Role of Nadishodhana Pranayama in Uchchhwasa karma of Udana Vayu

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Submitted by
Vd. Mrs. Manasi R. Nimbalkar
M.D. (Sharir Kriya)

Under the Guidance
Prof. Dr. Mrs. Sanjyot D. Ambawale
M.D. Ph.D. (Sharir Kriya)

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DECLARATION

I hereby declare that the thesis entitled "**Role of Nadishodhana Pranayam in Uchchhwasa karma of Udana Vayu**" completed and written by me has not previously formed the basis for the award of any degree or other similar title or any other university or examining body.

Place - Pune

Date – 05/06/2017

Vd. Mrs. Manasi R. Nimbalkar

M.D. (Sharir Kriya)

CERTIFICATE

This is to certify that the thesis entitled "**Role of Nadishodhana Pranayam in Uchchhwasa karma of Udana Vayu**" which is being submitted herewith for the award of the Degree of Vidyavachaspati (Ph. D.) in Ayurveda of Tilak Maharashtra Vidyapeeth, Pune is the result of original research work completed by Vd. Mrs.Manasi R. Nimbalkar under my supervision and guidance. To the best of my knowledge and belief the work incorporated in this thesis has not formed the basis for the award of any degree or similar title of this or any other University or examining body.

Place - Pune

Date – 05/06/2017

Prof. Dr.Mrs. Sanjyot D. Ambawale
M.D. Ph.D. (Sharir Kriya)

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ROLE OF NADISHODHANAPRANAYAMA IN UCCHWASA KARMA OF UDANA VAYU

I. INTRODUCTION

About 1 to 3 billion urban residents worldwide are exposed to air pollution level above permissible limits. In many developing countries air quality has deteriorated because of extremely toxic smoke, produced by increasing industrial activity, increasing power generation and constantly increasing motor vehicles using adulterated fuel.

The health effects of air pollution are both immediate and delayed. The immediate effects are observed mostly on the respiratory system, the resulting state being acute bronchitis, most of the times. The delayed effects most commonly linked with air pollution are chronic bronchitis, lung cancer, bronchial asthma, emphysema and respiratory allergies.

Precise estimate of the risk of air pollution to health is difficult to quantify because of problems in estimating the degree of exposure of individuals and the influence of probable confounding variables such as smoking, nutrition, occupation and climate. Air pollution damages the human respiratory and cardiovascular system in various ways[i].

Pollution control is out of scope for common man. To avoid exposure to pollutants in day to day life is rather unavoidable. Due to changing lifestyle, most of us have to face daily air pollution. Due to this, many toxic gases & harmful particles enter directly in respiratory system, inevitably. They accumulate there day by day & start causing health hazards.

The ill effects of pollution might be minimised if the lungs effectively expel out these unwanted, harmful foreign things.

For achieving this purpose, there should be good exhalation during respiration procedure. Can there be some procedure for daily practice to maintain the overall health of respiratory system, so that the pollutants entering the respiratory system can be effectively expelled out, so that they will be unable to harm?

Ayurved mentions exhalation as ucchwasprakriya[ii]. If it is improved then the consequent hazards can be avoided or minimised.

For this purpose, we need to understand basic physiology of respiration from Ayurvedic perspective first.
In basic Ayurvedic texts, popularly called as Brihattrayi, very few references are quoted regarding Shwasanprakriya (Respiration process). According to that Ucchwasa i.e. exhaling the air is the karma of UdanaVayu[iii] and Nishhwasa i.e. inhaling the air is the karma of PranaVayu[iv].
In other words, good exhalation can take place if bala of the UdanaVayu is good, which carries out Ucchwas karma.
So, can there be some simple exercises which can offer strength to the UdanaVayu, so as to carry out more effective Uchchhwasa, is the idea behind this study.
In addition to this issue, in today's era, there are many professions which are related to excessive talking such as, singing, acting, anchoring, debate shows, consulting, counselling, teaching, BPOs, etc. These professionals have to talk a lot, continuously & for longer durations. In such conditions, there is overuse of speech.

As per Ayurveda, Atibhashana (loud speech and overuse of speech) is termed as Sahas karma[v] (Exertive work). In Charaksidhisthan, Atibhashan is termed as Mahadoshakar (responsible for many illnesses) and Charak has enlisted the diseases those can occur due to loud speaking[vi].

In CharaksamhitaNidansthan,Atibhashya is mentioned as one of the principle causes of Shoshavyadhi[vii] (cachexia).

While going through all this references one thing is clear that if all this occupations are continued for long time then it may create some hazardous effects on the body of that person.

According to Ayurvedic texts, Vakpravrutti again is a function of UdanaVayu[viii]. It can be considered as modification of Uchchhwasa. So keeping these things in the mind, the Uchchhwasakarma of UdanaVayu must be improved as much as possible. To achieve this goal, some simple exercises can be done regularly which may be beneficial to increase the strength of UdanaVayu.

While going through traditional texts, some simple remedies were found, like OmkaraPranayama, BhramariPranayama, BhasrikaPranayama, Surya namaskara etc., which are simple, easy, economical and also less time consuming.

NadishodhanaPranayama is one such exercise.

This exercise is related to the vital organs like Nabhi (Navel) and Urasthan (Chest/lungs), which are sanchar (movement) and avashiti (reservoir) sthan (location) of UdanaVayu respectively[ix].

Assuming Pranayama exercise may prove beneficial to increase the strength of UdanaVayu, so it was chosen for this study for daily practice.

For this research work, healthy volunteers needed for this research are easily available. Time required for doing this Pranayama activity is very less that is hardly of 15-20 mins daily. Instrument required for evaluation of results, viz. Sphygmomanometer, Measuring Tape, Peak flow meter, Matchbox etc are easily available. The tests performed with these instruments before and after completion of Pranayama activity for assessment of bala of UdanaVayu are non invasive, less time consuming and easy to do for volunteers.
Thus this research topic is feasible.

As mentioned earlier, the problem of pollution is increasing day by day. So there is need of some remedy, which can offer some protection to general population, by improving the quality of uchhwas karma which will help in expulsion of toxic harmful pollutants. Also the hazardous effects due to excessive talking can be minimised by improving the strength of UdanaVayu. No such study has been done before, regarding UdanaVayu in this aspect. And also peakflowmeter has been used first time as a parameter to assess the function of Udanvayu. So in future it can be used in opd's regularly to know the status of Udanvayu in patients.
So this study is innovative as well as interesting.

If NadishodhanaPranayama is found to be beneficial to enhance the bala of Ucchwas karma of UdanaVayu, thenthis remedy can be applied on large scale starting from the school, colleges and different institutes to avoid the hazards of pollution. It will be also beneficial for the professionals like singers, actors, radio jockey, and teachers etc., to prevent the harmful side effects of overuse of speech, which is the

unavoidable part of their profession, which will be very much beneficial to our society.

Thus, the study is novel.

This experiment has been done on healthy volunteers with their prior consent, as no drugs have been used in this research, no surgical procedures done and also the respiratory tests involved in this research are non invasive& uncomplicated.

Thus, research is ethical.

Pollution in India is exponentially increasing & most of times pollution control is out of the reach of a common man, the diseases related to respiratory system are getting very common in all age groups. It is a growing health issue in front of us to fight with these diseases. It is not always possible to avoid the air pollution. Most of the times, we have to simply face it & bear it. So developing our inner strength to fight with it is the real need of time. For this purpose, some simple remedies which are practically easy to perform, economical and beneficial to all classes of the society irrespective of age, gender, socio economical condition, season, place etc. NadishodhanaPranayama seems probable answer to above problem. As name suggests it is a traditional shuddhiprakriya. As Ayurved and Yoga shastra are shashwat and chirantan (immortal), it is a time tested and very beneficial procedure.

Thus, the study is relevant.

Thus the research work was aimed at assessing & documenting the efficacy of NadishodhanaPranayama in improving Uchchhwasakarma (force of expiration).

II. CONCEPT NOTE

According to Ayurvedic Texts, five types of Vatadosha are elaborated[x]. UdanaVayu is second amongst them. Avasthitisthan (Seat) of UdanaVayu is Urasthan (chest) whereas; Kantha, Nasika and Nabhi (Pharynx, Nose & Navel) are its sancharsthan[xi] (work areas). According to Dalhanacharya[xii], Ucchwas (exhalation) is one of the important karmas of UdanaVayu.

उदानोनाम यस्तूर्ध्वमुपैति पवनोत्तमः ।।१४।।

तेन भाषितगीतादिविशेषोऽभिप्रवर्तते ।।

उर्ध्वजत्रुगतान रोगान्करोति च विशेषतः ।।१५।। सु.नि.१

डल्हण टीका - उपैतिगच्छति । स्थानं पुनः अनुक्तमप्यस्य नाभ्युरः कण्ठादि । भाषितगीतादिरिति आदिशब्दात् उच्छवासादि ।

NadishodhanaPranayama exercise involves almost all the respiratory organs like chest, diaphragm right upto the umbilicus while doing deerghaucchwas and deerghanishwas.

The main purpose of the NadishodhanaPranayama is to purify the principle channels of energy (Nadis) within the body. It is believed that because of our irregular schedules of meals, sleep, stress and other disrupting factors like pollution, the nadis are filled with impurities or the toxic substances (mala) and are therefore blocked. GherandSamhita advocates that one should perform the alternate nostril breathing before the main Pranayama as it will cleanse these nadis[xiii].

Thus, Urashan and Nabhisthan are common areas for UdanaVayu and NadishodhanaPranayama exercise. By doing the said exercise, one can gain strength to the organs which are the site of UdanaVayu and also the channels get purified. All the participating organs of respiration like diaphragm, respiratory muscles, accessory respiratory muscles, lungs will also get good exercise & due to this their force of ucchwas will increase. **So exercise of NadishodhanaPranayama will definitely have the positive effect on bala (force) of ucchwas which is the karma of UdanaVayu is the concept behind this study.** As Vatadosha is karmanumeyi, it can be assessed by examining its function. Ucchwas karma is one of the important functions of UdanaVayu. This karma is assessed quantitatively by four simple tests[xiv]:

1. Chest expansion test
2. 40 mmHg test,
3. Snider's test and
4. Peak flow metry,

To be examined, before and after Pranayama exercise.
The results will show the effect of NadishodhanaPranayama on Uchchhwasakarma of UdanaVayu.

If it works positively, then due to improvement in Uchchhwasakarma of Udana, it can be beneficial for the general population to protect themselves from toxic pollutants and also for minimising the hazardous effects of loud talking.

1. The characteristics/variables to be studied –

In this study, Ucchwasabala will depend upon NadishodhanaPranayama. So, Parameters to measure Ucchwasabala of UdanaVayu are dependent variables. i.e. Chest expansion, 40 mm of Hg test, Snider test &Peakflowmetry are dependent variables. Also, parameters which may be affected by Pranayama, like Pulse rate, Systolic Blood Pressure & Diastolic Blood Pressure are also dependent variables. Other variables like Age, Gender, Rutu, Prakriti,Vyayama-shakti, Pulse rate, Systolic blood pressure and Diastolic blood pressure are independent variables.

2. Time response relationship-

The NadishodhanaPranayama will be practised for 10 weeks, and results will be assessed before & after the exercise schedule.

3. Dose response relationship

10 avartanas of NadishodhanaPranayama will be practised daily.

III. HYPOTHESIS

10 avartanas of NadishodhanaPranayama daily for 10 weeks shows improvement inbala (strength) of Uchchhwasakarma of UdanaVayu which is measurable by four lung function tests viz. Chest expansion, 40 mm of Hg Test, Snider's Test and Peakflowmetry.

IV. RESEARCH QUESTION

Whether the practice of 10 awartanas of NadishodhanaPranayama daily for 10weeks can show effect on Ucchwas karma of UdanaVayu?

[i]Parks Text of Preventive and Social Medicine-16th edition M/S Banarsidas,Bhanotunnn,Publishers, 1167,Prem nagar,Jabalpur-Nov 2000

[ii]AshtangHrudayaSootrasthanamHemadri commentary

[iii]SushrutaSamhitaNidanasthana 1/15, Choukhamba Sanskrit Sansthana, Varanasi, YadavjiTrikamjiAcharya, Reprint 2013, Page 260.

[iv]AshtangHrudayaSootrasthanam11/1, JaikrushnaAyurvedGranthamala 52, ChoukhambaOrientalia, Varanasi, ISBN-81-6637-017-7, Page 182

[v]Charakanidansthanam 6/4, Kashi Sanskrit series 228, Choukhamba Sanskrit Sansthan, Varanasi, YadavjiTrikamjiAcharya, Reprint 1984, Page 219

[vi]Charakasiddhisthanam 12/10,11, Kashi Sanskrit series 228, Choukhamba Sanskrit Sansthan, Varanasi, YadavjiTrikamjiAcharya, Reprint 1984 ,Page 730

[vii]Charakanidansthanam 6/4, Kashi Sanskrit series 228, Choukhamba Sanskrit Sansthan, Varanasi, YadavjiTrikamjiAcharya, Reprint 1984, Page 219

[viii]AshtangHrudayaSootrasthanam12/6, JaikrushnaAyurvedGranthamala 52, ChoukhambaOrientalia, Varanasi, ISBN-81-6637-017-7, Page 193

[ix]AshtangHrudayaSootrasthanam12/5, JaikrushnaAyurvedGranthamala 52, ChoukhambaOrientalia, Varanasi, ISBN-81-6637-017-7, Page 193

[x]Charakasootrasthanam 12/8, Kashi Sanskrit series 228, Choukhamba Sanskrit Sansthan, Varanasi, YadavjiTrikamjiAcharya, Reprint 1984, Page 79

[xi]AshtangHrudayaSootrasthanam12/5, JaikrushnaAyurvedGranthamala 52, ChoukhambaOrientalia, Varanasi, ISBN-81-6637-017-7, Page 193

[xii]SushrutaSamhitaNidanasthana 1/15, Choukhamba Sanskrit Sansthana, Varanasi, YadavjiTrikamjiAcharya, Reprint 2013, Page 26

[xiii](Gh.S.V:38-42,53)

[xiv] Text book of practical physiology, C L Ghai, 8th Edition, Jaypee Bros. Medical publishers, New Delhi, Page 158

AIM AND OBJECTIVES:

Aim:

1. To evaluate the role of Nadishodhana Pranayama in the Ucchwas karma of Udana Vayu.

Objectives:

1. To study the effect of Nadishodhana Pranayama in persons of different age group.
2. To study the effect of Nadishodhana Pranayama in persons of both the genders.
3. To study the effect of Nadishodhana Pranayama in different Rutus.
4. To study the effect of Nadishodhana Pranayama in different DoshPrakrities.
5. To study the effect of Nadishodhana Pranayama in persons of different Vyayamashakti.
6. To evaluate the role of Nadishodhana Pranayama on other vital functions like Pulse rate.
7. To evaluate the role of Nadishodhana Pranayama on other vital functions like Systolic BP.
8. To evaluate the role of Nadishodhana Pranayama on other vital functions like Diastolic BP.

