# IMPACT OF ROTATION SHIFTS ON AUTONOMIC NERVOUS SYSTEM IN SHIFT WORKERS AS ASSESSED BY SHORT TERM HEART RATE VARIABILITY AND OTHER AUTONOMIC FUNCTION TESTS.

**Dissertation submitted in**

**Partial fulfillment of the regulations required for the award of**

**M.D. DEGREE**

**In**

**PHYSIOLOGY– BRANCH V**


**THE TAMIL NADU DR. M.G.R. MEDICAL UNIVERSITY**

**CHENNAI**

**April – 2016**

**Dissertation submitted to**

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

**CHENNAI**

# PSG INSTITUTE OF MEDICAL SCIENCE & RESEARCH
# PEELAMEDU, COIMBATORE – 4.

## CERTIFICATE

This is to certify that the dissertation titled ‘ Impact of rotation shifts on autonomic nervous system in shift workers as assessed by short term Heart Rate Variability and other autonomic function tests’ is an original work done by

Dr. S. Vijayabaskaran, Post graduate student, during the period of his post graduation in Physiology in our institution. This work is done under the guidance of Dr.T.Umamaheswari, Professor, Department of Physiology, PSG Institute of Medical sciences and Research, Coimbatore.

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# DECLARATION

I hereby declare that this dissertation entitled “Impact of rotation shifts on autonomic nervous system as assessed by short term Heart Rate Variability and other autonomic function tests ” was prepared by me under the guidance and supervision of Dr.T.Umamaheswari, Professor, Department of Physiology, PSG IMS&R.

This dissertation is submitted to The Tamilnadu Dr. MGR Medical University in fulfillment of the university regulations for the award of MD Degree in Physiology.

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April 23, 2014

To
Dr S Vijayabaskaran
Postgraduate
Department of Physiology
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The Institutional Human Ethics Committee, PSG IMS & R, Coimbatore -4, has reviewed your proposal on April 4, 2014 in its expedited review meeting held at IHEC Secretariat, PSG IMS&R, between 10.00 am and 11.00 am, and discussed your study proposal entitled:

*"Impact of rotation shifts on autonomic nervous system in shift workers as assessed by short term heart rate variability and other autonomic function tests"*

The following documents were received for review:

1. Duly filled application form
2. Proposal
3. Informed Consent forms
4. Proforma
5. CV
6. Budget

After due consideration, the Committee has decided to approve the study.

The members who attended the meeting at which your study proposal was discussed are as follows:

| Name | Qualification | Responsibility in IHEC | Gender | Affiliation to the Institution Yes/No | Present at the meeting Yes/No |
|---|---|---|---|---|---|
| Dr P Sathyan | DO, DNB | Clinician, Chairperson | Male | No | Yes |
| Dr S Bhuvaneshwari | M.D | Clinical Pharmacologist<br>Member - Secretary | Female | Yes | Yes |
| Dr Sudha Ramalingam | M.D | Epidemiologist<br>Alt. Member - Secretary | Female | Yes | Yes |
| Dr Y S Sivan | Ph D | Member –Social Scientist | Male | Yes | Yes |

The approval is valid for one year.

**We request you to intimate the date of initiation of the study to IHEC, PSG IMS&R and also, after completion of the project, please submit completion report to IHEC.**

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This Ethics Committee is organized and operates according to Good Clinical Practice and Schedule Y requirements.

Non-adherence to the Standard Operating Procedures (SOP) of the Institutional Human Ethics Committee (IHEC) and national and international ethical guidelines shall result in withdrawal of approval (suspension or termination of the study). SOP will be revised from time to time and revisions are applicable prospectively to ongoing studies approved prior to such revisions.

Kindly note this approval is subject to ratification in the forthcoming full board review meeting of the IHEC.

Yours truly,

23.4.14

SECRETARY
PSG IMS&R
COIMBATORE-641004.
INSTITUTIONAL HUMAN ETHICS COMMITTEE

**Dr S Bhuvaneshwari**
**Member - Secretary**
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The Institutional Human Ethics Committee, PSG IMS & R, Coimbatore -4, has reviewed your proposal on 4th March, 2015 in its expedited review meeting held at IHEC Secretariat, PSG IMS&R, between 10.00 am and 11.00 am, and discussed your application to renew the study entitled:

*"Impact of rotation shifts on autonomic nervous system in shift workers as assessed by short term heart rate variability and other autonomic function tests"*

The following documents were received for review:

1. Application for renewal dated 05.03.2015
2. Status report of the study

After due consideration, the Committee has decided to renew the approval for the above study.

The members who attended the meeting held on at which your proposal was discussed, are listed below:

| Name | Qualification | Responsibility in IHEC | Gender | Affiliation to the Institution Yes/No | Present at the meeting Yes/No |
|---|---|---|---|---|---|
| Dr P Sathyan | DO, DNB | Clinician, Chairperson | Male | No | Yes |
| Dr S Bhuvaneshwari | M.D | Clinical Pharmacologist Member – Secretary | Female | Yes | Yes |
| Dr S Shanthakumari | MD | Pathology, Ethicist | Female | Yes | Yes |
| Dr Sudha Ramalingam | MD | Epidemiologist Alt. Member - Secretary | Female | Yes | Yes |
| Dr D Vijaya | Ph D | Member – Basic Scientist | Female | Yes | Yes |

The renewal is valid for one year (From 23.04.2015 to 22.04.2016).

This Ethics Committee is organized and operates according to Good Clinical Practice and Schedule Y requirements.

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Kindly note this approval is subject to ratification in the forthcoming full board review meeting of the IHEC.

Yours truly,

SECRETARY
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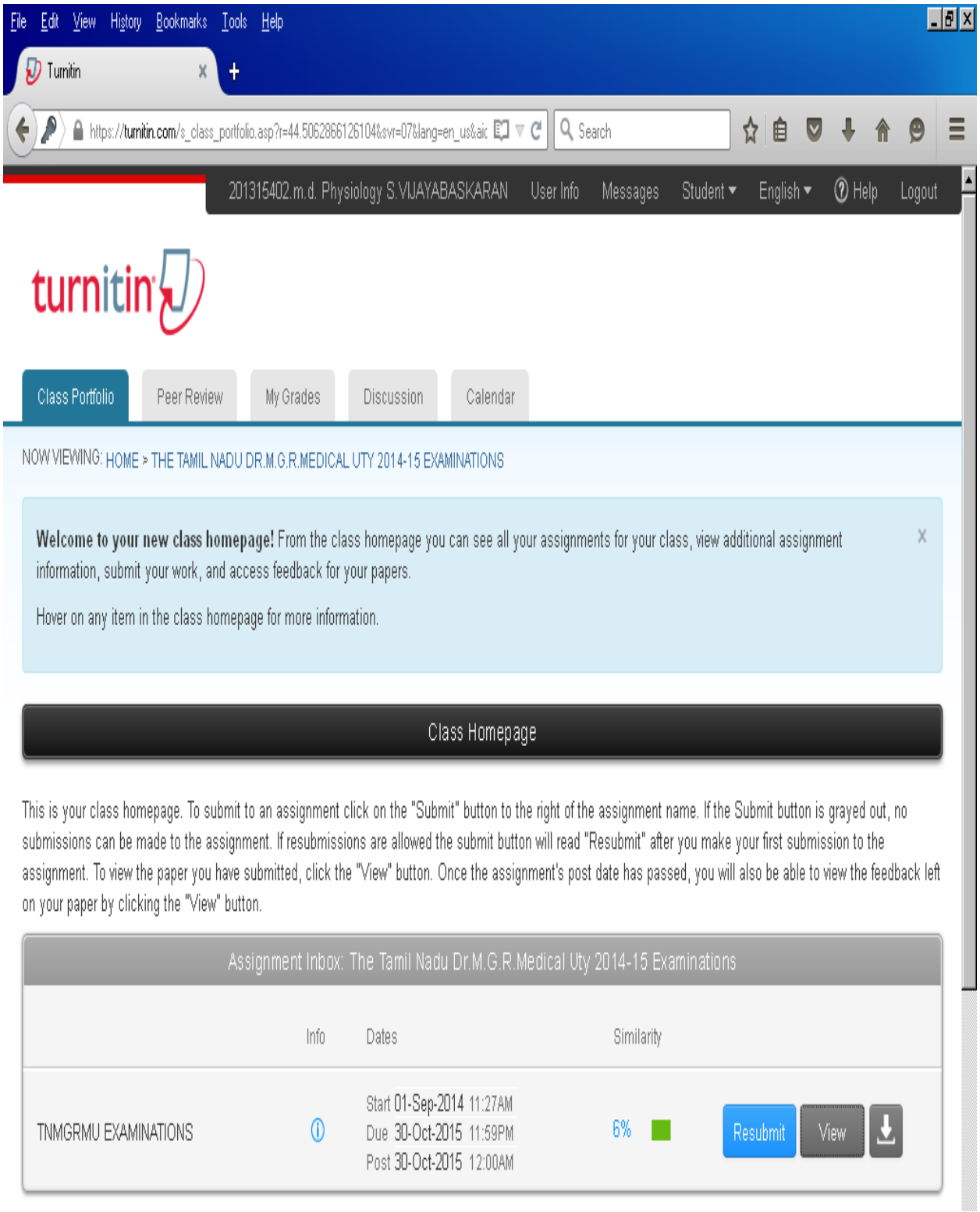
INSTITUTIONAL HUMAN ETHICS COMMITTEE

**Dr D Vijaya**
**Member**
**Institutional Human Ethics Committee**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First of all, I express my thanks to Dr.S.R amalingam, Dean, PSG Institute of Medical Sciences and Research, for allowing me to do my dissertation in PSG IMS&R.

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# CONTENTS

# INTRODUCTION

# INTRODUCTION

## SHIFT WORK

Shift work may be defined as the work which makes use of the unusual hours other than the usual day time work hours.

Shift work employs a rotational schedule which in turn makes sure the presence of employees even at night so that there is continuation of service round the clock.

In our modern fast paced world these kind of work schedules are increasingly employed in all the sectors. In the IT sector, to get in touch with the other half of the world having a different time zone, workers are forced to lead a night life most of the days in a month. However, in other kinds of works the night shifts are evenly spaced. The usual mode is one week per month as night shift.

So it is safe to say that shift work has become a necessity in the present scenario and it is important to study the consequences of these kinds of schedules in a human body as well as the psyche.

Previously it has been extensively researched and concluded that work stress is an important factor which has an adverse impact on the physical as well as mental wellbeing of workers.[1,2]

These kinds of shift work tend to disrupt circadian rhythm in the concerned persons and any disruption in the circadian rhythm predisposes to stress and stress as we know is a crucial factor which results in autonomic imbalance.

## AUTONOMIC NERVOUS SYSTEM

The human body responds to emotions as well as environment without involving the consciousness of an individual and these responses are covered by the autonomic component of the nervous system.

The term ‘Autonomic’ is derived from the latin word ‘autonomos’ in which the ‘auto’ means ‘self’ and ‘nomos’ means ‘control’.[3]

Autonomic nervous system is a part of the nervous system which is responsible for maintaining the homeostatic condition of the human body.

Of all the organs only the skeletal muscle is controlled by the somatic nervous system and the remaining get their innervations from the autonomic nervous system.[4] The ANS has its nerve terminals located in the smooth muscle lining the visceral blood vessels and gastrointestinal tract , cardiac muscle and glands.

Autonomic nervous system has two components: sympathetic and parasympathetic based on their anatomical and physiological properties. Sympathetic nervous system provides assistance when the body tries to cope up with the emergency conditions and stressful situations.

The parasympathetic nervous system has a reciprocal influence on the functions of the organs to which balances the sympathetic influence. In essence parasympathetic system provides a check to the sympathetic system and it smoothens the autonomic responses.

**STRESS**

The word 'Stress' has its origin from Latin and has a meaning ' to draw tight '[5] For long the term was extensively used in physics which means internal distribution of a force resulting in strain. In 1920 Walter Canon used it to refer to the factors which disrupt the homeostasis.[6]

Stress or physiological stress is nothing but the human body's response to a stressor environment or a stimulus. These responses are carried out through the activity of the sympathetic nervous system which results in 'fight or flight' response. However these responses will not persist long due to the opposing activity of the parasympathetic nervous system.

Stress even a transient one can be harmful to the body. When it persists for a longer time can trigger an abundant secretion of stress hormones which result in physiological disharmony.

Combined responses of human body to a stressful situation to cope up effectively are called as fight or flight response. Both the sympathetic component of the autonomic nervous system and adrenal medulla are involved in the physiological

responses of the body in these kind of situations. Even though they can function independently of one another they are generally activated together and hence referred as sympatho-adrenal medullary system.[7]

W.B. Cannon [8] first demonstrated the secretion of adrenalin experimentally in cats with hearts sensitized by denervation. Elevated catecholomine levels have confirmed Cannon's findings and showed that the secretion of catecholomines is stimulated by:

1. Emotional stress and physical exertion
2. Exposure to cold
3. Hypotension
4. Cerebral ischemia

**CIRCADIAN RHYTHM AND STRESS**

When a biological process shows a regular oscillation of about 24 hours which is endogenous as well as entrainable then it is called as circadian rhythm. These rhythms are regulated by a biological clock called as circadian clock. This circadian rhythm even though is termed to be endogenous it is constantly adjusted to the external environment by some external cues. They are called as zeitgebers. One of the most common zeitgebers is sunlight.

In 1729, an endogenous circadian oscillation was observed by a French scientist Jean-Jacques d'Ortous de Mairan . He observed this curious phenomenon in the

leaves of a plant called Mimos pudica. He noted that there was a regular pattern in the movement of leaves in a 24 hour cycle. He further observed that there is persistence of the movement even when the plants were kept in dark.[9,10]

It has been observed in 1896 by Patrick and Gilbert that the sleepiness waxes and wanes over a period of approximately 24 hours when the sleep is deprived for a prolonged period .[11]

**NEURAL COMPONENTS OF STRESS**

Reponses to the stress are carried out by the combined actions of the neural and endocrine components of the human body. These components play a key role in coping up with the stress.

Hypothalamus is a diencephalic structure extending between the mamillary body and the optic chiasma. As the name implies, it is located just below the thalamus. This structure has extensive neural as well as endocrine connections with other structures. Excitation of the anterior part of the hypothalamus leads to sleeping state. Stimulation of the posterior hypothalamus leads to awake state, as the mamillary body located in the posterior hypothalamus is the wakefulness centre. In the presence of stress this hypothalamic part of the brain secretes various hormones in response. Out of this the most important one is Corticotropin Releasing Hormone. On its release from the hypothalamus this stimulates the pituitary gland and triggers a massive stress response.[12]

The brain's limbic system contains amygdala. This structure has extensive inputs and outputs from and to with other structures such as hypothalamus, hippocampus, locus coeruleus, etc. Amygdala is found to be the structure responsible for processing emotions. Apart from processing emotions it has been found out that when anxiety or fear is involved it is responsible in modulating stress response. [13]

Hippocampus is an area concerned with the memory. This structure is also a part of the brain's limbic system. It is situated below the amygdala. It has various reciprocal connections with the other structures of brain such as cerebral cortex, amygdale and hypothalamus. Due to its role in memory hippocampus has an ability to enhance a stress response or suppress a stress response based on the previous experiences. In some instances it is thought to be capable of producing a stress response independently, ie, without involving the other structures. It has been proved that long standing stress can bring about damage to this area.[14]

The anterior most part of the frontal lobe in the cerebral cortex is called as prefrontal cortex. The main function of this area is cognition. Planning, attention and problem solving are the various cognitive functions. These cognitive functions are carried out by the prefrontal cortex through its extensive connections with the other structures of the brain. It has been found out during a stress response the functional ability of the prefrontal cortex is compromised.[15]

Situated just below the hypothalamus, at the base of the brain is a small glandular structure called as pituitary gland. This gland is an endocrine gland which secretes various hormones. These hormones are responsible for maintaining the homeostatic condition of the human body. Upon stress this pituitary gland releases a hormone called as Adreno Cortico Tropic Hormone. This hormone plays a key role in stress response. The ACTH acts on the adrenal cortex and causes the release of cotisol.

## HORMONAL COMPONENTS OF STRESS

### Cortico tropin releasing hormone

Corticotropin releasing hormone reaches the anterior pituitary by the means of hypothalamo – hypophyseal portal vessels. When it reaches the anterior pituitary it excites the corticotropes and triggers the synthesis as well as the release of adrenocorticotropic hormone. The factors which induce the secretion of corticotropic hormone are stress, emotional disturbances, trauma and circadian rhythm.

### Adrenocorticotropic hormone

The basophilic chromophilic cells of the anterior pituitary secrete ACTH which is a single – chained polypeptide with 39 amino acids. It acts on the adrenal cortex and triggers the synthesis and release of glucocorticoids. It also prolongs the action of glucocorticoids on various tissues.

**Cortisol**

Cortisol belongs to a group of steroid hormones called as glucocorticoids. Cortisol is secreted from the Zona Fascilculata of the adrenal cortex. It is synthesized in the adrenal cortex from cholesterol. Its primary function is to redistribute glucose during a fight or flight response. Cortisol increases the blood glucose by facilitating gluconeogenesis in the liver and by inhibiting the peripheral utilization of glucose. Also it suppresses the immunity in response to the fight or flight response.

**Noradrenaline**

In response to stress the hypothalamus activates locus coeruleus to release a neurotransmitter called as noradrenaline. It acts as a chemical messenger for the sympathetic component of autonomic nervous system and prepares the body for emergency response.

Other neurotransmitters thought to be involved in conditions of anxiety and stress are Serotonin and Neuropeptide Y.

**AUTONOMIC FUNCTION TESTS**

The autonomic nervous system as we know is involved in the regulation of almost all the physiological processes concerned with the homeostasis such as blood pressure, heart rate, metabolism, fluid electrolyte balance, digestion, body temperature, excretion, sexual responses, etc.

The autonomic nervous system has two major components that are sympathetic and parasympathetic.

The sympathetic system is catabolic in nature and triggers fight or flight response so it increases the rate and contractility of heart, dilates the bronchioles, re-distributes glucose and increases the rate of metabolism.

The parasympathetic is anabolic in nature and its primary function is conservation and restoration of internal environment, so it is secretomotor, as far as, the gastro intestinal tract is concerned and it slows down the heart rate and brings down the blood pressure.

When the autonomic nervous system is affected due to external factors the fine balance between sympathetic and parasympathetic component gets altered resulting in autonomic dysfunction. The symptoms of this autonomic dysfunction are orthostatic hypotension, intolerance to heat, constipation and urinary retention, nausea and dryness.

To find out the severity of autonomic dysfunction, there are some simple, noninvasive tests employed which are called as autonomic function tests. They are of the following types .

1. Cardio vagal innervation testing – assess the response of heart rate to deep breathing and to the Vasalva maneuver .

2. Vasomotor adrenergic innervation testing – it assesses the blood pressure response beat to beat to the head – up tilt and Valsalva maneuver .
3. Quantitative sudomotor axon reflex test (QSART) – with the help of iontophoresis it assess the post ganglionic neuron integrity.
4. Thermo regulatory sweat test (TST) - assessment of integrity of pre and post ganglionic pathway.
5. Sympathetic skin response (SSR) - provides index of sweat production

Thus these tests employ different techniques and test the different components of autonomic nervous system.

**HEART RATE VARIABILITY**

Heart rate variability is the variations that are displayed in the time interval between the two successive heart beats. Heart rate variability is measured by the changes in the beat to beat interval.

There are various methods to detect the beats such as Electrocardiogram, Ballistocardiogram ,[16] etc. Photoplethysmograph is also used on some occasions. Here they use the generated pulse wave to detect the beats.

Of all these measures employed electrocardiogram is still considered to be a cut above the rest because with the recorded wave forms it is easy to discard the beats which does not originate from the Sino-Atrial node.

The variations exhibited in the heart rate is a physiological process. Normally the pacemaker of the heart the Sino-Atrial node is responsible for generating the impulses which traverse the entire heart resulting in the mechanical events of the heart. In other words SA node controls the heart beat. However SA node doesn't function autonomously and it is controlled by different inputs .

Neural factors which control the SA node are sympathetic and parasympathetic components of the autonomic nervous system. Apart from this humoral factors also play a role.

Hence to sum it up, the main factors which affect the heart rate include stress, physical exertion, food intake, sleep-wake cycle, thermoregulation , hormonal factors, and baroreceptor activity.

HRV can be analyzed by various methods. The most commonly used methods are time-domain and frequency-domain methods. The other less commonly used methods are called as non linear methods.

**Time - domain method:**

These methods are based on the analysis of beat to beat or NN intervals.

**Frequency - domain method:**

In these methods different bands of frequencies are assigned then the number of NN intervals which match the particular band are counted.

**Non-linear methods:**

The frequently used non- linear method for analysis of HRV is Poincare plot. Here the quantification is done using mathematically defined geometric shapes to the corresponding data.

In general cardiac rhythm and the rate are mainly under the influence of autonomic nervous system. So HRV is used as a tool to assess the imbalance between the sympathetic and the parasympathetic influence on heart rate.

# AIMS AND OBJECTIVES

AIM:

To assess the autonomic dysfunction in the rotation (night) shift workers.

OBJECTIVES:

1) To assess and compare the differences in short term Heart Rate Variability between Regular (day) workers and the Rotation (night) shift workers.

