves convert the harmful ultraviolet sunrays into healthy rays ¹³ . It could be due to the presence of polyphenol,

Epigallocatechingallate (EGCG-a very beneficial ingredient in the skin rejuvenation treatment) in its leaf ¹⁴.

Topical treatment of human skin with EGCG inhibits UVB induced production of prostaglandin metabolites particularly PGE₂ which play a critical role in inflammatory disorders, photoaging, photocarcinogenesis and in proliferative skin diseases ¹⁵. In clinical setups administration of plantain leaf bath induce a good sleep and a sense of well-being after treatment which may have an impact on level of stress.

Stress which seems to worsen or increase the risk of conditions like Alzheimer's Disease, depression, obesity, psoriasis etc., which are successfully treated under heliotherapy. Stress is a factor, modifying the body homeostasis mechanism by acting through HPA axis in turn producing adrenaline and increasing the activity of sympathetic action in the body.

Heart rate variability (HRV) is the physiological phenomenon of variation in the time interval between heartbeats. It is measured by the variation in the beat-to-beat interval in heart rate, offers a non- invasive indicator of autonomic nervous system activity. HRV is also one of a valid tool used to measure the stress level through Polyvagal Theory^{16 17}. Naturopathy, is one of the major disciplines, which is considered as a significant therapeutic technique that assist in treating systemic diseases and abnormalities.

2.0 AIMS AND OBJECTIVES

AIMS: To evaluate the immediate effect of PLB on cardiovascular and autonomic function in healthy volunteers.

OBJECTIVES:

- To understand the effect of PLB on cardiovascular function such as blood pressure and pulse rate in healthy volunteers.
- To study the effect of PLB on autonomic functions such as heart rate variability changes in healthy volunteers.

3.0 REVIEW OF LITERATURE

Heliotherapy makes simple use of intentional direct exposure to natural sunlight to get the therapeutic benefits of the included ultraviolet radiation. The prevalence of this naturopathic treatment dates back to ancient period, especially in countries like India, Egypt and China. The therapy is primarily intended to treat several diseases .

The incorporation of plantain sunbath is quite popular and has been practiced in Western countries nowadays. This therapeutic intervention of incorporating plantain leaf bath is one of the primary features of naturopathy. Naturopathy is regarded as the art and science of leading a healthy life, without the reliability of drug. This well founded philosophy has been regarded as one of the major fields of ‘Ayush system’, similar to other disciplines like Yoga etc.

The recent surveys and available literature sources stated heliotherapy is an essential therapeutic approach for improving autonomic nervous system(ANS) and Cardiovascular system. These two bodily systems are correlated with one another. Plantain bath mediated heliotherapy, could aid as an essential interventional procedure for improving the autonomic imbalances. The autonomic imbalances are one of the serious threats, which could eventually result in CVD. The following chapter entails on the previously available literature sources, which supports the current study.^{17, 18}

3.1 CARDIOVASCULAR SYSTEM (CVS)

The circulatory system, otherwise known as cardiovascular system/vascular system, that assists in circulation blood flow, which aids in gaseous exchange with other organs, supply of essential nutrients such as electrolytes, amino acids, minerals etc to the entire body and also protects the body from harmful diseases. All these processes can be collectively known as homeostasis. Circulatory system is one of the major body systems that maintain balance in the homeostasis.¹⁹

The major essential components of cardiovascular systems are:

- Heart
- Arteries
- Capillaries
- Veins

The circulatory system comprises of the lymphatic system that circulates lymphatic fluid. Blood, unlike lymph is a vital bodily fluid comprising plasma, white blood cells, red blood cells and platelets, which are circulated with the help of heart.²⁰ This is the basic systemic functioning of vertebrate vascular system, aiding in the circulation of oxygen and nutrients to and the removal of waste materials that are released by the body tissues. The circulatory system of the blood can be majorly classified into two components, a systemic circulation and a pulmonary circulation. The

following illustrative representation of the circulatory system, gives an overview that represents the systemic as well as pulmonary circulation of blood.^{21, 22}

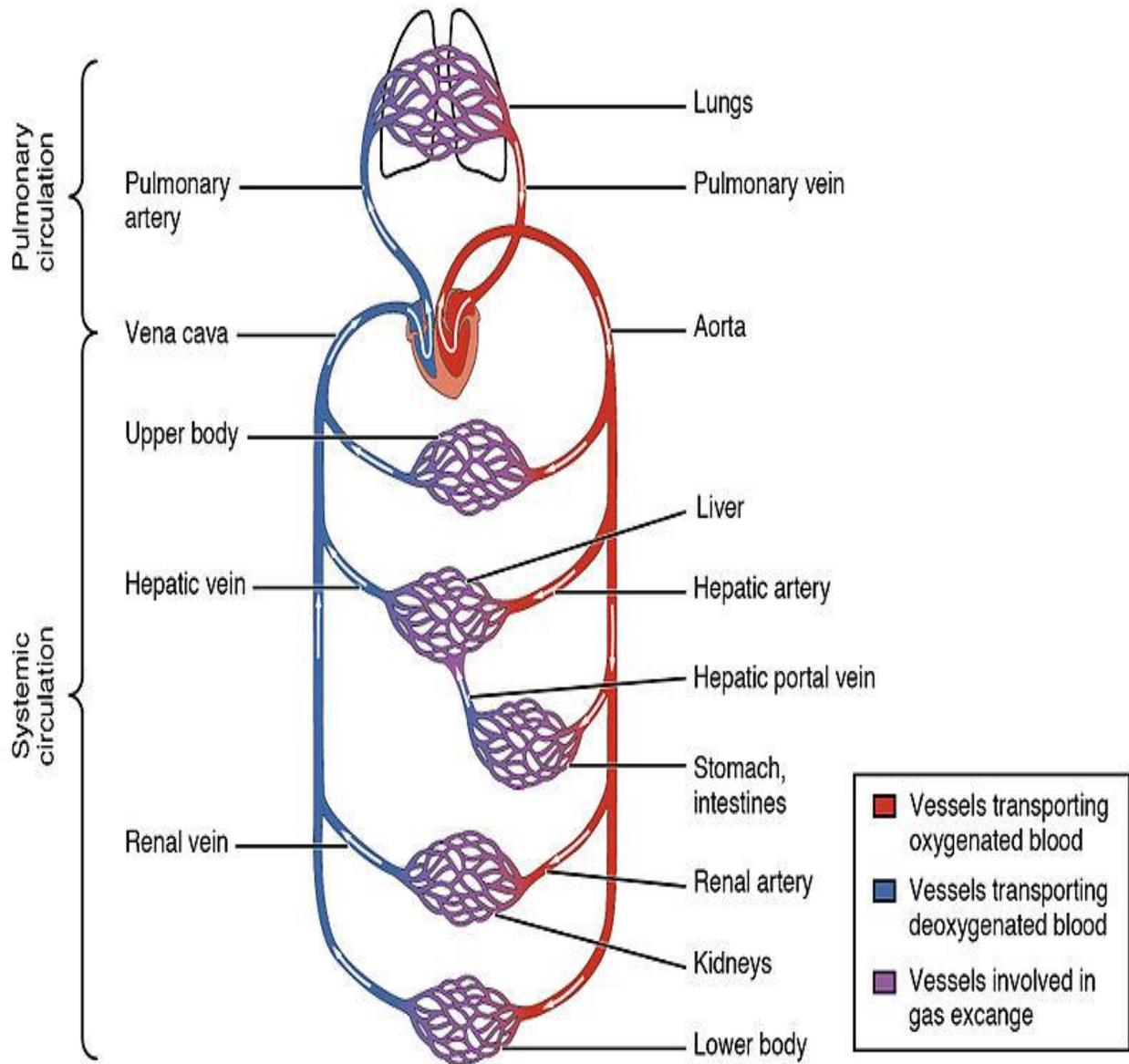


Figure 1. Illustrative representation of ‘The systemic circulation’

3.2 CVS ROLE IN MAINTENANCE OF HEALTH

The role of CVS is significant for leading a healthy life. They play some of the vital functions such as:

- Transportation of gases, nutrients, and waste products that are released as toxins from the metabolic functioning of the tissues/cells, throughout the body.
- Assists in protecting the body from microbial infections and prevents from blood loss
- Helps in regulating the body temperature, which is otherwise referred to as ‘Thermoregulation’
- Helps in maintaining the fluid balance, in our body.²³

CVS serves as the internal network that links all body parts via veins, arteries, arterioles, venules and capillaries. The system thoroughly functions in a continuous manner by transporting the essential nutrients that are significant for the growth and development, followed by expelling the toxins and wastes from the body. Hormones that are secreted by the endocrine glands are effectively transported via CVS, to the target organs and the waste products on the other hand are released/expelled out through the urinary system. Similarly in the case of the gaseous exchange, the heart and lungs are primarily involved in the exchange of carbon-dioxide and oxygen. The oxygen and carbon-dioxide are exchanged through the pulmonary veins and arteries. The deoxygenated blood, comprising of carbon-dioxide is released from the heart to the lungs, which is expelled via exhalation. The inhaled oxygen is exchanged from simultaneously with that of lungs,

which in turn releases/transportes the oxygenated (oxygen rich) blood to other parts of the body that are deprived of oxygen.^{24, 25}

Other than CVS serving as the transporter of nutrient and gases, they assist in protecting the bodily systems from the foreign bodies, known as antigens, and other harmful microbes.

Blood comprises of three different types of cells, which have distinctive functions. The following three types of cells are:

- Red blood cells: Assists in transportation of oxygen, through a specialized pigment, which is significant for carrying the oxygen molecule, known as haemoglobin.
- White blood cells: White blood cells assist in detecting any unknown entry of foreign bodies/infections. They protect by enveloping around the foreign body and kill/deactivate them from causing any threat to the organs and surrounding tissues.
- Platelets are specialized cells that aid in coagulation/clotting of blood.

The normal temperature range of a healthy adult should be between 36.1°C-37.8°C, with 37°C as the average/normal body temperature. In case of the individual's body temperature raises or lowers than the actual ranges, could result in hypothermia and hyperthermia, respectively. The bodily circulation/ CVS aids in thermoregulation of the body, aiding in maintaining the normal body temperature.²⁶

3.2.1 Associated medical complications/diseases in CVS

The circulatory system helps in maintaining the proper health through monitoring the above mentioned functions. However under certain contributory factors (both external and internal) disrupts the normal functioning of the CVS. The abnormal functioning of CVS could result in the emergence of cardiovascular abnormalities/diseases.^{27, 28} Some of the major cardiovascular diseases, that affects the normal structural integrity and functioning of the hearts are as follows:

- Coronary artery disease (causes narrowing of the arteries)
- Heart attack
- Abnormal heart rhythms/arrhythmias
- Heart failure
- Heart valve disease
- Congenital heart disease
- Heart muscle disease/cardiomyopathy
- Pericardial disease
- Aorta disease and Marfan syndrome
- Vascular disease

3.3 BLOOD PRESSURE AND PULSE RATE EFFECT ON CVS

The normal functioning of CVS is majorly attributed through two major parameters namely

- Blood pressure
- Pulse rate

These are two separate indicators/measurements, representing the health of CVS. The blood pressure is determined through determining the force of the individual's blood flow that is moving through the blood vessels, whereas the heart rate involves with determining/evaluating the number of times the individual's heart beats occur within a minute.²⁹

These two are separate health indicators, helps in determining whether the functioning of heart tends to be within the normal ranges. The change in the normal blood pressure and pulse rate directly reflects the abnormalities or complications in CVS of the particular individual. The following subsections provide a thorough knowledge and the distinction that lies between pulse rate and blood pressure. This could be identified through determining the underlying relationship that exists between these two parameters. The following subsection entails on determining the overall differences and relationship as follows.³⁰

3.3.1 Pulse rate

The term pulse determines the arterial palpation of heartbeat via trained fingertips. The pulse could be palpated in any part that facilitates the artery which is compressed/present along superficially, on the body surface.³¹ Major areas where the protrusion of surface artery could be witnessed for measuring the pulse rate are:

- wrist(radial artery),
- neck (carotid artery),
- groin (femoral artery),
- behind the knee (popliteal artery),
- near the ankle joint (posterior tibial artery), and
- On foot (dorsalis pedis artery).

Pulse rate is the actual count of the arterial pulse per minute, which is almost equivalent with that of measuring the heart rate. The below tabulation (Table 1) represents the difference in pulse rate among individuals with respect to their ages is given under the standard measurements.

Table 1: Normal pulse rates at rest (BPM) ³²

Newborn (0–3 months old)	(3 – 6 months) infants	(6 – 12 months) children	(1 – 10 years) children	over 10 years & adults, including seniors	well-trained adult athletes
99-149	89–119	79-119	69–129	59–99	39–59

The normal pulse could be determined through identifying the regularity in the rhythm and the force of the pulse. In case of the irregularity observed in the pulse rate could be mainly due to

- Sinus Arrhythmia
- Ectopic Beats
- Atrial Fibrillation
- Paroxysmal Atrial Tachycardia
- Atrial Flutter
- Partial Heart Block Etc.

The dropping out of the pulse/beat is referred to as intermittent pulse. The examples of the regular intermittent pulses include pulsus bigeminus, second-degree atrioventricular block, whereas the irregular intermittent pulse is known as atrial fibrillation.³³

3.3.2 Blood pressure

The arterial blood pressure (BP) is the lateral exertion of pressure by blood against that of the arterial walls. During a cardiac cycle, the highest pressure is attained by the systolic pressure, whereas the lowest pressure is attained by the diastolic pressure.