REVIEW OF LITERATURE

Ayurved perspective:

1. **Doshas, Dhatus and Malas** are basic constituents of living body[i]. Vata, Pitta and Kapha are the three Doshas which carry out all the functions of the body[ii]. These are direct physical descendents/replica of universal PanchaMahabhootaas[iii]. All principal qualities in the body are acquired from Mahabhootaa[iv]. Prithvi, Aap, Tej, Vayu and Aakash are those five elements, called as PanchaMahabhootaa[v]

दोष धातुमलमूलं हि शरीरम् । सु.सू. १५/३

दूषणस्वभावात् दोषा इति । अ.सं.सू. २०/३

वायुपित्तकफश्चोक्तः शारीरो दोषसंग्रहः । च.सू. ५६

पित्तं पंगु कफः पंगु पंगवो मलधातवः ।
वायुना यत्र नीयन्ते तत्र गच्छन्ति मेघवत् ।। शा. पू. ५/४३

एवमयं लोकसम्मितः पुरूषः । यावन्तो हि लोके मूर्तिमन्तो भावविशेषास्तावन्तः पुरूषे, यावन्तः पुरूषे तावन्तो लोके इति; बुधास्त्वेवं द्रष्टुमिच्छन्ति ।।

विसर्गोदानविक्षेपैः सोमसूर्यानिला यथा ।
धारयन्ति जगद्दोहं कफपित्तानिलास्तथा ।। सु.सू.२१/८
महाभूतानि खं वायुरग्निरापः क्षितिस्तथा ।
शब्दः स्पर्शश्च रूपं च रसो गन्धश्च तद्गुणाः ।। च.शा.१/२७

When this PanchaMahabhootaas are in samyavastha, all the functions of universe goes smoothly but vititation of any one of these leads to severe destruction. Likewise Doshas in the body when are in normal condition execute many functions and swasthya of the body is retained but when they get vititated vyadhis are produced in the body[vi].

विकारो धातुवैषम्यं साम्यं प्रकृतिरुच्यते ।
सुखसंज्ञकमारोग्यं विकारो दुःखमेव च ।। च.सू. ९-४

So a group of bodily entities, which rules body metabolism and which estalishes homeostasis in the body is collectively called as Dosha. These doshas are biological gears of living body and are responsible for manipulating various functions needed for human life. Within physiological limits, they maintain homeostasis in the human

body and when they are out of these limits, they are responsible to generate diseases[vii].

विकृताऽविकृता देहं घ्नन्ति ते वर्तयन्ति च ।। अ.हृ.सू. १/७

2. Vata Dosha:

Amongst three doshas, Vata is the most important[viii]. From PanchaMahabhootaas, perspective, Vata dosha is a combination of Aakash and Vayu. Akash provides free space for movement and Vayu supplies energy needed for it .Wihout Vata dosha, no movement is possible in the body. Since Prithvi Mahabhoota is extremely less in amount in structure of Vata dosha, it is called as Amurta & Karmanumeya[ix].

वाय्वाकाशधातुभ्यां वायुः । अ.सं.सू. २१-१

अव्यक्तो व्यक्तकर्मा च रुक्षः शीतो लघुः खरः ।

तिर्यग्गो द्विगुणश्चैव रजोबहुल एव च ।। सु.नि. १-७

The physical properties like colour, odour cannot be perceived about Vata. It is not seen, smelt or tasted. It can be only be realised by its function[x].

Both the words Vata and Vayu come from one root verb, 'वा'.Meaning of" gati" is movement and "gandhan"is enthusiasm needed to start any work[xi].

तत्र 'वा' गतिगन्धनयोरिति धातु । सु.सू.२१-५

2.a. Site of Vata dosha:

Pakwashaya (Rectum), Kati Pradesh (waist), Sakthi (Thighs), Shrotra (Ear), Asthi dhatu (bones), Sparhanendriya (Skin) are seats of Vata Dosha. Amongst these, Pakwashaya is the main controlling centre of Vata dosha[xii].

पक्वाशयकटीसक्थिश्रोत्रास्थिस्पर्शनेन्द्रियम् ।

स्थानं वातस्य तत्रापि पक्वाधानं विशेषतः ।। वा.सू. १२-१

2.b. Gunas of Vata dosha[xiii]

रूक्ष लघुशीतदारूणखरविशदाः षडिमे वातगुणा भवन्ति । च.सू.१२-४

तत्र रूक्षो लघुः शीतः खरः सूक्ष्मश्चलोऽनिलः।अ.हृ.सू. १/११

1. Ruksha (Dryness):

The property which absorbs moisture is "Ruksha"[xiv].Agni and Vayu Mahabhootaas are dominant in the ruksha dravyas.

शोषणे रुक्षः । अ.हृ.सू. १/१८ हेमाद्री टीका

रुक्षस्तद्विपरीतः स्याद्विशेषात् स्तम्भनः खरः ।। सु.सू. ४६/५१६

Principle action of Ruksha guna:

a. It is anti-snigdha. So this property of Vata Dosha balances the unctuousness of Kapha Dosha in the body.

b. It is hygroscopic.

c. It nourishes Vata and is anti-Kapha in action.

2. Laghu (Lightness):

The property which creates lightness in the substance is called Laghu[xv].

लंघने लघुः। अ.हृ.सू.१/१८ हेमाद्रि टिका

These dravyas have Aakash, Agni and Vayu mahabhoota dominance.

Principle action of Laghu guna:

a. It is anti guru in action. So it balances heaviness of Kapha Dosha.

b. In excess intake it emaciates tissues and impoverises body.

c. Due to this property of lightness, Vata Dosha is able to move faster.

3. Sheeta (Coldness):

The property which offers resistance to the movement of the substance, due to contraction of channels by coldness, is called Sheeta[xvi].

स्तम्भने हिमः। अ.हृ.सू.१/१८ हेमाद्रि टिका

These dravyas have Aap mahabhoota aadhikya.

Principle action of Sheeta guna:

a. Little increase in this property restricts body movements.

b. It eradicates swoon, thirst, sweat, and burning sensation.

c. This property balances Ushna guna of Pitta

4. Khara (Roughness):

The property of scrubbing is called Khara[xvii].

लेखने खरः। अः हृ.सू. १/१८ हेमाद्रि टिका

These dravyas have dominance of Prithvi, Agni and Vayu mahabhoota.

Principle action of Khara guna:

a. It has catabolic action on tissues.

b. This property helps Vata dosha to scrub unwanted substances from the body

5. Sukshma (Minute):

The property due to which substance is very minute in nature is called Sukshma[xviii].

सूक्ष्मस्तु सौक्ष्म्यात् सूक्ष्मेषु स्त्रोतःस्वनुसरः स्मृतः ।। सु.सू. ४६/५२४

विवरणे सूक्ष्मः, संवरणे स्थूलः । अ.हृ.सू. १/१८ हेमाद्री टीका

These dravyas have dominance of Vayu, Aakash and Tej mahabhoota.

Due to this, Vata Dosha reaches microcavities in body constituents.

6. Chala (Motile):

The property of initiating any work is called Chala[xix].

प्रेरणे चलः । अ.हृ.सू. १/१८ हेमाद्री टीका

This property helps Vata dosha to initiate and controls all sorts of movement in the body.

7. Vishada (Cleasening):

The cleansing property is called as Vishada[xx].

विशदो विपरीतोऽस्मात् क्लेदावूषणरोपणः ।। सु.सू.४६/५१७).

क्षालने विशदः। अ.हृ.सू. १/१८ हेमाद्री टीका

Due to this cleaning property, all waste particles are flown away due to continous movements of this Dosha.

2.c. Functions of Vata dosha:

All kinds of body movements are due to Vata Dosha[xxi].

It is responsible for maintaining all mechanical movements of body including reflex actions, moves based on electrical signals like cardiac cycle, moves based on pressure gradient like diffusion of gases, moves based on filtration like formation of urine etc.

It induces all kinds of movements. Willing or Unwilling attention is duty of Vata. Vata induces all organs of sense and reciprocation. Vata perceives sensory signals conveyed through all sense organs. To prepare architecthure is duty of Vata. It is responsible for synthesis of body entities. It induces speech. Touch sensation and hearing is carried out by Vata. Expression of happiness and expression of wish and will to work is due to Vata. It helps to keep Agni in the body alive.

Absorption of moisture is duty of Vata. It is responsible for excretion of excreta. It penetrates through broad and minute spaces in the body. It is responsible for embryological differentiation in intrauterine life.

As long as Vata Dosha is working and remains in physiological condition, life of individual continues[xxii].

उत्साहोच्छ्वासनिःश्वास चेष्टा वेगप्रवर्तनैः ।

सम्यग्गत्या च धातूनां अक्षाणां पाटवेन च । वा.सू. ११-१

वायुस्तन्त्रयन्त्रधरः । प्रवर्तकश्चेष्टानामुच्चावचानाम् । नियन्ता प्रणेता च मनसः । सर्वेन्द्रियाणामुद्योजकः । सर्वेन्द्रियार्थानामभिवोढा ।सर्वशरीरधातुव्युहकरः । सन्धानकरः शरीरस्य । प्रवर्तको वाचः । प्रकृतिः स्पर्शशब्दयोः । श्रोत्रस्पर्शनयोर्मूलं । हर्षोत्साहयोर्योनिः । समीरणोऽग्नेः । दोषसंशोषणः । क्षेप्ता बहिर्मलानां । स्थुलाणुस्रोतसां भेत्ता । कर्ता गर्भाकृतीनाम् । आयुषोऽनुवृत्तिप्रत्ययभूतो भवत्यकुपितः । च.सू. १२-८

The karma of each dosha is described in all compendia. Yet depending upon the sites, qualities, proportion of panchabhoutic composition and ability to produce disease, five types of each dosha are described. Sushrutacharya, says that different names of five types of Vata dosha indicates different actions and functional output so different diseases as well[xxiii].

यथाग्निः पग्चधा भिन्नो नामस्थानात्मकर्मनि ।

भिन्नोनिलस्तथा हयेको नामस्थानक्रियामयैः ।। सु.नि.१-११

Ashtang hridaya commentator agrees with Sushrut samhita to classify all three doshas into five catagories depending upon their specific locations and differentiated functions.

According to this, there are five types of Vata Dosha, viz. Prana, Vyana, Udana, Samana, and Apana.

Udana Vayu is principle topic of discussion.

3. Udana Vayu:

Nabhi, Ura sthan and Kantha are its main location of working[xxiv].

उदानस्य पुनः स्थानं नाभ्युरः कण्ठ एव च । च.चि. २८

Obvious direction of Udana Vayu is upwards[xxv], i.e. it is chiefly concerned with the functions showing upward direction.

उदानो नाम यस्तूर्ध्वमुपैति पवनोत्तमः ।।१४।। सु.नि.१-१४

वाक्प्रवृत्तिः प्रयत्नौर्जाबलवर्णादि कर्म च ।।७।। च.चि. २८-७

तेन भाषितगीतादिविशेषोऽभिप्रवर्तते ।।

उर्ध्वजत्रुगतान् रोगान् करोति च विशेषतः ।।१५।। सु.नि.१-१५

डल्हण टीका - उपैति गच्छति। स्थानं पुनः अनुक्तमप्यस्य नाभ्युरः कण्ठादि। भाषितगीतादिरिति उच्छवासादि।

3.a. Location of Udana Vayu:

Urasthan is its avasthiti sthan (basic seat) and Kantha, Nasika and Nabhi are its sanchar sthan[xxvi] (functional movements).

उदान उरसि अवस्थितः कंठनासिकानाभिचरः। अ.सं.सू. २०

उरः स्थानमुदानस्य नासानाभिगलांश्चरेत् ।।५।। वा.सू. १२-५

हेमाद्री - उदानस्य प्रधानमुरः स्थानम् नासादींश्च चरति ।

अरूणदत्तः- उदानस्य उरः अवस्थितिस्थानम्। नासादि विचरणस्थानम्। प्रयत्नः उत्साहः।उर्जा प्राणनम्।

Phuphusa (lungs) are its main location[xxvii].

उदानवायोराधारः फुप्फुसः प्रोच्यते बुधैः । शाङर्गधर

3.b. Functions of Udana Vayu:

वाक्प्रवृत्तिप्रयत्नोर्जाबलवर्णस्मृतिक्रियः । वा.सू. १२-६

तेन भाषितगीतादिविशेषोऽभिप्रवर्तते ।।

उर्ध्वजत्रुगतान् रोगान् करोति च विशेषतः ।।१५।। सु.नि.१-१५

वाक्प्रवृत्तिप्रयत्नोर्जाबलवर्णस्रोतः प्रीणनधीधृतिमनोबोधनादिक्रियः । अ.सं.सू. २०

3.b.1. Vakpravritti (Speech) – The act of speech is called Vakpravritti.[xxviii]

१) भाषते इति तात्वादिस्थानव्यापारनिष्पादिताकारादिवर्णव्यक्तियुक्तं शब्दं करोति । सु.नि.१/१७-२६०

२) उर्ध्वजत्रुगतानिति नयनवदनघ्राणश्रवणशिरःसंश्रयान । सु.नि.१-१५

As per Panini philosophy[xxix], Vakpravrutti means speaking alphabates of various languages. Sound is produced when Vayu flows through covered spaces. For example while making melodious sound through flute we have to blow it. When air flows through it, sound is produced. Like this, while speaking also, Vayu have to pass through some covered spaces like sound box. For this, there is upward lift of Nabhistha Vata dosha. It hits the voice box with specific power. After that it comes upwards and hits, teeth and palate and creates shabda.According to pitch of speech and tone of voice, Udana Vayu uses its power differently.