2) To assess and compare the differences in cardiac autonomic function tests between Regular (day) workers and the Rotation (night) shift workers.

3) To know whether these tests can be used as early predictors to determine the risk of cardiovascular diseases in shift workers.

# REVIEW OF LITERATURE

# REVIEW OF LITERATURE

## AUTONOMIC NERVOUS SYSTEM

Most of the visceral functions of the body are controlled by the autonomic nervous system. This system involuntarily regulates the blood pressure, controls the motility and secretions of the gut, regulates the emptying of the bladder, controls the sweat glands, regulates the body temperature and many other activities of the human body.[17]

The functional significance of the Autonomic Nervous System is to maintain the optimal environment inside the human body. It controls the visceral functions without the awareness of the concerned person. Hence it is also called as Efferent Visceral Nervous System or Involuntary Nervous System.[18]

The autonomic nervous system has two divisions: sympathetic and parasympathetic.

### Sympathetic division

Sympathetic nerve fibres arise from the spinal cord from the intermediolateral grey horn. Sympathetic division of the autonomic nervous system is also called as thoracolumbar division because these nerve fibres arise from the spinal segments beginning from the first thoracic vertebra up to the second or third lumbar vertebra.

Sympathetic nervous system has three components. They are,

the preganglionic fibres, ganglia and the postganglionic fibres..

Preganglionic fibres leave the spinal cord through the ventral root and synapse with the postganglionic fibres in the paravertebral sympathetic ganglia or the prevertebral ganglia. Due to the closer proximity of these ganglia to the spinal cord the preganglionic fibres are relatively short.

There are two chains of ganglia situated on either side of the spinal cord known as the sympathetic trunk. Due to their location on either side of the vertebra, they are also called as paravertebral chain.

The fibres arising from the ganglia are called as postganglionic fibres. These fibres extend all the way to the effector organs and innervate them. When compared to the preganglionic fibres these postganglonic fibres are longer in nature.[19]

**Parasympathetic nervous system**

This division is also a part of the central nervous system which work against and complements the sympathetic division in general or work in tandem with the sympathetic division in some areas.

There are four cranial nerves and three spinal nerves which act as parasympathetic nervous system. The cranial nerves are the occulomotor nerve, facial nerve, glossopharyngeal nerve and the vagus nerve. The spinal nerves are those which arise from the second, third and fourth sacral segments. These spinal nerves are

collectively known as pelvic splanchnic nerves. It is to be noted that almost three fourths of the parasympathetic fibres are carried by the vagus nerve.

Due to their nature of origin i.e. from the brain itself or from the sacral segment of the spinal cord this division is also called as craniosacral division[18].

This division of the autonomic nervous system has also three components similar to that of the sympathetic division. They are the preganglionic fibres, ganglia and the postganglionic fibres.

Unlike the sympathetic division, the parasympathetic ganglia are situated either within the effector organs or closer to the organs they innervate. There are some minor exceptions to this like the sphenopalatine ganglia or the otic ganglia. Hence as a general rule , parasympathetic preganglionic fibres are longer than the postganglionic fibres.

**Types of nerve fibres**

As a whole, the autonomic preganglionic nerve fibres of both the divisions are myelinated. They belong to the B group of fibres.

The postganglionic nerve fibres of both the divisions belong to C type of fibres and they lack the myelin sheath.

**Neurotransmitters**

The main neurotransmitter released from the preganglionic fibres of both the divisions is acetylcholine.

In the sympathetic division the neurotransmitter involved in the neurotransmission from the postganglionic fibres to the effector organs is nor-epinephrine.

In the parasympathetic division the major neurotransmitter responsible for neurotransmission from the postganglionic fibres is acetylcholine.

**Neurons**

Depending on the neurotransmitter released, the neurons of the autonomic nervous system are classified into adrenergic and the cholinergic neurons. The adrenergic neurons secrete either adrenaline or noradrenaline whereas the cholinergic neurons secrete acetylcholine.

**Receptors**

The receptors responding to the respective neurons are also classified as adrenergic and cholinergic receptors.

**Adrenergic receptors**

The adrenergic receptors are again divided into α adrenergic and β adrenergic receptors. This distinction is based on the ability of these receptors to respond or block certain chemical agents or drugs.[20]

Stimulation of α adrenergic receptor results in excitation of smooth muscles and inhibition of neural as well as metabolic functions. α adrenergic receptors are further subdivided into $\alpha_1$ and $\alpha_2$.

$\alpha_1$ receptors are located in cutaneus and splanchnic vascular smooth muscles , sphincters of gastrointestinal tract and urinary bladder and radial muscles of iris. These receptors are excitatory, ie, they cause contraction of smooth muscles or constriction of sphincters in the effector organs.

On the other hand $\alpha_2$ receptors are present in the presynaptic nerve endings , platelets, adipocytes and the walls of the gastrointestinal tract . These receptors are inhibitory and tend to cause dilatation of sphincters or relaxation of smooth muscles in the effector organs.

Beta adrenergic receptors are of three types and they are $\beta_1$, $\beta_2$ and $\beta_3$ .

$\beta_1$, receptors are situated in the sinoatrial node, atrioventricular node and the muscles of the ventricles. These receptors are excitatory and on stimulation increase the

rate, conductivity and force of contraction in the heart. These receptors respond equally to adrenaline as well as noradrenaline.

$\beta_2$ adrenergic receptors are found in the smooth muscles of the blood vessel supplying the skeletal muscles , smooth muscles of the bronchi, walls of the gastrointestinal tract and the urinary bladder. These receptors are more sensitive to adrenaline when compared to noradrenaline and on stimulation dilate the blood vessels, dilate the bronchioles and relax the bladder .

$\beta_3$ adrenergic receptors are situated in the adipocytes and on stimulation cause lipolysis.

**Cholinergic receptors**

Depending upon their ability to respond to certain chemical agents they are divided into,

1. Nicotinic receptors.
2. Muscaranic receptors.

**1. Nicotinic receptors**

They are further subdivided into NN and NM receptors. They are situated in the ganglia of the autonomic nervous system , neuromuscular junction and the adrenal medulla. They respond to low doses of nicotine as well as the

neurotransmitter acetylcholine. On stimulation these receptors cause excitation in the effector organ.

**2. Muscarinic receptors**

These receptors are again subdivided into $M_1$ , $M_2$ and $M_3$. They are found in the heart , all the smooth muscles except in blood vessels and the glands. These receptors respond to Muscarine and Acetylcholine. On stimulation they decrease the heart rate and conductivity in the AV node. On the other hand, they cause excitation in the smooth muscles and glands i.e. increase the gastrointestinal motility and augment the secretion.[20]

**Functional principles**

Autonomic nervous system as a whole is responsible for maintenance of homeostasis and they function beyond the voluntary control. Most of the internal organs are innervated both by the sympathetic as well as the parasympathetic divisions of the autonomic nervous system. Due to this dual nature of innervation and the antagonistic action of each other they exert a fine control over the effector organ.

In the case of smooth muscles controlling the sphincters, both sympathetic and the parasympathetic divisions are excitatory. However, one division innervates the constrictor muscles whereas the other division supplies the dilator muscle.

Very few internal organs are supplied either by sympathetic or by the parasympathetic division. For instance the uterus, adrenal medulla and the arterioles are supplied by the sympathetic division whereas the gastric glands and the pancreas are controlled by the parasympathetic division.

The neurotransmitter acetylcholine is rapidly destroyed by the enzyme acetylcholine esterase at the cholinergic nerve endings. Due to this the cholinergic transmission lasts for a brief period.

The effects of the neurotransmitter noradrenaline last longer and span over a wider area than the acetylcholine. Adrenaline and dopamine are secreted mainly from the adrenal medulla whereas the noradrenaline is released from the adrenergic nerve endings.

Adrenaline stimulates α and β receptors in equal measures. In the β adrenergic receptors it has a special quality of acting on the $\beta_2$ receptors.

Noradrenaline stimulates α receptors and the $\beta_1$ receptors. However $\beta_2$ receptors fail to respond to noradrenaline.

**Fight -or- Flight response**

In a critical or a life threatening situation one has a choice either to fight or to run away from that situation. This response is known as Fight -or- Flight response and is triggered by the activation of sympathetic nervous system and the release of

catecholamine from the adrenal medulla. The combined effects of the both are listed below.

a. On CVS: The action of sympathetic nervous system gives rise to an increase in the cardiac output and generalized vasoconstriction which in turn causes a rise in blood pressure. So there will be a redistribution of the blood flow to the skeletal muscles and heart which enhances the performance.

b. In Lungs: There is an increase in the rate of respiration and bronchiolar dilatation. This leads to an increase in the gas exchange which in turn results in the increased supply of oxygen to the tissues.

c. Salivary secretion: There is a decrease in the total amount of secretion due to the sympathetic activation but the mucus component of the secretion increases which allows the lubrication of the oral cavity

d. Metabolic substrates: The supply to the tissues increases due to increased plasma glucose concentration from glycogenolysis and increased free fatty acids due to lipolysis.

e. Sweat glands: Increased sympathetic activity initiates a watery secretion and facilitates the dissipation of heat.

f. Piloerector muscles: Activation of these muscles causes hair erection which preserves the body heat. Also this gives a person a ferocious demeanor in response to the situation.

g. Pupils: Pupils dilate to increase acuity of vision and perception.

h. Reticular system: Due to the activation of Reticular Activating System, the individual is highly alert and fully focused.

i. Due to the constriction of the sphincters the bowel movement and the bladder emptying ceases temporarily.

**Autonomic failure**

They are two types of autonomic failure.

1. When the autonomic failure results due to unknown or unexplained causes then it is known as primary autonomic failure. The major clinical feature is the orthostatic hypotension.
2. When the autonomic failure occurs secondary to some medical causes it is known as secondary autonomic failure. The most common causes are diabetes mellitus and thyroid disorders.

**Clinical features**

1. Cardiovascular features – tachycardia and orthostatic hypotension.
2. Sudomotor features – anhydrosis and heat intolerance.
3. Gastrointestinal features – constipation , diarrhoea and dysphagia.
4. Urinary features – nocturia , incontinence and retention of urine.

To sum it up, the sympathetic system is catabolic and helps in the defense of the body and gets activated in crucial situations. It acts on the brain, muscles, pancreas, thyroid and

adrenal glands. It is responsible for release of insulin, cortisol and thyroid hormones. On activation it raises the blood pressure, blood sugar and heat production. This system is activated by stress, anger, anxiety and exercise.

The parasympathetic system on the other hand is anabolic and restorative in function. It acts on the liver, kidneys, pancreas, spleen, stomach, small intestines and colon and releases parathyroid hormone, pancreatic enzymes, bile and other digestive enzymes. On activation it facilitates digestion, excretion and immune function The factors which stimulate the parasympathetic nervous system are rest , sleep, relaxation and meditation.

## CIRCADIAN RHYTHM

Circadian rhythm is the biological rhythm which oscillates over a rough span of 24 hours. This time span is controlled by a biological clock i.e. the suprachiasmatic nucleus in the human body. This biological clock is periodically recalibrated by external cues like sunlight.

### Criteria

A biological rhythm, if it is to be called as circadian rhythm, it has to meet the following criteria.[21]

1. The biological rhythm should have an endogenous time span of approximately twenty four hours.

2. The rhythm should be entrainable. It means that the rhythm can be recalibrated by the external factors. This process of recalibration is called as entrainment. The external cues like sunlight and heat which entrain the rhythm are known as zeitgebers.
3. The rhythm should be able to maintain its periodicity over a wide range of physiological variations in the temperature.

The circadian rhythm is linked to the sleep-wake cycle and this cycle is also regulated by the biological clock i.e. the suprachiasmatic nucleus which is situated in the hypothalamus.

The external factor sunlight conveys the information through the eyes. The ganglion cells of the retina are also photosensitive and they project into the suprachiasmatic nucleus of the hypothalamus. Thus the information is conveyed to the suprachiasmatic nucleus, synchronizes the biological clock and entrains the circadian rhythm. [22]

The ganglion cells of the retina contain a pigment called melanopsin. These cells are photosensitive and respond to light and convey the signals to suprachiasmatic nucleus through a pathway called retinohypothalamic tract. When the cells of the suprachiasmatic nucleus are isolated and cultured, it has been found out that in the absence of the external cues, they exhibit their own rhythm.[23]

**Markers of the circadian rhythm**

The timing of the circadian rhythm can be measured using some markers in the human body. They are,

1. Secretion of melatonin from the pineal gland
2. The minimum core body temperature
3. The plasma level of cortisol

In their study, Baehr et al. found that, the core minimum body temperature occurred closer to the middle of their sleeping period in morning type of young adults, but in the evening types it was closer to the waking period. [24]

Though the onset of melatonin ( Dimlight melatonin onset ) has been used as the biological marker for the circadian rhythm in the past , it has been found out the offset of melatonin is much more effective as a marker.

Benloucif et al. found out that the sleep offset and melatonin offset has a stronger correlation with the phase markers than the sleep onset and these phase markers are more reliable when compared to the core temperature minimum.[25]

Disruption in the circadian rhythm has been associated with development of metabolic disorders[26]. It has been found out that the shift work disrupted the circadian rhythm and might be a potent risk factor for hypertension and cardio metabolic syndrome[27].

# STRESS

Any change in the external environment which alters the homeostasis and produces a marked response is known as stress. When the stress persists for a longer period it is called as chronic stress. This type of stress may result in multiple physical manifestations like fatigue, peptic ulcer and suppression of the immunity. Unlike acute stress, the chronic stress may affect the body more significantly and there is an increased possibility of hypertension, cardiovascular disorders and anxiety disorders.

It has been shown that the acute stress doesn't affect the young and healthy individuals significantly whereas the chronic stress affect health in a significant manner in older or unhealthy individuals and these affects of the chronic stress may persist for a longer term[28].

**Biological response to stress**

Stress is of three types. They are,

1. Emotional stress.
2. Physical stress.
3. Biological stress.

Any of these types will trigger an immediate response in the human body. This response is mediated through sympathoadrenal medullary system and hypothalamic – pituitary –

adrenal cortex axis. There are various steps involved in the adaptation to stress by the human body. They are,

**Stress perception**

The stress to the human body is perceived in the various areas of the Central Nervous System and they are cerebral cortex , brain stem , limbic system and reticular activating system.

**Hypothalamic activation**

In the hypothalamus especially in the paraventricular nucleus the neurons of the Corticotrophin Releasing Hormone and Anti Diuretic Hormone are activated.

**Role of hypothalamic – pituitary – adrenal axis**

The activated neurons of the hypothalamus release Corticotropin Releasing Hormone and the Anti Diuretic Hormone. These hormones in turn will effect in the release of AdrenoCorticoTropic Hormone. Thus released ACTH in the blood will reach the adrenal gland and act on the adrenal cortex and effect in the release of cortisol.

**Sympathoadrenal medullary system activation**

The exposure to stress spontaneously produces sympathetic activation and fight or flight reaction. Excitation of the adrenergic neurons in the hypothalamus finally results in the release of adrenaline from the adrenal medulla and noradrenaline from the sympathetic ganglion.

**Role of hormones in stress adaptation**

1. Increase in glucose synthesis – catecholamines activates glycogenolysis. Cortisol aids in gluconeogenesis. They decrease the peripheral glucose utilization and make more glucose available to be utilized by the Central Nervous System.
2. Supply of Free Fatty Acids – cortisol has a lipolytic action whereas the noradrenaline facilitates the supply of free fatty acids to the heart and the skeletal muscles.
3. Cardiovascular responses – catecholamines and cortisol increase blood pressure and cardiac output and hence they make more substrates available to the tissues.
4. Arousal response – Due to the activation of adrenergic neurons and Reticular Activating System the subject becomes more attentive and focused.
5. Inhibitory activities – CRH decreases appetite and feeding in response to stress. Thus they are redirecting the resources to stress response.

## SHIFT WORK

Shift work is a kind of work schedule which makes use of all the twenty four hours of a day. Here the working hours are divided into convenient or set periods of time in which the workers perform their designated duties so as to provide round the clock service.

Invariably shift works make use of the work schedules involving the night hours. These work schedules are designed in such a way that the employees follow a pattern of changing their scheduled times or follow a rotating shift.

In general shift work is attributed as a predisposing factor for cardiovascular disease and other psychosomatic disorders because of its interference with the circadian rhythm of the concerned individuals.[29]

The shift work tends to worsens the fatigue because it restricts the resting time. Moreover, the staff working in the shifts tend to do overtime which again interferes with their resting time. Shift work can also affect food intake and quality of sleep. Many workers who work in night shifts take artificial stimulants such as caffeine or nicotine to stay awake. All these factors associated with disruption in circadian rhythm contribute to chronic stress.

## HEART RATE VARIABILITY

Beat to beat variation in the heart rate is called heart rate variability. This is a physiological phenomenon caused due to the changes in the activity of the heart with respiration.

**HRV and autonomic nervous system**

Automaticity of the heart depends on the cardiac pace maker Sinoatrial Node. However the cardiac rate and the rhythm are determined by the sympathetic and parasympathetic influences. The parasympathetic nerve vagus, inhibits the heart rate by acting on the muscarinic receptors. Vagus releases the neurotransmitter acetylcholine and increases the cell membrane conductance to potassium ions. Acetylcholine also inhibits the pace maker current activation by hyperpolarization.

Sympathetic nervous system, on activation increases the heart rate by the release of the neurotransmitter adrenaline or noradrenaline, These act on the β adrenergic receptors and produce phosphorylation of the membrane proteins mediated by cAMP and increase the intracellular calcium.

Normally the sympathetic and the vagal influence on heart interact each other and exert a control over the heart, However, the influence of vagus is dominant over the sympathetic influence in a resting state. Though there is vagal dominance the stimulation of vagus lasts for a brief priod of time due to the activity of the enzyme acetylcholinestrase which is abundantly present in the nodal tissues.

Vagal dominance may be due to,

1. Decreased release of noradrenaline due to cholinergic activation
2. Decreased response to adrenergic stimulus due to cholinergic attenuation

**Significance of HRV**

The rate of the heart and its beat to beat variation depends solely on the discharge from the cardiac pacemaker SA node which in turn is influenced by the autonomic nervous system. Hence the HRV parameters which reflect the cardiac autonomic activity serve as a sensitive indicator for the sympathovagal balance.

As mentioned in the introduction, HRV can be assessed by various methods and they are,

1. Time domain methods
2. Frequency domain methods
3. Non linear methods

Time domain methods[3] though easier to assess, do not provide significant details about the finer variations. Time domain measures measure the rate of heart and the changes in the time interval between two successive normal to normal complexes. The time domain variables routinely assessed are mean NN interval, the mean heart rate, the difference between the longest NN and the shortest NN intervals, and the variation between the day and the night heart rate.

When cyclic intervals are recorded for 24 hours the statistical methods are employed. These methods use the direct measurements of NN intervals and the difference in NN intervals. These measurements determine the high frequency variation in heart rate.

The other method is called geometrical method and this method, with the aid of Lorenz plot of RR intervals measure the sample density distribution. This method is based on the number as well as the quality of the RR intervals.

The frequency domain measures[3] of the HRV make use of various frequency bands in the spectrum of 0.0 - 0.4 Hz. HF component of the frequency domain measure reflects the vagal activity and it serves as an index for vagal modulation. LF components have an oscillatory pattern and they reflect the fluctuations in the blood pressure. VLF component reflects the change in heart rate due to temperature, hormonal influence and the local factors.

**The time domain parameters**

The Time Domain parameters are,

1. NN
2. SDNN
3. RMSSD
4. PNN50
5. SDANN
6. SDSD

MEAN RR ( NN )

This is a normal to normal interval. This is an average of all RR intervals. This interval at a given physiological state is inversely proportional to the mean cardiac rate. Hence it reflects the autonomic imbalance.

SDNN.

This parameter is a measure of total variability. This is a standard deviation of all NN intervals . When taken for a short period of time this parameter reflects HRV.

NN50 COUNT

In the entire recording when the number of pairs of adjacent NN intervals which differ more than 50ms are counted it gives the NN50 count. This provides an estimation of variation in heart rate of high frequency nature.

PNNN50

When the NN50 count is divided by the total number of NN intervals this proportion gives the PNN50. This is also an estimation of heart rate variation of high frequency.

RMSSD

When a square root is taken of the mean of the sum of the squares of the differences between the adjacent NN intervals it gives the parameter RMSSD. This too is an estimation of high frequency variation in heart rate and it reflects the vagal response.

The other parameters are

Standard deviation of average NN intervals ( SDANN )

Standard deviation of differences between adjacent NN intervals ( SDSD ).

**The Frequency Domain Measures:**

For frequency domain analysis the artifacts as well as the abnormal beats were removed. Resampling was done to the cardiac tachogram to make the signal a regularly sampled one. Thus modified recording was subjected to a standard spectral analysis and at a 5 minutes intervals the following parameters were estimated.

Low frequency power (LF)

LF spectrum is in the range from 0.04 to 0.15 Hz.

This reflects both sympathetic and parasympathetic tone.

High frequency power (HF)

HF power spectrum is in the range from 0.15 to 0.4 Hz.

This indicates vagal tone.

LF norm (nu)

It is low frequency power in normalized units.

LF norm = LF/ (Total power – VLF) X100

HF norm (nu)

It is high frequency power in normalized units.

HF norm = HF/ (Total power – VLF) X100

LF/HF power ratio

The LF/HF ratio is used to asses sympathovagal balance and to study the coordinated functioning between sympathetic and parasympathetic tone.