The mean blood pressure (MBP) is defined as the geometric mean that is calculated via integrating the pressure pulse. The MBP of systolic and diastolic pressure is calculated by the following formulas.

$$\text{MBP} = [\text{systolic pressure} + 2 (\text{diastolic pressure})]/3.$$

$$\text{MBP} = [\text{diastolic pressure} + (\text{pulse pressure})]/3.$$

The following figure (Figure 2) represents the systolic and diastolic blood pressure of the heart.³⁴

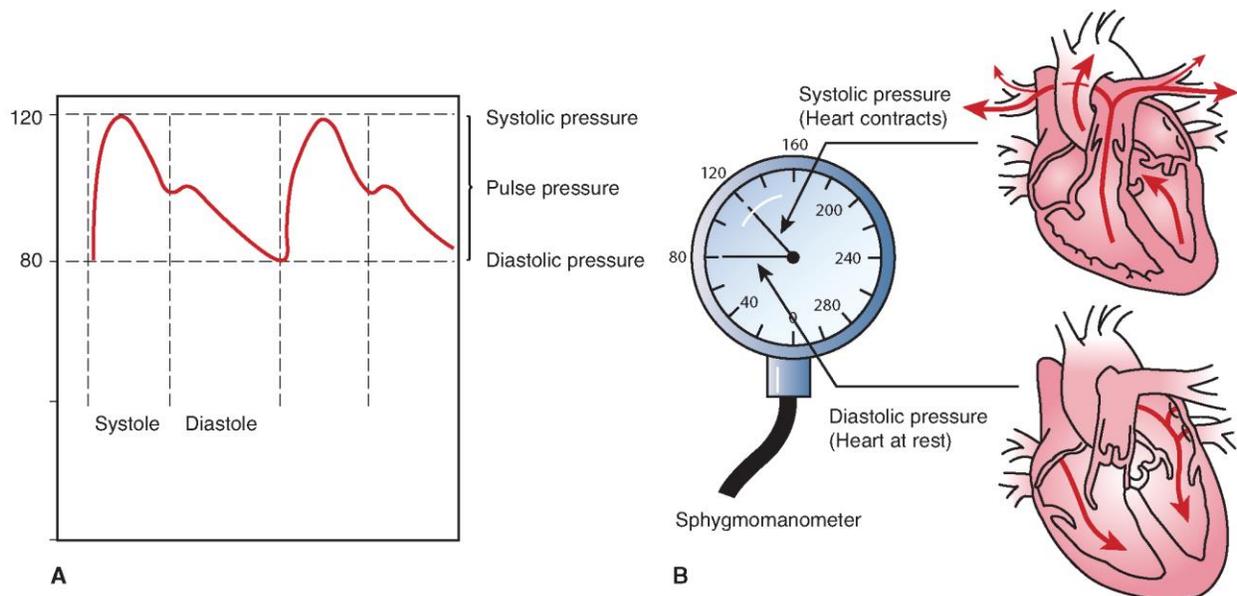


Figure 2: Illustrative representation of Blood pressure measurement

The blood pressure is determined by the difference in the systolic and diastolic pressures.

The systolic pressure depends on

- Stroke
- Volume
- Peak-systolic cardiac ejection rate
- Arterial compliance

Whereas the diastolic pressure depends on

- Total Peripheral Resistance
- Heart Rate,
- Systolic Pressure, and

- Arterial Elastic Recoil (I.E., Increases Or Decreases In These Parameters Increase Or Decrease, Respectively, The Diastolic Pressure).³⁵

3.3.2.1 Normal Blood pressure at different age groups

The arterial blood pressure of the first day of the newborn after the birth is measured to be 70/50 mm Hg. This systolic and diastolic pressure tends to increase gradually, after the next several months of child's development, which appears to be in ranges of about 90/60 mm Hg. After the subsequent years of development the percentile rise in the blood pressure is very much slow, until the individual reaches adulthood, where the normalized blood pressure was 115/70 mm Hg (adolescence), whereas normal blood pressure for adults is 110 to 140 mm Hg in the case of systolic pressure and 60-90 mm Hg in the case of diastolic pressure.^{36, 37}

The variations in the blood pressure could be as a result of apprehension, excitement and several other factors. Activities such as eating, exercising and smoking could raise the blood pressure. While performing Strenuous exercise could raise the pressure up to 200/100 mm Hg. The systolic pressure could significantly reduce during the sleep to ranges of 15-30 mm Hg. Many evidences support that the pressure tends to increase progressively with growing age, which is observed generally in the average population.

The systolic pressure was identified to increase approximately about 1 mm Hg/y from 110 mm Hg when the individual reaches the age of 15 years. Thus reflecting the progressive reduction in the arterial compliance, which is especially, noted when an

individual reaches beyond 60 years of age. In the case of diastolic pressure, was observed to increase in ranges of about 0.4 mm Hg/y from 0 mm Hg when the individual reaches the age of 15 years, thus reflecting the rise in total peripheral resistance. This progressive rising of pressure with age results due to the aging effects over the long-term BP controlling mechanism.^{38, 39}

3.4 BRIEF OVERVIEW ON NERVOUS SYSTEM (CENTRAL NERVOUS SYSTEM, PERIPHERAL NERVOUS SYSTEM)

The following section provides an overview regarding CNS and peripheral nervous system. The distinction between central and peripheral nervous system are illustrated in a detailed manner in Figure 3.

The Nervous System

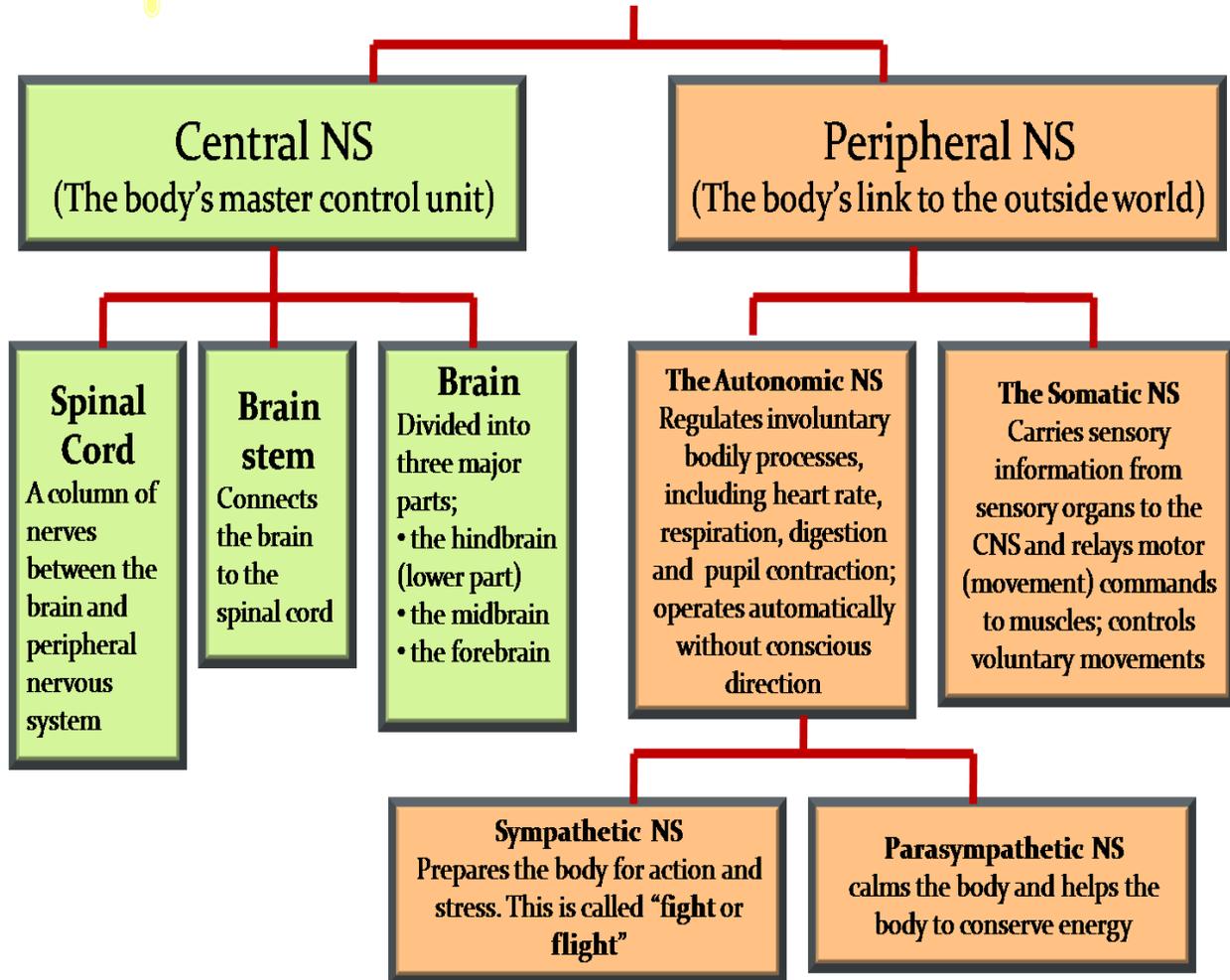


Figure 3. Representation of CNS

3.4.1 CNS

CNS comprises collectively of brain and spinal cord. The system is referred “central” since it primarily combines the information throughout the body and coordinates the activity across the whole individual. The following illustration represents the CNS and the associated organs.⁴⁰

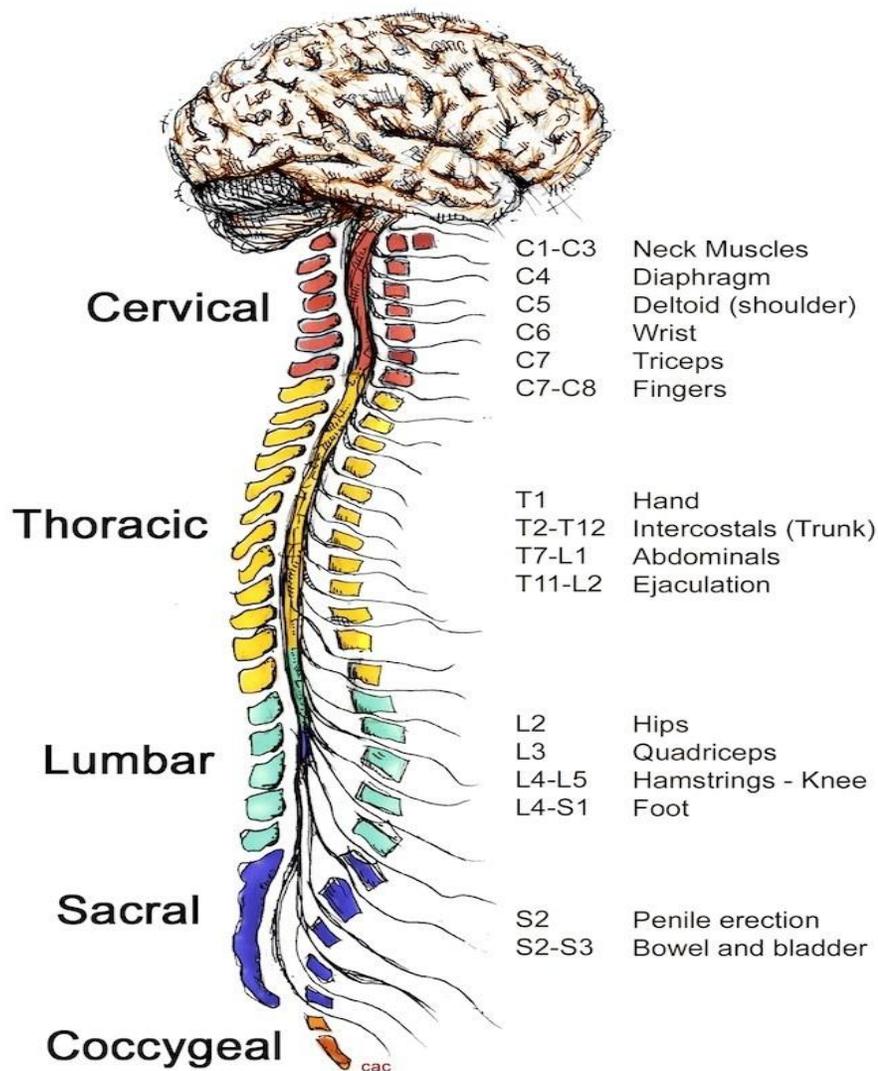


Figure 4. Central Nervous System

3.4.1.1 Brain

Brain is regarded as the complex organ in the human body as it uses more than 20% of the oxygen, and consists more than 100 billion neurons, with each connected to thousands more. The brain can be broadly divided into the following four main lobes

- Temporal,
- Parietal,
- Occipital
- Frontal.

The brain is enclosed by the protective covering by the skull (known as the cranial cavity) and the spinal cord that travels back to the brain and towards the spine's center, ending at the lumbar portion of the lower back. Both the brain and spinal cord are housed via triple membrane layer called meninges.⁴⁰

CNS controls the cognition and thoughts, emotions, desires and movements. The other major controls involving with breath, heart rate, hormonal release, and temperature control and many more, are monitored by CNS. The CNS alongside the spinal cord and brain also comprised of:

- The retina
- Optic nerve
- Olfactory nerves and

- Olfactory epithelium

3.4.1.2 Spinal cord

The major function involves with spinal cord in relaying the information from the brain to other parts of the body. The spinal cord, runs almost over the full length of the back, and carries information between the body and brain, apart from performing other tasks. From the brainstem meeting the spinal cord with that of the brain with 31 spinal nerves enter the cord.