आत्मा बुध्द्या समेत्सर्थान् मनोवक्ते विवक्षया ।

मनः कायाग्निमाहन्ति स प्रेरयति मारुतम् ।।

मारुतस्तूरसि चरन् मन्दं जनयति स्वरम् ।

सोदीर्णो मूध्न्यभिहतो वक्त्रमापद्य मारूतः ।।

वर्णाञ्जनयते, तेषां विभागः पञ्चधा शृणुः ।

अष्टौ स्थानानि वर्णानाम् उरः कण्ठशिरस्तथा ।।

जिव्हामूलं दन्ताश्च नासिकोष्ठौच तालु च । पाणिनीय शिक्षा ६/१३

In Vatakshay, less talking is one of the important symptoms[xxx]

लिगं क्षीणेऽनिलेऽङ्गस्य सादो**ऽल्पं भाषिते** Sहितम् ।

संज्ञामोहस्तथा श्लेष्मवृध्दयुक्तामयसम्भवः ।। अ.हृ.सू. ११/१५-१८५

On the contrary, in Vatavriddhi, Pralap (Excessive & irrelevant talking), is one of the important symptoms[xxxi].

वृध्दस्तु कुरुतेऽनिलः ।

कार्श्यकार्ष्ण्योष्णकामत्वकम्पाऽनाहशकृद्ग्रहान् ।

बलनिद्रेन्द्रियभ्रंश**प्रलाप**भ्रमदीनताः ।। अ.हृ.सू. ११/५-६

It means when Udana function is increased, person speaks a lot irrespective of subject.

3.b.2. Prayatna (Effortful tendency) –

Energy required for working is due to Udana Vayu. Udana Vayu inspires for work which the mind has decided to do. Consistancy in any work is maintained by the prayatna karma of Udana Vayu[xxxii].

प्रयतनं प्रयत्नः, उर्जः उत्साहः प्रयत्नादिकर्मत्वेन, प्रयत्नोर्जाबलवर्णनिष्पादनमुच्यते। च.चि.२८/७ चक्र - ६१६

प्रयत्नः कार्यसमारम्भेषूत्साहः ।। डल्हण

प्रयत्नः प्रेरणाविशेषः कार्यास्थाप्रवृत्तिर्वा । मनसाकल्पितं

कार्यंकर्तुं उदानवायुः प्रेरयति । प्रयत्नः उत्साह । अरूणदत्त अ.हृ.सू. १२/५

3.b.3. Utsah/ Urja (Enthusiasm) –

It is basically related to mana .Udana Vayu provides refreshment to mind to work the body with its full strength[xxxiii].

उर्जा प्रीणनम् । अ.हृ.सू.१२/५ हेमाद्रि

उच्छवासः श्वासनिर्गमः । अ.हृ.सू.११/१ हेमाद्रि

3.b.4. Bala- Udana Vayu is one of the factors which provides bala to the body[xxxiv].

विशेषाज्जीवितं प्राण उदानो बलमुच्यते

स्यात्तयोः पीडनात् हानिरायुषश्य बलस्य च ।।।५६।। अ.हृ.नि १६

टीका -उदानाख्यो वायुर्विशेषेण बलमुच्यते ।

Bala of Udana Vayu is related to lifting of things that is Udvahan[xxxv]. Heavy physical work or exercises are mostly dependant on Udana Vayu.

उदानः क्षवधूदगारच्छर्दिनिद्राविधारणैः ।

गुरुभारातिरूदितहास्यार्द्यैर्विकृतो गदान् ।।२१।।

कण्ठरोधमनोभ्रंशच्छर्द्यरोचकपीनसान् ।

कुर्याच्य गलगण्डादींस्तांस्तान् जत्रुर्ध्वसंश्रयान् ।।२२।। वा.नि.१६-२२

According to modern science also, heavy physical work depends on the vital capacity of lungs[xxxvi]. To do heavy exercise, immediate removal of carbon dioxide and excess supply of oxygen is needed.Besides this; more energy supply to muscles of respiration is required. As main seat of Udana Vayu is urasthan which includes Hridaya (Heart) and Phuphusani (Lungs), Udana Vayu is the main factor for producing bala during Udvahan (Lifting weights), Bhashan (speech).

3.b.5. Smruti (Memory):

To reproduce the knowledge which has been experienced previously is called Smruti[xxxvii]. It depends upon the status of Udana Vayu[xxxviii].

दृष्टश्रुतानुभूतानां स्मरणात् स्मृतिरूच्यते । च.शा.१/१४९

3.b.6. Ucchwas (Exhalation): In Shwasan kriya, act of exhaling is Ucchwas.

उच्छवासः उर्ध्वश्वसनं श्वासमुक्तिः ।अ.ह्र.सू.११/१ अरूणदत्त

उच्छवासः श्वासनिर्गमः। अ.ह्र.सू.११/१ हेमाद्रि

उपैति गच्छति। स्थानं पुनः अनुक्तमप्यस्य नाभ्यूरःकण्ठादि भाषितगीतादिरिति आदिशब्दात्

उच्छवासादिविशेषाः।। डल्हण- सु.नि.१-१५

As stated earlier, the physiologically, Udana Vayu is directed upwords. In samyak Shwasan prakriya, Uccwas and Niccwas are two stages. Due to upward direction Ucchwas is worked out by Udana Vayu while Nicchwas by Prana Vayu[xxxix]. It is the one of the major functions depicted by Aacharya Dalhan, the commentator of Sushrut samhita.

3.b.7. Geet (Singing): Besides Vakpravritti and Ucchwas, Geet that is singing is also the function related to Udana Vayu[xl].

तेन भाषित**गीता**दिविशेषोऽभिप्रवर्तते ।।

उर्ध्वजत्रुगतान् रोगान् करोति च विशेषतः ।।१५।। सु.नि.१

3.b.8. Varna (Skin complexion): Varna that is body complexion is dependant on the status of Udana Vayu[xli].

वर्णस्तु त्वग्गतो रूपविशेषः।वर्णस्तु सर्व शरीरवर्ती ।। अ.ह्र.सू.१२/५ हेमाद्रि

3.c. Hetus responsible for vitiation of Udana Vayu-

Udana Vayu is vitiated by[xlii]

1. Controlling the urges like Kshawathu, Udgar, Chhardi, and Nidra.

2. Lifting heavy weights.

3. Uncontrolled crying.

4. Excessive laughing.

उदानः क्षवधूदगारच्छर्दिनिद्राविधारणैः ।

गुरुभारातिरूदितहास्यार्द्यैर्विकृतो गदान् ।।२१।।

कण्ठरोधमनोभ्रंशच्छर्द्यरोचकपीनसान् ।

कुर्याच्य गलगण्डादींस्तांस्तान् जत्रुर्ध्वसंश्रयान् ।।२२।। वा.सू. १६-२२

3.d. Importance of Udana Vayu:

Udana Vayu is amongst the one of the factors which are responsible for creating the "bala" in the body. So in Ashang Hridaya, Udana Vayu is called as Bala and if there is any harm to Udana Vayu then it causes loss of bala[xliii].

विशेषाज्जीवितं प्राण उदानो बलमुच्यते ।।५६।। वा.नि १६

स्यात्तयोः पीडनाऽदृनिरायुषश्य बलस्य च ।

टीका - उदानाख्यो वायुर्विशेषेण बलमुच्यते ।

यतश्चैवमतस्तयोः - प्राणोदानयोः,पीडनात् – क्षोभणात् , यथास्वमायुषो बलस्य च हानिर्भवेत ।

तथा च वक्ष्यति (ह्.चि.अ. २२/६९) – "प्राणो रक्ष्यश्चतुर्भ्योऽपि तत्स्थितौ देहसंस्थितिः।" इति

3.e. Overuse or abuse of Udana Vayu:

If the Udana Vayu is overused or abused, then it may create many grave symptoms[xliv]

तत्र

उच्चैर्भाष्यातिभापाभ्यांशिरस्तापशंखकर्णनिस्तोदश्रोत्रोपरोधमुखतालुकण्ठशोषतैमिर्यपिपासाज्वरतमहनुग्रहमन्यास्तम्भ

निष्ठीवनोरः पार्श्वशुलस्वरभेद हिक्काश्वासादयः स्युः (१)

एतां प्रकृतिमप्राप्तःसर्ववर्ज्यानि वर्जयेत् ।

महादोष कराण्यष्टाविमानि तु विशेषतः ।।१०।।

उच्चैर्भाष्यंरथक्षोभमविचडक्रमणासने ।

अजीर्णाहितभोज्ये च दिवास्वप्नं समैथुनम् ।।११।। च.सि.१२-१०,११

तत्र साहसं शोषस्यायतनमिति यदुक्तं तदनुव्याख्यास्यामः - यदा.....जल्पति वाऽप्यतिमात्रम्, अतिमात्रं वा भारमुद्वहति.....तस्यातिमात्रेण कर्मणोरः क्षण्यते । च.नि. ६-४

If there is loud speech or speech for a long time, then it causes headache, pricking pain in Shankh pradesh, pain in ear, disability in hearing, dryness in mouth, palate, larynx, blackness in front of eyes, thirst, fever.....chest pain, axillary pain, laryngitis, hiccough and asthma etc.

Loud speech which is related to Udana Vayu, is stated as "Maha doshakar" (leading to major illnesses).

According to Aacharya Charak, if a person talks a lot for a long period or lifts heavy weight then it may causes trauma to the chest region[xlv].

4. **Prakriti:** .

Prakriti is an expression of one's own constitution[xlvi]. It is one's own constitution, which is individual specific, means it is controlled by its own physiology. It is enumeration of body features, internal as well as external. Understanding Prakriti is is best guideline for healthy life.

प्रकृतिस्तु स्वभावः । च.वि.८/९५ चक्रपाणिटीका

प्रकृतिः शरीरस्वरूपम् । अ.ह्र.सू. १/१० अरुणदत्त

स्वभावमिति प्रत्यात्मनियतरुपम् । च १-१४७ चक्रपाणिटीका

Even though so many meanings of Prakriti are enumerated, Ayurveda principally refers to Prakriti of a human, as Dosha Prakriti or Deha Prakriti[xlvii].

दोषानुशयिता ह्येषां देहप्रकृतिरूच्यते । च.सू.७/४०

Anushay means close connection or attachment. The qualities of Doshas are expressed on body. This is called as DehaPrakriti. These expressions are by way of structure or morphology or by way of function or physiology or by way of mental reactions or psychology. Thus Prakriti in Ayurveda is expression of a person in context to morphology, physiology and psychology.

प्रत्येकदोषप्रकृतिग्रहणेनैव द्वंव्दप्रकृतिरपि ग्राह्यः । च.सू.७/४० चक्रपाणिटीका

Even though one dosha dominance is mentioned in the verse of samhita, two dosha predominance needs to be considered for practical application[xlviii].

4.a. Definition of Prakriti

In development of foetus, due to its own reason Dosha become intensified.This non-pathogenic intensified status of Dosha remains constant from birth till death and this is Prakriti[xlix].

प्रकृतिः नाम जन्ममरणान्तरकालभाविनी, गर्भावक्रांतिसमये स्वकारणोद्रेकजनिता निर्विकारिणी दोषस्थितीः । रसवैशेषिक सू. १/६

Predominance of one, two or all three Dosha, in various proportions, affects foetus. Exhibition of such predominance is Dosha Prakriti of that individual[l].

एतानि हि येन येन दोषेणऽधिकेनैकेनाऽकेन ता समनुबध्यते,

तेन तेन दोषेण गर्भोनुबध्यते, ततः सा सा दोषप्रकृतिरूच्यते । च.वि.८/९५

4.b. Types of DehaPrakriti:

Seven types of Prakriti are observed in people. Three types with predominance of single Dosha; three types with predominance of two dosha and one type with predominance of all three dosha[li].

सप्त प्रकृतयो भवन्ति । दोषैः पृथक व्दिशः समस्तैश्च ।।६१।।

समपित्तानिलकफाः केचिद्गर्भादि मानवाः ।

दृश्यन्ते वातलाः केचित्पित्तलाः श्लेष्मलास्तथ ।।३९।।

तेषामनातुराः पूर्वे वातलाद्याः सदातुराः ।

दोषानुशयिता ह्येषां देहप्रकृतिरूच्यते ।।४०।। च.सू. ७/३९-४०

People are born with various proportions of Doshas. Their body constitution is refered accordingly. Those born with equal proportions of three Doshas i.e. proportion of Vata, Pitta and Kapha equal to each other are समपित्तानिलकफाः (balanced constitution). These individuals are generally healthy people and remain healthy. Few others show predominance of one or two Doshas. Those exhibiting predominance of Kapha, Pitta, and Vata are Ekadoshaja Prakriti (UniDosha constitution) and those showing any two dosha dominance are called as Dwi doshaja Prakriti (Bidoshaj constitution).

Single Dosha dominated and mixed categary usually exhibit some sort of health problem. They need to observe regime for everyday and every season regularly.Failing to do so begins acculation of dominant Dosha.

4.c. Formation of Prakriti:

Prakriti is organised in accordance to attributes of predominant dosha at the time of fertilisation[lii].