A decrease in the score indicates either decrease in sympathetic tone or increase in parasympathetic tone.

## AUTONOMIC FUNCTION TESTS

The assessment of the autonomic functions can be done by a number of tests. Some of them are invasive and the others are noninvasive. The invasive tests make use of complex procedures and are helpful in determining the site of lesion. The noninvasive tests which we employ here are simple to perform and do not trouble the subjects. These tests are helpful in screening for autonomic imbalance and confirming the diagnosis of autonomic neuropathy [32].

**Cardiovascular response to standing**

On change of posture from supine to standing, initially the heart rate increases and reaches a maximum at about the $15^{th}$ beat. After that it slows down gradually and reaches a steady rate at about $30^{th}$ beat. When we take the ratio of the RR intervals between $30^{th}$ beat and $15^{th}$ beat it is called as 30:15 ratio. This ratio is a measure

of parasympathetic function. When the ratio is less than 1.04 in young individuals, it is considered abnormal.

Conversely, the blood pressure falls immediately on standing and gradually returns to normal after sometime. These changes in blood pressure reflect the sympathetic activity. Orthostatic hypotension is where the fall in systolic BP is above 20 mmHg or diastolic BP above 10 mmHg.

**Valsalva ratio**

In Valsalva maneuver the parasympathetic fibres are the afferent for the signals and the sympathetic nerves act as efferent. So, the Valsalva ratio reflects both the sympathetic and the parasympathetic function. However, this ratio assesses more of the cardiovagal function because the vagus acts as afferent. Valsalva ratio is normal when it is above 1.45 and abnormal if it is below 1.2 .

Various factors like age, sex, position of the subject during the maneuver, the expiratory pressure exerted by the subject and the duration of the strain will affect the Valsalva ratio. In sympathetic dysfunction the heart rate fails to rise during strain and in parasympathetic dysfunction the heart rate fails to slow down after strain.

**Heart rate response to breathing**

Changes in heart rate with respiration are known as sinus arrhythmia. During inspiration the heart rate increases and during expiration it decreases. These changes are brought due to the activity of stretch receptors in the lung, mechanoreceptors of the heart itself and the barorecptors. The signals from these receptors are mediated by the parasympathetic nervous system. The parameters E: I ratio and deep breathing difference (DBD) assess the parasympathetic activity. They decrease with age.

**Isometric exercise**

During this exercise there is a simultaneous rise in blood pressure and heart rate. These changes are mediated by cardiovascular centers and the metabolic and mechanical changes due to muscle contraction. In normal individuals, the diastolic pressure will rise more than 15 mmHg due to increased sympathetic activity and the heart rate will rise by 30% due to decreased parasympathetic activity.

# REVIEW

Turek[33] in his study concluded that the endogenous neural rhythms in mammals that govern the circadian cycle are generated within the suprachiasmatic nucleus. These signals are responsible for regulating biochemical, physiological and behavioral circadian rhythms. These signals may act directly or indirectly and they are multioscillatory in nature. There are many neural oscillators located within the

suprachiasmatic nucleus and the combined neural output of the multiple neural oscillators will determine the regulation of circadian rhythm. He also added that there are pacemakers responsible for circadian rhythm which may be located outside the suprachiasmatic nucleus and their location remain unknown. The circadian neural signals may be produced without the influence of external environment in the suprachiasmatic nucleus and the other components may function as damped oscillators.

Dickmeis T[34] in his review about the glucocorticoids and the circadian clock concludes that there may be a circadian clock located within the adrenal gland itself. He further adds the circadian regulation of synthesis and secretion of glucocorticoids is governed by both the central pacemaker i.e. suprachiasmatic nucleus and the circadian clock in the adrenal gland. The circadian clock in the adrenal gland may sensitize the gland to the adrenocoticotropic hormone.

Massin M.M.[35] et al, in their study, have found significant changes in heart rate and HRV in response to circadian rhythm, especially in late infants and early childhood. They also concluded that a progressive maturation of the autonomic nervous system was seen in children. Their data confirmed that the sympathetic withdrawal associated with sleep organization was responsible for the circadian rhythm of heart rate and HRV.

Freitas J[36] et al, in their study about autonomic failure have concluded that the disabling orthostatic symptoms were induced by autonomic failure. They have

observed that the heart rate variability related to sleeping and waking hours showed a normal circadian pattern only in healthy individuals. Subjects with symptoms of autonomic failure did not show any circadian variations. They have also observed that the asymptomatic subjects having autonomic failure exhibited some degree of autonomic impairment in their heart rate variability. They concluded that the autonomic failure could be screened by the usage of simple methods like monitoring the blood pressure and heart rate over 24 hours.

Ito H.[37] et al, in their study, have observed that the circadian rhythm of cardiac autonomic activity in shift workers was largely modified by the extent of the physical exertion irrespective of the time.

Bodreau P[38] et al, in their study, set out to find out how the circadian adaptation to shift work involving night duty affects the heart rate variability, plasma melatonin levels, mood and alertness of the subjects involved. The study was conducted among two groups of policemen, one group adapted to the night shift and the other not adapted to it. They found out the non adapted group had a higher LF: HF ratio when they slept during the day. They concluded that the adapted group when compared to the non adapted group performed better, were more alert, slept longer in the day and had a lesser sympathetic dominance during the daytime sleep.

Puttonen S[39] et al, in their review, noted that the shift work which affected the circadian rhythm could affect the behavior of the individual. The sleep – wake pattern of

the concerned individuals were severely affected. The shift workers suffered from inadequate or excessive sleep and insomnia. Shift work might also have a role in inducing behavioral changes like smoking and alcohol intake. They have also reported that there was less parasympathetic modulation of heart rate variability and high sympathetic activity in shift workers. They also added that the regulation of secretion of cortisol was altered by the shift work and the secretion of catecholamines exhibit a clear circadian variation. However, in their review of cross sectional epidemiological studies, they could not find a significant association between shift work and the blood pressure. Finally they concluded that even though there was no specific evidence for underlying mechanisms there was enough to suggest that shift work could be a risk factor for cardiovascular diseases.

Frese M[40] et al, in their study, have concluded that though the overall sleeping time did not vary between the shift and non shift workers, the shift workers showed a greater variation in the sleeping time across different shifts. They have also concluded that the amount of sleep cannot be predicted accurately by the relevant factors and also added the length of sleep was very different from the quality of sleep.

Josephine A[41], in her review says that the exposure to the sunlight in the morning affects the night shift workers in a way that there is a delay in their adaptation of the circadian clock. She also adds that there are many field studies which imply increased exposure to morning light affects the circadian adaptation adversely.

Frese M[42]., in his review, have concluded that the psychosomatic complaints and the stress had a definite correlation. He also added that the psychosomatic complaints could not be explained fully by the variables such as age and income. Also, he found out that the relationship between the stress and the psychosomatic complaints did not depend on the type of individuals.

Frese M[43] et al, in their study consisting of shift workers and never – shift workers, have concluded that the factors like age and skill level did not have any significant impact on the psychosomatic effects and the stress of the individuals concerned.

Kobayashi F[44] et al, in their study about the impact of changes in the shift work schedules on the physical activity, sympathetic and parasympathetic activity and the mood states in night shift nurses, have found that there was some negligible degree of changes in the general alertness, tiredness and irritation during the night work. They have also found that at the time of night shift, the cortisol levels were less and the activity of NK cell were diminished. They have concluded that working night shifts induced a high degree of stress which was harmful to the biodefence.

Ishi N[45]et al, in their study involving the female nurses working rotating three shift system have found out that LF percentage and LF/HF ratio in the shift work subjects were significantly high when compared to those without shift work. They also found out that there was no significant change in the QT interval corrected by the heart rate

between the shift and non – shift workers. They have concluded, irrespective of the selection bias the shift work might have induced a prolonged state of sympathetic over activity and some neuro motor changes.

Furlan R[46] et al in their study have found out, irrespective of the time, the physical activity and sleeping time have a significant role in producing the maximum and minimum spectral markers LF n.u. and HF n.u. They have also found out that during every shift days, LF n.u and LF/HF ratio were high during the working time and low during the sleeping time thus matching the circadian rhythm of heart rate. More over they have observed the spectral indices governing the sympathetic modulation of heart were low during the night shift. They have concluded that the indices of cardiac sympathetic modulation were reduced during night shifts. They also added that the continuous changes in the shift schedules changed the autonomic control of the heart and this might play a key role in high prevalence of cardiovascular diseases in shift workers.

Souza B.B[47] et al, in their study, have concluded that the autonomic control of the heart was affected by the shift work. They have added that there was a reduction in the parasympathetic modulation of heart during night shifts and an elevation in the resting blood pressure.

Brown D.L.[48] et al, in their cohort study of registered female nurses, have found out that the night shift among the study group was associated with a 4% increase in risk for ischemic stroke every five years. They have concluded that the females had a

modest risk of the increase in the incidence of stroke due to extended periods of night shift work.

Tenkanen L.[49]et al, in their cohort study of industrial workers, have found out that the shift workers had an elevated systolic blood pressure when compared to the workers who had white – collar jobs. They have concluded that the shift work was an important occupational risk factor for coronary heart disease. They have also added that the increased coronary risk might be stress – related.

Taylor P.J.[50] et al, have conducted a study on 8603 male manual workers belonging to ten organizations who were employed for more than 10 years. They have found out that there was some difference in the mortality between day and shift workers. However they have attributed these differences to occupational and regional factors. They concluded that the shift work did not have any impact on the mortality.

Kario K.[51] et al, in their study conducted among the female nurses who work different shifts, have found out that the diurnal blood pressure variation was determined by the cardiovascular reactivity due to psychological and physical stress. Though this determinant was significant, it has a weaker role. They also added that the pressor mechanisms were moderated by the type of shift schedule i.e. day or night.

Freitas J.[52]et al, have conducted a study to determine the impact of day – night cycle on the circadian pattern of heart rate variability. They have found out that there were no statistical differences in all the HRV parameters between day and night

work shifts. They have also found out that the very low and high frequency components of HRV were elevated but the LF and HF ratio was reduced during the sleep period, irrespective of the shifts. They have concluded that the circadian pattern of HRV is strongly associated with the sleep and wakefulness of the subject and not related to the day – night cycle.

Van Amelsvoort L.G.P.M[53]et al, have found out that the incidence of premature ventricular complexes was significantly raised in the shift workers compared to day workers when they were followed up for 1 year. They have also found out that the premature ventricular systoles were more frequent in shift workers. However, the changes in the HRV detected were small and non – significant. They have concluded there was an increase in the arrhythmogeneity in shift workers which might be a risk factor for cardiovascular disease but their change in the cardiac autonomic control is negligent.

Esquirol[54] Y. et al, in their review have found out there was a significant elevation in the systolic blood pressure of males over 30 years when they were employed in shift work for more than 1-10 years but the women were not affected. They also added that in both genders, during their first year of exposure to shift work, their BP did not show any change. They explained this phenomenon was due to partial adaptation to circadian rhythm. They have concluded that the studies in the past 10 years implied that the shift work had an impact on some cardiovascular risk factors. They explained this might be due to disturbances in the circadian rhythm, sleep and behavior.

Thayer J.F[55]et al, in their review, have found out the existence of sufficient evidence for the hypothesis which says the decreased HRV has got a bad prognosis and increased HRV is found in lower risk profiles.

Acharya[56] U. R. et al, in their review article, conclude that stress and exercise leads to sympathetic activation which increases the discharge of sinoatrial node which in turn increases the heart rate. They concluded that they have enough evidence to support the view that HRV is a useful tool to assess the sympathetic and parasympathetic components of autonomic nervous system particularly in postinfarction and diabetic patients. They also suggest that the therapeutic adjustments in postinfarction patients using HRV analysis may be possible in the near future.

Bonnemeir[57] et al, in their study, found out that there is a decrease in HRV as the age progresses. They also conclude that females have more variation when compared to males.

Malliani[58] et al, in their study have found that there is a definite relation between the LF and HF oscillations and the sympathetic and the vagal predominance. They have also found that the shift of LF – HF balance towards LF component reflects the sympathetic over activity and the shift towards HF component implies the increased vagal activity.

Cabiddu R.[59] et al, in their study, conclude that there is a shift in the sympathovagal balance towards the parasympathetic activity during deep sleep. They also add that during REM sleep the balance shifts towards the sympathetic activity.

Fujiwara S.[60]et al, in their study found out that the circadian phases were delayed in the shift workers taking evening shifts and the delays were found to be related with the oral temperature and the urinary free noradrenaline levels. In workers taking night shifts these delays were found to be more. They have also found out that the diurnal variations in the serum cortisol and free adrenaline levels were profoundly affected and their relationships with the circadian rhythm were completely abolished in the night shift workers. Based on their findings they concluded that the time of onset and the period of the sleep were the potent factors which modified the circadian rhythm of the serum cortisol.

Oriyama S[61]. et al, in their study, have found out that the excretion of adrenaline and noradrenaline in the urine was more during the working hours in the day shift whereas it was closer to normal or less in the night shift. They have also found out that the fall in systolic blood pressure during sleep was less than 10% in the night shift workers when compared to the dayshift workers. Based on their study they concluded that the higher levels in the blood pressure during sleep might be a contributory factor to the adverse effects of shift work.

Sherwood A.[62] et al, in their study about the role of sympathetic system to the dipping of blood pressure in the night, have concluded that there was enough evidence to suggest that the sympathetic over activity in individuals contributed to the nondipping status of their blood pressure during sleep.

Lo S. H.[63] et al in their study on young female nurses have found out that there was a significant association between the shift work and the blood pressure and a possible connection with the nondipping of the blood pressure during the sleep. They also found out that the return of the blood pressure to the baseline was observed only in the dayshift and the evening shift workers but not in the night shift workers.

Fialho G.[64] et al, in their study among the medical residents, have shown that the mean 24 hour blood pressure, both systolic and diastolic, was high during the 24 hour shift work. They have also observed a higher mean diastolic blood pressure during the shift days when compared to the non shift days. They have concluded that the 24 hour shifts led to abnormal fluctuations in the blood pressure which might predispose to cardiovascular diseases.

Jarvelin – Pasanen S[65] et al, in their study among the female nurses who have worked in normal shifts and extended work shifts, have found out there were significant variations in the HRV parameters between the work time and the leisure time. They also found out that during the working hours there was an increase in the sympathetic modulation of the HRV and a decrease in the parasympathetic modulation.

These changes were observed more in the older subjects. However they could not find out significant changes in the HRV parameters between the normal shift and the extended work shift. They concluded that this negligent variation might be due to the adaptation of the subjects to the extended shifts.

Van Amelsvoort L.G.P.M[66] et al, in their study have found out there were higher levels of 24 – hour LF % during the night shift when compared to the day shift. They have also found out the LF % values were higher during the sleep on night shift days. They have concluded that there was a sympathetic over activity in the individuals working night shifts. They also have added that this sympathetic dominance was more pronounced during the sleep. They have also suggested this autonomic imbalance might be a burden to the cardio vascular system.

Lo S-H.[67]et al, in their study have found out there were no significant changes in the cardiac stress parameters between the day and night shifts. However, they have found out that the vascular stress reflected by systolic blood pressure was high in night shift workers. Also they have found out that the diastolic blood pressure was less during the sleeping period in night shifts when compared to the day shift. They have also found out that these changes in the systolic and diastolic blood pressure appeared to spike during the waking hours on the day after the night shifts. They have concluded that some part of the vascular stress produced during the shift work might be carried over to the following off – duty day.

Sliskovic A.[68] et al, in their study about the variations in the heart rate variability between working and non – working nights, have found out that the patterns and the levels of cardiac activity were different between the two situations indicating sympathetic influence due to work stress at night. However the circadian effects (reflected by mean R – R) were prevalent in both. They have concluded that the parasympathetic influence due to circadian effect super ceded the sympathetic influence due to work stress.

Amirian I.[69] et al, in their study, have found that the surgeons had lower HF activity and higher median pulse rate and LF: HF ratio during the night shifts. Based on their study they have concluded that the HRV showed a significant decrease whereas the pulse rate exhibited a significant increase among the surgeons during their night shifts when compared to their non – shift days.

Mosendane T.[70] et al, in their review, have concluded that the shift work might predispose to cardiovascular disorders due to disruption in circadian rhythms, altered lifestyles and psychosocial stress. However they also added this association might be confounded by the physical inactivity, smoking, drinking and dietary factors.

Chung M-H. [71] et al , in their study observed the shift working nurses displayed a higher sympathetic activity and reduced parasympathetic activity after their night shifts with a significant reduction in the HF and a significant increase in the LF/HF ratio. However they also observed that the detrimental effects of the shift duty were

compensated when the workers took rest properly during their day off. They concluded that rotating shifts might be acceptable if the free time was allocated for proper rest.

Wehrens S.M.T.[72] et al , in their study of shift working males have observed a higher LF/HF ratio and lower HR variance when compared to the non shift workers. They concluded that the increased cardiovascular risk among the shift workers might be contributed by the sympathetic over activity or reduced cardiovagal tone as indicated by the HRV parameters.

Kirthana U.K.[73] et al, in their study have observed a significant reduction in mean RR and a significant increase in mean HR in night shift workers but a lower HF, higher LF and a higher LF/HF which were not statistically significant. They concluded that there was an inclination towards the sympathetic dominance in night workers which might predispose to cardiovascular diseases in shift workers.

# MATERIALS

# AND

# METHODOLOGY

# MATERIALS AND METHODOLOGY

This study was conducted in the department of Physiology, PSG IMS&R . Prior to the study proper approval was obtained from the Institutional Human Ethics Committee . Before the commencement of the study, the enrolled subjects were explained fully about the study and an informed written consent was obtained.

This study was prospective and observational.

A total number of 60 subjects were enrolled for the study out of which 30 were controls and the remaining 30 were cases.

The cases were the shift workers who were involved in a rotational kind of shift work which has a night shift. The controls were the day workers who work in the regular hours, ie,. between 8 AM to 8 PM.

The subjects were enrolled according to the inclusion and exclusion criteria. The information specified in the data collection tool regarding each of the subjects was collected methodically.

The study group and the control group were divided into three groups to match the age as given below .

20 - 25 yrs

25 - 30 yrs

30 - 35 yrs

**Sample Size (30):**

1) 30 regular (day) shift workers
2) 30 rotation (Night) shift workers

**Inclusion criteria:**

1) Age : 20-35 Years
2) Sex: Males and Females

**Exclusion criteria:**

1) Hypertensives
2) Diabetics
3) Asthmatics
4) On medications
5) Parkinson's disease
6) Hypo & hyperthyroid patients
7) Cardiac patients
8) Pregnancy

Both the groups thus selected were subjected to the following tests.

**Methods:**

1) Short term HRV
2) Orthostatic hypotension
3) Valsalva maneuver
4) Deep breathing test
5) Handgrip dynamometry

The duration of the study was **one year.**

The data collection tool has the details of the subjects like the personal history, general details like height, weight and BMI and any past history of significance. Once these the necessary information was obtained the subjects were taken to the Physiology Research Laboratory in the Department of Physiology, PSG IMS&R. There they were subjected to ECG recording for analysis of HRV.

## ECG RECORDING AND HRV ANALYSIS

Short term Heart Rate Variability is a procedure which is simple as well as non invasive. Here a Lead II electrocardiogram was recorded for a minimum of 5 minutes using a computerized physiograph (NEVIQURE- Digital ECG recorder). The analysis of the HRV was done with the aid of Finland software.

## ECG RECORDING

The enrolled subjects were made to relax by asking them to lie down on the couch quietly prior to the procedure in the Physiology laboratory. This is done to alleviate the anxiety which is likely to interfere with the HRV recording. The electrodes were connected to the subjects in Lead II position and the ECG recordings were taken in the supine posture with the aid of computerized physiograph for a minimum of 5 minutes.

From the entire study subjects baseline ECG were recorded. Any abnormal ECG and artifacts were excluded. The subjects who were having ectopic beats were let off and not included in the study. Using the digital filters the noise and the fluctuations in the base line were eliminated. Here the digital filters used were of a sampling of 1000 samples / sec.

The software which was inbuilt selected the desired RR intervals. These selected RR intervals were entered into a Microsoft excel sheet and noted down in a notepad file as time points.

Using this HRV analysis the two sets of parameters were determined.

They were,

Time Domain parameters

Frequency Domain parameters.

The harmonic components of RR intervals recorded in the notepad file were subjected to the analysis of HRV by the software belonging to a version of 1.1 from Biomedical Signal Analysis group, Department of Applied Physics, University of Kuopio, Finland. Using a fast Fourier transformation the power spectral analysis was done.

## STATISTICAL ANALYSIS

With the aid of a SPSS software (statistical package for the social science version-19) the statistical analysis was done. The analysis was done using an independent students unpaired t' test, comparing the study group and control group.

HRV values and the results of autonomic function tests were compared between the two groups in consideration..

Values were expressed as Mean ± SD.

$p > 0.05$ was considered not significant.

$p \leq 0.05$ was considered statistically significant.

$p < 0.01$ was considered moderately significant.

$p < 0.001$ Methods was considered highly significant

## AUTONOMIC FUNCTION TESTS

### Cardiovascular response to standing

From a supine position when a subject stands the systolic blood pressure decreases by a minimum of 20 mmHg or the diastolic pressure decreases by a minimum of 10 mm Hg and the rate of heart increases 10 to 20 beats from the basal rate immediately. This change in heart rate happens in the initial 5 – 15 seconds.