Alongside its length, that connects the nerves of the peripheral nervous system (PNS) which runs along the muscles, joints and skin. The motor commands from brain centers travel through the spine with that of the muscles and relays the sensory information, thus travelling through the sensory tissues namely the skin, spinal cord and ultimately to the brain region. The spinal cord contains the necessary sensory circuits that aid in controlling the reflexive actions/responses. Similarly the circuits that is present within the spinal cord assists in complex processes/movements such as walking.^{41, 42}

3.4.2 PNS

Peripheral nervous system, abbreviated as PNS is one of the major parts of the nervous system that is present outside that of the brain and spinal cord of CNS. CNS is separate from that of the PNS, even when the two systems are interconnected with each other. The major differences between CNS with that of PNS could be attributed with difference in cell size. The axons of the nerve cells which carry impulses are shorter and more slender

in the case of CNS. PNS nerve axons ranges about 1 meter in length. Similarly the regeneration of cells in PNS is much more effective compared to CNS, which lack regeneration ability.^{40, 41}

Peripheral Nervous System

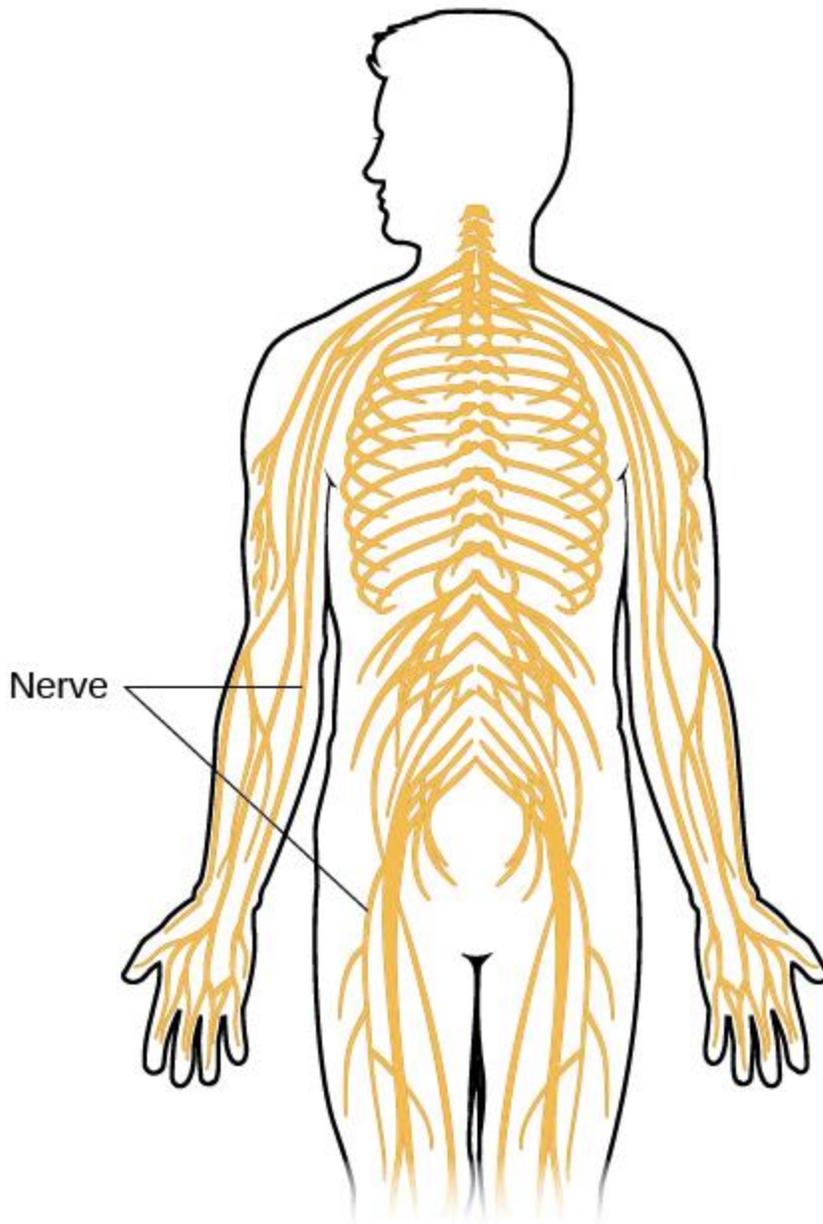


Figure 5. Peripheral Nervous System

3.5 AUTONOMIC NERVOUS SYSTEM (ANS) AND THE IMPACT OF SYMPATHETIC AND PARASYMPATHETIC NERVOUS SYSTEM ON HEALTH

ANS constitutes a part of the nervous system that assists in controlling and regulating the internal organs, without conscious recognition or any sort of effort exerted by the organism. The involuntary nervous system (otherwise ANS/vegetative system) aids in regulating the body processes which cannot be consciously induced or influenced.

The system constantly functions in regulating mechanisms such as:

- Breathing
- Heart rate
- Metabolic processes and signaling.

These processes were effectively achieved by the signals which were received from the brain and which is passes on to the bodily systems. The signals are relayed in the other direction, which is from the body towards the brain, thus providing the brain with the necessary information regarding certain bodily functions, such as how full the bladder is or how quickly the heart has been beating.

The involuntary nervous system can react quickly to changes, altering processes in the body to adapt. For instance, if the body gets too hot, the involuntary nervous system increases the blood circulation to the skin and makes the body to cool by inducing sweat.

Both the central and peripheral nervous systems have voluntary and involuntary parts. However, whereas these two parts are closely linked in the central nervous system, they are usually separate in other areas of the body.

The involuntary nervous system is made up of three parts:

- The sympathetic nervous system
- The parasympathetic nervous system
- The enteric (gastrointestinal) nervous system...

Sympathetic nervous system aids in connecting the internal organs with that of brain via spinal nerves. Upon stimulation, the nerves tend to prepare the organisms for stress, by modifying/increasing HR (Heart Rate), thus the blood flow rapidly rises and in the muscles, whereas reduces substantially in the skin.⁴³

The nerve fibers of parasympathetic nervous system comprises primarily:

- Cranial Nerves
- Vagus Nerves, and
- Lumbar Spinal Nerves

Upon stimulation, the nerves induce specialized mechanism, involved with digestive secretions and reduce heartbeat. The following figure illustrates the overall functional role of sympathetic and parasympathetic nervous system.

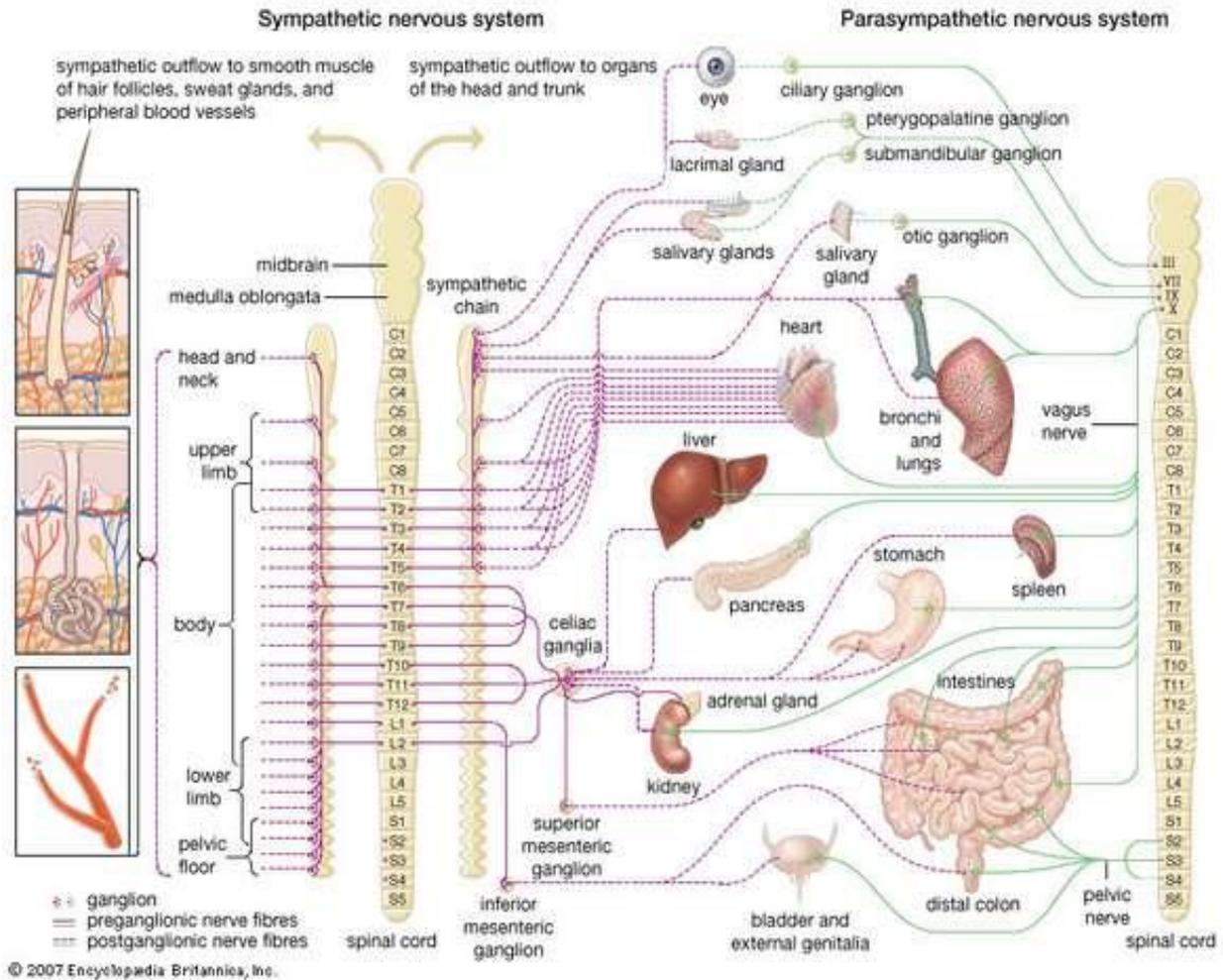


Figure 6. Illustration on functional roles of sympathetic and parasympathetic nervous system

3.6 RELATIONSHIP BETWEEN ANS IN HEART RATE

The HR could be normally determined via the activity of the pacemaker which represents the SA (Sinoatrial node) that resides in the posterior wall of the right atrium. SA node in turn exhibits the automaticity, which is determined by the abrupt and spontaneous changes that are resulted by the Ca^{++} , K^+ and Na^+ conductance. The resulting intrinsic automaticity, if remained unmodified by the neurohumoral factors, thus exhibiting a spontaneous firing rate of the heart beats ranging from 100-115 beats per minute. The intrinsic firing rate of the heart is in direct relationship with that of age.^{43, 44}

HR decreases below the intrinsic rate, majorly due to the activation of vagus nerve innervations of the SA node. When the individual is stationary or at rest, the vagal tone appears to be quite significant for the SA node, such that the resting heart rate lies between 60-80 beats per minute. The vagal influence could be direct attributed by the administration of certain complex chemical messengers such as muscarinic receptor antagonist, atropine, which in turn results in the increase of heart bear further to 20-40 beats per minute, depending on the initial value that is exhibited by the vagal tone.

In the case of the increase in the heart rate above that of the intrinsic rate could be due to the direct withdrawal exhibited by the vagal tone as well as the activation caused by the sympathetic nerves that innervate the SA node. The reciprocation of change in the sympathetic as well as the parasympathetic activity allows the HR to rise during intensive activities such as exercising.

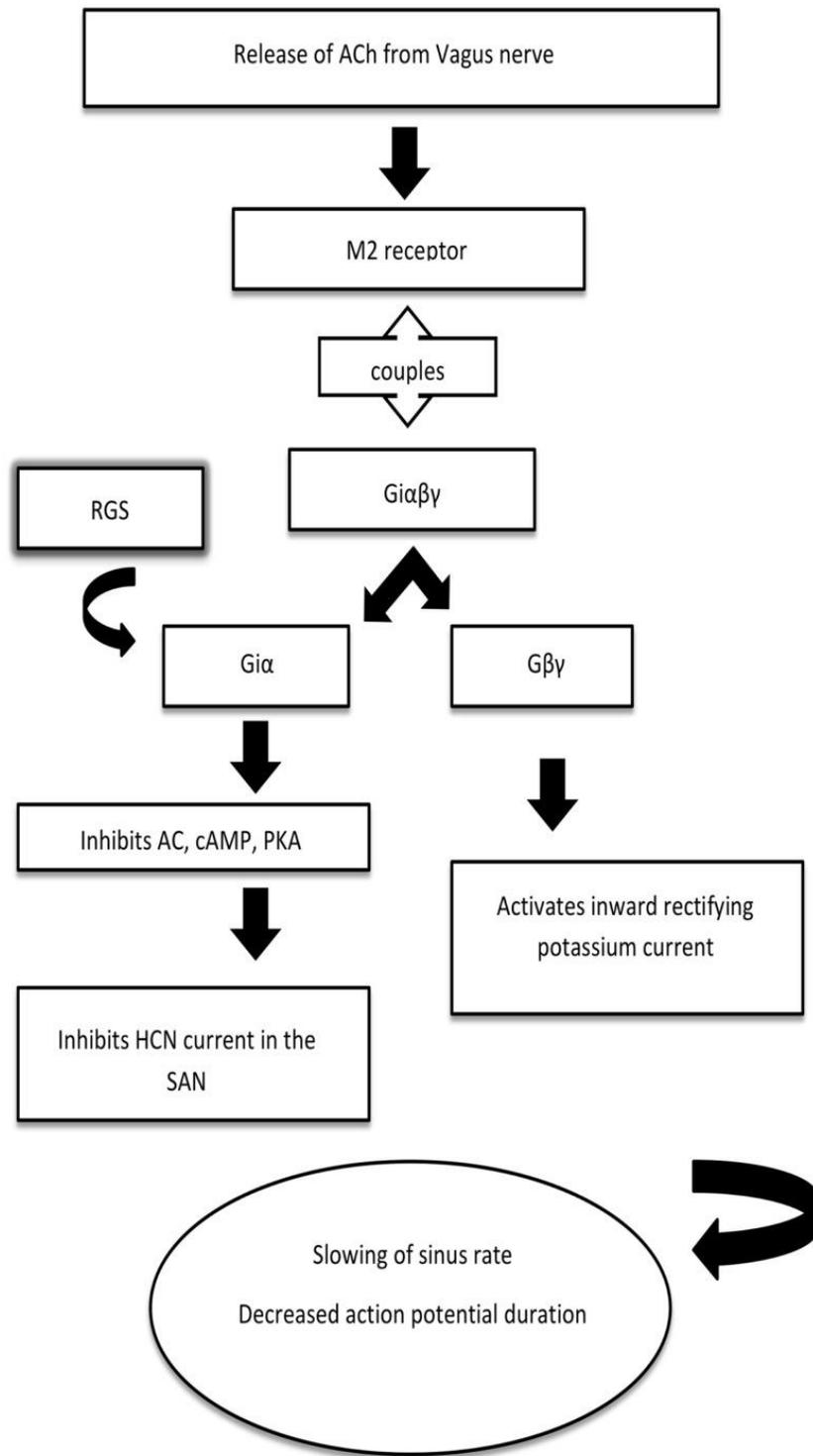


Figure 7. ANS Mechanism involved in Heart rate

For heart rate to increase above the intrinsic rate there is both a withdrawal of vagal tone and an activation of sympathetic nerves innervating the SA node. The reciprocal change in both parasympathetic and sympathetic activity permits HR to increase while performing exercise. HR is modified by the circulating catecholamines, which acts via β_1 -adrenoceptors, located on SA nodal cells. ^{44, 45}

The dysfunction in SA node could result in:

- Sinus Bradycardia,
- Sinus Tachycardia/sick-sinus syndrome.