शुक्रशोणितसंयोगे यो भवेद् दोष उत्कटः ।

प्रकृतिर्जायते तेन तस्या मे लक्षणं श्रृणु ।।६२।। च.वि.८/९५

4.d. Prakriti Nirmankar Bhava (Governing factors for formation of constitution):

Factors affecting the predominance are[liii]

1. Beeja (Sperm, ovum)

2. Kshetra (Status of uterus)

3. Vaya (Age of a woman)

4. Rutu (Season of conception)

5. Garbha-Poshana (Nutrition fetus receives in intrauterine life)

6. Garbhini Cheshta (Behaviour of mother during pregnancy)

शुक्रासृग्गर्भिणीभोज्यचेष्टा गर्भाशयर्तुषु ।

यः स्याद् दोषोऽधिकस्तेन प्रकृतिः सप्तधोदिता । अ.ह्र.शा. ३/८२

शुक्रशोणितप्रकृतिं कालगर्भाशयप्रकृतिं मातुराहारविहारप्रकृतिं महाभूतविकारप्रकृतिं च गर्भशरीरमपेक्षते। च.वि.८/९५

Prakriti or physical characteristic features of Prakriti of fetus is determind by following factors -

1. Sperm and Ovum

2. Season and condition of uterus

3. Food and regimes of mother

4. Role of Mahabhootaa comprising fetus

प्रकोपो वाऽन्यथाभावः क्षयो वा नोपजायते ।

प्रकृतीनां स्वभावेन जायते तु गतायुषः ।।७७।। सु.शा.३९

Prakriti is not output of day to day working Doshas, which undergo constant variations, but it is determined by Doshas, which make basic constitution, and it is permanent.

4.e. Types of Prakriti:

Prakriti is initially of two types

1. Doshaja (due to predominance of Dosha mainly physical)

2. Gunaja (due to reflection of psychological effects).

दोषप्रकृतिः गुणप्रकृतिश्चेति द्विविधा पुरूषाणां प्रकृतिः ।

तत्र दोषप्रकृतिः वातादि दोषकृता गुणप्रकृतिश्च सत्वादि गुणकृता ।

सप्तदोषप्रकृतयः सप्त च गुणप्रकृतयः भवन्ति । नागार्जुन

Both are again divided into various categories.

4.e.1. Doshaj Prakriti[liv] is grouped under following heads -

Doshaj Prakriti

1. Vataja
2. Pittaja
3. Kaphaja
4. Combination of Vataja and Pittaja
5. Combination of Pittaja and Kaphaja
6. Combination of Kaphaja and Vataja
7. Combination of Vataja, Pittaja and Kaphaja.

समपित्तानिलकफाः केचिद् गर्भादि मानवाः ।

दृश्यन्ते वातलाः केचित्पित्तलाः श्लेष्मलास्तथा ।।

तेषामनातुराः पूर्वे वातलाद्याः सदातुराः । च.सू.७/३९-४०

तैश्च तिस्त्रः प्रकृतयो हीनमध्योत्तमा पृथक् ।

समधातुः समस्तास्तु श्रेष्ठा निन्द्या व्दिदोषजाः । अ.हृ.सू. १/१०

4.e.2 Gunaja Prakriti (Charak Sharirsthan 4-36)

According to Charakacharya, during time of conception, the dominance of Satva, Raja, or Tama guna decides the Gunaj Prakriti.

1. Satvaja
2. Rajas
3. Tamas

4.e.3. Bhautik Prakriti

Sushrutacharya (Sushrut Sharirsthan 4 -80) considers Vata, Pitta and Kapha Prakriti do include Vayu Mahabhootaa, Tej Mahabhootaa and Prithvi Mahabhootaa Prakriti.

4.e.4. Jatyadi Prakriti

Charakacharya referred to extrauterine factors influencing Prakriti.These factors are read as habits inherited due to those symptoms, such as characteristics due to Jati are cleanliness etc.[lv]

In this type influence of factors like Jati or caste, Kula or family trends, Desha or habitat, Kala or time, Vaya or age, Bala or power and Pratyatmaniyatatva is

observed. One or more of these factors are observed to be so strong that inspite of other type of Prakriti, Jatyadi type strongly exhibit their characteristics.

तत्र प्रकृतिर्जातिप्रसक्ता च, कुलप्रसक्ता च, देशानुपातिनी च, कालानुपातिनी च, वयोऽनुपातिनी च प्रत्यात्मनियता चेति । जातिकुलदेशकालवयप्रत्यात्मनियता हि तेषां तेषां पुरुषाणां ते ते भावविशेषा भवन्ति ।। च.इं. १/५

Even though, one dosha predominance is mentioned in samhita, two dosha predominance should be considered for practical convenience. Commentator suggests existence of such combinations.

प्रत्येकदोषप्रकृतिग्रहणेनैव द्वंद्वप्रकृतिरपि ग्राह्यः । चक्रपाणिटीका

The characteristics of Prakriti are divided into three groups viz. Vata Prakriti, Pitta Prakriti And Kapha Prakriti.

- **Vata Prakriti**[lvi]

Sharir Rachana

1. Due to Rukha guna, Person is slim, having small frame of body.
2. Due to Bahu guna, person has very superficially seen blood vessels, muscle tendons and muscular outlines.
3. Due to Parusha guna, person has rough hair, body hair, beard, mustaches, nails, skin of face and mouth, skin of hands and feet.
4. Due to Vishada guna, person has cracked skin.

Sharir Kriya

1. Due to Rukha guna.the voice of person may be diffused or weak or shattered, or defective or feeble or obstructed, or dull.
2. Due to Laghu guna, person is quick in general movements, eats and speaks fast.
3. Due to Chala guna,person is never steady.His one or more of the following organs are in habit of remaining unsteady.His joints, bones, eyelashes, chin, lips, tongue, head, shoulders, legs and feet are observed unsteady.
4. Due to bahu guna person speaks too much and speaks irrelevant.
5. Due to Sheeta guna person is intolerant to cold.He gets frozen joints or such problems in cool environment.
6. Due to Vishada guna, person has crackling joints.

Due to all these properties of Vata dosha, person of VataPrakriti is physically weak, has less children, lives short span of life, gets fewer facilities for living and are crooked minded.

वातस्तु रूक्षलघुचलबहुशीघ्रशीतपरूषविशदः । तस्य रौक्ष्याव्दातला रुक्षापचितात्पशरीराः प्रततरूक्षक्षामसन्नसक्तकजर्जरस्वरा जागरूकाश्च भवन्ति, लघुत्वाल्लघुचपलगतिचेष्टाहारव्याहाराः, चलत्वादनवस्थितसन्ध्यक्षिभ्रूहन्वोष्ठजिहवाशिरःस्कन्धपाणिपादाः, बहुत्वाव्दहुप्रलापकण्डरासिराप्रतानाः, शीघ्रत्वाच्छ्रीघ्रसमारम्भक्षोभविकाराः शीघ्रत्रासविरागाः श्रुतग्राहिणोऽल्पस्मृतयश्च, शैत्याच्छीतासहिष्णवः प्रततशीतकोव्देपकस्तम्भाः, पारुष्यात् परुषकेशश्मश्रुरोमनखदशनवदनपाणिपादाः, वैशद्यात् स्फुटितांगावयवाः सततसन्धिशब्दगामिनश्च भवन्ति; त एवं गुणयोगाव्दातलाः प्रायेणाल्पबलाश्चाल्पा-युषश्चाल्पापत्याश्चाल्पसाधनाश्चाल्पधनाश्च भवन्ति ।। च.वि. ८/९८

- **Pitta Prakriti**[lvii]

1.Ushna-.Due to Ushna guna,persons have intolerance to hot things, having hot face,tender and clear body of portwine mark,freckles,blackmoles,having excessive hunger and thirst,quick advent of wrinkles,graying of hair and baldness,presence of some soft and brown hair on the face,head and other parts of the body,

2.Tikshna(Sharp)- Due to Sharp guna, sharp demonstration of physical strength, strong digestive power, intake of food and water in large quantity , inability to face difficult situations and glutton habits.

3. Drava-(Liquor)- Due to Drava guna, person having looseness and softness of joints and muscles, voiding of sweat, urine and feces in large quantity.

4. Visra-(Fleshy smel)l-Due to visra guna, putrid smell of axilla, mouth head and body in excess.

5. Amla and Katu-(Pungent and Sour)-Due to these guna, insufficiency of semen, sexual desire.

पित्तमुष्णं तीक्ष्णं द्रवं विस्त्रमम्लं कटुकं च । तस्यौष्ण्यात् पित्तला भवन्त्युष्णासहा,उष्णमुखाः, सुकुमारावदातगात्राः, प्रभूतविप्लव्यंगतिलपिडकाः, क्षुत्पिपासावन्तः, क्षिप्रवलीपलितखालित्यदोषाः, प्रायो मृव्दल्पकपिलश्मश्रुलोमकेशाश्च; तैक्ष्ण्यात्तीक्ष्णपराक्रमाः, तीक्ष्णाग्नयः, प्रभूताशनपानाः, क्लेशासहिष्णवो, दन्दशूकाः, द्रवत्वाच्छिथिलमृदुसन्धिमांसाः, प्रभूतसृष्टस्वेदमूत्रपुरीषाश्चः; त एवंगुणयोगात् पित्तला मध्यबला मध्यायुषो मध्यज्ञानविज्ञानवित्तोपकरणवन्तश्च भवन्ति ।। च.वि. ८/९७

- **Kapha Prakriti**[lviii]

1. Snigdha (Unctuous)-Due to this guna, unctuousness of organs.

2. Shlakshna (Smooth)-Due to this, persons having smoothness of organs.

3. Mrudu (Soft)-Due to this, persons having pleasing appearance, tenderness and clarity of complexion,

4. Madhura (Sweet)- Due to this, persons having increased quantity of semen, desire for sex act and number of procreation.

5. Sthira (Firm)-Due to sthir guna, firmness, compactness and stability of the body.

6. Sara (Dense)- Due to Sara guna, plumpness and roundness of all organs.

7. Manda (Slow)- Due to Manda guna, persons are slow in action, intake of food and movements.

8. Sthira (Stable)-Due to Sthir guna, slowness in initiating action, getting irritated and morbid manifestations.

9. Guru (Heavy)- Due to Guru guna, non slippery and stable gait

10 .Sheeta (Cold)- Due to Sheet guna, lack of intensity in Hunger,thirst,heat and perspiration.

11. Vijjala (Viscous)-Due to Vijjal guna, firmness and compactness in joints.

12. Accha (Clear)-Due to Accha guna, happiness in the look and face, happiness and softness of complexion and voice.

By virtue of the above mentioned qualitites.a Kapha Prakriti person is endowed with the excellence of strength, wealth knowledge, energy peace and longevity.

श्लेष्मा हि स्निग्धश्लक्ष्णमृदुमधुरसारसान्द्रमन्दस्तिमितगुरुशीतविज्जलाच्छः । तस्य स्नेहाच्छ्लेष्मलाः स्निग्धांगाः, श्लक्ष्णत्वाच्छ्लक्ष्णांगाः, मृदुत्वाद्दूष्टिसुखसुकुमारावदातगात्राः, माधुर्यात् प्रभूतशुक्रव्यवायापत्याः, सारत्वात् सारसंहतस्थिरशरीराः, सान्द्रत्वादुपचितपरिपूर्णसर्वांगाः, मन्दत्वान्मन्दचेष्टाहारव्याहाराः, स्तैमित्यादशीघ्रारम्भक्षोभविकाराः, गुरूत्वात् साराधिष्ठितावस्थितगतयः, शैत्यादल्पक्षुत्तृष्णासन्तापस्वेददोषाः, विज्जलत्वात् सुश्लिष्टसारसन्धिबन्धनाः, तथाऽच्छत्वात् प्रसन्नदर्शनाननाः प्रसन्नस्निग्धवर्णस्वराश्च भवन्ति । त एवंगुणयोगाच्छ्लेष्मला बलवन्तो वसुमन्तो विद्यावन्त ओजस्विनः शान्ता आयुष्मन्तश्च भवन्ति ।। च.वि.८/९६

5. Vaya (age):

Vaya is divided into 3 parts viz. Balya, Tarunya and Vardhakya[lix].

In Balyavastha, there is dominance of Kapha dosha, In Tarunyavastha, there is dominance of Pitta dosha and in Vardhakyavastha,Vata dosha is vitiated.

तद्वयो यथास्थूलभेदेन त्रिविधं - बालं, मध्यं, जीर्णमिति। तत्र बालमपरिपक्व
धातुमजातव्यजनं सुकुमारमक्लेशसहमसंपूर्णबलं श्लेष्मधातुप्रायमा षोडशवर्ष,
विवर्धमानधातुगुणं पुनः प्रायेणानवस्थितसत्त्वमात्रिंशद्वर्षमुपदिष्टं,

मध्यं पुनः समत्वागत बलवीर्यपौरूषपराक्रमग्रहणधारणस्मरणवचनविज्ञानसर्वधातुगुणं

बलस्थितमवस्थित सत्त्वमविशीर्यमाण धातुगुणं पित्तधातुप्रायमाषष्टिवर्षमुपदिष्टम, ।

च.वि.८-१२२

According to Charakacharya, Balyavastha is from birth upto thirty years of age. It is again divided into two phases, first phase from birth to sixteen years and second phase from sixteen to thirty years.
Tarunyavastha is from thirty years to sixty years.

Jeernavastha is from is from sixty years upto hundred years.

According to Sushrutacharya, Vaya is divided into three stages, viz. Bala, Madhya and Vriddha.Balyavastha is again classified into Kshirapa, Kshirannada and Annad.Upto age of one year, it is called as Ksirapa, Upto two years, Kshirannada and after that Annada avastha of Vaya.

Madhya vaya is between sixteen to seventy years. It is again divided into Vriddhi that is upto twenty years of age, upto thirty Youvanam, upto forty Sampurnata and upto seventy Parihani. Jeernavastha is above seventy years of age.

6. Kala / Rutu (Season of exercise):
The collection of moments is Kala[lx]. It never stops and proceed continuously. Different rutus are one of the faces of the kala.There are twelve months. By making a rutu of combination of two months, six rutus are formed[lxi].

स सूक्ष्मामपि कलां न लीयत इति कालः, संकलयति कालयति वा भूतानीति कालः ।।३।। सु.सु.६-३

According to dominanace of Shaitya i.e. coldness and Aushnya i.e. hotness, these six rutus are again divided into Dakshinayan and Uttarayana, depending upon the movement of the Sun throughout the year.