### Materials used

1) A multichannel polygraph with the capacity to record beat to beat variation in heart rate.
2) A sphygmomanometer.

### Procedure

First the subject was made to lie down on a couch in a supine position. Then the ECG leads were connected and the cuff of the sphygmomanometer was tied around his arm.

The subject was made to relax completely by taking rest in this position for a minimum period of 10 minutes. When a completely relaxed state was obtained the basal blood pressure was noted and the heart rate was recorded using the polygraph.

Then the subject was made to stand up and as soon as he stood up his BP was noted and his heart rate recorded.

Using the polygraph his heart rate was recorded serially for 3 minutes and at the end of 3 minutes once again the blood pressure was recorded.

**Calculation**

From the ECG strip recorded by the polygraph 30 : 15 RR ratio was calculated. This is obtained by dividing the longest RR by the shortest RR.

**Precautions taken**

1) The subject was made to relax completely before recording the blood pressure and the heart rate.
2) When the subject was asked to stand up he was made to lean against wall so that he stands passively without any effort. This negated the effect of muscular exertion on blood pressure and heart rate while standing actively.
3) The observation of changes in heart rate and blood pressure was taken in the first 15 seconds immediately after standing.

**Valsalva ratio**

Valsalva maneuver is nothing but force expiration against closed glottis. So the measure of variations in heart rate during this maneuver is called as Valsalva ratio. There will be a change in the sympathetic and the parasympathetic activity during this maneuver and after the maneuver. This is due to the activation of baroreceptors such as carotid sinus and aortic arch and other stretch receptors present in the thorax.

**Instruments used**

1) A sphygmomanometer
2) Polygraph
3) Mouth piece
4) Nose clip

**Procedure**

The subject was asked to take a sitting position. His nostrils were blocked with the help of nose clip. Through the electrodes he was connected to the polygraph. A mouthpiece was fitted to the mouth of the subject and its other end connected to the manometer.

Then the polygraph was turned on to take down a continuous recording of ECG of the subject.

Now the subject was made to breathe out forcefully into the manometer and he was asked to exhale at a steady pressure of 40 mmHg and this state was maintained for about 10 to 15 seconds.

ECG recording was continued for 30 more seconds after the procedure.

**Precautions**

1) Valsalva maneuver was properly explained to the subject and he was made to practice it thoroughly before the actual procedure.

2) It was made sure that a steady pressure of about 40 mm Hg was maintained during the procedure.

**Calculation**

Valsalva ratio was calculated by dividing the longest RR interval after the maneuver by shortest RR interval during the maneuver.

**Impact of deep breathing on heart rate variation**

When a person inspires his heart rate goes up due to decrease in cardiac vagal activity. Likewise, when a person exhales his heart rate goes down due to increase in cardiac vagal activity. This change in heart rate is observed by making the subject to breathe deeply and recording his heart rate simultaneously.

**Instruments used**

1) Polygraph with ECG provision
2) Adjustable Couch

**Procedure**

Here the method using 6 breaths per minute is employed to determine the changes in heart rate during deep breathing.

The subject was properly explained about the procedure. Then he was made to lie down comfortably on a couch in a supine position. The couch was adjusted in such a way the head is elevated at 30◦ .

With the help of electrodes the subject was connected to polygraph for recording of ECG.

Then the subject was asked to take deep breaths, ie, slow and deep inspiration followed by slow and deep expiration, at a rate of six breaths per minute.

With the aid of ECG the maximum and minimum heart rate of the subject was recorded.

**Precautions**

1) Proper instructions about the procedure were given.
2) The subject was made comfortable and asked to be relaxed.

**Calculation**

The expiration to inspiration ratio, otherwise known as E:I ratio was calculated by dividing the mean of maximum RR intervals during expiration by the mean of minimum RR intervals during deep inspiration.

**Isometric exercise**

When a subject is asked to maintain a sustained hand-grip against resistance, there will be an increase in cardiac rate and the blood pressure.

**Instruments used**

1) Polygraph with ECG provision

2) Sphygmomanometer.
3) Hand grip dynamometer.

**Procedure**

Subject was properly explained about the procedure. Then he was made to lie down in a semi-recumbent position and made comfortable.

ECG leads were connected to the subject as well as to the polygraph for recording the ECG. The manometer cuff was tied around his arm to record the blood pressure.

First the basal cardiac rate and the blood pressure of the subject were recorded.

The maximum activity of the subject with the hand grip dynamometer was noted. Then the subject was instructed to maintain a steady grip of 30 percent of his maximum activity for about five minutes.

The change in the heart rate as well as the blood pressure was recorded.

**Precautions taken**

1) Proper instructions were given.
2) Basal BP was recorded properly.
3) It was made sure that the subject maintained a pressure of 30% of his maximum activity throughout the five minutes.

## Calculation

The difference in the last diastolic blood pressure recording before the release of grip at the end of 5 minutes and the basal diastolic blood pressure taken before the procedure was calculated.

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# RESULTS

# RESULTS

In this study 60 subjects were included out of which 30 were day workers ( control group) and the remaining 30 were night shift workers ( study group). The study was conducted for a period of one year from June 2014.

Each group i.e. the control group and the study group were subjected to five minutes recording of ECG and the short term HRV analysis was done. Time domain and the frequency domain measures were calculated. The parameters of the time domain and the frequency domain measures were compared between the control group and the study group.

Likewise the control group and the study group were subjected to autonomic function tests outlined in the methodology. The results obtained were compared between the control group and the study group.

For statistical analysis the independent student t test was used.

Group I – Control group – day workers

Group II – Study group - night shift workers

P – value less than 0.05 was considered as significant ( <0.05)

# MAIN ANALYSIS – COMPARISON BETWEEN STUDY GROUP AND CONTROL GROUP

**Comparison of HRV parameters between control group and the study group**

**(Table 1A)**

**Time Domain Measures:**

**Mean RR (Chart 1)**

Mean of the mean RR interval of the control group was 0.89 ± 0.11 and the mean RR of the study group was 0.79 ± 0.09 This decrease was statistically highly significant with a p-value of 0.00 .

**Mean HR (Chart 2)**

The mean of the mean HR of the control group was 68.03 ± 8.68 and the study group was 77.97 ± 10.37. This increase in HR was statistically highly significant with a p-value of 0.00.

**SDNN (Chart 3)**

The mean SDNN of the control group was 53.01 ± 17.29 and the study group was 51.94 ± 25.13. This decrease in mean SDNN was not statistically significant with a p-value of 0.849.

**RMSSD (Chart 4)**

The mean RMSSD of the control group was 47.62 ± 19.49 and study group was 34.93 ± 12.49. This decrease was statistically significant with a p-value of 0.04.

**NN50 (Chart 5)**

The mean Nn50 of the control group was 74.17 ± 49.83 and the study group was 50.93 ± 43.95. This decrease in mean Nn50 was not statistically significant with a p-value of 0.060.

**pNN50 (Chart 6)**

The mean Pnn50 of the control group was 28.56 ± 17.92 and the study group was 18.06 ± 14.18. This decrease in mean Pnn50 was statistically significant with a p-value of 0.015.

## Frequency Domain Measures:

**VLF (Chart 7)**

The mean VLF of the control group was 85.91 ± 9.45 and the study group was 89.79 ± 4.29. This increase in mean VLF was statistically significant with a p-value of 0.045.

**LF (Chart 8)**

The mean LF of the control group was 7.87 ± 3.19 and the study group was 10.42 ± 6.75. This increase in mean LF was not statistically significant with a p-value of 0.066.

**HF (Chart 9)**

The mean HF of the control group was 3.48 ± 2.55 and the study group was 2.41 ± 1.28. This decrease in mean HF was statistically significant with a p-value of 0.043.

**LF/HF (Chart 10)**

The mean LF/HF ratio of the control group was 3.18 ± 0.80 and the study group was 3.50± 1.10. This increase in mean LF/HF was not statistically significant with a p-value of 0.195.

**LF n.u. (Chart 11)**

The mean LF n.u. of the control group was 75.55 ± 4.68 and the study group was 76.29 ± 5.43. This increase in mean LFn.u. was not statistically significant with a p-value of 0.574.

**HF n.u. (Chart 12)**

The mean HF n.u. of the control group was 24.58 ± 4.76 and the study group was 23.58 ± 5.45. This decrease in mean HFn.u. was not statistically significant with a p-value of 0.451.

## Comparison of the cardiovascular autonomic function test parameters between the control group and study group (1B)

**Basal Blood Pressure (Systolic) (Chart 13)**

The mean basal blood pressure SBP of the control group was 106.33 ± 12.45 and the study group was 111.03 ± 9.15. This increase in mean basal blood pressure SBP was not statistically significant with a p-value of 0.101.

**Basal Blood Pressure (Diastolic) (Chart 14)**

The mean basal blood pressure diastolic of the control group was 70.67 ± 8.68 and the study group was 72.60 ± 7.34. This increase in mean basal blood pressure DBP was not statistically significant with a p-value of 0.355.

**E/I Ratio (Deep Breathing) (Chart 15)**

The mean E/I Ratio of the control group was 1.36 ± 0.12 and the study group was 1.35 ± 0.16. This decrease in mean E/I Ratio was not statistically significant with a p-value of 0.780.

**Valsalva Ratio (Chart 16)**

The mean Valsalva Ratio of the control group was 1.64 ± 0.26 and the study group was. 1.45 ± 0.19. This decrease in mean Valsalva Ratio was statistically moderately significant with a p-value of 0.003.

**Standing (Immediate) Blood Pressure (systolic) (Chart 17)**

The mean Standing (Immediate) Blood Pressure (systolic) of the control group was 98.87 ± 13.06 and the study group was 101.00 ± 11.82. This increase in mean Standing (Immediate) Blood Pressure (systolic) was not statistically significant with a p-value of 0.510.

**Standing (Immediate) Blood Pressure (Diastolic) (Chart 18)**

The mean Standing (Immediate) Blood Pressure (Diastolic) of the control group was 70.87 ± 9.27 and the study group was 71.07 ± 8.83. This increase in mean Standing (Immediate) Blood Pressure (Diastolic) was not statistically significant with a p-value of 0.932.

**30:15 Ratio (Chart 19)**

The mean 30:15 Ratio of the control group was 1.44 ± 0.18 and the study group was 1.42 ± 0.13. This decrease in mean 30:15 Ratio was not statistically significant with a p-value of 0.670.

**Rise in Diastolic BP during Isometric exercise (Chart 20)**

The mean raise in diastolic BP of the control group was 19.40 ± 11.57 and the study group was 21.67 ± 8.74. This increase in mean raise in diastolic BP during isometric exercise was not statistically significant with a p-value of 0.396.

## SUB-GROUP ANALYSIS - AMONG MALES

### Comparison of HRV parameters between control group males and the study group males (Table 2A)

**Time Domain Measures:**

**Mean RR**

Mean of the mean RR interval of the control group was 0.96 ± 0.10 and the mean RR of the study group was 0.81 ± 0.12. This decrease was statistically highly significant with a p-value of 0.001.

**Mean HR**

The mean of the mean HR of the control group was 63.33 ± 6.33 and the study group was 77.73 ± 13.33. This increase in HR was statistically highly significant with a p-value of 0.001.

**SDNN**

The mean SDNN of the control group was 59.43 ± 18.14 and the study group was 57.73 ± 30.86. This decrease in mean SDNN was not statistically significant with a p-value of 0.856.

**RMSSD**

The mean RMSSD of the control group was 50.15 ± 21.94 and study group was 33.27 ± 10.86. This decrease in mean RMSSD was statistically significant with a p-value of 0.012.

**NN50**

The mean Nn50 of the control group was 62.07 ± 48.94 and the study group was 33.07 ± 27.92. This decrease in mean Nn50 was not statistically significant with a p-value of 0.056.

**pNN50**

The mean Pnn50 of the control group was 28.93 ± 19.41 and the study group was 15.26 ± 12.30. This decrease in mean Pnn50 was statistically significant with a p-value of 0.029.

## Frequency Domain Measures:

**VLF**

The mean VLF of the control group was 85.08 ± 11.85 and the study group was 90.98 ± 2.58. This increase in mean VLF was not statistically significant with a p-value of 0.070.

**LF**

The mean LF of the control group was 7.29 ± 2.18 and the study group was11.45 ± 8.63. This increase in mean LF was not statistically significant with a p-value of 0.081.

**HF**

The mean HF of the control group was 3.46 ± 3.31 and the study group was 1.80 ± 0.53. This decrease in mean HF was not statistically significant with a p-value of 0.067.

**LF/HF**

The mean LF/HF ratio of the control group was 3.66 ± 0.66 and the study group was 3.95± 1.07. This increase in mean LF/HF was not statistically significant with a p-value of 0.368.

**LF n.u.**

The mean LF n.u. of the control group was 78.07 ± 3.28 and the study group was 78.90 ± 3.61. This increase in mean LFn.u. was not statistically significant with a p-value of 0.513.

**HF n.u.**

The mean HF n.u. of the control group was 21.87 ± 3.14 and the study group was 20.96 ± 3.67. This decrease in mean HFn.u. was not statistically significant with a p-value of 0.473.

## Comparison of the cardiovascular autonomic function test parameters between the control group and study group males (2B)

**Basal Blood Pressure (Systolic)**

The mean basal blood pressure SBP of the control group was 114 ± 9.86 and the study group was 116.33 ± 7.19. This increase in mean basal blood pressure SBP was not statistically significant with a p-value of 0.465.

**Basal Blood Pressure (Diastolic)**

The mean basal blood pressure diastolic of the control group was 76.67 ± 6.17 and the study group was 75.20 ± 6.32. This decrease in mean basal blood pressure DBP was not statistically significant with a p-value of 0.525.

**E/I Ratio (Deep Breathing)**

The mean E/I Ratio of the control group was 1.34 ± 0.10 and the study group was 1.35 ± 0.12. This increase in mean E/I Ratio was not statistically significant with a p-value of 0.783.

**Valsalva Ratio**

The mean Valsalva Ratio of the control group was 1.73 ± 0.31 and the study group was 1.38 ± 0.18. This increase in mean Valsalva Ratio was statistically highly significant with a p-value of 0.001.

**Standing (Immediate) Blood Pressure (systolic)**

The mean Standing (Immediate) Blood Pressure (systolic)of the control group was 104.93 ± 12.00 and the study group was 106.53 ± 11.72. This increase in mean Standing (Immediate) Blood Pressure (systolic) was not statistically significant with a p-value of 0.715.

**Standing (Immediate) Blood Pressure (Diastolic)**

The mean Standing (Immediate) Blood Pressure (Diastolic) of the control group was 76.80 ± 7.12 and the study group was 75.60 ± 7.18. This decrease in mean Standing (Immediate) Blood Pressure (Diastolic) was not statistically significant with a p-value of 0.649.

**30:15 Ratio**

The mean 30:15 Ratio of the control group was 1.46 ± 0.193 and the study group was 1.39 ± 0.09. This decrease in mean 30:15 Ratio was not statistically significant with a p-value of 0.211.

**Rise in Diastolic BP during Isometric exercise**

The mean raise in diastolic BP of the control group was 22 ± 8.62 and the study group was 22.13 ± 14.46. This increase in mean raise in diastolic BP during isometric exercise was not statistically significant with a p-value of 0.976.

## SUB-GROUP ANALAYSIS – AMONG FEMALES

### Comparison of HRV parameters between control group and the study group among the female subjects (Table 3A)

**Time Domain Measures:**

**Mean RR**

Mean of the mean RR interval of the control group was 0.84 ± 0.09 and the mean RR of the study group was 0.77 ± 0.07. This decrease was not statistically significant with a p-value of 0.053.

**Mean HR**

The mean of the mean HR of the control group was 72.73 ± 8.29 and the study group was 78.20 ± 6.70. This increase in HR was not statistically significant with a p-value of 0.057.

**SDNN**

The mean SDNN of the control group was 46.59 ± 14.20 and the study group was 46.15 ± 16.86. This decrease in mean SDNN was not statistically significant with a p-value of 0.939.

**RMSSD**

The mean RMSSD of the control group was 45.08 ± 17.09 and study group was 36.60 ± 14.16. This decrease in mean RMSSD was not statistically significant with a p-value of 0.149.

**NN50**

The mean Nn50 of the control group was 86.27 ± 49.36and the study group was 68.80 ± 50.37. This decrease in mean Nn50 was not statistically significant with a p-value of 0.346.

**pNN50**

The mean Pnn50 of the control group was 28.19 ± 16.97 and the study group was 20.87 ± 15.75. This decrease in mean Pnn50 was not statistically significant with a p-value of 0.231.

**Frequency Domain Measures:**

**VLF**

The mean VLF of the control group was 86.75 ± 6.56 and the study group was 88.59 ± 5.33. This increase in mean VLF was not statistically significant with a p-value of 0.405.

**LF**

The mean LF of the control group was 8.44 ± 3.95 and the study group was 9.39 ± 4.19. This increase in mean LF was not statistically significant with a p-value of 0.530.

**HF**

The mean HF of the control group was 3.51 ± 1.58 and the study group was 3.01 ± 1.53. This decrease in mean RMSSD was not statistically significant with a p-value of 0.386.

**LF/HF**

The mean LF/HF ratio of the control group was 2.70 ± 0.62 and the study group was 3.05± 0.96. This increase in mean LF/HF was not statistically significant with a p-value of 0.242.

**LF n.u.**

The mean LF n.u. of the control group was 73.03 ± 4.59 and the study group was 73.68 ± 5.79. This increase in mean LFn.u. was not statistically significant with a p-value of 0.737.

**HF n.u.**

The mean HF n.u. of the control group was 27.29 ± 4.61 and the study group was 26.19 ± 5.79. This decrease in mean HFn.u. was not statistically significant with a p-value of 0.569.

## Comparison of the cardiovascular autonomic function test parameters between the control group and study group females (3B)

**Basal Blood Pressure (Systolic)**

The mean basal blood pressure SBP of the control group was 98.67 ± 9.90 and the study group was 105.73 ± 7.85. This increase in mean basal blood pressure SBP was statistically significant with a p-value of 0.039.

**Basal Blood Pressure (Diastolic)**

The mean basal blood pressure diastolic of the control group was 64.67 ± 6.40 and the study group was 70 ± 7.56. This increase in mean basal blood pressure DBP was statistically significant with a p-value of 0.046.

**E/I Ratio (Deep Breathing)**

The mean E/I Ratio of the control group was 1.39 ± 0.13. and the study group was 1.36 ± 0.20 This decrease in mean E/I Ratio was not statistically significant with a p-value of 0.615.

**Valsalva Ratio**

The mean Valsalva Ratio of the control group was 1.54 ± 0.17 and the study group was 1.52 ± 0.18. This decrease in mean Valsalva Ratio was not statistically significant with a p-value of 0.785.

**Standing (Immediate) Blood Pressure (systolic)**

The mean Standing (Immediate) Blood Pressure (systolic)of the control group was 92.80 ± 11.43 and the study group was 95.47 ± 9.30. This increase in mean Standing (Immediate) Blood Pressure (systolic) was not statistically significant with a p-value of 0.489.

**Standing (Immediate) Blood Pressure (Diastolic)**

The mean Standing (Immediate) Blood Pressure (Diastolic) of the control group was 64.93 ± 7.21 and the study group was 66.53 ± 8.12. This increase in mean Standing (Immediate) Blood Pressure (Diastolic) was not statistically significant with a p-value of 0.573.

**30:15 Ratio**

The mean 30:15 Ratio of the control group was 1.41 ± 0.16 and the study group was 1.45 ± 0.15. This increase in mean 30:15 Ratio was not statistically significant with a p-value of 0.524.

**Rise in Diastolic BP during Isometric exercise**

The mean raise in diastolic BP of the control group was 16.67 ± 7.23 and the study group was 21.33 ± 9.15. This increase in mean raise in diastolic BP during isometric exercise was not statistically significant with a p-value of 0.133.