The overall maximal HR could be determined for an individual through the following formula:

$$\text{Maximal Heart Rate} = 220 \text{ beats/min} - \text{age in years}$$

Therefore a 20-year-old person will have a maximal heart rate of about 200 beats/min, and this will decrease to about 170 beats/min when the person is 50 years of age. This maximal heart rate is genetically determined and cannot be modified by exercise training or by external factors.

- Acetylcholine (ACh) released from vagus nerve binds to muscarinic receptor, coupled with inhibitory G protein.

- The $\beta\gamma$ -dimer activates the G protein, which is coupled inward rectifying potassium (GIRK) channel to slow the sinus rate, decrease the action potential duration and allow arrhythmia generation.
- Regulators of G protein signaling (RGS) interact with α -subunit to switch off this pathway through GTPase accelerating protein activity and allow the heterotrimer to reform.⁴⁴

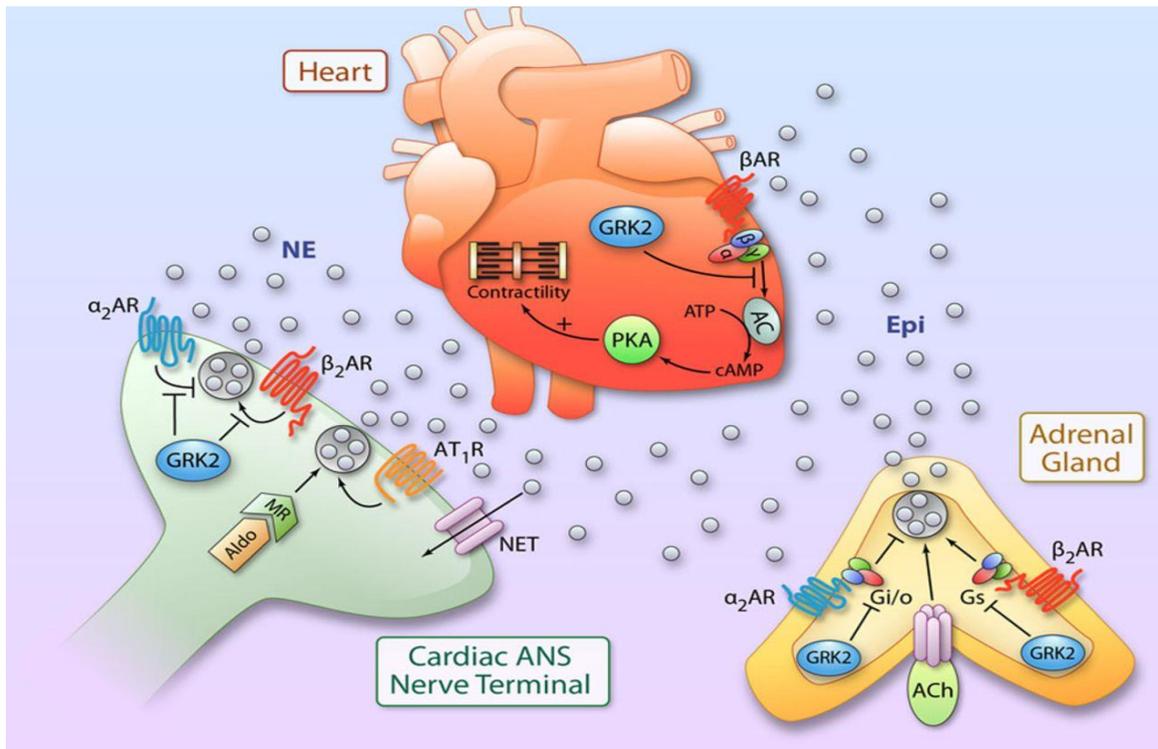


Figure 8. Mechanism involved in HR

3.7 RELATIONSHIP BETWEEN HEART RATE AND BLOOD PRESSURE

Both blood pressure and heart rate are assessed majorly for determining the medical complication known as hypertension. This particular clinical problem serves as the major

risk factor that contributes in the emergence of other CVD (Cardiovascular Diseases). By monitoring the heart rate and blood pressure, helps in identifying the elevated pressure and heart rate. This is a direct indicator for the individual's susceptibility for hypertension.⁴⁶

The relationship between both heart rate and blood pressure could be referred to as location dependent. There is a direct relationship exist between HR and peripheral BP. However, certain reports suggest that the relationship is inverse in nature, between both the parameters. A recent study demonstrated that the increased range of HR through pacing was found to decrease the augmentation index as well as the systolic BP, thus representing that the elevated HR is directly associated with increased peripheral BP.^{47,48}

The HR monitoring devices facilitates in measuring one's HR under the real time and record the heart rate for later part of the study.

3.8 FUNCTIONAL MECHANISMS OF BRAIN IN CONTROLLING HEART

Functional regulation of heart is majorly attributed with that of the brain. The heart-brain communication in general referred to as the efferent pathways of ANS, involving in the regulation and functioning of the heart. The fibers that are connected in majority by the vagus nerves are afferent (ascending) in its nature. Additionally majority of the ascending neural pathways are pretty much related to CVS and heart, compared to other systems and associated organs. This directly represents the relationship between brain and heart is quite significant as heart sends much information to the brain and vice versa.

Additionally, the intrinsic cardiac nervous system comprised

- Short-term memory functions
- Long-term memory functions

operating independently of central neuronal command. The information is processed via heart's intrinsic nervous system. The signals which are appropriate for the normal functioning of heart are relayed to SA node of the heart and similarly to the other tissues within the heart. Under the normal physiological condition of the heart, the underlying intrinsic nervous system serves as the significant role in most of the routine controls of the available nervous system.^{49, 50}

Heart's intrinsic nervous system acts a vital part in the maintenance of cardiovascular stability and efficiency. The absence of the pathway results in heart's dysfunction. The neural output/messages from intrinsic cardiac nervous system travels to brain via ascending pathways in the both spinal column and vagus nerves, travelling to the medulla, hypothalamus, thalamus and amygdala and then to the cerebral cortex. The nervous-system pathways between the heart and brain are shown in Figure.

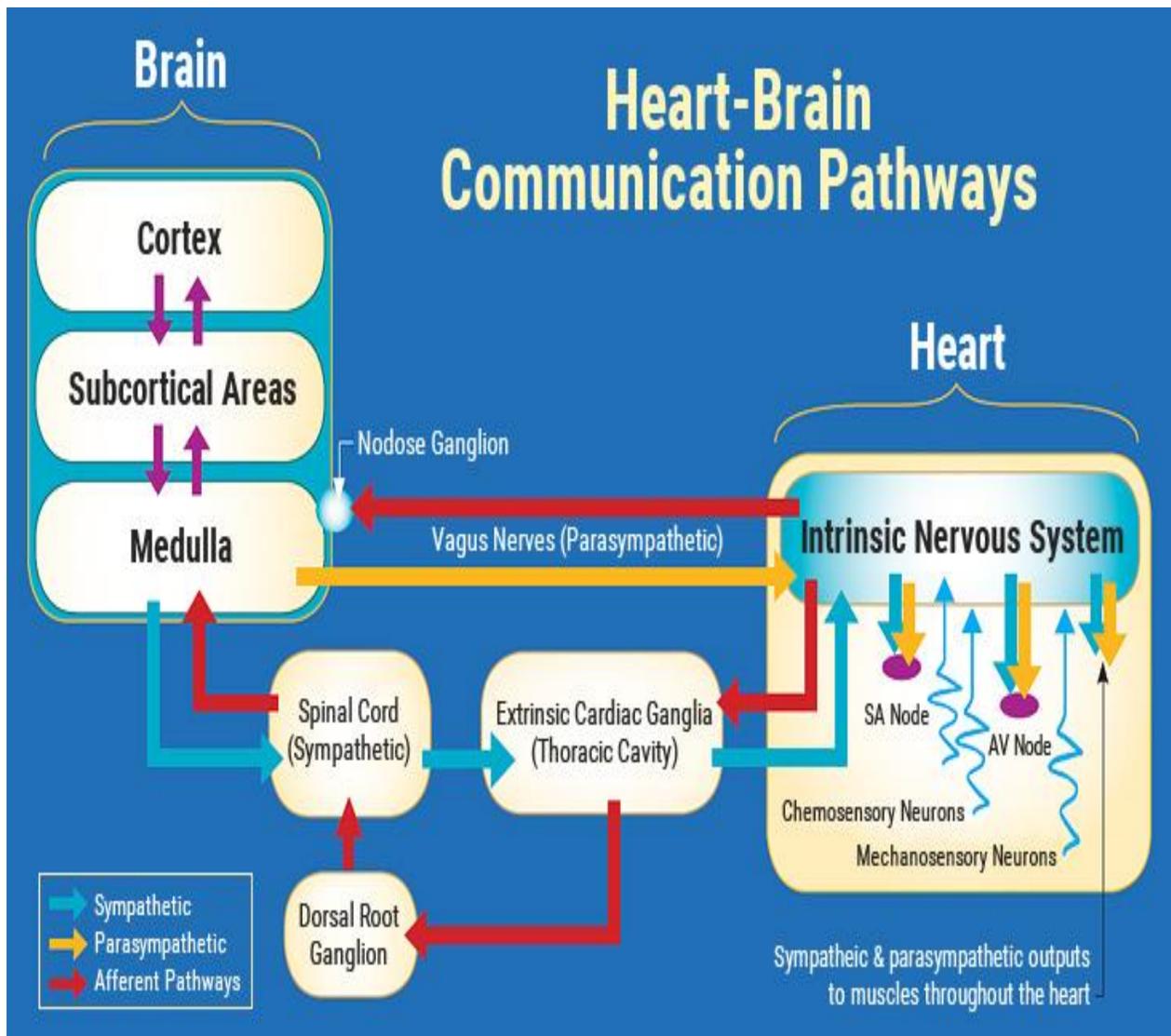


Figure 9. Heart-brain Communication Pathways

3.9 HEART RATE VARIABILITY (HRV)

HRV is defined as the measure of the beat-beat changes of HR. The diagrammatic representation of HRV on electrocardiogram (ECG) is as follows:

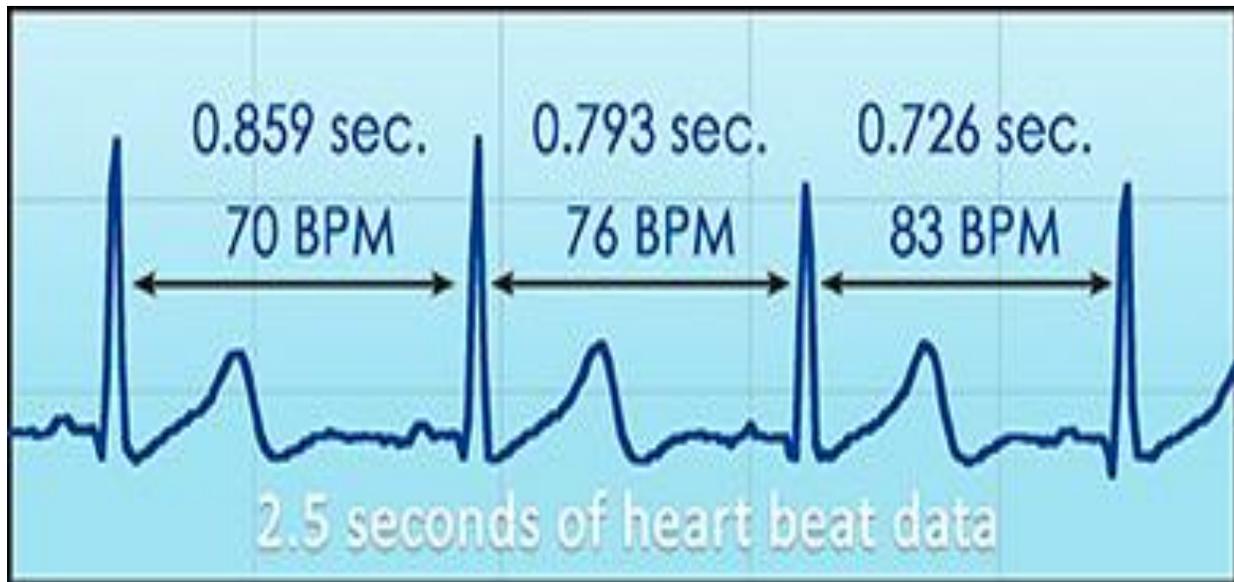


Figure 10. Variation in the Heart Beat, represented in ECG

The following figure represents three heartbeats recorded on electrocardiogram (ECG). The variation in time intervals between consecutive heartbeats, giving different heart rate (BPM) in each interbeat interval.⁵¹

The normal variability of HR could be due to the synergistic actions carried out by two branches of ANS. ANS constitutes a major part of nervous system, which regulates body's entire internal functions. Sympathetic nerves aids by accelerating the HR, whereas parasympathetic nervous system (vagus) slows the HR.^{52, 53}

Both sympathetic as well parasympathetic branches in ANS continually interacts in maintaining the cardiovascular activity within the optimal range and permits

appropriate reactions by changing the internal and external conditions. Analysis of HRV serves as dynamic window to the balance and functioning of ANS.