Amongst these, Varsha, Sharad and Hemant rutus are included in Dakshinayan. In these three rutus there is dominance of Aap or soumya bhava, so these are stronger and stronger seasons respectively.

Shishir, Vasant and Greeshma represents Uttarayana.The dominance of Usna bhava is present in these season, So these are weaker and weaker season progressively.

तत्र माघादयो व्दादश मासाः, व्दिमासिकमृतुं कृत्वा षङतवो भवन्ति; ते शिशिरवसन्तग्रीष्मवर्षा-

शरध्देमन्ताः; तेषां तपस्तपस्यौ शिशिरः, मधुमाधवौ वसन्तः, शुचिशुकौ ग्रीष्मः, नभोनभस्यौ वर्षाः, इषोर्जौ शरत्, सहःसहस्यौ हेमन्त इति ।।६।। सु.सू.६-६

त एते शीतोष्णवर्षलक्षणाश्चन्द्रादित्ययोः कालविभागकरत्वादयने द्वे भवतो दक्षिणमुत्तरं च । तयोर्दक्षिणं वर्षाशरध्देमन्ताः; तेषु भगवानाप्यायते सोमः, अम्ललवणमधुराश्च रसा बलवन्तो भवन्ति, उत्तरोत्तरं च सर्वप्राणिनां बलमभिवर्घते । उत्तरं च शिशिरवसन्तग्रीष्माः, तेषु भगवानाप्या-यतेऽर्कः, तिक्तकषायकटुकाश्च रसा बलवन्तो भवन्ति,उत्तरोत्तरं च सर्वप्राणिनां बलमपहीयते ।।७।। सु.सू. ६

Thus Rutus are divided into six parts according to dominance of Rasa in that particular month.

इह तु वर्षाशरध्देमन्तवसन्तग्रीष्मप्रावृषः षडृतवो भवन्ति दोषोपचयप्रकोपोपशमनिमित्तं; ते तु भाद्रपदाद्येन द्विमासिकेन व्याख्याताः; तद्यथा-भाद्रपदाश्वयुजौ वर्षाः, कार्तिकमार्गशीर्षौ शरत् । सु.सू. ६-१०

Magha+Falgun= Shishir

Chaitra +Vaishakha=Vasanta

Jeshtha+Aashadha= Grishma

Shravan+Bhadrapada= Varsha

Aashwin+Kartik= Sharad

Margashirsha+Poush=Hemant

All the seasons have direct influence on the dosha status of the body.

Chaya, prakop and Prashama of Vata, Pitta and Kapha takes place in the following manner[lxii]

	VATA	PITTA	KAPHA
VARSHA	PRAKOP	CHAYA	
SHARAD	PRASHAM	PRAKOP	
HEMANT		PRASHAM	
SHISHIR			CHAYA
VASANT			PRAKOP
GRISHMA	CHAYA		PRASHAM

चयप्रकोपप्रशमा वायोर्ग्रीष्मादिषु त्रिषु ।
वर्षादिषु तु पित्तस्य, श्लेष्मणः शिशिरादिषु ।। अ.हृ.सू.१२/२४

So Kala is very important entity which deals with the variations in the status of Dosha .

7. Vyayamshakti (Effort tolerance):

Bala of a person is routinely examined by checking Vyayamashakti (ability to perform exercise).

बलं व्यायामशक्त्या परीक्ष्येत । च.वि.८

Any physical work which gives controlled stress to the body is called Vyayama. E.g. Ashwarohanam, Adhwagamanam, Jalataranam, Mrugaya are few types of ancient vyayamas.

7.a. Benefits of Vyayama:

Vyayama is very important entity which helps in following manner. After doing daily exercise, one can get the following benefits[lxiii]

1. Lightness of the body

2. Ability to work

3. Desire to eat

4. Reduction in excess fat

5. Stoutness of body organs

लाघवं कर्मसामर्थ्य दीप्तोऽग्निर्मेदसः क्षयः ।

विभक्तघनगात्रत्वं व्यायामादुपजायते ।। वा.सू. २-१०

टीका - स शरीरायासजननं कर्म व्यायाम उच्यते ।

आ.र. - आयासमात्रफलं शारीरं कर्म व्यायामः ।

If this exercise is done in proper way, it is very beneficial, but if it is done improperly, then it is called as Sahasa karma which can be very much harmful to the body and can create many diseases.

अयथाबलमारम्भः साहसम् ।

न हि व्यायामादि अतिभजनपर्याप्त्म पुंसां बलमस्ति । च.वि.८

Capacity of human being to do this physical work is called Vyayamshakti[lxiv]. According to power of body to perform work, bala is divided into three catagories that is Uttama bala, Madhyama bala and Alpa bala.

व्यायामशक्तितश्चेति व्यायामशक्तिरपि कर्मशक्त्या परीक्ष्या। कर्मशक्त्या ह्यनुमीयेत बलत्रैविध्यम्।।१२१।।

च.वि.८

टीका- कर्म भारवहनादि, तत्र शक्तिः कर्मशक्तिः ।

This Vyayamshakti is judged by doing any physical work like भारवहनादि, as stated in texts.

It is observed that, thin person can have Uttama bala and Alpa bala can be seen in Obese persons[lxv]. So bala of human being is decided by performing Vyayama and not by their external appearance.So it is important to know ones ability to perform work that is Vyayamshakti.

केचित् कृशाः प्राणवन्तः स्थूलाश्चाल्पबला नराः ।

तस्मात् स्थिरत्वं व्यायामैर्बलं वैद्यः प्रतर्कयेत् ।।३६।।सु.सू.३५

8. Desha:

There are 3 types of Deshas that is geological regions mentioned in Ayurvedic samhita, viz. Jangal Desha, Aanoopa Desha, and Sadharan Desha[lxvi].

1. Jangal Desha – Desha or region which has Vata dosha dominance is Jangal Desha.
2. Aanoopa Desha- Desha or region which has Kapha dosha dominance is Aanoopa desha.
3. Sadharan Desha-Desha or region which has neither Vata dominance nor Pitta dominance is Sadharan Desha.

जांगलं वातभूयिष्ठमनूपं तु कफोल्वणम् ।

साधारणं सममलं त्रिधा भूदेशमादिशेत् ।। अ.हृ.सू. १/२३

देशस्त्वानूपो जाङ्गलः साधारण इति । तत्र,बहूदकनिम्नोन्नतनदीवर्षगहनो मृदुशीतानिलो बहु-

महापर्ततवृक्षो मृदुसुकुमारोपचितशरीरमनुष्य प्रायः कफवातरोगभूयिष्ठश्चानूपः; आकाशसमः

प्रविरलाल्पकण्टकितृक्षप्रायोऽल्पवर्षप्रस्त्रवणोदपानोदकप्राय उष्णदारूणवातः प्रविरलाल्पशैलः स्थिर-

कृशशरीरमनुष्यप्रायो वातपित्तरोगभूयिष्ठश्च जाङ्गलः; उभयदेशलक्षणः साधारण इति ।।४२।। सु.सू.३५

साधारण देश

उभयदेशलक्षणः साधारण इति ।

समाः साधारणे यस्माच्छीतवर्षोष्ममारुताः ।

दोषाणां स मता जन्तोस्तस्मात्साधारणो मतः ।। सु.सू.३५/४२-४३

The study has been conducted in Sadharana Desha.

b. Yoga perspective:

9.a. Pranayama: Historical development of Yoga

Yoga is one of the oldest sciences of the world originated from India, which is very useful for both getting and maintaining the physical, mental and moral health. This yoga was started with the development of civilization. According to one of the classical texts of yoga known as Hathayoga pradipika, Lord Shiva is the first teacher of yoga, where as Bhagavad-Gita tells Lord Krishna is the first teacher of yoga.

Some historical researchers have proved that yoga was present during the time of Vedas. After the period of Vedas, a great sage Maharshi Patanjali systematized yoga, its meaning and its related knowledge through his Patanjala yoga sutras. After the Patanjali, many sages contributed greatly to the field through their practices and literatures.

For the purpose of systematic study of the historical development of yoga, it may be divided in to three periods. They are

1. Pre – Patanjali Period: [Before 500 B.C]
2. Patanjali period: [500 BC to 800 A.C]
3. Post Patanjali Period: [800 A.C onwards]

Pre Patanjali Period:

The historical evidences of yoga were seen up to 4500 B.C. So the time before 4500 B.C. and after 4500 B.C. up to Patanjali period is considered as pre Patanjali period. The main sources which we can get during those times are Vedas, Upanishads, Smriti, Teaching of Buddha, Jainism, Panini, Epics and Puranas.

Vedas: Among the available Vedas four are important, viz. Rigveda, Yajurveda, Samaveda and Atharvaveda. There is no any direct explanation of word yoga in Vedas, whereas the word `dhira`, is mentioned in all Vedas. The meaning of dhira is self-realized. The sitting posture i.e., Asana, the Pranayama, the Mudras, Meditation techniques, the cleanliness Yama and Niyama, the Dharanas are explained in Vedas. The asanas explained in Vedas are mainly for the purpose of meditation. The sun salutation was the part of routine activity during that time. The Pranayama that is told in the Yajurveda, which is practiced during the regular practice, is same as Anuloma Viloma. The various types of meditation techniques are also explained in

the Vedas. The practice of mudras is also explained in the Vedas. The Vedas also explain about the Tapas, Vratas and the ultimate aim of them are to attain Moksa (liberation).

Upanishads: Upanishads are the essences of the Vedas. Among the available Upanishads, 10 are important. The important Upanishads that have explanations about yoga are as follows. The Panchakosha theory is explained in Taittariya Upanishad is the main theory used in the treatment of diseases through yoga. Kathopanishad explains procedure to attain Samadhi. This Upanishad explains the qualities of soul. The Kenopanishad, the Ishavasya Upanishad, Shwetasvatara Upanishads are also gives details about yoga.

Smriti: The Smritis are the texts, which deal about the disciplines that one has to follow in his life. The main smritis, which give details about yoga, are Manusmriti, Yajnavalkya Smriti, and Harita Smriti. According to the smritis there are four stages in life, they are

1) Brahmacarya
2) Grihastha
3) Vanaprastha
4) Sanyasa

The Smritis also give details about the lifestyles that we have to follow during these different stages of life. According to smritis one has to sit in a seat that is prepared from Darbha (one type of grass) for meditation. The asanas good for meditation are also explained in smritis.

Jainism: In Jainism also yoga is explained. According to Jainism the movement of the mind and body towards the soul is called yoga.

Teachings of Buddha: According to Buddha, body is a fit vehicle to get the tranquility of mind. For getting the steadiness of mind the body should become steady at first. The methods of meditation are also explained in teachings of Buddha. According to that there are two types of meditations, Suksma dhyana and Nirhara dhyana.

Panini: He was a famous grammarian of Sanskrit. He wrote 8 chapters lessons of grammar, Astadhyayi. The usage of word yoga is there in his work.

The Epics: The Ramayana and Mahabharata are the two main epics that give the details about yoga. Ramayana consists of 24,000 shlokas distributed among seven chapters. The great book of yoga known asYoga Vasistha was written in this time. In

Ramayana the moral disciplines, Yama and Niyama are explained in detail. We can see the definition for Dharma in this book.

Mahabharata is another important epic, which gives details about yoga. The Bhagavad-Gita is known as jewel of Mahabharata gives the definition for yoga.

Puranas: Among the available puranas eighteen are important. Out of these few puranas give details about yoga. The Bhagavata purana explains Bhakti yoga. Linga Purana gives the details about Yama, Niyama and Pranayama. Vayu Purana gives details about Pratyahara, Dharana, and Dhyana.

Patanajali Period [500 BC – 800BC]: -

The period between 500 BC and 800 AD is considered as Patanjali's period. Patanjali systematized yoga in the form of sutras. Patanjlai was the author of classics in three important fields. He wrote a treatise on grammar; the Mahabbhasya. He has also written book on Ayurveda. He has the credit of compiling Yoga sutra.

Patanjali's yoga sutra consists of 196 sutras, it is divided into four chapters, and they are,

1. Samadhi pada: This chapter deals with the nature of Samadhi.
2. Sadhana Pada: This chapter deals with the methods for refining the body mind and senses.
3. Vibhuti Pada: In this chapter the properties of Yoga and art of integration through concentration, meditation and absorption. The manifestation of super natural power is discussed.
4. Kaivalya Pada: In this final section, Patanjali draws the attention of the Yogi to the soul. The various types of Samadhi are explained in this chapter.

These Yoga sutras explain every aspects of yoga in systematically.

Post Patanjali Period:

The time after Patanjali up to today is known as post Patanjali Period. The yoga developed gradually after the period of Patanjali. Many classical texts about yoga were written during these periods. The great personalities of yoga and their texts on yoga are as follows.

*Shankaracharya (8th Century): Sri Shankaracharya proposed Advaita Philosophy. He has written Yoga Taravali, which tells about Hatha Yoga and Saundarya lahari that explains Kundalini Yoga. He has also written commentary on Patanjala Yoga Sutras.

* Ramanujacarya (11th Century): He has written the book Tantra Sara that explains

Kundalini yoga. He proposed Vishistadvaita philosophy.

* Bhakti Yoga Period:

Bhakti Yoga was popular during 12th century to 16th century. Narada Bhakti sutra, the famous text on Bhakti became popular at that time.

Surdasa, Tulasidasa, Purandara dasa, Kanaka dasa, Vittala dasa, Merabai were some of the famous Bhakti Yogis. They popularized the Bhakti Yoga through devotional songs. They have also written devotional songs.

* Hatha Yoga period:

The Hatha Yoga period is from 9th century to 18th century. The development was at its peak during the 14th century. Adinatha was the founder of Hatha Yoga.

The various Hatha yogis and the books written by them on Yoga are as follows.

• Matsyendranatha (9th Century) --- Kala jnana nirnaya.

• Goraksanatha (9th Century) --- Goraksa Shataka

• Chauranginatha (11th century) --- Chaurangi Shataka.

• Svatmarama (14th Century) --- Hatha Pradipika

• Gheranda (15th Century) ---- Gheranda Samhita

• Shrinivasa Bhatta (17th Century) --- Hatha Ratnavali.