# TABLES

**Table : 1(A)**

**Comparison of HRV Parameters between the control group and the study group**

| Parameters | Mean + Standard Deviation | | P value |
|---|---|---|---|
| | Controls n= 30 | Study Group n= 30 | |
| Mean RR | 0.89 ± 0.11 | 0.790 ± 0.09 | 0.000*** |
| Mean HR | 68.03 ± 8.68 | 77.97 ± 10.373 | 0.000*** |
| SDNN | 53.01 ± 17.29 | 51.94 ± 25.13 | 0.849 |
| RMSSD | 47.62 ± 19.49 | 34.93 ± 12.49 | 0.04* |
| NN50 | 74.17 ± 49.83 | 50.93 ± 43.95 | 0.06 |
| pNN50 | 28.56 ± 17.92 | 18.06 ± 14.18 | 0.015* |
| VLF | 85.91 ± 9.45 | 89.79 ± 4.29 | 0.045* |
| LF | 7.87 ± 3.19 | 10.42 ± 6.75 | 0.066 |
| HF | 3.48 ± 2.55 | 2.41 ± 1.28 | 0.043* |
| LF/HF | 3.18 ± 0.8 | 3.50 ± 1.1 | 0.195 |
| LF n.u. | 75.55 ± 4.68 | 76.29 ± 5.43 | 0.574 |
| HFn.u. | 24.58 ± 4.76 | 23.58 ± 5.45 | 0.451 |

| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

**Table : 1 (B)**

**Comparison of autonomic function test Parameters between the control group and the study group**

| Parameters | Mean ± Standard Deviation | | P value |
|---|---|---|---|
| | Controls n= 30 | Study Group n= 30 | |
| Basal BPSBP | 106.33 ± 12.45 | 111.03 ± 9.15 | 0.101 |
| Basal BP DBP | 70.67 ± 8.68 | 72.6 ± 7.34 | 0.355 |
| E/I ratio deep breathing | 1.36 ± 0.12 | 1.3 ± 0.16 | 0.780 |
| Valsalva ratio | 1.64 ± 0.26 | 1.45 ± 0.19 | 0.003** |
| Standing Immediate (Systolic) | 98.87 ± 13.06 | 101 ± 11.82 | 0.510 |
| Standing Immediate (Diastolic) | 70.87 ± 9.27 | 71.07 ± 8.83 | 0.932 |
| 30:15 ratio | 1.44 ± 0.18 | 1.42 ± 0.13 | 0.670 |
| Rise in DBP during isometric exercise | 19.40 ± 11.57 | 21.67 ± 8.74 | 0.396 |

| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

**Table : 2 (A)**

**Comparison of HRV Parameters between the control group and the study group males**

| Parameters | Mean ± Standard Deviation | | P value |
|---|---|---|---|
| | Controls n= 30 | Study Group n= 30 | |
| Mean RR | 0.96 ± 0.01 | 0.81 ± 0.12 | 0.001*** |
| Mean HR | 63.33 ± 6.33 | 77.73 ± 13.33 | 0.001*** |
| SDNN | 59.43 ± 18.14 | 57.74 ± 30.86 | 0.856 |
| RMSSD | 50.15 ± 21.94 | 33.27 ± 10.86 | 0.012* |
| NN50 | 62.07 ± 48.94 | 33.07 ± 27.92 | 0.056 |
| pNN50 | 28.93 ± 19.41 | 15.26 ± 12.30 | 0.029* |
| VLF | 85.08 ± 11.85 | 90.98 ± 2.58 | 0.070 |
| LF | 7.29 ± 2.18 | 11.45 ± 8.63 | 0.081 |
| HF | 3.46 ± 3.31 | 1.81 ± 0.53 | 0.067 |
| LF/HF | 3.66 ± 0.66 | 3.95 ± 1.07 | 0.368 |
| LF n.u. | 78.07 ± 3.28 | 78.9 ± 3.61 | 0.513 |
| HFn.u. | 21.87 ± 3.144 | 20.96 ± 3.67 | 0.473 |

| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

**Table : 2 (B)**

**Comparison of autonomic function test parameters between the control group and the study group males**

| Parameters | Mean ± Standard Deviation | | P value |
|---|---|---|---|
| | Controls n= 30 | Study Group n= 30 | |
| Basal BPSBP | 114 ± 9.86 | 116.33 ± 7.19 | 0.465 |
| Basal BP DBP | 76.66 ± 6.17 | 75.20 ± 6.32 | 0.525 |
| E/I ratio deep breathing | 1.34 ±0.10 | 1.35 ± 0.12 | 0.783 |
| Valsalva ratio | 1.73 ± 0.31 | 1.38 ± 0.18 | 0.001*** |
| Standing Immediate (Systolic) | 104.93 ± 12.00 | 106.53 ± 11.72 | 0.715 |
| Standing Immediate (Diastolic) | 76.80 ± 7.12 | 75.6 ± 7.18 | 0.649 |
| 30:15 ratio | 1.46 ± 0.19 | 1.39 ± 0.09 | 0.211 |
| Rise in DBP during isometric exercise | 22 ± 8.62 | 22.13 ± 14.46 | 0.976 |

| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

**Table : 3 (A)**

**Comparison of HRV Parameters between the control group and the study group females**

| Parameters | Mean ± Standard Deviation | | P value |
|---|---|---|---|
| | Controls n= 30 | Study Group n= 30 | |
| Mean RR | 0.84 ± 0.09 | 0.77 ± 0.07 | 0.053 |
| Mean HR | 72.73 ± 8.29 | 78.20 ± 6.7 | 0.057 |
| SDNN | 46.59 ± 14.2 | 46.15 ± 16.86 | 0.939 |
| RMSSD | 45.08± 17.09 | 36.6 ± 14.16 | 0.149 |
| NN50 | 86.27 ± 49.36 | 68.80 ± 50.37 | 0.346 |
| pNN50 | 28.19 ± 16.97 | 20.87 ± 15.75 | 0.231 |
| VLF | 86.75 ± 6.56 | 88.59 ± 5.33 | 0.405 |
| LF | 8.44 ± 3.95 | 9.39 ± 4.19 | 0.530 |
| HF | 3.51±1.58 | 3.01 ± 1.53 | 0.386 |
| LF/HF | 2.7 ± 0.62 | 3.05 ± 0.96 | 0.242 |
| LF n.u. | 73.03 ±4.59 | 73.68 ± 5.79 | 0.737 |
| HFn.u. | 27.29 ± 4.61 | 26.19 ± 5.79 | 0.569 |

| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

**Table : 3(B)**

**Comparison of autonomic function test parameters between the control group and the study group females.**

| Parameters | Mean ± Standard Deviation | | P value |
|---|---|---|---|
| | Controls n= 30 | Study Group n= 30 | |
| Basal BPSBP | 98.67 ± 9.90 | 105.73 ± 7.85 | 0.039* |
| Basal BP DBP | 64.67 ± 6.40 | 70 ± 7.56 | 0.046* |
| E/I ratio deep breathing | 1.39 ± 0.13 | 1.36 ± 0.20 | 0.615 |
| Valsalva ratio | 1.54 ± 0.17 | 1.52 ± 0.18 | 0.785 |
| Standing Immediate (Systolic) | 92.8 ± 11.43 | 95.47 ± 9.30 | 0.489 |
| Standing Immediate (Diastolic) | 64.93 ± 7.21 | 66.53 ± 8.12 | 0.573 |
| 30:15 ratio | 1.41 ± 0.16 | 1.45 ± 0.15 | 0.524 |
| Rise in DBP during isometric exercise | 16.67 ± 7.23 | 21.33 ± 9.15 | 0.133 |

| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

# CHARTS

**Chart 1**

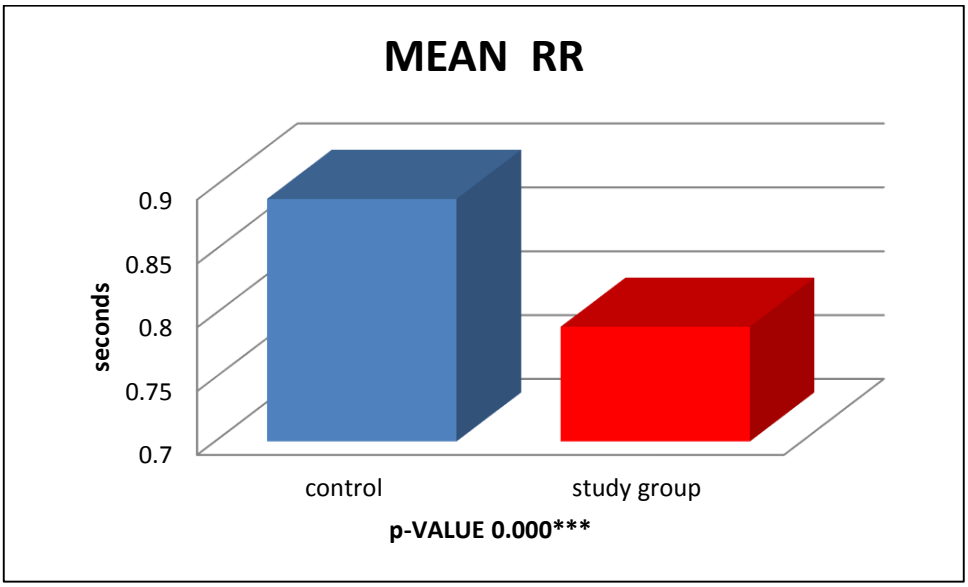
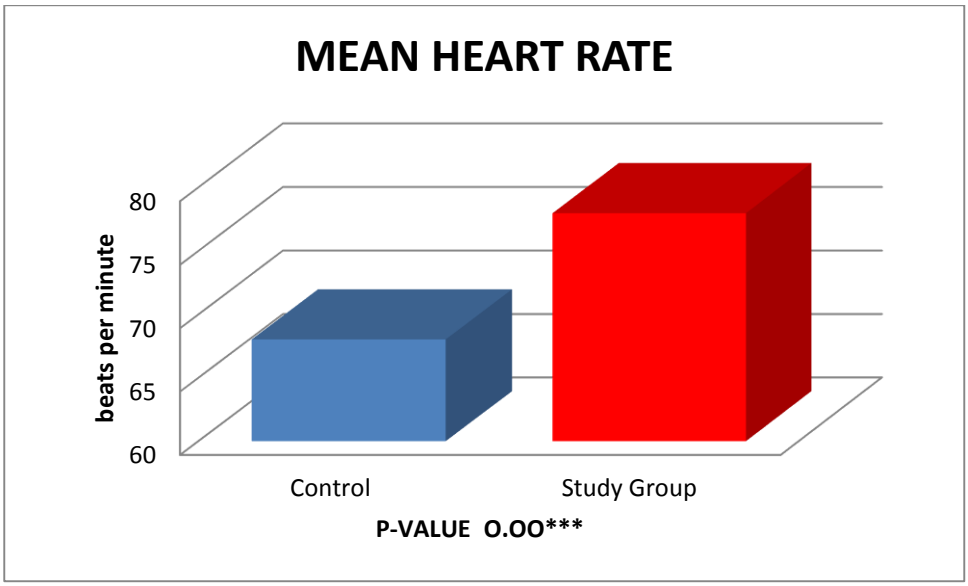



**Chart 2**




| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

**Chart 3**

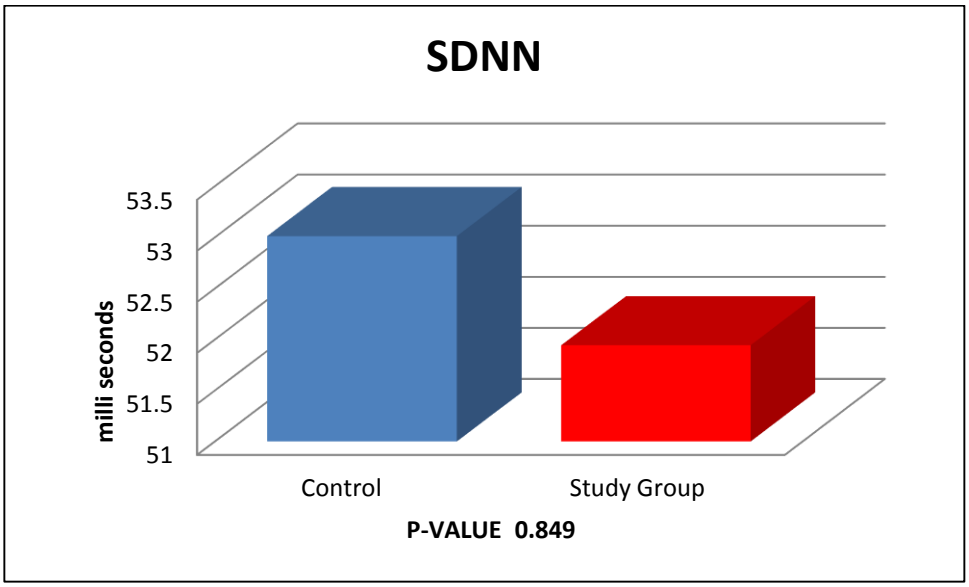
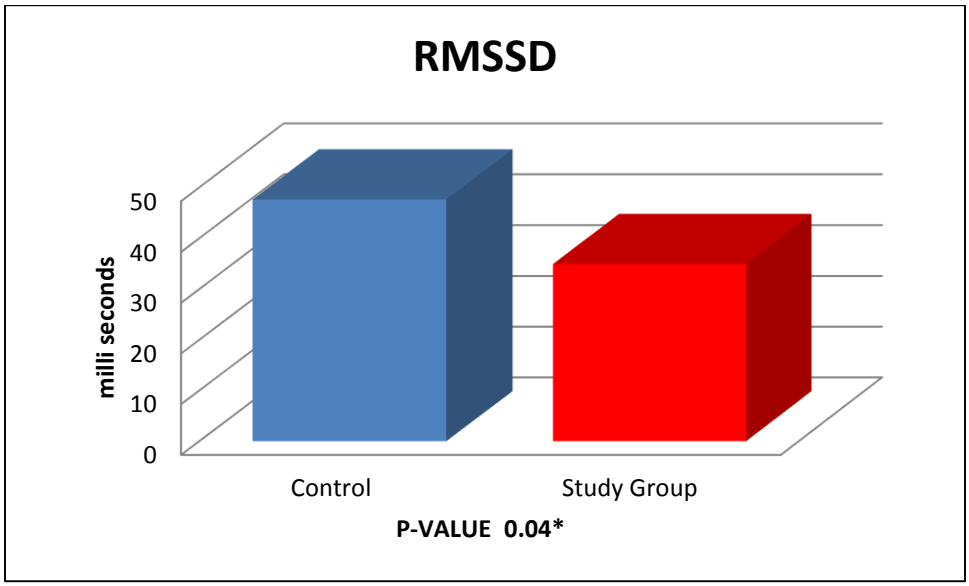
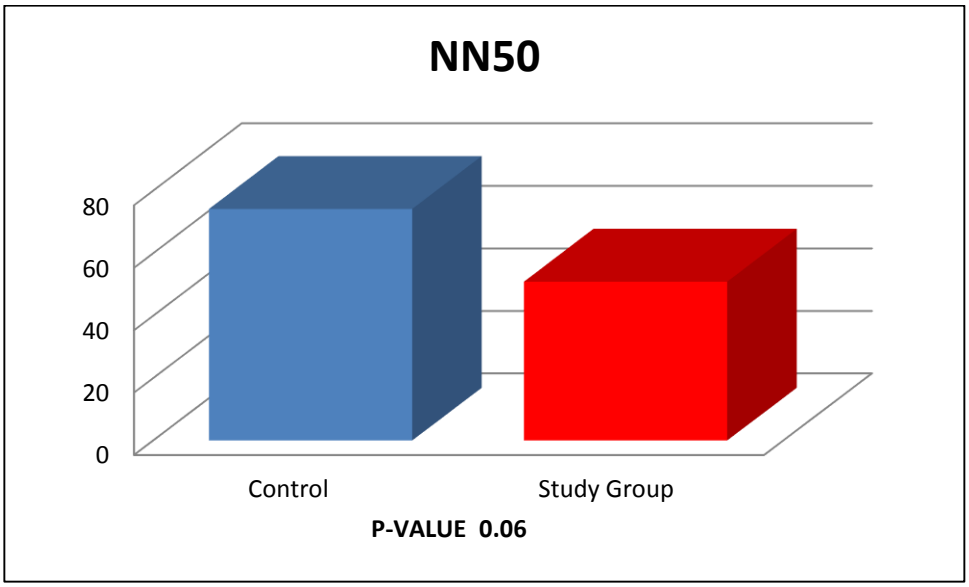



**Chart 4**




| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

**Chart 5**

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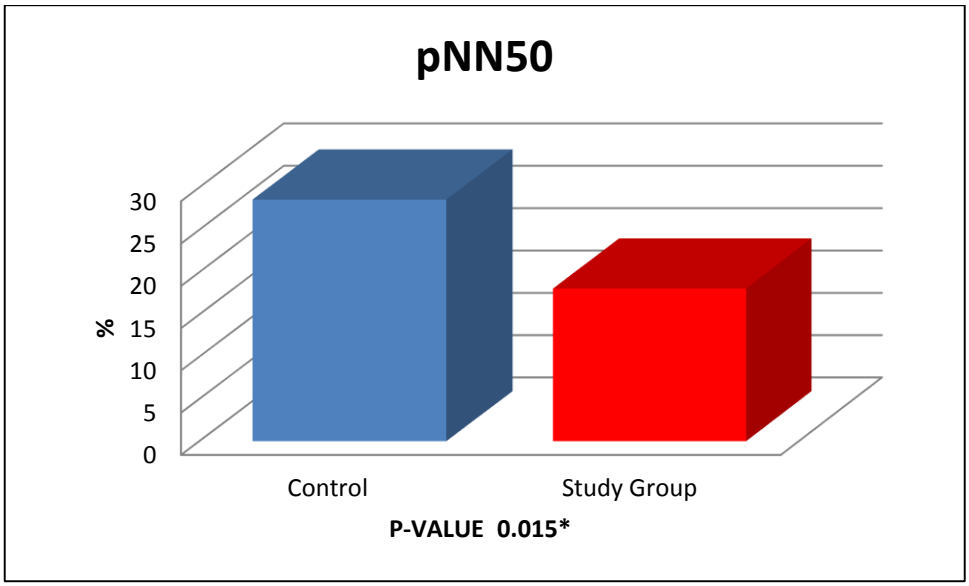



| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

**Chart -7**

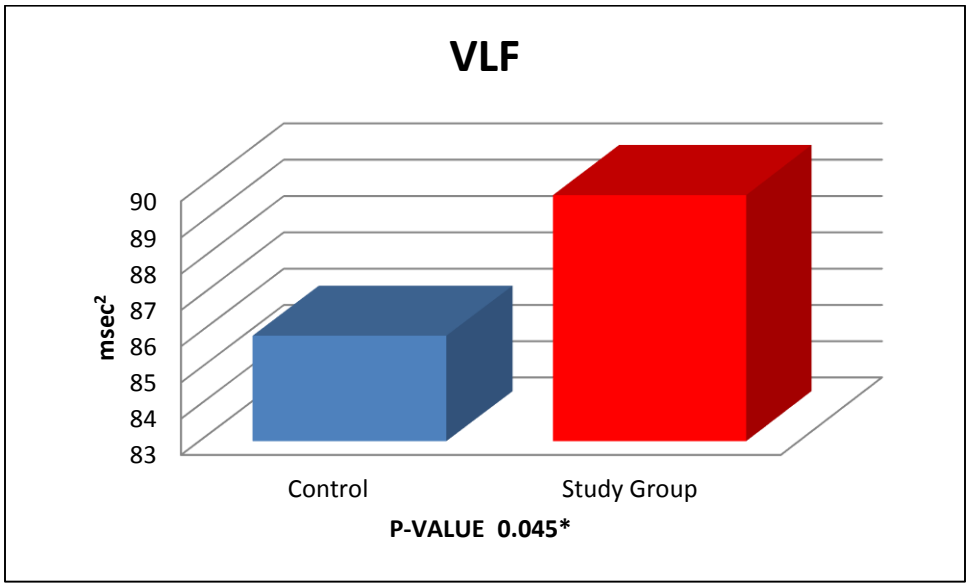
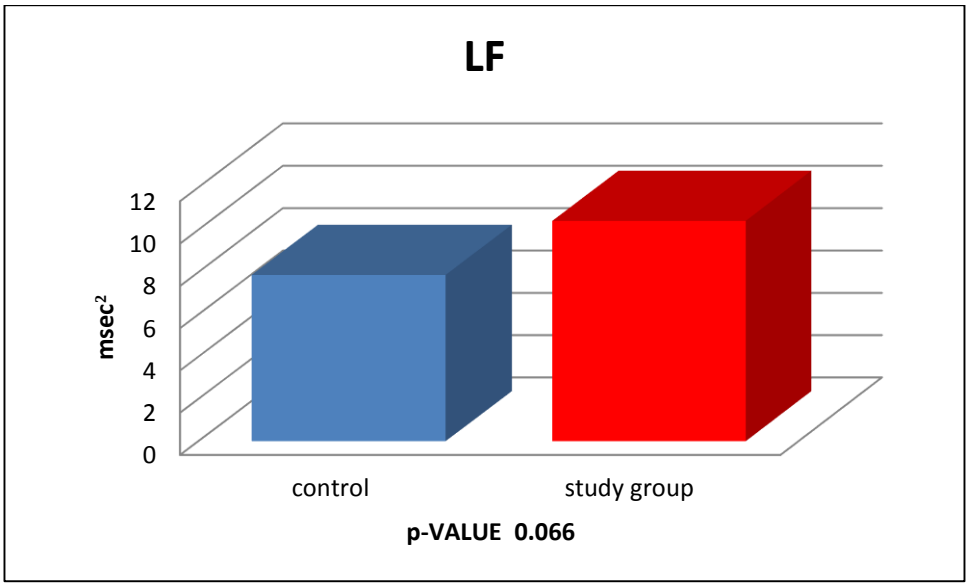
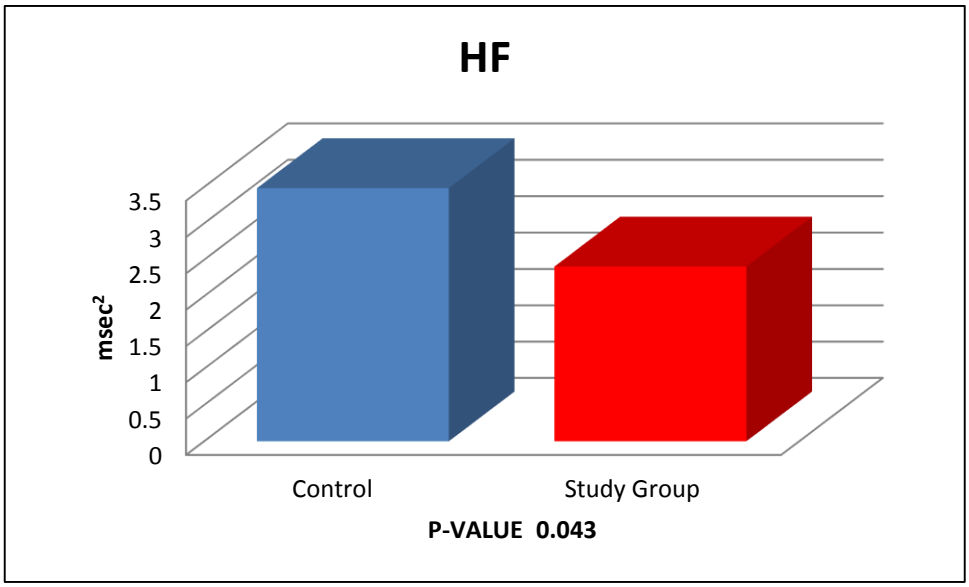