3.10 HRV VARIABLES (TIME AND FREQUENCY DOMAIN)

HRV is a non-invasive effective tool in detecting both sympathetic as well as parasympathetic balance of ANS. The variations being analyzed via HRV is effective in estimating the cardiac autonomic modulations. Variations in the frequency and time domains are major approaches for measuring the HRV.⁵³

Heart rate variability is influenced by various physiological and pathological factors. For several decades, obstetricians have recognized diminished beat-to-beat variation in fetal heart rate as an indicator of distress. In cardiology, prior studies have documented adverse prognostic implications of reduced heart rate variability in patients after myocardial infarction and with other pathological conditions.

Recently, many studies reported that there is direct association between reduced heart rate variability and risk for all-cause mortality in elderly original participants in the Framingham Heart Study. The relation of altered heart rate variability to risk for cardiac events has not been studied in the general population.

Heart rate variability is a marker of sympathetic and parasympathetic influences on the modulations of heart rate. In patients with heart disease, increased sympathetic tone and/or decreased parasympathetic tone, which predispose to ventricular fibrillation, have been proposed as mechanisms explaining the associations of reduced heart rate variability with increased mortality.

However, our subjects were free of clinically apparent cardiac disease at baseline, and the vast majority of our outcomes were not arrhythmic (eg, sudden death); hence, it is difficult to attribute our results to autonomic imbalance precipitating fatal arrhythmic events. Rather, other factors such as cardiac chronotropic responsiveness may play an important role. In this sense, reduced heart rate variability may reflect subclinical cardiac disease.

Alternatively, autonomic imbalance or other factors related to heart rate variability, such as the renin-angiotensin system, may contribute to the pathogenesis of coronary heart disease, but this hypothesis requires additional support.

Mean heart rate reflects autonomic balance and correlates inversely with all eight heart rate variability measures.²² Although adjustment for mean heart rate may reduce the inherent predictive value of heart rate variability as an indicator of autonomic tone, 2-hour SDNN remained predictive of prognosis even after adjustment for mean heart rate. Two reasons for this can be considered. First, heart rate variability is a more sensitive

tool for detecting autonomic balance than mean heart rate. Second, heart rate variability reflects additional information beyond autonomic imbalance.

3.10.1 Time variable

Time domain measurement of HRV is considered as one of the simplest, yet an effective method. The method involves with determining the heart rate at any point of time/interval between the successive normal complexes are determined. From the continuous ECG records, the RS complex is determined and the Normal-to-Normal or otherwise known as the instantaneous HR is determined.

The measurement of time domain variable involves with calculating the mean NN interval. In the time domain, the standard deviation of the NN interval (SDNN), the square root of the mean squared differences of the successive NN intervals (RMSSD), the number of interval differences of successive NN intervals greater than 50 ms (NN50), and the proportion derived by dividing NN50 by the total number of NN intervals (pNN50) were used.⁵⁴ The selected time domain measures of HRV is represented in Table 2.

Table 2. Selected Time Domain Measures of HRV

Variable	Units	Description
SDNN	ms	Standard deviation of all NN intervals
SDANN	ms	Standard deviation of the averages of NN intervals in all 5- minute segments of the entire recording
RMSSD	ms	The square root of the mean of the sum of the squares of differences between adjacent NN intervals
SDNN index	ms	Mean of the standard deviation of all NN intervals for all 5-minute segments of the entire recording
SDSD	ms	Standard deviation of differences between adjacent NN intervals
NN50		Number of pairs of adjacent NN intervals differing by more than 50 ms in the entire recording; three variants are possible counting all such NN intervals pairs or only pairs in which the first or the second interval is longer
pNN50	%	NN50 count divided by the total number of all NN intervals

3.10.2 Frequency Variables

This method involves with incorporating various spectral method. Through analysis of tachogram and PSD (Power Spectral Density) analysis provides basic information on how distribution of power (variance), serves as a function of frequency. Methods involved in PSD measurement of frequency variable can be generally classified under parametric and nonparametric approaches. For most of the instances, both the results exhibit comparable results.

The advantages in incorporating non-parametric approaches for frequency domain measurements are:

- The simplicity of the algorithm used (fast Fourier transform [FFT] in most of the cases) and
- Greater processing speed,

The advantages of parametric approaches for frequency domain measurements are:

- Smoother spectral components which can distinguished as independent frequency bands,
- Easier post processing of the spectrum with automatic calculation of low- as well as high-frequency power components with easy identification of central frequency for each components and

- An accurate estimation of PSD even in small number of samples on which the signal is supposed to maintain stationarity. The basic disadvantage of parametric methods is the need of verification of the suitability of the chosen model and of its complexity (that is, the order of the model).^{55, 56} The selected frequency domain measures of HRV is represented in Table 3.

Table 3. Selected Frequency Domain Measures of HRV

Variable	Units	Description	Frequency Range
5-min total power	ms ²	The variance of NN intervals over temporal segment	≤ 0.4 HZ
VLF	ms ²	Power in VLF ranges	≤ 0.4 HZ
LF	ms ²	Power in LF ranges	0.04-0.15 HZ
LF norm	Nu	LF power in normalized units LF/(total power-VLF) * 100	
HF	ms ²	Power in HF range	0.15-0.4 HZ
HF norm	nu	HF power in normalized units HF/(total power- VLF)*100	
LF/HF		Ratio LF (ms ²)/HF(ms ²)	

3.11 NATUROPATHY AND ITS BENEFITS

Naturopathy is a discipline of science that assists in elimination of drugs without the help of external drugs. The system involves in building a harmonious relationship with constructive principles on mental, physical, moral and spiritual elements of living. It facilitates in creating a health promotive, disease preventive and curative approach with much greater restorative potential.

According to the manifesto of British Naturopathic Association, "Naturopathy is a system of treatment which recognizes the existence of the vital curative force within the body." Thus the interventional approach aids in determining the human system and removes the underlying factors that contribute in causing diseases and expels the toxins and unwanted waste products from the human body. These actions, in turn facilitate in curing the diseases much more effectively.^{57, 58}

The method involved with practicing naturopathy majorly employs natural elements such as air, water, light, heat, food etc., for expelling the toxins and curing the diseases thoroughly. The major aim of practicing naturopathy can be attributed into three fundamental elements:

- Removing the contributory factor that lowers a person's vitality.
- Removal of foreign material of
- Rectifying the underlying abnormalities of the systemic circulation (blood and lymph)

The aim of naturopathic treatment is majorly towards improving an individual's vitality by eliminating the accumulated waste products. This could be essentially rectified through approaches such as:

- Sauna Bath
- Steam Bath
- Therapeutic Colon Cleansing
- Therapeutic Fasting
- Heliotherapy

These intended treatments facilitate in the complete elimination of toxins.⁵⁹

3.12 HELIOTHERAPY AND ITS IMPACT ON GENERAL HEALTH BENEFITS

Heliotherapy is the treatment of disease by exposing the body to sunlight. Heliotherapy (also called climatotherapy) makes simple use of intentional direct exposure to natural sunlight to get the therapeutic benefits of the included ultraviolet radiation. The healing effects of the sun and its benefits in many medical treatments could be traced back to the ancient times. Even in the modern times, during the first half of the 20th century saw heliotherapy to be an effective treatment and was even practiced in the western world, in places like Europe, America, especially for the treatment of cutaneous tuberculosis.^{60, 61}

Sun bath facilitates in protecting the body from several forms of cancer, type-1-diabetes, cardiovascular related diseases and multiple sclerosis and many other diseases. Besides the production of Vitamin-D, sun bath helps in inducing several physiological changes.

3.12.1 Types of Sun Bath

1. General Sun Bath (Direct Sun Bath):

- Lying naked in the sun with wet compress over head.
- Lying naked in the sun and rubbing the body with dry towel/ soft wet brush
- Massaging the body with oil while lying in the sun.

2. Indirect Sun Bath:

Same way as General Sun bath, but in this type the whole body should be covered with thin white cotton clothes and head and eye covered by wet pack.

3. Localised Sun Bath

In this type exposure of Sun to positive area of the body for treatment, other parts of the body covered by a wet sheet. It is effective in respiratory diseases and all joint diseases.

4. Plantain Leaf Bath / Banana Leaf Sun Bath

Similar to General Sun Bath, the body is covered with banana leaves and then exposed to sunlight.⁶²

3.12.2 HELIOTHERAPY EFFECT ON SYSTEMIC HOMEOSTASIS OF CVS AND OTHER SYSTEMIC FUNCTIONS

The major impact recognized from the response to sun exposure is the development of elevated levels of vitamin D status, which serves as one of the key factor in maintaining homeostasis of different systemic functions. When the skin is stimulated with UVA radiation, nitric oxide is released, stimulating vasodilatation and lowering of blood pressure. During active exposure to UVA, diastolic blood pressure in one study fell by roughly 5 mmHg and remained lower for 30 minutes after exposure.⁶³

The reduction in the diastolic blood pressure by more than 5 mmHg decreases the overall risk for the individual from attaining stroke by more than 34% and similarly reducing risk of an individual from attaining coronary heart disease by 21%. The major physiological response of skin exposure to sunlight involves with thickening of the stratum corneum (the outermost layer of the epidermis) and this ensures in increased skin pigmentation through production of melanin. This paired response, in turn protects the skin as well as the deeper tissues from the penetrating and damaging effects of UVA rays, and also retaining benefits from UVB exposure as well.⁶⁴

Though both UVA and UVB exposure result in increased skin pigmentation, the mechanisms are different, with UVB being responsible for the up-regulation of melanin synthesis and thus the protective effects against UV damage to DNA. The best time for creating this response coincides with the time of maximal UVB availability (10 AM–3 PM). Additionally, human skin produces beta-endorphin in response to UVB exposure.⁶⁵

The opioid peptides have the result of increasing a feeling of well-being, boosting the immune system, relieving pain, promoting relaxation, wound healing, and cellular differentiation. Light signals received through the eye regulate production of melatonin and serotonin for circadian rhythm control and also play a role in seasonal affective disorder.

Impact of Sunlight and/or Vitamin D on Specific Health Conditions Cancer Studies of the relationship between cancer, sun exposure, and vitamin D began decades ago with geographic associations with cancer mortality. In 1941, Apperly reported an association between latitude and cancer mortality based on sun exposure although vitamin D was not yet explicitly implicated.⁶³

In 1980, Garland and Garland reported the association between latitude and colon cancer using sun exposure as a proxy for vitamin D status. By 1990 it had been hypothesized that deficiency of vitamin D was the main cause of breast cancer.⁶⁵

The effect produced by the sun rays on the health can be explained in the following ways

- Photo chemical reaction,
- Photo thermal or heating effects,
- Photosynthesis.

In 2006 WHO reported very low levels of UVR exposure produces a markedly larger annual disease burden of about 3.3 billion DALYs worldwide.⁶⁶

Chlorosis, anaemia, leukaemia, emaciation, muscular debility, degeneration of heart and liver, dropsical effusion, softening of bones, nervous excitability, physical deformity, stunted growth and consumption are the conditions resulting from inadequate sun exposure.

Lindqvist et al. 2014 concluded that moderate sun exposure group had 40% increased mortality rate and among avoiders of sun exposure the all cause mortality rate was doubled when compared with highest sun exposure group.⁶⁷

Fermini et al. 2016 found in his study that Active sun exposure habits of a women were associated with lower mortality rate of cardiovascular cause and other non-cancer mortality, and he noted the similar magnitude of risk factor for death of avoidance of sun exposure as like smoking.⁶⁸

Shelley Gorman et al in 2015 stated, Sun produce local and systemic effects on health by its UV rays. The later potentially suppress Non Alcoholic fatty liver disease(NAFLD) through vitamin D-dependent and -independent mechanisms. In Vitamin D(Vit D) dependent mechanism Vitamin D derived from UV exposure prevent liver pathology by suppressing the potentially interacting pathways consist of hepatocyte apoptosis, liver inflammation and fibrosis, oxidative stress, the expression of protective adipokines, and changes to the composition of the gut microbiome.

Skin exposure to UVR induces several immune effector molecules, including vitamin D, NO, hemeoxygenase, cis-urocanic acid and serotonin . UVR induces the

production of mediators such as NO and HO-1, which may contribute towards the protective effects of sunlight through a variety of mechanisms that suppress liver inflammation. They finally stated by their studies and suggesting that UVR has the potential to suppress Non Alcoholic fatty liver disease development through vitamin D-dependent and -independent mechanisms.⁶³

Jacobsen et al. 2015 found that more sun exposure during the third gestational trimester of a mother was associated with lower risk of type 1 diabetes in male children.⁶⁹ Sun exposure produces a clinical improvement of psoriasis by a rapid reduction in local and systemic inflammatory markers. It was extensively documented that UV irradiation is potentially inducing immunosuppression by significantly reducing CD4+ and CD8+ T cells in lesional skin of the epidermis and dermis.⁶³

3.13 HELIOTHERAPY IN RECTIFYING CVS RELATED ISSUES

Exposing skin to sunlight is essential for releasing nitric oxide from the enzymatic and non-enzymatic sources. Nitric oxide is one of the agents that facilitates in arterial muscle relaxation and in enhanced blood flow. This eventually represents that the exposure to sunlight helps in improving the cardiovascular health. Sun's exposure on sunlight helps in synthesis of Vitamin D as well, thus helps in preventing vitamin-D deficient diseases such as Rickets. Sunlight has beneficial impact in

- Immunity
- Autoimmunity

- Cardiovascular disease
- Cancer
- Fertility Pregnancy
- Dementia.