After the hatha yogis period Yoga was popularized by some great personalities. The famous personalities and their contributions for popularizing Yoga during this period are as below.

• Sadashiva Brahmendra Saraswati: He has written‘Shiva Yoga dipika’, which tells about Yama, Niyama, Asanas, and Adharas of the body.

Ramana Maharshi, Ramakrishna Parama hamsa, Parama hamsa yogananda gave their contributions for Raja Yoga. The great disciple of Ramakrishna Paramahamsa, Swami Vivekananda, has written commentary on Patanjala Yoga Sutras. He was also a great Sadhaka.

Yoga in the present world:

It’s very happy to see that present day ‘Yoga’ has become famous in the whole world. Till 1960, its value was not known to the outer world. After realizing its importance for the healthy peaceful life, Europeans started to follow Yoga, then whole world addicted to yoga. Now one can find every countries lot of yoga centres. Soldiers, children’s, IT professional, farmers, sick peoples, older people etc., like this each and all category, parts of the society following yoga .The Yoga spread all

over the world by the great personalities like Swami shivananda, Swami Rama,Shri Kuvalayananda, Sri Krishnamacharya, Osho Rajanish, Maharshi Mahesh yogi, Yogi Arabindo, Prof Pattabhi Jois, Sri B.K.S Iyyengar, Baba Ramdev, Sri Sri Ravishankar,.etc.Nowadays one can find most places of the world different types of yoga centres, mediation centres. Millions of people got benefited by following yoga. There is no doubt in future, to get a healthy future generation and for the formation of peaceful world

9.b. Pranayama:

In Sushrut sutrasthan, while describing the location of shalya, the refrence of Pranayama is given[lxvii].That is while doing acts, vyayama, adhwagaman, jrumbha, Pranayama etc if their is pain, then the shalya must be their at the site of the pain.

सामान्यलक्षणमपि..... हसन प्राणयामै..... । सु.सु.२६-१३

Dalhanacharya states the definition of Pranayama that[lxviii]

प्राणायामेति प्राणवायोरायमनमवरोधनं प्राणायामः । डल्हण

To control or to obstruct act of respiration is Pranayama.

Pranayama is described In Hathayogapradipika and Patanjal Yoga Darshana.

In HathaYoga Pradipika, it is mentioned that[lxix]

1. When Vata in the body is moving very fast, mind will be very unstable. So it is very necessary to aquire command over Vata.

चले वाते चलं चित्तं निश्चले निश्चलं भवेत् ।

योगी स्थाणुत्वमाप्नोति ततो वायुं निरोधयेत् ।।२।।हठ्योग प्रदीपिका व्दितीय उपदेश

2. Life is present in the body, whenever there is existence of Vata in the body.When there is departure of Vata from the body, the death occurs.So it is necessary to control the Vata in the body[lxx].

यावद्वायुः स्थितो देहे तावज्जीवनमुच्यते ।

मरण तस्यनिष्क्रांतिस्ततो वायुं निरोधयेत् ।।३।।हठ्योग प्रदीपिका व्दितीय उपदेश

3. The nadis or channels in the body are obstructed, Vata can not flow through them fluently.So one must clean all the channels for free flowing of Vata[lxxi].

शुद्धिमेति यदा सर्वं नाडीचक्रं मलाकुलम् ।

तदैव जायते योगी प्राणसंग्रहणे क्षमः ।।५।।हठ्योग प्रदीपिका व्दितीय उपदेश

4. To do the purification of the channels in the body, daily exercise of Pranayama is necessary[lxxii].

प्राणायामं ततः कुर्यान्नित्य सात्त्विकता धिया ।

यथा सुषुम्नानाडीस्था मलाः शुद्धिं प्रयांति च ।।६।।हठ्योग प्रदीपिका व्दितीय उपदेश

5. The procedure of Nadishodhana Pranayama is also given in this text as following[lxxiii].

Take the breathe or Prana first with left nadi that is Ida and release it from right nadi that is Pingala. Then breath is taken from right nadi that is Pingala and release it via left Nadi that is Ida. By doing this for more than three months, Nadishodhana is done.

प्राणं चेदिड्या पिवेन्नियमितं भूयोऽन्यया रेचयेत्पीत्वा।

पिंगलया समीरणमथो बद्ध्वा त्यजेद्वामया ।

सूर्या चन्द्रमसोरनेन विधिनाभ्यासं सदा तन्वतां

शुद्धा नाडिगणा भवन्ति यमिनां मासत्रयादूर्ध्वतः ।।१०।। हठ्योग प्रदीपिका द्वितीय उपदेश

6. Practising the Pranayama daily, all the impurities or Malas get dried.so do the Pranayama regularly[lxxiv].

प्राणायामैरेव सर्वे प्रशुष्यन्ति मला इति ।

आचार्याणां तु केषांचिदन्यत्कर्म न संमतम् ।।३७।। हठ्योग प्रदीपिका द्वितीय उपदेश

6. If Pranayama is done properly, then all the diseases get cured, but if done improperly, then all the diseases occurs in the body[lxxv].

प्राणायामादियुक्तेन सर्वरोगक्षयो भवेत् ।

अयुक्ताभ्यासयोगेन सर्वरोगसमुद्भवः ।।१६।। हठ्योग प्रदीपिका द्वितीय उपदेश

In Patanjal Yogadarshan , Pranayama is mentioned as follows.

तस्मिन्सति श्वासप्रश्वासयोर्गतिविच्छेदः प्राणायामः ।।४९।। पातञ्जल योगदर्शन साधनपाद

After getting mastery in Asanas, Pranayama should be practised.Achamanam that is taking air in (thorax) is called as Shwasa and letting air out that is located in Koshtha (abdomen)is called as Prashwas. The breaking of natural rythem they are maintaining that is absence of Shwas and prashwas both is called as Pranayama[lxxvi].

This Pranayama is divided into three types viz. Bahyavritti, Aabhyantar vritti, and Stambha vritti.

It can also be divided accordingly by Desha, Kala and Samkhya[lxxvii]

स तु बाह्याभ्यन्तरस्तम्भवृत्तिर्देशकालसंख्याभिः

परिदृष्टो दीर्घसूक्ष्मः ।।५०।। पातञ्जल योगदर्शन साधनपाद

Besides the three types that is Puraka, Kumbhak and Rechaka, Kevala Kumbhaka is the fourth type[lxxviii].

When there is absence of Prana gati (motion of Prana) by Prashwasa(exhalation), then it is called as Bahyavritti or Rechaka Pranayama. When there is absence of Prana gati (motion of Prana) by Shwas (Inhalation), then it is Abhyantaar vritti or Purak Pranayama. When there is absence of Prana gati by both types i.e. Bahya and Aabhyantar, then it is called as bahyabhyantarvishay kshepi i.e. Keval kumbhak.

बाह्याभ्यन्तरविषयाक्षेपी चतुर्थः ।।५१।। पातञ्जल योगदर्शन साधनपाद

After doing regular practice of Pranayama, the false knowledge that is covering the Buddhi, gets weaker and weaker and True knowledge increases[lxxix].

ततः क्षीयते प्रकाशावरणम् ।।५२।। पातञ्जल योगदर्शन साधनपाद

The main advantage of Pranayama is it gives stability to the mind and prepared the mind for Dharana[lxxx].

धारणासु च योग्यता मनसः ।।५३।। पातञ्जल योगदर्शन साधनपाद

9.c. Current and contemporary review

Current view on Pranayama-

Pranayama occupies second place in Hatha yoga while it constitutes fourth step of Ashtang yoga. The word Pranayama is formed by two words i.e.Prana and Ayama. Prana means a subtle life force which provides energy to different organs (including mind) and also controls many vital procecess. Ayama signifies the voluntary effort to control and direct this Prana.Breathing is one of the vital activities governed by Prana on a gross level.This is the only Pranaic activity which could be exercised voluntarily.Secondly, this system is linked with the nervous function on one hand and the consciousness on the other.Yoga has taken best advantage of this situation, considering that the mind could be controlled effectively with the voluntary control over breathing which in turn would control materialistic inclination of Chitta[lxxxi] (Mind).

Therefore Pranayama essentially becomes a process by which Prana is controlled by regulating the breathing, voluntarily.So Prana is simply a breathe and Ayama means a control over it. So Pranayama means a voluntary and temporary pause in the movement of breathe[lxxxii].

तस्मिन्सति श्वासप्रश्वासयोर्गतिविच्छेदः प्राणायामः ।।४९।। पातञ्जल योगदर्शन साधनपाद

The pause brought in the movement of inhalation and exhalation is the Pranayama.According to Patanjali, a slightest change brought in the normal speed of breathing (gati viccheda) is Pranayama. So, prolonged inhalations and exhalations done systematically will be a Pranayama. Obviously, to do this, a voluntary control is necessary. In normal breathing also, there is a pause between inhalation and exhalation which may be for few milliseconds only.Therefor voluntary control brought on any one of them that is inhalation ,exhalation or the pause, will be called as Pranayama.

Pranayama essentially consists of a voluntary control on the breathing and probably due to this fact, it is referred to as "Breathing exercise"

Pranayama is never done mechanically. Awareness of breathing is most important while practising Pranayama. Talking, singing are also voluntarily controlled respiratory acts but they can not be compared with Pranayama because they involve some kind of emotions or expressions and they are the acts of communication. Pranayamaic breathing does not produce any emotions nor it expresses any. PRANA means a subtle life force which provides energy to different organs including mind and which also controls many vital life processes. AYAMA signifies the voluntary effort to control and direct this PRANA. Breathing is one of the vital activities governed by PRANA on a gross level. This is the only Pranaic activity available to us which could be exercised voluntarily. Secondly, this Pranaic activity is linked with the nervous function (mental activity) on one hand and the consciousness (chitta) on the other hand. Yoga science has taken best advantage of this situation, considering that the mind could be controlled effectively with the voluntary control over breathing. Therefore the Pranayama essentially becomes a process by which the Prana is controlled effectively by regulating the breathing voluntarily.

PRANA is simply a "breath" and AYAM means a control over it. Just like we have speed breakers on the road to control the flow of traffic, we bring a pause in the breathing .So the Pranayama means a voluntary and temporary pause in the movement of breath[lxxxiii].

तस्मिन्सति श्वासप्रश्वासयोर्गतिविच्छेदः प्राणायामः ।।४९।। पातञ्जल योगदर्शन साधनपाद

The meaning is that the pause brought in the movement of inhalation and exhalation is nothing but Pranayama.

The technique of Pranayama includes specific rules regarding the methods of breathing, in terms of

1. Force of breathing
2. Duration of each phase of breathing
3. Number of rounds of Pranayama
4. Attention on breathing

The following important principals are commonly observed during the practice of almost all types of Pranayama.

1. One has to sit in any suitable meditative asana, keeping the spine in a straight and well balanced condition. Eyes are closed gently so that atleast one major external stimulation is cut off.This helps one to pay attention to the inner happenings.
2. Inhalation for Puraka and exhalation for Rechaka is slow, smooth and without any haste.The flow of air is kept uniform having some force all through out that is in most controlled way.
3. Every Puraka and Rechaka must end quietly. The habit of expanding the chest or contracting the body musculature violently at the end of Puraka and Rechaka respectively is avoided consciously. An attempt of snatching the air at the end of Puraka and forcing out some more air at the end of Rechaka would disturb the next cycle of Pranayama. Therefore Puraka and Rechaka should end pleasantly and smoothly without any strain.
4. Rechaka is always given longer time than Puraka.
5. Incraese in the airway resistance is another peculiarity of Pranayama. Inhaling or exhaling through only right or left nostril at a time as in Anuloma-viloma Pranayama reduces the air passage. Naturally, the volume of air passing in and out will be controlled. The ratio between the volume of air and the volume of blood reaching the lungs will be different as the ventilation is reduced to 50%

Aims of Pranayama:

Any activity which requires a total concentration of our mind will also control our breath which even may be stopped for a while e. g. While threading through needle, our breathing is stopped for a moment. This shows clearly that there is a corelation between our mind and our breath. It is our common experience that when we became angry or emotionally upset, our breathing is changed in its rate, depth and as a whole. The emotions and mental activities are related to the nervous system through it they change our breathing. Pranayama aims at the control on the mind. When the mind is standstill, no thought process or emotional disturbances is possible.

So long as breathing is continued and the Vayu is moving in and out of the body, the mind remains unstable. When the breath is stopped, the activity of the mind is also controlled and it becomes stand still. Thus the yogi attains the complete motionless state of mind.

Different Nadis are also purified with the practice of Pranayama. This is known as Nadishuddhi. Nadi in the yogas are the channels or the passages for the transmission of nerve impulses or the conduction of Prana, for the circulation of the blood or lymph or even the flow of air through them .Thus Pranayama eradicates all types of malas from the body and mind. Mala according to yoga science are that toxic factors which gives rise to imbalance in the body and the mind by obstructing or blocking the normal functions of the nadis.

During Pranayama, the breathing is consciously made even, deep and rhythmic. This will bring about noticeable relaxation, tranquillity, balance, sense of well being to the mind. By judicious practice of Pranayama, one attains sound health, steady and peaceful mind, slim and lustrous body.

Mechanism of Pranayama:

The respiratory system works involuntarily through various reflex mechanisms. The rate and depth is maintained automatically according to the oxygen requirements of the body from moment to moment. When so many changes are brought about in the breathing during Pranayama, the whole mechanism of breathing gets altered. So the physiological changes occur due to the modification in breathing during different phases of the Pranayama.

PURAKA PHASE

Shwas is the natural involuntary process of inspiration, regulated by the respiratory centre in the medulla oblongata. Puraka is the voluntary prolongation of the inspiratory phase .It is well controlled in terms of time, force, ventilation and depth as per the proportion. Inhalation in Puraka is done in a very smooth way by keeping the force uniform. The speed at which the lungs are filled is thus regulated. When we increase the duration and prolong the phase of inhalation, the force is automatically decreased .In Nadishodhana Pranayama, Puraka is done through only right or left nostril at a time. Thus the mechanics of inspiration is modified voluntarily during Puraka.