**Chart 8**

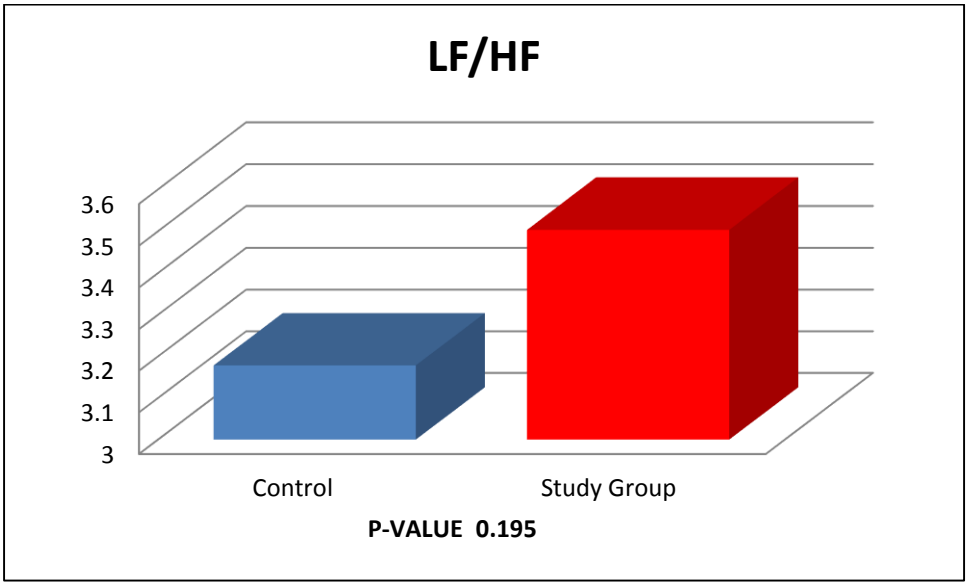



| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

## Chart 9




## Chart 10




| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

**Chart 11**

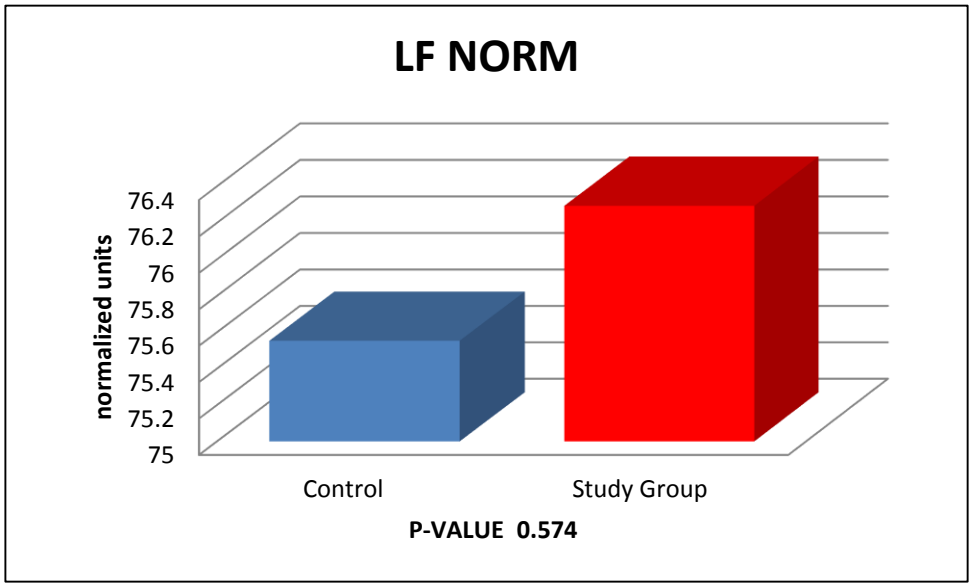
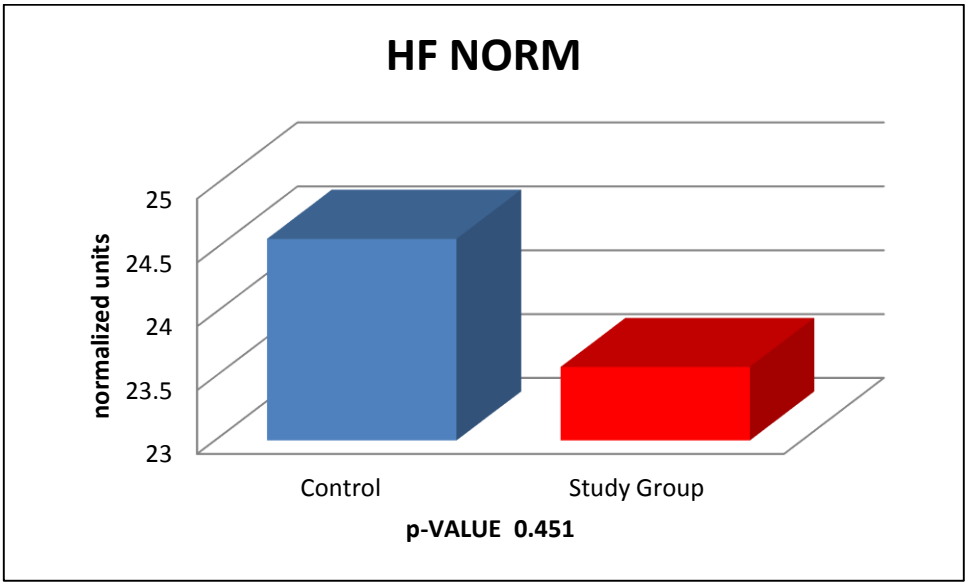



**Chart 12**




| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

**Chart 13**

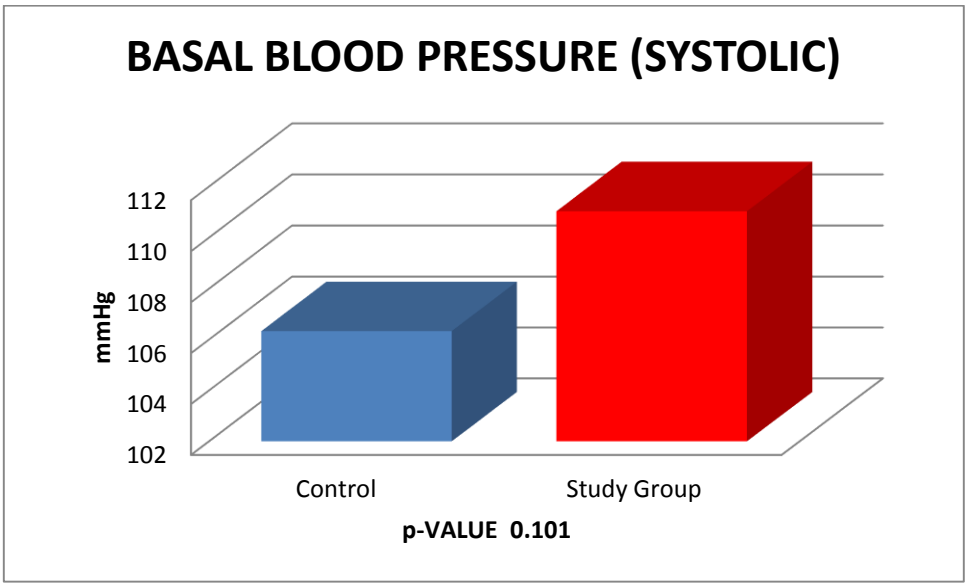
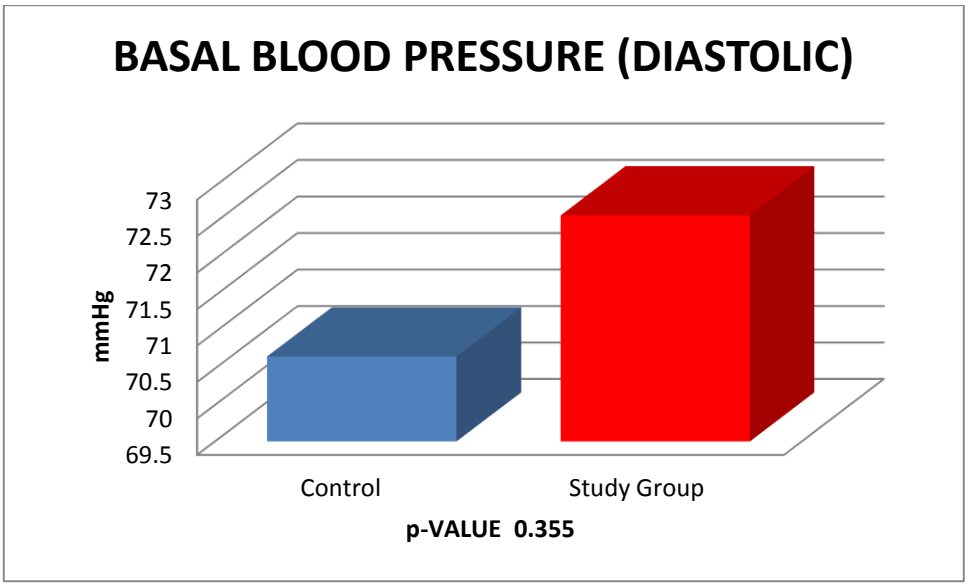



**Chart14**




| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

**Chart 15**

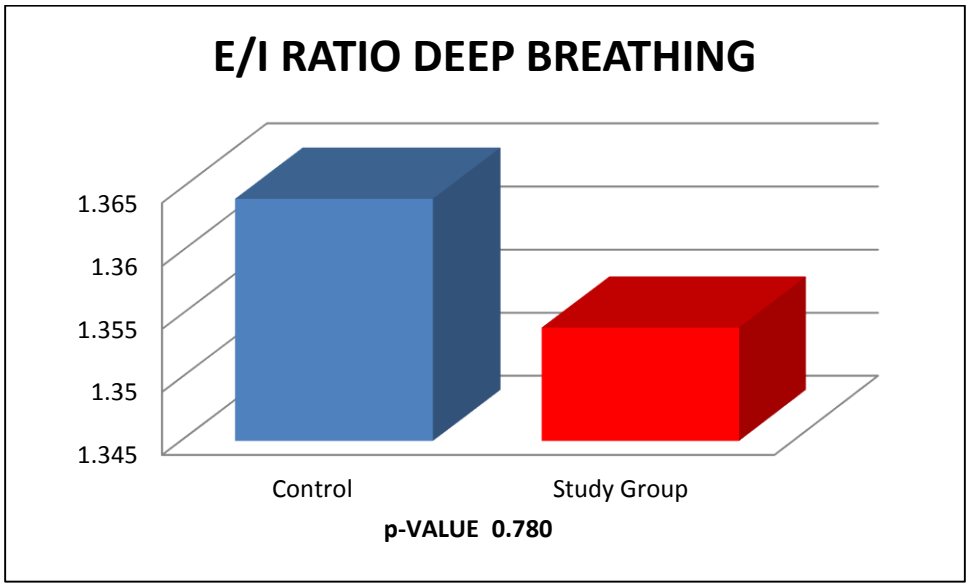
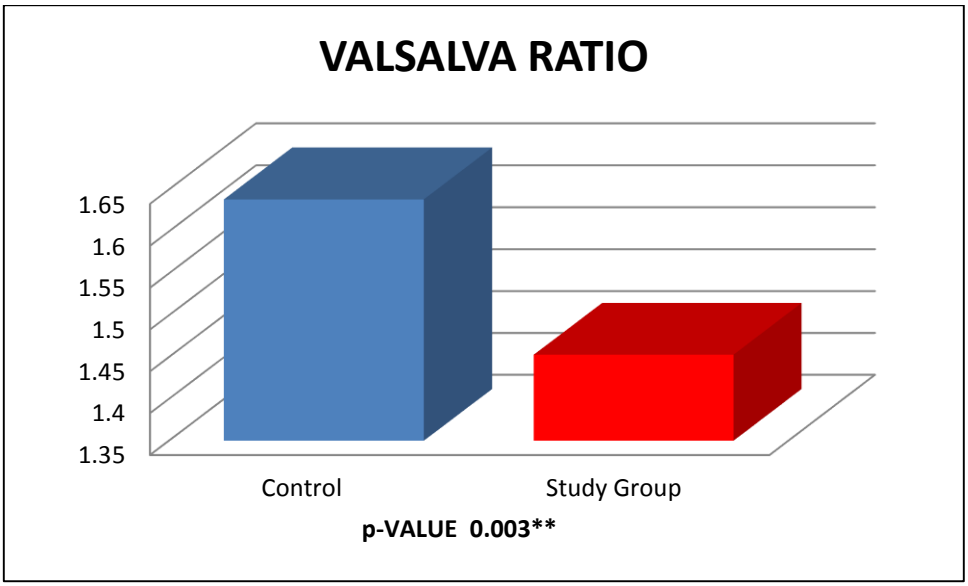



**Chart 16**




| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

**Chart 17**

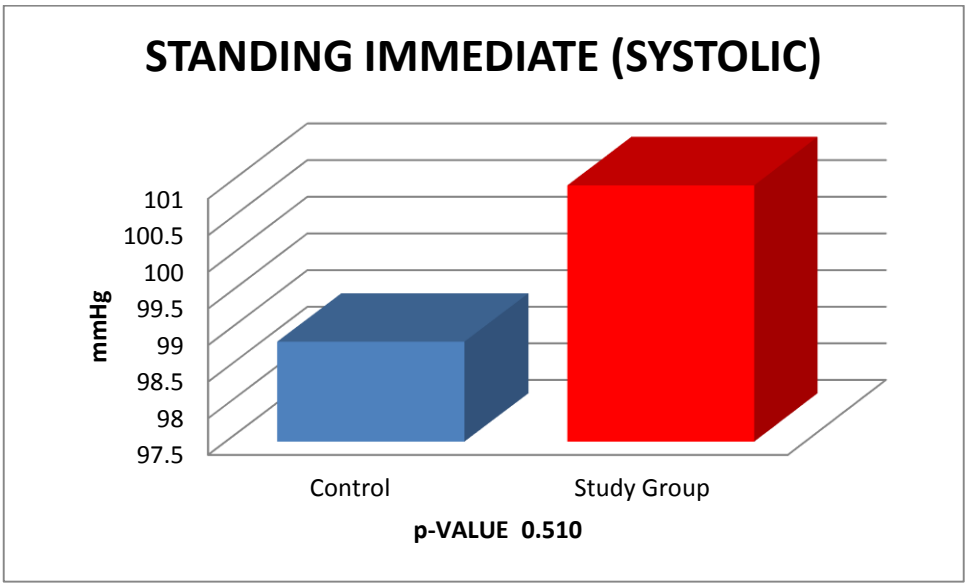
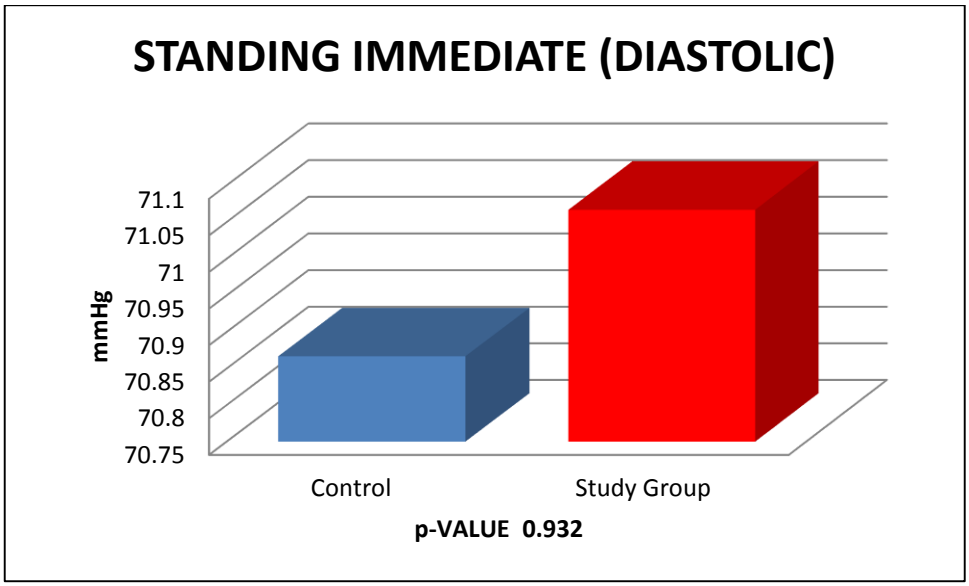



**Chart 18**




| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

**Chart 19**

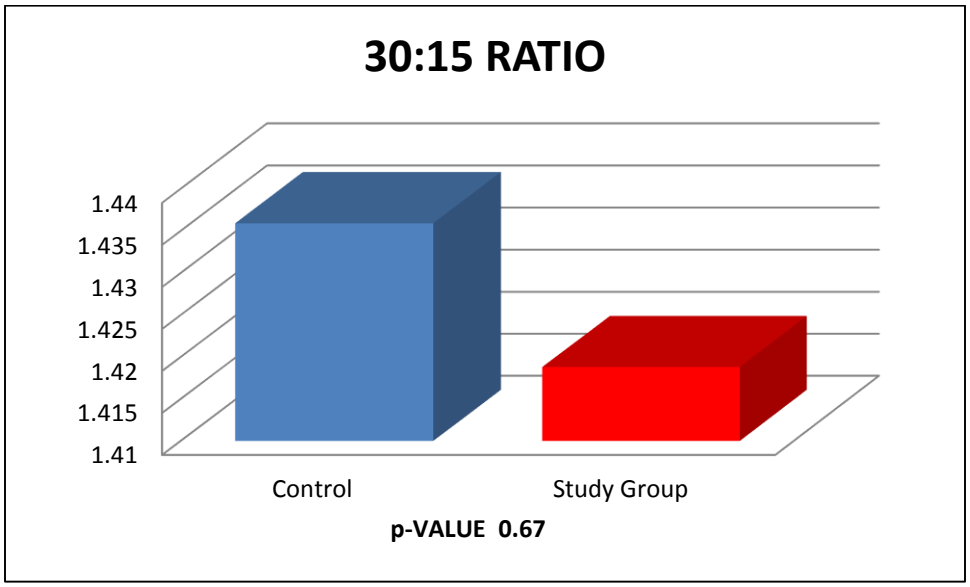
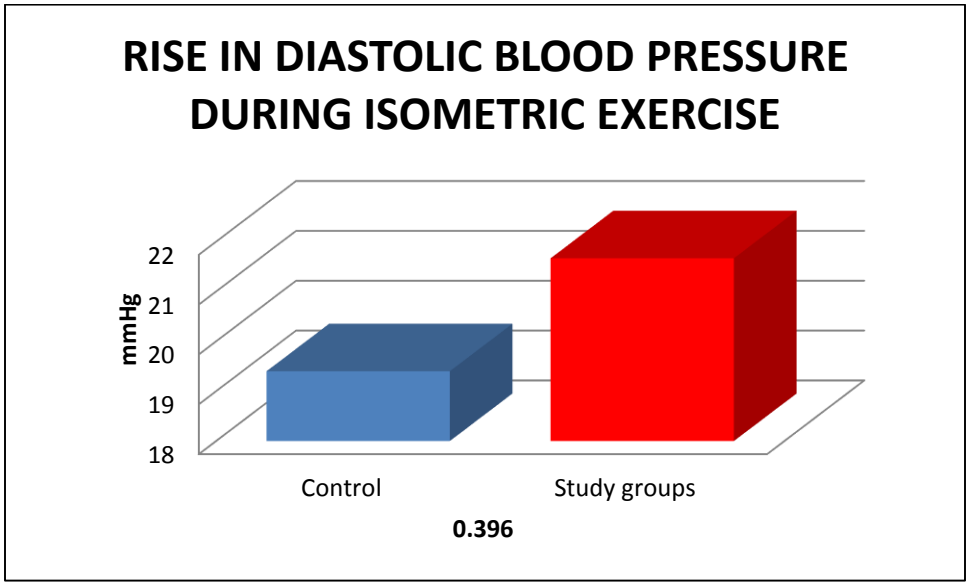



**Chart 20**




| | |
|---|---|
| p-Value <0.05 to 0.01* | significant |
| p-Value <0.01 to 0.001** | moderately significant |
| p- Value <0.001*** | highly significant |

# DISCUSSION

# DISCUSSION

Shift works involve a round the clock schedule which affects the sleep-wake cycle as well as the circadian rhythm in the workers. These kinds of disruptions in the physiological cycle of the human body ideally should have dire consequences if not for the corrective measures by the feedback systems that are activated.