Individuals with high serum vitamin D levels are at reduced risk of hypertension, cardiovascular disease and metabolic syndrome, yet multiple trial data show that oral vitamin D supplementation has no effect on these endpoints. Sunlight is a risk factor for skin cancers, but no link has been shown with increased all-cause mortality. Cohort studies from Scandinavia show a dose-dependent fall in mortality with increased sun-seeking behavior. Skin contains significant stores of nitrogen oxides, which can be converted to NO by UV radiation and exported to the systemic circulation. Human studies show that this pathway can cause arterial vasodilatation and reduced BP.⁶³ Murine studies suggest the same mechanism may reduce metabolic syndrome.⁶⁴The following figure illustrates, the mechanism involved in the synthesis of vitamin-D from the sunrays.

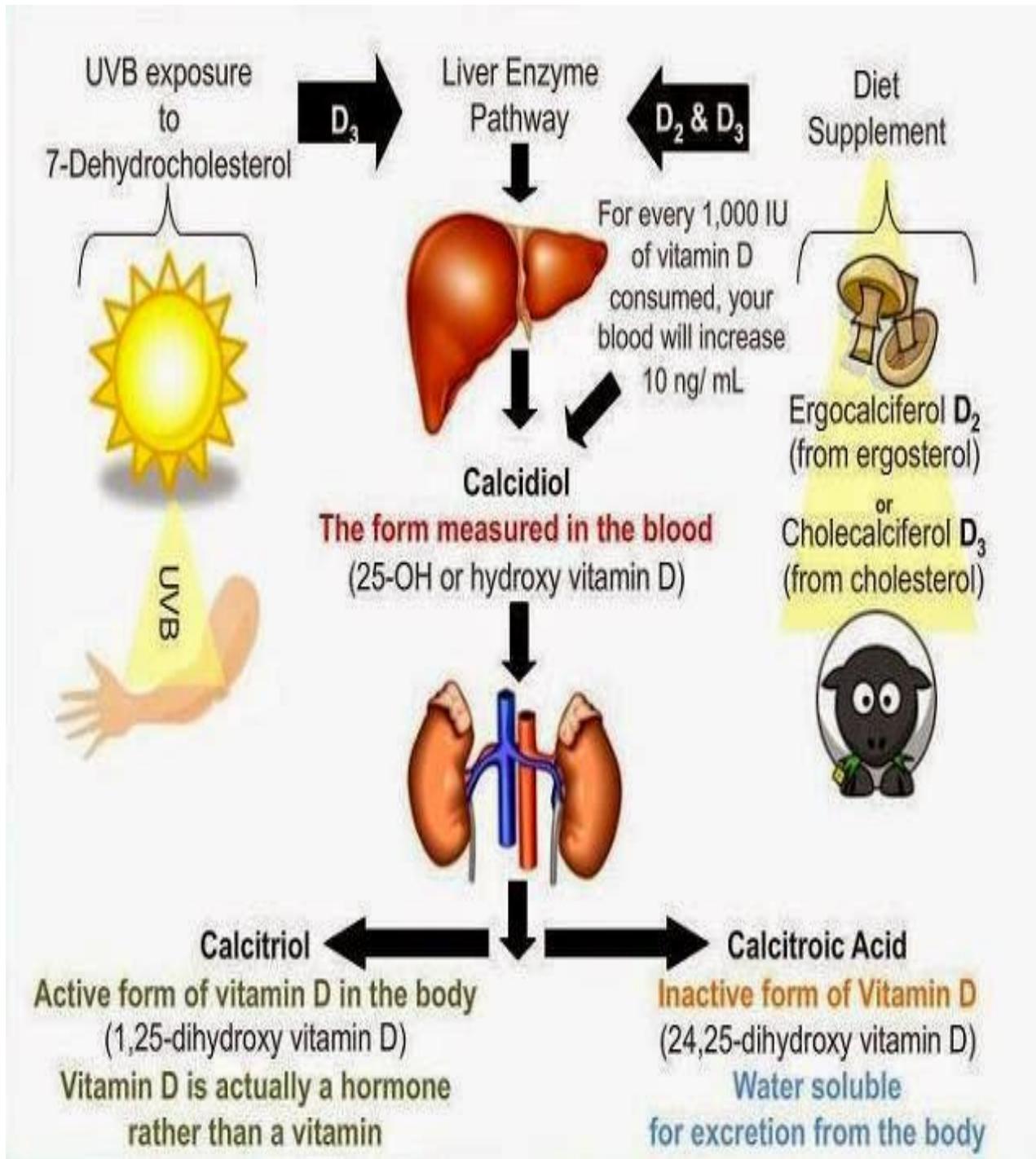


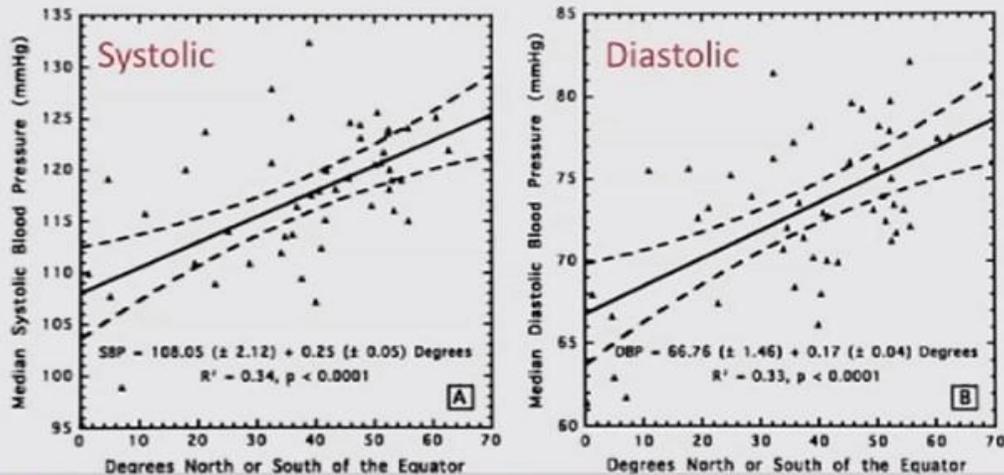
Figure 11. Synthesis of Vitamin D from sunrays.

The full solar spectrum is essential to optimal health and well-being. Humans are physiologically adapted to produce vitamin D in response to sun exposure, specifically UVB radiation; other regions of the spectrum seem to confer benefit as well. Though, some vitamin D comes from our diet (and more recently from supplements), we should not ignore the natural capacity that we possess to produce our own. Through moderate sun exposure (less than the time required to burn) to the arms, shoulders, trunk, and legs should be sought rather than avoided. Once that limited time has been achieved, covering the skin or seeking shade by the individuals can be allowed.

The benefits of such exposure go beyond production of vitamin D and include other physiological responses to sunlight, still inadequately explored, including release of nitric oxide, production of beta-endorphin, and regulation of circadian rhythms—all important components of lifelong health and well-being. The current policy of sun avoidance is creating probable harm for the general population. Ignorance of the effects of portions of the solar spectrum at wavelengths longer than the ultraviolet is due mainly to lack of suitable measurement tools for cutaneous and systemic responses to those regions.

The following figure expresses the difference in the blood pressure with respect to the latitude ranges.

Latitude and Blood Pressure



Blood pressure increases as distances from the equator increases.

Beneficial effects of UV radiation
on diseases other than cancer
Asta Juzeniene

Rostand (1997) *Hypertension*

Figure 12. Difference in blood pressure with variation in the exposure to sunlight

3.14 PLANTAIN LEAF BATH

3.14.1 Overview on plantain leaf

Plantain's scientific name: *Musa paradisiaca* is one of the monoherbaceous plant belonging to the family; Musaceae. It is commonly referred to as plantain. Plantain refers in India to a coarse banana. In most part of the India like Assam, Madhya Pradesh, Bihar, Gujarat, Andhra Pradesh, Karnataka, Jalgaon district in Maharashtra, West Bengal, Tamilnadu etc. as well as in Burma, where the species is abundantly distributed. Apart

from Asia, they are available densely in the regions of America, Australia and tropical Africa.⁷²



Figure 13. Plantain tree (*Musa paradisiaca*)

3.14.2 Benefits:

Traditionally the Plant *Musa paradisiaca* was used for different purposes such as:

Abscess, Alopecia (female), burns, cancer, cataplasm, diabetes, diarrhea, dog bites, snake bite, dysentery, dyspepsia, fracture, gangrene, hematuria, hemiplegia, hemoptysis,

hemorrhage, hypertension, lizard bites, marasmus, migraine, ringworm, shingles, smallpox, syphilis, tuberculosis, tumor, uremia, otalgia, psoriasis, urticaria, warts and wounds.

3.14.3 Benefits of Plantain Leaf bath as a naturopathic ailment

Banana leaf bath involves basically a different form of heliotherapy treatment, involving with exposure to sunlight with the individuals covering themselves thoroughly with plantain leaves.

The treatment aids in facilitating the movement of green rays present in the sun, directly in the body. The rays were found to serve as a good antiseptic agent. This process is regarded as one of the detoxification processes involving with inducing a profuse sweating.^{73, 74}

Asides their removal of toxin, they aid in burning the fat, effective for diabetic patients and asthma patients. Some of the major benefits of PLB include:

- Detoxifying the body and aids in weight loss, arthritis and curative for all sorts of skin diseases
- Maintain the skin's glow and clears the acne and black heads from the skin.
- Induces to open the pores and clears the dirt away
- Excellent anti-inflammatory properties.

Plantain leaf helps in soothing the lungs as well as promotes respiratory health thus aids in treating coughs and bronchitis. Additionally, their purported use for plantain leaf includes enhanced circulation, stimulating the uterus, treating cystitis and hay fever and reducing total cholesterol levels. Through enhanced circulation, rejuvenates entire body and the circulatory system. This in turn assists in improving the circulatory system to a greater extent.⁷⁴

As this is the first study evaluating the effect of PLB, previous evidence based study was not available for literature review.

4. MATERIALS AND METHODOLOGY:

The methodology involved in the following research is described in detail in the below chapter.

4.1 STUDY DESIGN:

The study employed Pre and post study. This intended study is entailed on evaluating the efficacy of 'PLB' in improving the HRV and cardiovascular parameters.

4.2. ETHICAL CONSIDERATIONS

4.2.1 Ethical clearance

Ethical clearance was sought from the Institutional Ethics Committee prior to the start of the study and the approval for the same was granted.

4.2.2 Written informed consent

Subjects who fulfilled inclusion criteria were apprised about the purpose of the study and their rights as research subjects. Informed consent form was administered in English. As all the subjects understood spoke English, there was no requirement of translating the signed informed consent form into native language i.e., Tamil. Adequate time was given to each patient to go through the information sheet and their queries were answered. Their right to withdraw anytime from the study and the need for willingness to participate voluntarily in the study was explained. All the subjects expressed their willingness to

participate in the study by giving a signed informed consent. (A sample information sheet and consent form is enclosed as Annexure 1).

Figure 14: Getting Informed Consent from the participant



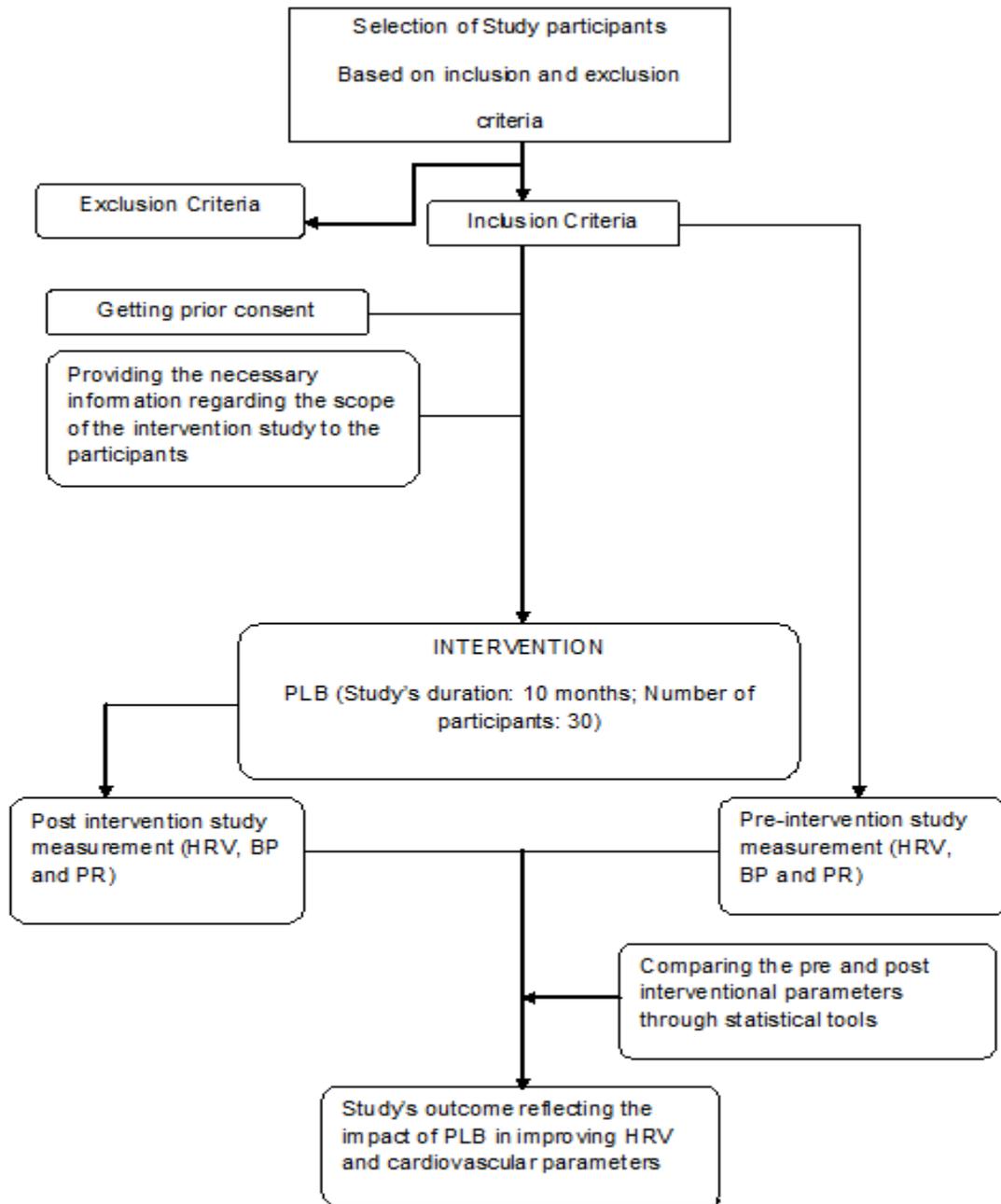


Figure 15 : Flowchart representing the research plan

4.3 STUDY PERIOD:

The entire duration of the study was 10 months.