During the phase of Puraka, the lungs are expanded considerably and the walls of alveoli are stretched maximum. After a particular degree of stretching, the stretch receptors situated in the alveolar walls are stimulated. In the normal breathing, at this stage or even before this, they would have sent inhibitory impulses to the inspiratory centre and the phase of exhalation would have been started in a reflex. But as we continue the phase of inhalation with our strong voluntary control, the normal stretch reflex is inhibited and therefore no exhalation is possible. The chest continues to get expanded under critical control. The stretch receptors are thus trained to withstand more and more stretching. This helps us to hold the breath for a longer time, easily.

As we continue to inhale, the intrapulmonary pressure is also raised. The diaphragm does not move freely as the abdomen is kept slightly inward and controlled. Therefore the alveoli in the upper pulmonary part are filled with air. One uses his inspiratory capacity for prolonged phase of Puraka. This has a beneficial effect on the gaseous exchange which then takes place efficiently throughout the day.

Normally we finish our inhalation in 1.5 to 2 seconds during which the exchange of gases is almost completed. Now although the need of oxygen is very less, we are prolonging our inhalation from 2-5 seconds. Instead of usual 500ml air, we are now breathing in 1 to 1.5 lits of air and the volume of blood reaching the lungs is also more. The exchange of O_2 and CO_2 is very effective.

During Puraka phase which is a concious act, the filling of the lungs is done as per ones limit is well attended. When Puraka is well adjusted and made shorter. Rechaka is also gone through smoothly without any feeling of suffocation or pressure in the chest. Thus Puraka is not merely a mechanical prolongation of inspiration but it is done with full concentration of mind.

RECHAKA PHASE

Rechaka is a voluntarily controlled exhalation as compared to the to the normal exhalation .This control, as in Puraka, is brought in terms of time, force, ventilation and the flow of air.

In order to increase the duration of Rechaka as per the time ratio, the exhalatory force is reduced and the limited air is allowed to escape. For this purpose, exhalation is carried out through the right or left nostril only. Thus the volume of air to be expelled out per unit of time is regulated by creating slight airway resistance. This helps in prolonging the exhalation and to reduce the force of the air going out. In Rechaka, one uses his expiratory reserve volume for exhaling completely before starting next Puraka.

Now the intrapulmonary pressure is slowly reduced and the alveoli are also gradually dilated. By this time when one is exhaling slowly, the percentage of Co_2 is still increasing in the blood and the chemoreceptors in the medulla are trying to inhibit exhalation and to start inhalation by stimulating the inspiratory centre. Similarly the peripheral chemoreceptors are also trying to bring about reflex inspiration as they are sensitive to the lowered of O_2 concentration in the blood. But the both the reflexes are controlled by our strong volition and we continue to breathe out. The purpose seems to acclimatize these receptors to higher CO_2 tensions in the blood. It may denoted that CO_2 has got a calming effect on the nervous system up to certain limits and has been found to reduce anxiety when administered in the form of a mixture containing 65% CO_2 and 35% O_2. This would help mind to undergo the meditational state.

The duration of Rechaka is however so adjusted that there is no feeling of air hunger at any stage .If it is not well adjusted in proportion, the following Puraka is hurried and the whole proportion of the Pranayama cycle is disturbed.

Significance of double time proportion for Rechaka

One is supposed to follow 1:2 ratio for the duration of Puraka and Rechaka .Rechaka is given double time than puraka. Really speaking Puraka is a true measure as other phases depend on it for proportion. Puraka is so adjusted so as to give double proportion to Rechaka.

Significance

1 .Normally the instinct of inhalation is always stronger than that of exhalation. This is due to increase in CO_2 tension in the blood at the end of normal expiration .When we prolong the phase of exhalation ,we tackle this chemoreceptors reflex and discard the urge of inspiration. Prolonged duration of Rechaka facilitates such training of the chemoreceptor to withstand more and more concentration of CO_2 in the blood.

2. It is our common experience that we feel relaxed whenwever we exhale deeply and smoothly. The experiments have shown that various tensions as well as the anxiety are reduce during prolonged exhalations. Prolonged Rechaka would then liberate more pscyco physiological tensions and one would feel calm and quiet. The degree of physiological arousal is responsible for any emotion to occur. Prolonged exhalation gives rise to the parasympathetic tone in the body and reduces the level of excitation and therefore one feels relaxed and peaceful.

3. In order to observe a particular time ratio in each cycle of Pranayama, a total concentration is necessary .When Rechaka is prolonged smoothly, we remain aware of the force, flow of the air and the time thus keeping our mind away from perception of external stimuli thought process for maximum time.

4. Increased duration of Rechaka makes the exhalation most complete .As one is using his expiratory reserve volume, the air containing maximum % of CO_2 is completely squeezed out of the lungs(except dead space volume and residual volume). When we inhale for Puraka of the next cycle of Pranayama, we get maximum quantity of a fresh air equivalent to 75% of our vital capacity. This offers better scope for effective gaseous exchange. If the Rechaka phase is not sufficiently prolonged, some amount of air remains in the alveoli at the end of incomplete exhalation. This volume of air which contains accumulated CO_2 would be mixed with incoming fresh air and the amount of O_2 reaching the alveoli will be less in

every cycle .One may not be able to keep proper ratio of time as he may feel suffocated after a few rounds.

5. We are prolonging Rechaka so we are also maintaining intra-abdominal pressure for such time. This pressure reduces the blood circulation in the lower abdominal region which may be diverted towards the sacral region. Thus prolonging the duration of Rechaka, the sacral nerves are provided with more nutrition which are thus toned up and made stronger.

ANULOMA AND VILOMA PRANAYAMA

This Pranayama is also known as Lom-viloma Pranayama or Nadishodhana Pranayama. The main characteristic of this Pranayama is the alternate breathing through the left and right nostril with or without Kumbhaka.

The human nose is composed of two parallel chambers separated by a thin septum. The inner wall of these chambers is lined with a covering called mucous membrane .The chambers extend into the skull and end just above the posterior part of the hard palate. The inner side of the nasal cavities contain horizontal shelve like turbinate bones which are covered with erectile tissues .This is a spongy and thick tissue which can be filled with large quantities of blood and expanded in size. This engorgement of the erectile tissue, due to vasodilatation, causes congestion and produces resistance to the air flow in that nostril. At the same time ,the blood flow to the the other nostril is reduced due to vasoconstriction of the blood capillaries, the erectile tissue shrinks and thus the air flow resistance is decreased in this nostril. The volume of airflow passing through this nostril is increased. There is rhythmic alteration of degree of congestion of the mucosal membrane of each nostril. If the left nostril is less congested and offer less resistance to the airflow, that means a greater air volume is flowing through the left nostril and this condition is known as “left nostril dominance”.

The nose is innervated by both sympathetic and parasympathetic efferent nerves of ANS. The sympathetic stimulation causes vasoconstriction and thereby decongestion of the nostril which increases airflow through that nostril. At the same time the parasympathetic action results in the increasd blood flow to the erectile tissue in the other nostril and bring about congestion thereby blocking the nostril. Thus rythemic

shift in ANS tone is responsible for alternate nasal nostril dominanace. So the emotional and psychological states are found to affect and disturb these natural rhythmic functions as tensions and emotions are related with the ANS and its centre in the limbic portion in the brain.

Yoga believes that left nostril breathing dissipates more heat from the body or it has a cooling and calming effect on the body.Left nostril is known as Ida nadi or Chandra nadi. Ida nadi represents the constructive anabolic or energy conservation aspect of the Pranaic (autonomic) function .The right nostril is known as Pingala nadi or Surya nadi. It has got heating and activating, strengthening effect on the body. It represents destructive, catabolic or energy consuming aspect of the body. The main purpose of Anuloma Viloma Pranayama is to purify the principle channels of energy within the body. It is believed that because of our irregular schedules of meals, sleep, stress due to pollution, infection and other disrupting forces, the nadis are filled with impurities or the toxic sbstances and are therefore blocked. The flow of Prana may be obstructed. Gherand samhita advocates that one should perform the alternate nostril breathing before the main Pranayama as it will cleanse this nadis (Gh,s,v.38-42,53). HathaYog pradipika (H.P.2:7-10) gives a detailed technique of this Pranayama in order to remove different malas from the body and the mind. When both the nadis work evenly and simultaneously, the third nadi start functioning.This nadi is known as Sushumna nadi. Prana is supposed to travel through this nadi during Pranayama. For this purpose, it is necessary to purify all this nadis with the help of Anulom vilom Pranayama. So that the vital force would flow through them and control over the mind would be established.

The mechanism ofAnulom vilom Pranayama

One sits comfortably in Padmasan or in any suitable medidative asana. The spine is maintained in a balanced and straight position and the abdomen is controlled after moving it slightly inward. After this, one forms a special mudra of the right palm by folding and supporting the index and middle finger together at the bottom of the thumb. The ring finger and the small finger are used for closing the left nostril. The right nostril is closed with the help of the thumb.

One inhales slowly and deeply through the left nostril. The force and flow of the breath is kept uniform till the inhalation is complete. This is Puraka phase. At the

end of Puraka, the left nostril is immediately closed with the help of ring finger and little finger .Since the right nostril is already closed before Puraka, now both the nostrils are closed. Breath is retained according to ones capacity. This is Kumbhaka phase. When there is moderately strong desire to release the breath, one opens the right nostril just by removing the thumb from it and starts exhaling slowly and smoothly through the right nostril. This is Rechaka phase. Now the next Puraka is done through the right nostril. After doing the Kumbhaka as before, the Rechaka is done through the left nostril. This is considered as one round of Nadishodhana Pranayama. Such 3,7,10 or even more rounds are gone through at a stretch. Puraka phase is long and slow (deergha and manda) while Rechaka phase is more prolonged and slower (pradergha and manda) in nature. This helps to maintain a ratio of 1:4:2 for Puraka, Kumbhaka and Rechaka. Breathing is however very smooth and without any frictional sound.

PURAKA-KUMBHAKA_RECHAKA

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RECHAKA_KUMBHAKA_PURAKA

The beginners should however practise only Puraka and Rechaka phases through the left and right nostrils alternately (without Kumbhaka) with the time ratio of 1:2. Even this much voluntary control will slowly train the nervous system associated with breathing mechanism. Kumbhaka phase should be introduced in the form of a pause, and to be expanded gradually over a long practise. Numbers of rounds are to be increased gradually.

Since the breathing is done through only one nostril at a time during Puraka and Rechaka, the minute ventilation is reduced. Another reason for this is the controlled prolongation of both the phases as per the ratio. The amount of air reaching the lung is restricted while the volume of the blood being circulated in the lungs remains unchanged. That is, the ratio between air and blood volume in the lungs is altered. The gaseous exchange, therefore takes place more efficiently. The awareness is directed towards the breathing process which reduces the perception of the disturbing sensory inputs from the external environment. This helps one to become more sensitive to and conscious of the flow of the air in the beginning and later on

the inner happenings. This will also restore the natural, regular rhythm and balance in the nasal cycle phenomenon.

It purifies all the neural functions and therefore it is essentially practised before other Pranayamas.

c. Modern perspective:

10. Respiration[lxxxiv]:

The goal of respiration is to provide oxygen to the tissues and to remove carbon dioxide. To achieve this, respiration can be divided into four major functional events,

1. Pulmonary ventilation which means the inflow and outflow of air between the atmosphere and the lung alveoli.
2. Diffusion of Oxygen and Carbon di oxide between the alveoli and the blood.
3. Transport of Oxygen and Carbon di oxide in the blood and body fluids to and from the cells.
4. Regulation of ventilation and other facets of respiration.

MECHANICS OF PULMONARY VENTILATION

Muscles that cause lung expansion and contraction

The lungs can be expanded and contracted in two ways;

1. By downward and upward movement of the diaphragm to lengthen or shorten the chest cavity
2. By elevation and depression of the ribs to increase and decrease the antero-posterior diameter of the chest cavity.

Normal quiet breathing is accomplished almost entirely by the first of the two methods, that is movement of the diaphragm. During inspiration, contraction of the diaphragm pulls the lower surfaces of the lungs downwards. Then, during expiration, the diaphragm simply relaxes, and the elastic recoil of the lungs, chest wall, and abdominal structures compresses the lungs. During heavy breathing, however, the elastic forces are not powerful enough to cause the necessary rapid expiration, so that extra force is achieved mainly by contraction of the abdominal muscles, which pushes the abdominal content upwards against the bottom of the diaphragm.

The second method for expanding the lungs is to raise the rib cage. This expands the lungs because in the natural resting position, the ribs slant downwards, thus allowing the sternum to fall backwards towards the vertebral column. But when the rib cage is elevated, the ribs study almost directly forward so that the sternum now also moves

forwards, away from the spine, making the antero-posterior thickness of the chest about 20 % greater during maximum inspiration than during expiration. Therefore, all the muscles that elevate the chest cage are classified as muscles of inspiration, and the muscles that depress the chest cage are classified as muscles of expiration. The most important muscles that raise the rib cage are the external intercostals, but others that help are

1. The sternocleidomastoid muscles, which lift upward the sternum

2. The anterior serati, which lift many of the ribs

3. The scalene, which lifts the first two ribs.

The muscles that pull the rib cage downwards during expiration are

1. The abdominal recti, which have the powerful effect of pulling downwards on the lower ribs at the same time that they and the other abdominal muscles compress the abdominal contents upwards towards the diaphragm, and

2. The internal intercostals, shows the mechanism by which the external and internal intercostals act to cause inspiration and expiration. To the left, the ribs during expiration are angled downwards and the external intercostals are elongated forward and downwards. As they contract, they pull the upper ribs forwards in relation to lower ribs , and this cause leverage on the ribs to raise them upwards , thereby causing inspiration. The internal intercostals functions exactly oppositely, functioning as expiratory muscles, because the angle between the ribs in the opposite direction and cause opposite leverage

MOVEMENT OF AIR IN AND OUT OF THE LUNGS- AND THE PRESSURE THAT CAUSES THE MOVEMENT

The lung is an elastic structure that collapses like a balloon and expels all its air through the trachea whenever there is no force to keep it inflated. Also, there are no attachments between the lung and the walls of the chest cage except where it is suspended at the hilum from mediastinum. Instead, the lung litreally floats in the thoracic cavity, surrounded by a thin layer of pleural fluid that lubricates the movements of the lungs within the cavity. Furthermore, continual suction of excess fluid into lymphatic channels maintains a slight suction between the visceral surface

of the lung pleura and parietal pleural surface of the thoracic cavity. Therefore the lungs are held to the thoracic wall as if glued there, except that they can slide freely, well lubricated, as the chest expands and contracts.