Here we are going to analyze whether the disruptions are present in the study participants as assessed by the short term HRV and other autonomic function tests or the corrective measures of the body has nullified these effects.

HRV is a simple and effective way to analyze the autonomic balance of an individual . Autonomic nervous system is the primary regulator of the variability in heart rate. In normal individuals the heart rate shows a high degree of variability which reflects the oscillations between sympathetic and parasympathetic dominance. These changes have a tendency to increase during inspiration and decrease during expiration.

Frequency domain measures of the HRV are the most reliable quantitative methods to assess the sympathetic and parasympathetic dominance of an individual. In case of sympathetic predominance there is tachycardia and reduced beat to beat variation where as in the parasympathetic over activity there will be bradycardia and rise in beat to beat variation. Ideally the high beat to beat variation in an individual is desirable whereas low beat to beat variation is an established predictor of cardiovascular diseases and mortality due to cardiac etiology.

The mean age between the control group and the study group when statistically analyzed showed no statistical significance. This implies the selection of the control and study group was age matched.

## MAIN ANALYSIS

### Comparison of HRV parameters between shift workers and day workers

The mean RR interval and the mean HR reflect the balance between the sympathetic and the parasympathetic components. Rise in HR and reduced RR interval indicate sympathetic over activity whereas reduced HR and prolongation of RR interval imply parasympathetic dominance. Here the study group showed an increase in heart rate and decrease in RR interval of statistical significance when compared to the control group. This implies that the night shift workers have a sympathetic dominance when compared to the day workers.

SDNN is a measure of total heart rate variability. Though the study showed a decrease in the total heart rate variability among night workers, it was not statistically significant. This is similar to the study conducted by Freitas J.et al[36].

RMSSD, NN50, pNN50 all these parameters estimate the heart rate variation of high variation and are measures of vagal response. The study group showed a decrease in these parameters which imply a decrease in the vagal activity in night shift workers. Among these parameters RMSSD and pNN50 were statistically significant.

These findings are similar to the study conducted by Souza B.B.et al[47], who found out a reduction in the parasympathetic modulation of heart during night shifts.

VLF indicates sympathetic activity and in this study, the study group showed a significant increase in VLF. This implies the night shift induces sympathetic over activity among the workers.

LF reflects sympathetic tone and the study showed that there was an increase in the sympathetic tone among night shift workers but it was not statistically significant.

HF indicates vagal tone and the study showed a significant decrease in the vagal tone among the night shift workers. This is similar to the study conducted by Amirian I.[69] et al who have found a lower HF activity during night shifts.

LF / HF reflect sympatho – vagal balance. Malliani et al[58], in their study, concluded that the shift of LF/HF towards LF component indicates sympathetic over activity. In our study the LF/HF showed a shift towards LF indicating an increase in the sympathetic activity among the night shift workers but it was not statistically significant. This is similar to the study conducted by Freitas .J. et al[52].

LF n.u. showed a non significant increase and the HF n.u. showed a non significant decrease among the night shift workers which indicate that there some amount of increased sympathetic activity and decreased parasympathetic activity. This is similar to the study conducted by Freitas .J. et al[52].

**Comparison of cardiovascular autonomic function test parameters between night workers and day workers**

The basal blood pressures, systolic as well as the diastolic, among the night shift workers showed a non significant rise which indicate that there is some amount of sympathetic dominance among night shift workers.

E/I ratio a measure of parasympathetic activity is decreased among the night shift workers but it was not significant which indicates that there was a decrease in the vagal activity among the night shift workers.

Vasalva ratio a measure of cardiovagal activity showed significant decrease which indicates that the vagal response is compromised among the night shift workers.

On immediately standing, the systolic blood pressure of day workers and night workers fell about 8 mm Hg and 10 mm Hg respectively from the baseline values which suggests that there was no orthostatic hypotension. The diastolic blood pressure did not change much from the basal blood pressure.

30:15 ratio is measure of parasympathetic function and the night shift workers showed a non significant decrease in the parasympathetic function when compared to the day workers.

Isometric systolic and diastolic blood pressures showed no difference between the day workers and night workers. The night workers showed an increase in the

diastolic blood pressure which was not significant. This indicates that there might be some amount of sympathetic over activity among night workers.

# SUBGROUP ANALYSIS - AMONG MALES

## Comparison of HRV parameters between day and night shift males

The mean RR interval showed significant decrease and mean HR showed a significant increase in the night shift males. This indicates that there was an autonomic imbalance precipitated by the shift work.

SDNN, showed a non significant decrease among the night shift workers which indicates the total heart rate variability was less in night workers.

RMSSD showed a significant decrease which indicates that the vagal activity was reduced in the night workers.

NN50 showed a non significant decrease which indicates a reduced vagal activity in night workers

pNN50 showed a significant decrease in night shift workers with implies that their parasympathetic activity is reduced.

VLF reflects the sympathetic response and the study showed an increase in the sympathetic activity among night shift workers but it was not significant.

LF which reflects sympathetic tone was found to be raised but it was not significant.

The night shift workers showed a decrease in HF which was not significant. It indicates that there was some amount of reduction in the vagal response among night shift males.

LF / HF ratio was high in night shift male but it was not significant. It indicates that there was a shift in the sympathovagal balance towards the sympathetic component. Amirian .I.[69] et al, in their study, has found a higher LF/HF in night shift surgeons.

LF n.u and HF n.u showed no significant difference in night shift males.

**Comparison of cardiovascular autonomic function tests between day and night shift males.**

Basal blood pressures, systolic as well as diastolic, were increased in night shift males which indicate that there might be a sympathetic over activity but it was not significant. This is similar to the study conducted by Fialho .G[64] et al, who observed a higher blood pressure during shift work.

E/I ratio showed no significant difference between day shift and night shift males.

Valsalva ratio was significantly reduced in night shift males which indicate that the cardiovagal function was reduced.

Immediately after standing systolic blood pressure, was low when compared to the basal blood pressure but it was not low enough to suggest orthostatic

hypotension. Also there was no significant difference between the night shift and day shift males.

30:15 ratio which indicates vagal response was reduced in night shift workers but it was not significant.

Isometric systolic and diastolic blood pressures showed no significant difference. Rise in diastolic blood pressure, which indicates increased sympathetic activity during isometric exercise, was high in night shift male workers but it was not significant.

# SUBGROUP ANALYSIS - AMONG FEMALES

## Comparison of HRV parameters between day and night shift females

The mean RR interval showed a decrease and the mean heart rate showed an increase in the night shift females. This implies that there was some amount of sympathetic dominance in night shift females but it was not significant.

SDNN, a measure of total variability, was less in night shift females but it was not significant.

RMSSD was less in night shift females which indicates that the vagal response was reduced in night workers but it was not significant.

NN50 and pNN 50, measures of vagal activity, were reduced in night shift females when compared to day shift females but it was not significant.

VLF, a measure of sympathetic activity, was more in night shift females but it was not statistically significant.

LF, which reflects sympathetic tone, showed an increase in night shift females but it was not significant. A similar finding was reported by Kirthana .K.U. et al in their study and they have found a non significant increase in the LF among BPO employees who work in night shifts.

HF, a measure of vagal tone, was reduced in night shift females but it was not significant. This is similar to the study conducted by Chung .M.H. et al but they have found a significant decrease in the night shift nurses.

LF/HF, a measure of sympatho – vagal balance, showed an increase indicating that there was an increase in the sympathetic or decrease in the parasympathetic tone but it was not significant. This was similar to the findings of Kirthana .K.U. et al.

LF n.u., a measure of sympathetic activity, was high and HF n.u., a measure of parasympathetic tone, was low in night shift females but they were not significant.

**Comparison of cardiovascular autonomic function tests between day and night shift females**

The basal blood pressures (systolic and diastolic) were significantly high in night shift females indicating that there was a sympathetic over activity precipitated by night shift work. This is similar to the study conducted by Lo .S.H.[63] et al, who found out a significant association between shift work and blood pressure in young female nurses.

E/I ratio was reduced in night shift females indicating that the parasympathetic activity during night work was reduced but it was not significant.

Valsalva ratio was also reduced in night shift females indicating some amount of reduced cardiovagal function during night work but it was not significant.

Immediately after standing blood pressure showed an increase in systolic as well as diastolic components but they were not significant.

The mean fall in systolic blood pressure of the control group was 5.55 mmHg whereas the study group was 10.26 mmHg from the baseline suggesting some amount of autonomic imbalance but it was not low enough to be deemed orthostatic hypotension[32].

The fall in the diastolic blood pressure of the control group was 0.74 mmHg and the study group was 3.47 mmHg which also suggests some autonomic imbalance but it was not significant.

30:15 ratio, a measure of parasympathetic function, was reduced in night shift females but it was not significant.

The rise in diastolic blood pressure during isometric exercise, a measure of sympathetic activity, showed an increase in night shift females but it was not significant.

# CONCLUSION

# CONCLUSION

In this study of comparison between day and night shift workers, using spectral analysis of short term HRV and other cardiac autonomic function tests, it has been found that there exists a significant autonomic dysfunction in night shift workers which might be a contributory factor to cardiovascular complications in night shift workers.

The reduced mean RR and increased HR implied a significant sympathetic dominance and the decreased RMSSD and pNN50 implied a significant reduction in parasympathetic activity in night shift workers.

The frequency domain measures, such as increased VLF, indicate sympathetic over activity whereas reduced HF implies a reduction in vagal tone among night shift workers.

The other cardiovascular function tests, like reduced Valsalva ratio, suggest a reduction in vagal response.

Subgroup analysis among males showed a significant decrease in RR interval which implies a sympathetic dominance in night shift males. Time domain measures, such as a decreased RMSSD and pNN 50, imply a reduced parasympathetic activity in males. The reduced Valsalva ratio indicates a reduction in parasympathetic activity among night shift males.

Subgroup analysis among females showed significantly high basal systolic as well as diastolic blood pressures in night shift workers which indicate a sympathetic dominance.

To sum it up, the night shift induces autonomic imbalance causing a sympathetic dominance and reduced cardiovagal activity in shift workers. Also it has been found the detrimental effects of shift work affects night workers irrespective of the gender. This shift in the autonomic balance towards the sympathetic component during night work may be a predisposing factor for cardiovascular complications in shift workers.

Also this study shows short term HRV and other cardiovascular autonomic function tests which assess the autonomic imbalance can be used as early predictors of cardiovascular disorders.

However, the delayed effects of the shift work, the effects of the intermittent changes in the shift schedule, the role of rest in the shift workers and the adaptation of the workers to the night work have to be further explored.

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# ANNEXURES

Study Volunteer ID:
Study Volunteer Name:

**PSG Institute of Medical Science and Research, Coimbatore**
**Institutional Human Ethics Committee**
**INFORMED CONSENT FORMAT FOR RESEARCH PROJECTS FOR CASES**

I, , am carrying out a study on the topic: as part of my project being carried out under the aegis of the Department of Physiology

(*Applicable to students only*): My research guide is:

The justification for this study is:

**The objectives of this study are:**

**Sample size:**
**Study volunteers / participants** are (specify population group & age group): **only female workers, age 20-35years**.

**Location**:
We request you to kindly cooperate with us in this study. We propose collect background information and other relevant details related to this study. We will be carrying out **Initial interview for 10 mins** and **collect participants details through data collection tools and the volunteers selected will be subjected to the short term HRV & other autonomic function tests and final data to be collected.**

Data collected will be stored for a period of fifteen years. We will not use the data as part of another study.

**Risks** involved by participating in this study: **NO**

How the **results** will be used:

- **To my dissertation study.**

If you are uncomfortable in answering any of our questions during the course of the interview, **you have the right to withdraw from the interview / study at anytime.** You have the freedom to withdraw from the study at any point of time. Kindly be assured that your refusal to participate or withdrawal at any stage, if you so decide, will not result in any form of compromise or discrimination in the services offered nor would it attract any penalty. You will continue to have access to the regular services offered to a patient. You will **NOT** be paid any remuneration for the time you spend with us for this interview / study. The information provided by you will be

kept in strict confidence. Under no circumstances shall we reveal the identity of the respondent or their families to anyone. The information that we collect shall be used for approved research purposes only. You will be informed about any significant new findings - including adverse events, if any, – whether directly related to you or to other participants of this study, developed during the course of this research which may relate to your willingness to continue participation.

**Consent:** The above information regarding the study, has been read by me/ read to me, and has been explained to me by the investigator/s. Having understood the same, I hereby give my consent to them to interview me. I am affixing my signature / left thumb impression to indicate my consent and willingness to participate in this study (i.e., willingly abide by the project requirements).

Signature / Left thumb impression of the Study Volunteer / Legal Representative:

Signature of the Interviewer with date: Witness:

**Contact details of PI: Phone: +91-0422-2570170 Extension No.: 5809.**
**PHONE: 9443820715**
**vbkr70@gmail.com.**

**Contact details of IHEC: Phone: +91-0422-2570170 Extension No.: 5818.**

Study Volunteer ID:
Study Volunteer Name:

**PSG Institute of Medical Science and Research, Coimbatore**
**Institutional Human Ethics Committee**
**INFORMED CONSENT FORMAT FOR RESEARCH PROJECTS FOR CONTROLS**

I, **Dr.S.Vijayabaskaran**, am carrying out a study on the topic: **"Impact of rotation shifts on autonomic nervous system in female workers as assessed by short term Heart Rate Variability and other autonomic function tests.".** as part of my project being carried out under the aegis of the Department of Physiology

(*Applicable to students only*): My research guide is: **Dr. T. Uma Maheswari,**

The justification for this study is:

- **Although many studies have been conducted to study the association between shift work and autonomic functions using HRV , there are no significant studies conducted in India .**

**The objectives of this study are:**

**Primary Objectives:**

- **To assess and compare the differences in short term Heart Rate Variability and other autonomic function tests between regular (day) shift workers and rotation (night) shift workers.**

**Secondary Objectives:**

- **To know whether these tests can be used as early indicators to determine the risk of cardiovascular diseases in shift work.**

**Sample size: 30 Night shift workers, 30 Day shift workers ( 60 participants).**

**Study volunteers / participants** are (specify population group & age group): **only female workers, age 20-35years**.

**Location**: **Female workers working in PSGIMS&R .**

We request you to kindly cooperate with us in this study. We propose collect background information and other relevant details related to this study. We will be carrying out **Initial interview for 10 mins** and **collect participants details through data collection tools and the volunteers selected will be subjected to the short term HRV & other autonomic function tests and final data to be collected.**

Data collected will be stored for a period of fifteen years. We will not use the data as part of another study.

**Risks** involved by participating in this study: **NO**

How the **results** will be used:

- **To my dissertation study.**

If you are uncomfortable in answering any of our questions during the course of the interview, **you have the right to withdraw from the interview / study at anytime.** You have the freedom to withdraw from the study at any point of time. Kindly be assured that your refusal to participate or withdrawal at any stage, if you so decide, will not result in any form of compromise or discrimination in the services offered nor would it attract any penalty. You will continue to have access to the regular services offered to a patient. You will **NOT** be paid any remuneration for the time you spend with us for this interview / study. The information provided by you will be kept in strict confidence. Under no circumstances shall we reveal the identity of the respondent or their families to anyone. The information that we collect shall be used for approved research purposes only. You will be informed about any significant new findings - including adverse events, if any, – whether directly related to you or to other participants of this study, developed during the course of this research which may relate to your willingness to continue participation.

**Consent:** The above information regarding the study, has been read by me/ read to me, and has been explained to me by the investigator/s. Having understood the same, I hereby give my consent to them to interview me. I am affixing my signature / left thumb impression to indicate my consent and willingness to participate in this study (i.e., willingly abide by the project requirements).

Signature / Left thumb impression of the Study Volunteer / Legal Representative:

Signature of the Interviewer with date: Witness:

**Contact details of PI: Phone: +91-0422-2570170 Extension No.: 5809.**
**PHONE: 9443820715**
**vbkr70@gmail.com.**

**Contact details of IHEC: Phone: +91-0422-2570170 Extension No.: 5818.**

ஒப்புதல் படிவம்

தேதி : 26/3/2014

திரு. S. விஜயபாஸ்கரன் ஆகிய நான், **PSG** மருத்துவக் கல்லூரியின் உடலியங்கியல் துறையின், கீழ், பெரிய பணியாளர்களின் அனிச்சை நரம்பு மண்டலத்தின் மேல் கிரஞ்சுப் பணி எற்படுத்தும் தாக்கம் என்ற தலைப்பில் ஆய்வு மேற்கொள்ள உள்ளேன்.

என் ஆய்வு வழிகாட்டி: பேரா. டாக்டர். தி. உமா மகேஸ்வரி

ஆய்வு மேற்கொள்வதற்கான அடிப்படை: இது போன்ற கிரஞ்சுப் பணியின் பாதிப்புகள் பற்றிய ஆய்வுகள் பல உலக அளவில் மேற்கொள்ளப் பட்டிருந்தாலும், இந்திய அளவில் போதுமான ஆய்வுகள் இல்லை.

ஆய்வின் நோக்கம்: கிரஞ்சுப் பணியாளர்களுக்கும், பகல்நேரப் பணியாளர்களுக்கும். அவர்களது இதயத்துடிப்பு வேகவேறுபாடு மற்றும் பிற அனிச்சை நரம்பமண்டல செயல்பாட்டு அளவைகளில் உள்ள மாற்றங்களைக் கண்டறிந்து ஒப்பிடுதல்.

ஆய்வு மேற்கொள்ளும் இடம்:

சு.ச.கோ. மருத்துவக் கல்வி மற்றும் ஆராய்ச்சி மையம்

ஆய்வின் பலன்கள்:

கிரஞ்சுப் பணியின் பாதிப்புகளைக் கண்டறிதல்.

இந்த ஆய்வில் கிடைக்கும் தகவல்கள் ---15--- வருடங்கள் பாதுகாக்கப்படும். இவை வேறு எந்த ஆய்விற்கும் பயன்படுத்தப் பட மாட்டாது. எந்த நிலையிலும் உங்களைப் பற்றிய தகவல்கள் யாருக்கும் தெரிவிக்கப்பட மாட்டாது. அவை இரகசியமாக வைக்கப்படும்.

இந்த ஆய்வில் பங்கேற்க ஒப்புக்கொள்ளுவதால் எந்த விதமான பலனும் உங்களுக்குக் கிடைக்காது. எந்த நேரத்தில் வேண்டுமானாலும் ஆய்விலிருந்து விலகிக்கொள்ளும் உரிமை உங்களுக்கு உண்டு.

ஆய்விலிருந்து விலகிக்கொள்வதால் உங்களுக்கு அளிக்கப்படும் சிகிச்சையில் எந்த வித மாற்றமும் இருக்காது.

இந்த ஆராய்ச்சிக்காக உங்களிடம் சில கேள்விகள் கேட்கப்படும் / சில இரத்த மாதிரிகள் அல்லது திசு மாதிரிகள் எடுக்கப்படும்.

மேலும், இந்த ஆய்வில் பங்கு கொள்வது உங்கள் சொந்த விருப்பம். இதில் எந்த விதக் கட்டாயமும் இல்லை. நீங்கள் விருப்பப் பட்டால், இந்த ஆய்வின் முடிவுகள் உங்களுக்குத் தெரியப் படுத்தப்படும்.

ஆய்வாளரின் கையொப்பம் :

தேதி : 26/3/2014

**ஆய்வுக்குட்படுபவரின் ஒப்புதல்:**

நான் இந்த ஆராய்ச்சியின் நோக்கம் மற்றும் அதன் பயன்பாட்டினைப் பற்றி தெளிவாகவும், விளக்கமாகவும் தெரியப்படுத்தப் பட்டுள்ளேன். இந்த ஆராய்ச்சியில் பங்கு கொள்ளவும், இந்த ஆராய்ச்சியின் மருத்துவ ரீதியான குறிப்புகளை வரும் காலத்திலும் உபயோகப்படுத்திக் கொள்ளவும் முழு மனதுடன் சம்மதிக்கிறேன்.