4.4 SAMPLE SIZE:

The study comprised a total of 30 study participants.

4.5 SELECTION CRITERIA:

The following intervention study was carried out, by carrying out certain inclusion and exclusion criteria, which is given below.

4.5.1. Inclusion Criteria:

- Age : 18 to 35 years,
- Gender: Both male and females
- Body mass index (Kg/ m²) : 18.5 to 24.99
- Willingness to participate in the study.

4.5.2. Exclusion Criteria:

While selecting the study participants, there are certain factors that must be observed beforehand. These exclusion factors are:

- Subjects with a history of any systemic and/or psychological disorders,
- Subjects who are regularly uses medications.
- Subjects who were recently hospitalized.
- Avoiding subjects who are chain smokers and/or consume alcohol on a regular basis, and
- Participants who did not consent and are not willing to take part in the study.

4.6 METHODOLOGY:

A single group pre-post study design were adopted in this study. All the recruited subjects were given PLB for an overall duration of 30 minutes. Assessments such as blood pressure, pulse rate and heart rate variability will be taken before and after the intervention.

4.7 INTERVENTION PROCEDURE:

- PLB (Plantain Leaf bath) was performed among the study participants in the morning sessions between 7.00 am to 9.00am.
- The Subjects were instructed to wear minimum dress during PLB.
- Subjects were made to lie supine over the plantain leaves spread on a mat.
- The subjects were wrapped with the plantain leaves and tied with 4 to 6 ropes which were laid between the mat and the plantain leaves at fixed intervals.
- The anterior (ventral) portion of the subjects should be covered with plantain leaves and tied with the rope underneath. This ensures in preventing the entry of air inside.

- The full body was completely wrapped with plantain leaves, with a small slit on the leaves above the nostrils to facilitate breathing. Maximum duration of the bath will be 30 minutes.
- Subsequently, on completion of the above procedure, the subjects were instructed to take cold affusion for a minute.

The below (figure) represents a study participant/subject, who was employed with PLB:



Figure 16. Plantain Leaf Bath

4.8 ASSESSMENT OF CARDIOVASCULAR AND HRV PARAMETERS:

4.8.1 Blood Pressure and Pulse Rate:

Pulse rate and blood pressure will be obtained before and after PLB using a digital sphygmomanometer. Three consecutive readings will be taken and the average was recorded.



Figure 17. BP and pulse rate assessment via sphygmomanometer

4.8.2 Heart Rate Variability:

Before HRV data recording, all the subjects were instructed to maintain their normal sleep pattern, not ingest beverages with caffeine or alcohol, and not perform physical exercise 12 hours before the assessment. This test was conducted in morning between

7am to 9am. Subjects were encouraged to void urine before commencement of the recording. After 15 minutes of supine rest, ECG was recorded for 5 minutes with controlled breathing. For recording of short-term HRV, recommendation of the Task Force on HRV was followed (17). Time domain and frequency domain parameters were analyzed in this study. In the time domain, the standard deviation of the NN interval (SDNN), the square root of the mean squared differences of successive NN intervals (RMSSD), the number of interval differences of successive NN intervals greater than 50 ms (NN50), and the proportion derived by dividing NN50 by the total number of NN intervals (pNN50) were used. In frequency domain power spectral density (PSD) analysis in non parametric method (fast Fourier transform) were used. They were low frequency (LF, 0.04–0.15 Hz) and high frequency (HF, 0.15–0.40 Hz) in square milliseconds (ms^2) as well as normalized units (LF nu and HF nu, respectively), and LF/HF ratio. Figure 18 represents the HRV data collection.



Figure 18: HRV data collection

In 5 mins recorded ECG, Ectopics and artefacts were removed after the manual checking of the recorded ECG in offline mode. The HRV data consisting of artifacts time of more than 5%, premature beats of more than 10% in the recorded time were excluded. Raw R-R interval data were obtained from simple analog converter stored in the system and HRV analysis had been done using kubios HRV analysis software version 2.2 (Bio-signal Analysis group, Finland). Schematic representation of result sheet generated by Kubios are presented in Figure 19.

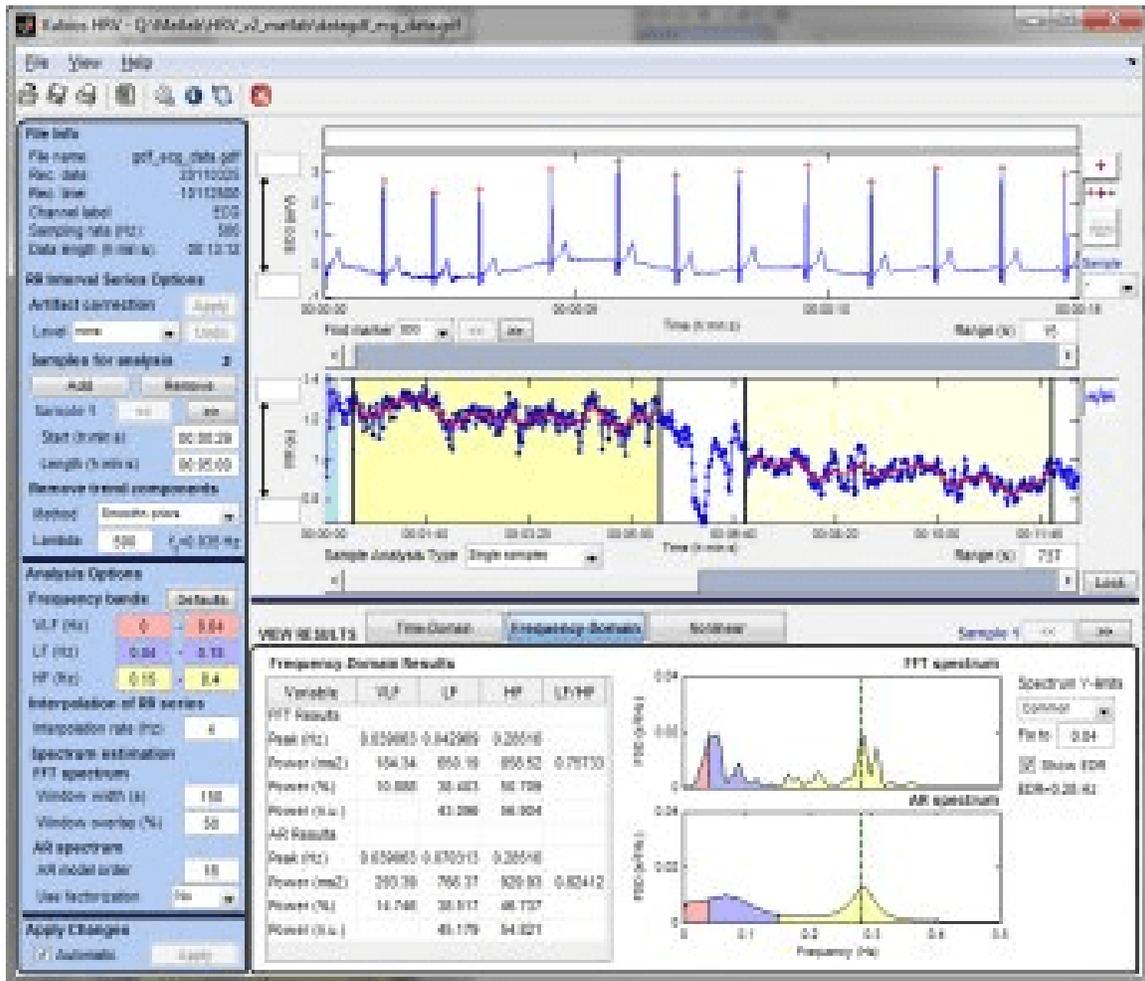


Figure 19. Kubios HRV analysis software

4.9 DATA COLLECTION METHODS:

TOOLS:

All the parameters were recorded by Short term HRV- Lead II Simple analog to digital converter and Digital sphygmomanometer before and after the plantain leaf bath intervention.

4.10 DATA MANAGEMENT AND STATISTICAL ANALYSIS:

Data expressed Mean \pm SD. Comparison of Mean in between the pre and post intervention was analyzed by paired t test and Wilcoxon signed-rank test which is applicable. R statistical software version 3.1.1 was used for the analysis

5.RESULTS

5.1 INTRODUCTION

The following chapter represents the overall results of the current study that determines the effectiveness of PLB. The resultant outcomes from the interventional studies were monitored from the HRV and cardiovascular parameters, which were further subjected to statistical analysis.

5.2 STATISTICAL ANALYSIS

The results for the following studies were statistically determined for both HRV and cardiovascular parameters and the results were graphically plotted by R-statistical software. The following data for each subsets were expressed Mean \pm SD. In this study 30 healthy individuals consisting of 16 females and 14 males were participated. The mean age of all the participants is 18.74.

Table: 4 Baseline characteristic of study participants

Variables	Mean \pm SD
Age (yrs)	18.74 \pm 3.93
Height (cm)	153.12 \pm 10.12
Weight (kg)	54.28 \pm 9.53
BMI (kg/m ²)	21.44 \pm 4.07

Table 4 shows the anthropometry parameters of participants . All the parameters like height (153.12 \pm 10.12cm), weight (54.28 \pm 9.53kg) and BMI (21.44 \pm 4.07kg/m²) were normal in range. They are considered as healthy volunteers and were recruited for this study.

Table 5: Immediate effect of PLB on Blood pressure variables.

Cardiovascular parameter- Blood pressure	PRE n-30	POST n-30	P Value
SBP mmHg	103.06±9.92	110.49±11.95	0.01
DBP mmHg	63.11±7.89	65.58±7.18	0.2

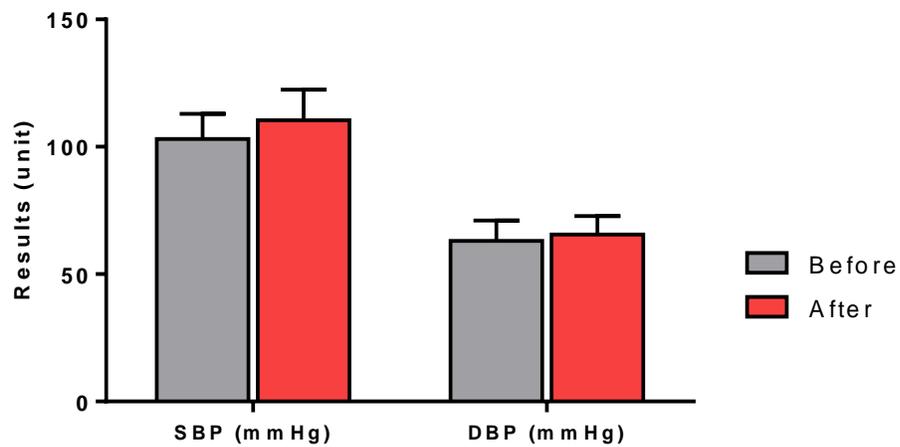


Figure 20: Graphical representation on Blood pressure

Table 5 and Figure 20 shows immediate effect of PLB on blood pressure variables and found significant increase in systolic blood pressure from 103.06±9.92 to 110.49±11.95 mmHg ($p \leq 0.01$) and the changes noticed in DBP was not significant.

Table 6 : Immediate effect of PLB on Pulse Rate .

Cardiovascular parameter	PRE n-30	POST n-30	P Value
PR bpm	73.09±8.92	68.46±9.14	0.05

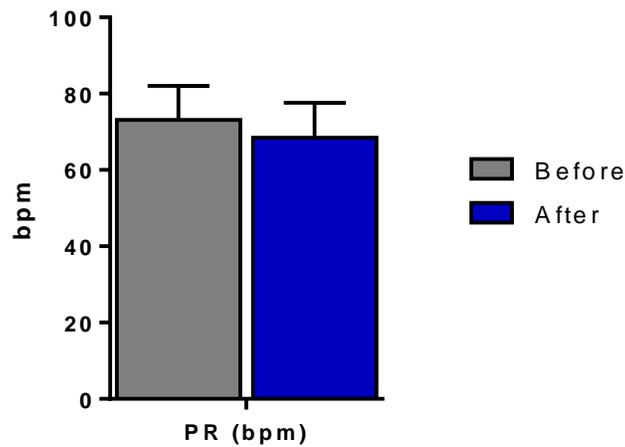


Figure 21: Graphical representation on Pulse rate

Table 6 and Figure 21 shows that Pulse rate changes immediately after PLB practice.

PR reduced significantly from 73.09±8.92 to 68.46±9.14 bpm ($p \leq 0.05$) after the intervention of PLB among the healthy volunteers.