ஆய்வுக்குட்படுபவரின் பெயர், முகவரி :

கையொப்பம் :

தேதி :

# DATA COLLECTION TOOL

NAME:

AGE:

SEX:

HEIGHT:

WEIGHT:

BMI:

TYPE OF SHIFT WORK : ( REGULAR or NIGHT SHIFT )

TREATMENT HISTORY:

ARE YOU ON TREATMENT FOR ANY OTHER CHRONIC DISEASE :

1) Hypertension
2) Any cardiac illness
3) Diabetes
4) Bronchial asthma
5) Parkinson's
6) Hypo & hyperthyroidism
7) Chronic use of any medications

PERSONAL HISTORY (ALCOHOLIC/SMOKING/TOBACCO CHEWING):

1. Pregnancy

SIGNATURE OF THE PARTICIPANTS

# CONTROLS

| S.NO | SEX | AGE | HEIGHT | WEIGHT | BMI | E/I RATIO | VALSALVA RATIO | MEAN RR | MEAN HR | SDNN | RMSSD | NN50 | pNN50 | VLF | LF | HF | LF/HF | Lf n.u. | Hf n.u. | BASAL BP SBP | BASAL BP DBP | STANDING IMMEDIATE SBP | STANDING IMMEDIATE DBP | 30:15 RATIO | ISOMERTIC SBP | ISMETRIC DBP | RAISE IN DBP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | MALE | 22 | 168 | 55 | 19.5 | 1.31 | 1.918 | 0.995 | 60 | 84.8 | 80.432 | 139 | 67.1 | 89.2 | 4.4 | 2.5 | 3.32 | 76.9 | 23.1 | 90 | 70 | 88 | 70 | 1.211 | 150 | 110 | 40 |
| 2 | MALE | 24 | 174 | 102 | 33.66 | 1.38 | 1.458 | 0.906 | 66 | 53.76 | 42.223 | 85 | 26 | 87.1 | 7.1 | 2.1 | 5.14 | 83.7 | 16.3 | 100 | 60 | 80 | 60 | 1.39 | 130 | 90 | 20 |
| 3 | MALE | 24 | 172 | 65 | 22.03 | 1.41 | 1.354 | 0.993 | 60 | 60.64 | 46.378 | 74 | 30.7 | 87.4 | 4.9 | 2.7 | 3.67 | 78.6 | 21.4 | 120 | 80 | 110 | 80 | 1.39 | 140 | 100 | 30 |
| 4 | MALE | 22 | 168 | 54 | 19.14 | 1.48 | 1.694 | 0.983 | 61 | 75.97 | 83.453 | 181 | 64.9 | 94.8 | 6.1 | 1.1 | 3.73 | 78.8 | 21.2 | 100 | 70 | 90 | 70 | 1.552 | 140 | 90 | 20 |
| 5 | MALE | 22 | 165 | 50 | 18.38 | 1.39 | 1.637 | 0.944 | 64 | 67.34 | 71.333 | 92 | 32.4 | 70.2 | 6.8 | 7.2 | 3.13 | 75.5 | 24.2 | 110 | 80 | 100 | 80 | 1.412 | 160 | 120 | 50 |
| 6 | FEMALE | 24 | 148 | 48 | 21.91 | 1.25 | 1.723 | 0.902 | 67 | 30.17 | 33.298 | 43 | 13.1 | 91.2 | 6.1 | 2.1 | 3.19 | 76.1 | 23.9 | 80 | 60 | 70 | 60 | 1.447 | 110 | 90 | 20 |
| 7 | FEMALE | 22 | 155 | 53 | 22.08 | 1.47 | 1.664 | 0.799 | 75 | 51.5 | 51.308 | 118 | 39.5 | 86.9 | 3.2 | 4 | 2.28 | 69.5 | 30.5 | 100 | 60 | 96 | 60 | 1.372 | 140 | 90 | 20 |
| 8 | FEMALE | 21 | 156 | 51 | 20.98 | 1.45 | 1.806 | 0.964 | 62 | 60.22 | 86.943 | 174 | 65.9 | 84.7 | 5.6 | 4.6 | 2.33 | 69.9 | 30.1 | 90 | 60 | 80 | 60 | 1.604 | 130 | 90 | 20 |
| 9 | FEMALE | 22 | 159 | 77 | 30.43 | 1.47 | 1.672 | 1.002 | 60 | 47.91 | 46.391 | 63 | 33.2 | 85.5 | 6.6 | 3.8 | 2.84 | 74.5 | 26.4 | 110 | 70 | 100 | 70 | 1.547 | 130 | 90 | 10 |
| 10 | FEMALE | 20 | 149 | 55 | 24.77 | 1.48 | 1.484 | 0.743 | 81 | 50.23 | 43.409 | 99 | 28.4 | 88.8 | 8 | 2.7 | 3.15 | 75.9 | 24.1 | 110 | 70 | 110 | 78 | 1.104 | 130 | 90 | 10 |
| 11 | MALE | 26 | 174 | 64 | 21.19 | 1.21 | 1.85 | 1.119 | 54 | 99.15 | 83.218 | 21 | 46.7 | 61.3 | 11.1 | 8.5 | 3.55 | 78 | 22 | 120 | 80 | 110 | 80 | 1.8111 | 160 | 120 | 50 |
| 12 | MALE | 29 | 165 | 69 | 25.36 | 1.32 | 1.991 | 1.134 | 53 | 63.5 | 65.43 | 28 | 38.4 | 58.2 | 8 | 12.6 | 2.32 | 69.9 | 30.1 | 120 | 80 | 110 | 80 | 1.925 | 140 | 100 | 20 |
| 13 | MALE | 30 | 164 | 65 | 24.16 | 1.44 | 1.552 | 0.912 | 66 | 42.45 | 27.682 | 25 | 7.1 | 92.3 | 7.5 | 1.4 | 4.5 | 81.8 | 18.2 | 120 | 80 | 110 | 80 | 1.467 | 140 | 100 | 20 |
| 14 | MALE | 27 | 179 | 77 | 24.06 | 1.06 | 1.556 | 0.798 | 75 | 32.87 | 15.989 | 2 | 5 | 90.9 | 7.2 | 1.8 | 4.11 | 81.3 | 19.8 | 120 | 80 | 110 | 80 | 1.251 | 120 | 100 | 10 |
| 15 | MALE | 28 | 153 | 50 | 21.36 | 1.38 | 1.873 | 0.881 | 68 | 41.52 | 25.141 | 23 | 9.1 | 91.6 | 6.9 | 1.9 | 3.42 | 77.4 | 22.6 | 120 | 70 | 110 | 70 | 1.352 | 130 | 90 | 20 |
| 16 | FEMALE | 29 |  |  |  | 1.45 | 1.362 | 0.768 | 78 | 38.02 | 40.109 | 81 | 22 | 84.5 | 8.5 | 5.4 | 1.89 | 65.8 | 34.8 | 100 | 60 | 90 | 60 | 1.594 | 110 | 70 | 10 |
| 17 | FEMALE | 30 | 153 | 57 | 24.35 | 1.29 | 1.23 | 0.697 | 86 | 28.72 | 21.27 | 18 | 4.4 | 91.7 | 19.3 | 2.1 | 3 | 75.9 | 25.3 | 110 | 70 | 100 | 70 | 1.243 | 140 | 100 | 30 |
| 18 | FEMALE | 28 | 154 | 79 | 33.33 | 1.48 | 1.429 | 0.894 | 67 | 57.27 | 52.036 | 131 | 37.1 | 87.2 | 8.1 | 3.9 | 2.26 | 68.8 | 30.5 | 100 | 60 | 98 | 60 | 1.371 | 130 | 90 | 10 |
| 19 | FEMALE | 29 | 158 | 65 | 26.1 | 1.14 | 1.358 | 0.872 | 69 | 52.52 | 47.055 | 114 | 33.7 | 94.1 | 10.3 | 1.5 | 2.93 | 74.6 | 25.4 | 90 | 60 | 86 | 60 | 1.558 | 130 | 90 | 20 |
| 20 | FEMALE | 28 | 164 | 64 | 23.88 | 1.29 | 1.386 | 0.77 | 78 | 41.32 | 44.508 | 113 | 30.1 | 92.3 | 8.4 | 2.5 | 2.12 | 68.8 | 32.5 | 110 | 70 | 110 | 70 | 1.532 | 130 | 90 | 20 |
| 21 | MALE | 32 | 160 | 67 | 26.1 | 1.26 | 1.944 | 1.073 | 56 | 47.57 | 45.363 | 65 | 31.4 | 85 | 12 | 3 | 4 | 80 | 20 | 120 | 80 | 130 | 90 | 1.453 | 130 | 85 | 7 |
| 22 | MALE | 32 | 162 | 61 | 23.24 | 1.36 | 2.51 | 0.881 | 68 | 48.11 | 41.647 | 46 | 14.2 | 93 | 7.9 | 1.6 | 3.38 | 77.1 | 22.9 | 110 | 80 | 100 | 80 | 1.619 | 140 | 85 | 5 |
| 23 | MALE | 31 | 172 | 78 | 26.37 | 1.38 | 1.898 | 1.001 | 60 | 57.7 | 47.32 | 85 | 29.4 | 89.6 | 4.8 | 2.5 | 3.16 | 76 | 24 | 120 | 80 | 110 | 80 | 1.36 | 140 | 90 | 20 |
| 24 | MALE | 33 | 177 | 94 | 30.03 | 1.39 | 1.398 | 0.88 | 68 | 72.4 | 47.854 | 32 | 22.2 | 91.4 | 5.5 | 1.7 | 4.06 | 80.2 | 19.8 | 120 | 80 | 110 | 80 | 1.407 | 130 | 90 | 10 |
| 25 | MALE | 31 | 165 | 65 | 23.89 | 1.34 | 1.388 | 0.842 | 71 | 43.71 | 28.806 | 33 | 9.4 | 94.2 | 9.2 | 1.3 | 3.39 | 75.9 | 22.4 | 120 | 80 | 106 | 72 | 1.355 | 140 | 90 | 10 |
| 26 | FEMALE | 31 | 150 | 62 | 27.55 | 1.35 | 1.708 | 0.695 | 86 | 25.1 | 18.805 | 4 | 1 | 91.8 | 14.7 | 2.2 | 2.77 | 74.4 | 26.8 | 90 | 70 | 86 | 68 | 1.128 | 110 | 80 | 10 |
| 27 | FEMALE | 33 | 145 | 44 | 20.93 | 1.53 | 1.468 | 0.814 | 74 | 35.98 | 28.118 | 24 | 6.6 | 66.5 | 8.3 | 7.5 | 1.91 | 65.7 | 34.3 | 90 | 60 | 86 | 60 | 1.333 | 140 | 80 | 30 |
| 28 | FEMALE | 33 | 152 | 58 | 25.11 | 1.16 | 1.488 | 0.845 | 71 | 39.74 | 47.15 | 123 | 35.3 | 83.2 | 7.7 | 3.9 | 3.31 | 76.8 | 23.2 | 110 | 80 | 100 | 80 | 1.306 | 130 | 90 | 20 |
| 29 | FEMALE | 32 | 151 | 65 | 28.51 | 1.54 | 1.637 | 0.972 | 62 | 74.15 | 67.846 | 130 | 44.2 | 88.6 | 5.7 | 2.2 | 4.18 | 80.7 | 19.3 | 90 | 60 | 80 | 58 | 1.43 | 120 | 80 | 10 |
| 30 | FEMALE | 34 | 154 | 63 | 26.58 | 1.47 | 1.71 | 0.798 | 75 | 66.03 | 47.94 | 59 | 28.4 | 84.2 | 6.1 | 4.2 | 2.33 | 78.1 | 22.3 | 100 | 60 | 100 | 60 | 1.553 | 130 | 80 | 10 |

# study group

| S.NO | SEX | AGE | HEIGHT | WEIGHT | BMI | RATIO DEEP BREAT | VALSALVA RATIO | MEAN RR | MEAN HR | SDNN | RMSSD | NN50 | pNN50 | VLF | LF | HF | LF/HF | Lf n.u. | Hf n.u. | BASAL BP SBP | BASAL BP DBP | NG IMMEDIATE SBP | STANDING IMMEDIATE DBP | 30:15 RATIO | ISOMERTIC SBP | ISOMETRIC DBP | RAISE IN DBP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | MALE | 24 | 167 | 64 | 23.02 | 1.239 | 1.158 | 0.65 | 92 | 57.234 | 39.77 | 72 | 26.7 | 94.1 | 8.3 | 1.4 | 3.143 | 74.6 | 23.7 | 130 | 70 | 140 | 90 | 1.613 | 120 | 90 | 20 |
| 2 | MALE | 22 | 168 | 72 | 25.53 | 1.452 | 1.259 | 0.834 | 72 | 55.632 | 38.886 | 62 | 18 | 90.9 | 10.8 | 1.1 | 3.381 | 78 | 23.1 | 110 | 70 | 90 | 60 | 1.335 | 110 | 80 | 20 |
| 3 | MALE | 24 | 179 | 79 | 24.68 | 1.388 | 1.67 | 0.713 | 84 | 52.985 | 35.083 | 56 | 16.6 | 93.6 | 9.9 | 1.5 | 3.267 | 76.6 | 23.4 | 120 | 70 | 110 | 70 | 1.435 | 130 | 90 | 10 |
| 4 | MALE | 24 | 164 | 52 | 19.4 | 1.507 | 1.38 | 0.858 | 70 | 145.22 | 50.621 | 7 | 41.2 | 91.9 | 4.1 | 2 | 3.05 | 75.3 | 24.7 | 110 | 70 | 100 | 80 | 1.282 | 140 | 100 | 30 |
| 5 | MALE | 23 | 165 | 68 | 24.97 | 1.414 | 1.398 | 0.863 | 83 | 40.428 | 31.19 | 50 | 12.3 | 93.1 | 22.5 | 1.8 | 3.777 | 77.2 | 23.2 | 120 | 70 | 110 | 70 | 1.318 | 130 | 100 | 20 |
| 6 | FEMALE | 22 | 151 | 42 | 18.42 | 1.09 | 1.538 | 0.795 | 75 | 34.832 | 37.844 | 72 | 19.9 | 92 | 6.7 | 1.9 | 3.211 | 76.3 | 23.8 | 100 | 70 | 80 | 60 | 1.369 | 100 | 90 | 30 |
| 7 | FEMALE | 23 | 145 | 41 | 19.5 | 1.438 | 1.509 | 0.702 | 85 | 58.589 | 40.506 | 95 | 25.9 | 95.1 | 9.1 | 1.7 | 1.882 | 65.3 | 34.7 | 110 | 70 | 104 | 70 | 1.609 | 120 | 90 | 30 |
| 8 | FEMALE | 21 | 158 | 48 | 19.27 | 1.242 | 1.559 | 0.707 | 85 | 43.841 | 33.669 | 55 | 14.9 | 92.5 | 10.7 | 1.9 | 2.947 | 74.7 | 25.3 | 110 | 70 | 100 | 68 | 1.698 | 120 | 90 | 30 |
| 9 | FEMALE | 23 | 182 | 81 | 24.45 | 1.43 | 1.245 | 0.768 | 78 | 33.542 | 33.154 | 59 | 15.2 | 92.1 | 10.8 | 1.3 | 5.077 | 83.5 | 16.5 | 116 | 80 | 100 | 70 | 1.3 | 130 | 100 | 30 |
| 10 | FEMALE | 22 | 153 | 46 | 19.65 | 1.253 | 1.7 | 0.793 | 76 | 43.105 | 51.212 | 124 | 36.8 | 88.7 | 8.5 | 3.2 | 2.5 | 70.8 | 28.3 | 120 | 80 | 110 | 70 | 1.562 | 130 | 80 | 10 |
| 11 | MALE | 29 | 171 | 68 | 23.25 | 1.569 | 0.974 | 0.536 | 112 | 34.745 | 23.982 | 1 | 3.1 | 85.6 | 30.2 | 3.3 | 3.364 | 77.1 | 22.9 | 120 | 70 | 110 | 70 | 1.32 | 140 | 90 | 10 |
| 12 | MALE | 26 | 165 | 72 | 26.44 | 1.205 | 1.218 | 0.655 | 92 | 23.014 | 12.456 | 1 | 2 | 89.5 | 29.2 | 2.5 | 3.2 | 76.2 | 23.8 | 100 | 80 | 90 | 70 | 1.344 | 130 | 100 | 20 |
| 13 | MALE | 27 | 164 | 68 | 25.37 | 1.262 | 1.478 | 0.954 | 63 | 70.264 | 40.025 | 73 | 23.5 | 90.8 | 6.3 | 1.6 | 4.688 | 81.5 | 17.4 | 120 | 80 | 110 | 78 | 1.405 | 140 | 90 | 10 |
| 14 | MALE | 30 | 156 | 50 | 20.57 | 1.503 | 1.435 | 0.864 | 69 | 46.733 | 27.085 | 21 | 6.3 | 91.1 | 7.4 | 1.7 | 4.235 | 80.9 | 19.1 | 120 | 90 | 110 | 80 | 1.449 | 130 | 100 | 20 |
| 15 | MALE | 27 | 166 | 69 | 25.1 | 1.352 | 1.577 | 0.87 | 69 | 27.899 | 23.35 | 6 | 1.8 | 92.3 | 6.5 | 1.4 | 4.93 | 83.2 | 16.1 | 110 | 70 | 108 | 80 | 1.476 | 140 | 90 | 20 |
| 16 | FEMALE | 26 | 158 | 45 | 18.02 | 1.482 | 1.446 | 0.725 | 83 | 64.765 | 33.706 | 66 | 17 | 88.7 | 10.2 | 2.9 | 2.931 | 75.2 | 25.7 | 100 | 60 | 90 | 60 | 1.455 | 120 | 70 | 10 |
| 17 | FEMALE | 26 | 163 | 70 | 26.35 | 1.264 | 1.433 | 0.882 | 68 | 41.505 | 39.996 | 77 | 23.3 | 75.1 | 6.3 | 5.6 | 3.446 | 77.5 | 22.5 | 100 | 70 | 90 | 60 | 1.231 | 120 | 80 | 10 |
| 18 | FEMALE | 26 | 147 | 47 | 21.75 | 1.289 | 1.344 | 0.773 | 78 | 55.604 | 44.95 | 118 | 32.5 | 88.5 | 8.8 | 3.4 | 2.832 | 70.4 | 29.6 | 110 | 80 | 100 | 80 | 1.38 | 130 | 100 | 40 |
| 19 | FEMALE | 26 | 154 | 53 | 22.36 | 1.461 | 1.941 | 0.846 | 71 | 71.167 | 56.985 | 112 | 44.8 | 87.7 | 4.4 | 2 | 5.15 | 83.7 | 15.3 | 110 | 70 | 100 | 60 | 1.598 | 110 | 80 | 20 |
| 20 | FEMALE | 28 | 159 | 50 | 19.77 | 1.663 | 1.727 | 0.886 | 68 | 68.302 | 65.161 | 175 | 54.3 | 86.7 | 5.3 | 4.9 | 1.714 | 63.2 | 36.8 | 100 | 70 | 98 | 70 | 1.425 | 130 | 90 | 20 |
| 21 | MALE | 33 | 159 | 51 | 20.17 | 1.312 | 1.521 | 0.777 | 77 | 33.506 | 23.908 | 10 | 2.6 | 86.3 | 12 | 1.7 | 7.059 | 87.6 | 12.4 | 120 | 78 | 100 | 80 | 1.259 | 160 | 120 | 40 |
| 22 | MALE | 33 | 156 | 58 | 23.86 | 1.321 | 1.558 | 0.892 | 67 | 90.119 | 40.724 | 58 | 21.6 | 90.3 | 5.4 | 1.8 | 4.389 | 81.4 | 18.6 | 110 | 80 | 100 | 78 | 1.522 | 150 | 110 | 30 |
| 23 | MALE | 34 | 154 | 53 | 22.36 | 1.218 | 1.338 | 0.828 | 72 | 69.904 | 34.036 | 55 | 15.4 | 93.7 | 7.9 | 1.5 | 3.2 | 76.2 | 23.8 | 120 | 70 | 100 | 70 | 1.368 | 160 | 110 | 30 |
| 24 | MALE | 35 | 155 | 61 | 25.41 | 1.297 | 1.326 | 0.95 | 63 | 41.013 | 25.53 | 15 | 4.5 | 92.8 | 6.9 | 1.7 | 3.235 | 76.4 | 23.6 | 115 | 80 | 110 | 80 | 1.357 | 140 | 110 | 30 |
| 25 | MALE | 35 | 176 | 83 | 26.86 | 1.245 | 1.436 | 0.846 | 81 | 77.4 | 52.342 | 9 | 33.3 | 88.7 | 4.4 | 2.1 | 4.381 | 81.4 | 18.6 | 120 | 80 | 110 | 78 | 1.402 | 130 | 100 | 20 |
| 26 | FEMALE | 34 | 153 | 54 | 23.07 | 1.191 | 1.632 | 0.85 | 71 | 67.564 | 35.021 | 53 | 15.4 | 78.7 | 6.1 | 6.5 | 2.62 | 69 | 30.5 | 100 | 70 | 80 | 60 | 1.281 | 110 | 90 | 20 |
| 27 | FEMALE | 33 | 156 | 52 | 21.39 | 1.397 | 1.494 | 0.672 | 89 | 24.987 | 19.685 | 13 | 3 | 88.6 | 22 | 3 | 2.767 | 72.8 | 26.3 | 90 | 50 | 80 | 50 | 1.29 | 110 | 80 | 20 |
| 28 | FEMALE | 31 | 148 | 40 | 18.26 | 1.16 | 1.48 | 0.708 | 85 | 34.838 | 18.216 | 2 | 5 | 89.5 | 12.9 | 2.7 | 2.852 | 73.3 | 25.7 | 110 | 70 | 100 | 70 | 1.425 | 120 | 90 | 10 |
| 29 | FEMALE | 32 | 159 | 54 | 21.36 | 1.156 | 1.287 | 0.766 | 78 | 23.753 | 18.714 | 4 | 1 | 92.8 | 9.2 | 2.3 | 2.478 | 71.3 | 28.8 | 100 | 70 | 100 | 80 | 1.688 | 100 | 80 | 20 |
| 30 | FEMALE | 31 | 149 | 47 | 21.17 | 1.82 | 1.527 | 0.737 | 83 | 25.832 | 20.131 | 7 | 4 | 92.2 | 9.8 | 1.8 | 3.389 | 78.2 | 23.1 | 110 | 70 | 100 | 70 | 1.367 | 100 | 80 | 20 |