Table 7: Immediate effect of PLB on time domain parameters of HRV

Time Domain Parameters	Before n-30	After n-30	P Value
HR (1/min)	71.69±9.34	66.53±7.69	0.02
RR (ms)	834.56±181.43	871.15±241.17	0.03
SDNN (ms)	53.63±4.71	70.6±8.04	0.03
RMSSD (ms)	48.16±9.08	61.83±8.13	0.008
NN50 (count)	69.64±10.47	110.6±12.3	0.001
pNN50 (%)	20.81±3.22	34.88±4.05	0.001
TOTAL POWER	3372±760	6025±1780	0.03

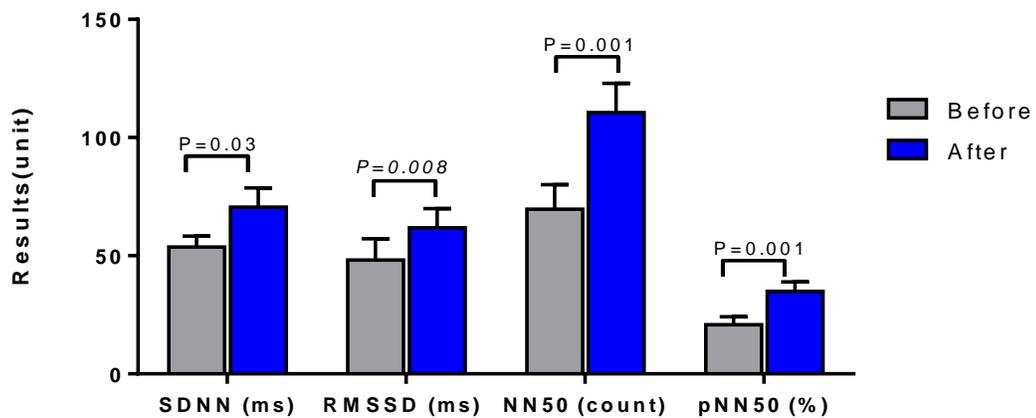


Figure 22: Graphical representation on HRV Time dependent domain

Table 7 and Figure 22 represents the Time domain parameters of Short term HRV parameters immediately after PLB. In time domain parameters, 30mins of PLB showed a significant increase RR interval ($p \leq 0.03$), SDNN($p \leq 0.03$), RMSSD($p \leq 0.008$), NN50($p \leq 0.001$) and pNN50($p \leq 0.001$). HR also showed a significant reduction immediately after the PLB among the healthy volunteers. The result strongly indicating that immediately after the PLB intervention produces parasympathetic domination.

Table 8: Immediate effect of PLB on Frequency domain parameters of HRV

Frequency Parameters	Before n-30	After n-30	P Value
LF (n.u)	48.32±3.15	42.53±3.77	0.02
HF (n.u)	51.54±3.14	57.3±3.77	0.02
LF/HF (ms ²)	1.26±0.20	1.19±0.66	0.02

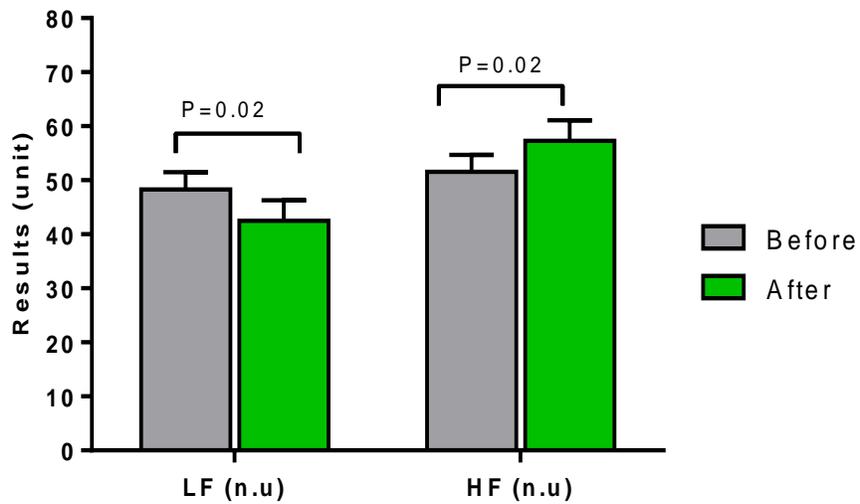


Figure 23: Graphical representation on HRV Frequency dependent domain

Table 8 and Figure 23 represent the Frequency domain parameters of Short term HRV. In frequency parameters, 30mins of PLB shows a significant reduction in low frequency parameters ($p \leq 0.02$) and significant increase in high frequency parameters expressed in normalized unit ($p \leq 0.02$). LF/HF also showed a significant reduction after PLB intervention indicates that improvement in the sympatho-vagal balance. These changes strongly reflected that immediately after PLB intervention parasympathetic domination was produced among the volunteers.

6. DISCUSSION

Heliotherapy mediated with PLB could facilitate in improving the systemic circulation, quite effectively but there is not enough literature studies have focused on PLB and its impact on CVS. Current public health advice advocates avoidance of direct sunlight in regard of skin cancer. The main aim of this study was to encourage the protective sunbath as plantain leaf bath and the evaluation of its physiological effect on cardiovascular function and autonomic functions by measuring blood pressure, pulse rate and heart rate variability. CVD is regarded as the dangerous threat, causing an increase in the mortality, of all age groups. There has been a growing concern with regards to CVD, which needs necessary interventional approach which is efficacious and impactful on a longer term. Under such situations, many countries rely on naturopathic approaches for treating systemic disorders¹³

The present study showed that PLB, have significant impact in the overall short term HRV ranges and cardiovascular parameters.

In the present study among the participants we have found that immediately after plantain leaf bath the resting cardiovascular parameter Systolic blood pressure and diastolic blood pressure significantly, and insignificantly increased respectively. In a various previous studies sunlight and irradiation of UV rays corresponding to sunlight were significantly reduces the systolic and diastolic blood pressure^{75,76,77}. Geographical difference, diurnal variation and repeated exposure had a role on blood pressure reduction

on the previous studies. The mechanism might be due to vasodilatation in response to release of nitric oxide from the skin to systemic circulation. In the current study blood pressure values were increased, this increase in blood pressure effect might be the result of increased peripheral resistance related with Vit D. In a previous study Vit D3 supplementation with daily dose of 2000 IU significantly reduced the vascular stiffness⁷⁸. The reduction of vascular resistance can be obtained by increasing the Vit D3 by taking PLB for a due period. In this study the increased blood pressure value was under normal range. The result has shown that PLB has a stabilizing effect on blood pressure which has to be evaluated in future study with proper study design.

In time domain parameters of HRV, HR has shown a significant reduction, RR interval, SDNN, RMSSD, NN50 and pNN50 has shown a significant improvement which indicates an activation of parasympathetic nervous system. Parasympathetic dominance was confirmed by Frequency domain parameters of HRV by significant improvement in HF, total power and significant reduction in LF. LF/HF reduction indicates improved sympatho-vagal balance. The possible mechanism behind the parasympathetic dominance might be due to the production of natural opiates beta endorphin by cleavage of the POMC pro-peptide in response to UV radiation⁷⁹. The current study result shows that Plantain leaf bath was found to be significantly enhancing the parasympathetic activity. This study suggests, PLB a type of sunbath can be used as a treatment modality for Sympatho vagal imbalances.

Thus PLB as a naturopathic approach could aid as an effective nonpharmacological technique for preventing cardiovascular complications. Volunteers showed a demonstrable change in HRV, with a significant decrease in sympathetic activity and trend toward an increase in parasympathetic activity, hence shifting sympatho vagal balance toward parasympathetic predominance.⁴⁴

6.1 LIMITATION OF THE STUDY

- The main limitation of the study was lack of control group.
- The sample size is relatively smaller.
- Sample size is not calculated by statistical method
- It is a pilot study
- The recording of assessments were not done during the plantain leaf bath , to have a better understanding of the physiology.
- Study focused only on the healthy individual.

6.2 STRENGTH OF THE STUDY

- This is the first study documented the immediate effect of PLB on resting cardiovascular and autonomic parameters by using short term HRV.
- There were no adverse effects reported during or after the intervention.

6.3 DIRECTIONS FOR THE FUTURE RESEARCH

- The study can be performed with larger sample size.
- Study can be conducted on general population and with applicable disorders.
- Study can be performed with proper study design like Randomized controlled trial which is a gold standard method for any kind of research and to validate the effect of PLB.
- Study can be performed with more outcome variable.

7.CONCLUSION

- ❖ The present study showed that there is a significant change on Resting cardiovascular parameters and short term HRV among the healthy participants immediately after plantain leaf bath intervention.
- ❖ The significant reduction of resting cardiovascular parameters reflected the status of parasympathetic domination immediately after plantain leaf bath intervention.
- ❖ Short term HRV parameters also showed a positive changes in both Time and Frequency domain parameters and adding more strength to cardiovascular parameters immediately after plantain leaf bath intervention.
- ❖ Based on the present study finding, PLB could be used for the conditions like Hypertension, insomnia, Anxiety, Hyperthyroidism and psychosomatic disorders were stress would be the causative factor.

8.0 SUMMARY

The study's objective was to determine the efficacy of PLB, in improving the HRV ranges and cardiovascular parameter. The underlying abnormalities in these parameters could have a deleterious impact on the CVS resulting CVD and related issues. There are several naturopathic approaches that have a positive impact on improving the overall cardiac health. Many literature studies have represented the benefits of naturopathy, in treating cardiovascular issues. It also ensures in reverting the sympatho-vagal balance to normal.

The following study was intended majorly towards determining the impact of PLB in improving the HRV and cardiovascular ranges. The study was conducted among the healthy study participants. The baseline measurements were monitored initially for evaluating the actual difference in the HRV and cardiovascular parameters (BP and PR). HRV and cardiovascular parameters were assessed during the pre intervention and the post intervention study. From the observed study, the participants who were administered PLB intervention, exhibited significant improvement in their overall BP, PR and HRV readings.

The overall (Mean \pm SD) showed significant improvement in the HRV, for both time variable and frequency variable domain. The measured HRV time variable domain during the pre intervention study was (HR- 71.69 \pm 9.34; RR - 834.56 \pm 181.43; SDNN- 53.63 \pm 4.71; RMSSD- 48.16 \pm 9.08; NN50- 69.64 \pm 10.47 and pNN50- 20.81 \pm 3.22)

significantly improved during the post intervention study (HR- 66.53 ± 7.69 ; RR - 871.15 ± 241.17 ; SDNN- 70.6 ± 8.04 ; RMSSD- 61.83 ± 8.13 ; NN50- 110.6 ± 12.3 and pNN50- 34.88 ± 4.05). Similarly the Frequency variable domain during the pre intervention study was (LF- 48.32 ± 3.15 ; HF- 51.54 ± 3.14 ; LF/HF- 1.26 ± 0.20) significantly improved after the PLB intervention (LF- 42.53 ± 3.77 ; HF- 57.3 ± 3.77 ; LF/HF- 1.19 ± 0.66). The SBP- 103.06 ± 9.92 ; DBP- 63.11 ± 7.89 during the baseline was increased SBP- 110.49 ± 11.95 ; DBP- 65.58 ± 7.18 and the PR- 73.09 ± 8.92 of baseline value were reduced 68.46 ± 9.14 after PLB intervention . From the overall study's outcome exhibited that by incorporating PLB tend to have a significant improvement in CVS functioning. Therefore, the study reflects the impact of naturopathic interventional approach of PLB can be considered as an effective complementary approach that can improve the autonomic functioning of the heart, upon daily treatment.

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9.0 ANNEXURE

9.1 INFORMATION SHEET

We are conducting a study on "Immediate effect of plantain leaf bath on cardiovascular and autonomic parameters in healthy volunteers" at Government Yoga and Naturopathy Medical College Hospital, Chennai and for that we need your participation which is valuable to us.

The purpose of the study is to evaluate the effectiveness of plantain leaf bath on cardiovascular and autonomic parameters.

The privacy of the patients in the research will be maintained throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

Taking part in this study is voluntary. You are free to decide whether to participate in this study or to withdraw at any time; your decision will not result in any loss of benefits to which you are otherwise entitled.

The results of the special study may be intimated to you at the end of the study period.

Signature of investigator:

Signature of participant:

Date:

9.2 INFORMED CONSENT FORM

Title of the study: Immediate effect of plantain leaf bath on cardiovascular and autonomic parameters in healthy volunteers

Name of the Participant:

Name of the Principal Investigator: Dr. M. Fathima Jebin

Name of the Institution: Government Yoga & Naturopathy Medical College, Chennai –
600 106

Documentation of the informed consent

I _____ have read the information in this form (or it has been read to me). I was free to ask any questions and they have been answered. I am over 18 years of age and, exercising my free power of choice, hereby give my consent to be included as a participant in "Immediate effect of plantain leaf bath on cardiovascular and autonomic parameters in healthy volunteers"

1. I have read and understood this consent form and the information provided to me.
2. I have had the consent document explained to me.

3. I have been explained about the nature of the study.
4. I have been explained about my rights and responsibilities by the investigator.
5. I have been informed the investigator of all the treatments I am taking or have taken in the past _____ months including any native (alternative) treatment.
6. I have been advised about the risks associated with my participation in this study.
7. I agree to cooperate with the investigator and I will inform him/her immediately if I sufferunusual symptoms.
8. I have not participated in any research study within the past _____month(s).
9. I am aware of the fact that I can opt out of the study at any time without having to give any reasonand this will not affect my future treatment in this hospital.
10. I am also aware that the investigator may terminate my participation in the study at any time, forany reason, without my consent.
11. I hereby give permission to the investigators to release the information obtained from me as resultof participation in this study to the sponsors, regulatory authorities, Govt. agencies, and IEC. Iunderstand that they are publicly presented.
12. I have understood that my identity will be kept confidential if my data are publicly presented.
13. I have had my questions answered to my satisfaction.
14. I have decided to be in the research study.

I am aware that if I have any question during this study, I should contact the investigator.

By signingthis consent form, I attest that the information given in this document has been

clearly explained to me and understood by me, I will be given a copy of this consent document.

For adult participants:

Name and signature / thumb impression of the participant (or legal representative if participant incompetent)

Name _____ Signature _____

Date _____

Name and Signature of impartial witness (required for illiterate patients):

Name _____ Signature _____