PLEURAL PRESSURE AND ITS CHANGES DURING RESPIRATION

Pleural pressure is the pressure of the fluid in the narrow space between the lung pleura and the chest wall pleura. This is normally a slight suction, which means a slightly negative pressure. The normal pleural pressure at the beginning of inspiration is about -5 centimeters of water, which is the amount of suction that is required to hold the lungs open to their resting level. Then, during normal inspiration, the expansion of the chest cage pulls outward on the lungs with still greater force and creates a still more negative pressure to an average of about -7.5 centimeters of the water.

ALVEOLAR PRESSURE

Alveolar pressure is the pressure of the air inside the lung alveoli. When the glottis is open and no air is flowing into or out of the lungs, the pressure in all parts of the respiratory tree, all the way to the alveoli, are equal to atmospheric pressure, which is considered to be the zero reference pressure in the airways – that is ,0 centimeters water pressure. To cause inward flow of air into the alveoli during inspiration, the pressure in the alveoli must fall to a value slightly below atmospheric pressure (below zero).During normal inspiration, alveolar pressure decreases to about -1 centimeter of water. This slight negative pressure is enough to pull 0.5 litre of air into the lungs in the 2 seconds required for normal quiet respiration.

During expiration, opposite changes occur. The alveolar pressure rises to about +1 centimeter of the water, and this forces the 0.5 litre of inspired air out of the lungs during the 2-3 seconds of expiration.

TRANSPULMONARY PRESSURE

The pressure difference between the alveolar pressure and the pleural pressure is called the transpulmonary pressure. It is a measure of the elastic forces in the lungs that tend to collapse the lungs at each instant of respiration, called the recoil pressure.

COMPLIANCE OF THE LUNGS

The extent to which the lungs expand, for each unit increase in transpulmonary pressure is called their compliance. The total compliance of both lungs together in

normal adult human being averages about 200 millilitres of air per centimetres of water transpulmonary pressure.

The characteristics of the compliance are determined by the elastic forces of the lungs. These can be divided into 2 parts

1. The elastic forces of the lung tissue itself
2. The elastic forces caused by surface tension of the fluid that lines the inside walls of the alveoli and the other lung air spaces.

The elastic forces of the lung tissue are determined mainly by the elastin and collagen fibres interwoven among the lung parenchyma, In the deflated lungs, these fibres are in an elastically contracted and kinked state, and then, when the lungs are expanded, the fibres become stretched and un kinked, thereby elongating, but still exerting elastic force to return to their natural state.

The elastic forces caused by surface tension are much more complex. However, surface tension accounts for about two third of the total elastic forces in the normal lungs.

The surface tension elastic forces of the lungs increase tremendously when the substance called surfactant is not present in the alveolar fluid.

SURFACTANT, SURFACE TENSION, AND COLLAPSE OF THE ALVEOLI

Principal of surface tension - When water forms a surface with air, water molecules on the surface of the water have an especially strong attraction for one another. As a result, the water surface is always attempting to contract. This is what holds rain drops together. i.e. there is a tight contractile membrane of water molecules around the entire surface of the raindrops. In the alveoli, the water surface is also attempting to contract. This attempts to force the air out of the alveoli through the bronchi, and in doing so, it causes the alveoli to attempt to collapse. The net effect is to cause an elastic contractile force of the entire lungs, which is called the surface tension elastic force.

SURFACTANT AND ITS EFFECT ON SURFACE TENSION

SURFACTANT is a surface active agent in water, which means that it greatly reduces the surface tension of the water. It is secreted by special surfactant secreting

epithelial cells that constitute about 10 %of the surface area of the alveoli. These cells are granular containing lipid inclusions; they are called type 2 alveolar epithelial cells.

Surfactant is a complex mixture of several phospholipids, proteins and ions.

EFFECT OF THORACIC CAGE ON LUNG EXPANSIBILITY

The thoracic cage has its own elastic and viscous characteristics, similar to those of the lungs; even if the lungs were not present in the thorax, muscular effort would still be required to expand the thoracic cage.

COMPLIANCE OF THE THORAX AND THE LUNGS TOGETHER

The compliance of the entire pulmonary system (the lungs and thoracic cage together) is measured while expanding the lungs of a totally relaxed or paralysed person.To do this, air is forced into the lungs a little at a time while recording the lung pressures and volumes. To inflate this total pulmonary system, almost twice as much pressure is needed as to inflate the same lungs after their removal from the chest cage. Therefore the compliance of the combined lung-thorax system is almost exactly one half that of the lungs alone 110 millilitres of volume per centimetre of water for the combined system, compared with 200 ml/cm for the lungs alone. Furthermore, when the lungs are expanded to high volumes or compressed to low volumes, the limitations of the chest then become extreme; when near these limits, the compliance of the combined lung- thorax system can be less than one fifth that of the lungs alone.

WORK OF BREATHING

During normal quiet respiration, almost all respiratory muscle contraction occurs only during inspiration, whereas expiration is almost entirely a passive process caused by elastic recoil of the lungs and chest cage structures. Thus, under resting conditions, the respiratory muscles normally perform “work” only to cause inspiration and not to cause expiration.

The work of inspiration can be divided into three fractions;

1. That required to expand the lungs against the lung and chest, elastic forces called compliance work or elastic work.

2. That required to overcome the viscosity of the lung and chest wall structures called tissue resistance work.

3. That required to overcome airway resistance during the movement of air into the lungs called airway resistance work.

Additional work required to expand and contract the thoracic cage-

The compliance of the total lung-thorax system is only slightly more than one half that of the lungs alone. Therefore almost twice as much energy is required for normal expansion and contraction of the total lung-thorax system as for expansion of the lungs alone.

COMPARISON OF THE DIFFERENT TYPES OF WORK

During normal quiet breathing, most of the work performed by the respiratory muscles is used simply to expand the lungs. Normally, only a small percentage of the total work is used to to overcome tissue resistance (tissue viscosity) and somewhat more is used to overcome airway resistance. Conversely, during heavy breathing, when air must flow through the respiratory passageway at high velocity, the greater proportion of the work is used to overcome airway resistance.

In pulmonary disease, all three types of work are frequently vastly increased. Compliance work and tissue resistance work are especially increased by diseases that cause fibrosis of the lungs, and airway resistance work is especially increased by diseases that obstruct the airways.

During normal quiet respiration, virtually no muscle “work” is performed during expiration because expiration results entirely from elastic recoil of the lungs and chest. In heavy breathing, however, or when airway resistance and tissue resistance are great, expiratory work does occur (requiring contraction of the expiratory muscles), and this sometimes becomes even greater than inspiratory work. This is especially true in asthma, which often increases airway resistance many fold during expiration but much less so during inspiration.

ENERGY REQUIRED FOR RESPIRATION

During quiet respiration, only 3 to 5 per cent of the total energy expended by the body is required to energize the pulmonary ventilatory process. **But during heavy exercise, the amount of energy required can increase as much as 50-fold, especially if the person has any degree of increased pulmonary compliance.**

Therefore one of the major limitations of exercise that a person can perform is the person's ability to provide enough muscle energy for the respiratory process alone.

PULMONARY VOLUMES AND CAPACITIES

PULMONARY VOLUMES

1**. TIDAL VOLUME**- is the volume of air inspired or expired with each normal breath; it amounts to about 500 millilitres.

2. **INSPIRATORY RESERVE VOLUME**- is the maximum extra volume of air that can be inspired over and above the normal tidal volume; it is usually equal to about 3000 millilitres.

3**. EXPIRATORY RESERVE VOLUME** – is the maximum extra volume of air that can be expired by forceful expiration after the end of a normal tidal expiration; this normally amounts to about 1100 millilitres.

4**. RESIDUAL VOLUME** – is the volume of air remaining in the lungs after the most forceful expiration. This volume averages about 1200 millilitres.

PULMONARY CAPACITIES

In describing events in the pulmonary cycle, it is sometimes desirable to consider two or more of the volumes together. Such combinations are called **PULMONARY CAPACITIES.**

1. **INSPIRATORY CAPACITY** –equals to tidal volume plus the inspiratory reserve volume. This is the amount of air (about 3500 millilitres) a person can breath in ,beginning at the normal expiratory level and distending the lungs to the maximum amount.

2**. FUNCTIONAL RESIDUAL CAPACITY** – equals the expiratory reserve volume plus the residual volume. This is the amount of air that remains in the lungs at the end of normal expiration.(about 2300 millilitres).

3**. VITAL CAPACITY**- equals the inspiratory reserve volume plus the tidal volume plus the expiratory reserve volume. This is the maximum amount of air a person can expel from the lungs after first filling the lungs to their maximum extent and then expiring to the maximum extent.(about 5800 millilitres).

4**. TOTAL LUNG CAPACITY** is the maximum volume to which the lungs can be expanded with the greatest possible effort (about 5800 millilitres); it is equal to the vital capacity plus the residual volume.

All pulmonary volumes and capacities are about 20 to 25 percent less in woman then in men, and they are greater in large and athletic people than in small and asthenic people.

Abbreviations used in pulmonary function studies

VC=IRV+VT+ERV

VC=IC+ERV

TLC=VC+RV

TLC=IC+FRC

FRC=ERV+RV

The minute respiratory volume is the total amount of new air moved into the respiratory passages each minute; this is equal to the tidal volume times the respiratory rate. The normal tidal volume is about 500 millilitres, and the normal respiratory rate is about 12 breaths per minute. Therefore, the minute respiratory volume averages about 6 L/min. A person can live for a short period with a minute respiratory volume as low as 1.5 L/min and a respiratory rate of two or four breaths per minute.

The respiratory rate occasionally rises to 40 to 50 per minute, and the tidal volume can become as great as the vital capacity, about 4600 millilitres in a young adult man. This can give a minute respiratory volume greater than 200 l/min. Or more than 30 times normal. Most people cannot sustain more than one half to two thirds these values for longer than 1 minute.

ALVEOLAR VENTILATION

The ultimate importance of the pulmonary ventilator system is to continually renew the air in the gas exchange areas of the lungs where the air is in proximity to the pulmonary blood. These areas include the alveoli, alveolar sacs, alveolar ducts and

the respiratory bronchioles. The rate at which new air reaches these areas is called alveolar ventilation. Strangely, however, during normal quiet respiration, the volume of air in the tidal air is only enough to fill the respiratory passageway down as far as the terminal bronchioles, with only a small portion of the inspired air actually flowing all the way into the alveoli. Therefore how does new air move this last, short distance from the terminal bronchioles into the alveoli?

The answer is diffusion. Diffusion is caused by the kinetic motion of molecules, each gas molecule moving at high velocity among the other molecules. The velocity of movement of the molecules in the respiratory air is so great and the distances so short from the terminal bronchioles to the alveoli that the gases move this remaining distance in only fraction of seconds.

DEAD SPACE

Some of the air a person breaths, never reaches the gas exchange areas but instead goes to fill respiratory passages where gas exchange does not occur, such as in the nose, pharynx, and trachea. This air is called dead space air because it is not useful for the gas exchange process; the space in the respiratory passages where no gas exchange takes place is called the dead space.

On expiration, the air in the dead space is expired first, before any of the air from the alveoli reaches the atmosphere. Therefore, the dead space is very disadvantageous for removal of the expiratory gases from the lungs.

Normal Dead Space Volume

The normal dead space air in a young adult man is about 150 millilitres. This increases slightly with age.

RATE OF ALVEOLAR VENTILATION

Alveolar ventilation per minute is the total volume of new air entering the alveoli and adjacent gas exchange areas each minute. It is equal to the respiratory rate times the amount of new air that enters these areas with each breath.

$Va = Freq .(Vt - Vd),$

Where Va is the volume of alveolar ventilation per minute, Freq is the frequency of respiration per minute, Vt is the tidal volume, and Vd is the physiological dead space volume.

Thus , with a normal tidal volume of 500 millilitres ,a normal dead space of 150 millilitres, and a respiratory rate of , 12 breaths per minute, alveolar ventilation equals 12*(500-150), or 4200 ml /min.

Alveolar ventilation is one of the major factors determining the concentration of oxygen and carbon dioxide in the alveoli. Therefore, almost all discussions of gaseous exchange emphasize alveolar ventilation .

FUNCTIONS OF THE RESPIRATORY PASSAGEWAYS

TRACHEA, BRONCHI AND BRONCHIOLES

The air is distributed to the lungs by way of the trachea, bronchi, and bronchioles.

One of the most important problems in all the respiratory passageways is to keep them open to allow easy passage of the air to and from the alveoli. To keep the trachea from collapsing, multiple cartilage rings extend about five sixth of the way around the trachea. In the walls of the bronchi, less extensive cartilage plates also maintain a reasonable amount of rigidity yet allow sufficient motion for the lungs to expand and contract. These plates become progressively less extensive in the later generation of bronchi and are gone in the bronchioles, which usually have diameters less than 1.5 millilitres. The bronchioles are not prevented from collapsing by the rigidity of their walls. Instead, they are kept expanded by the same transpulmonary pressure that expand the alveoli, i.e. as the alveoli enlarge; so do the bronchioles.

Muscular wall of the bronchi and bronchioles and its control

In all areas of the trachea and bronchi, not occupied by cartilage plates, the walls are composed mainly of smooth muscle. Also, the walls of the bronchioles are almost entirely smooth muscle, with the exception of the most terminal bronchiole, called the respiratory bronchiole, which has only a few smooth muscle fibres. Many obstructive disease of the lung result from narrowing of the smaller bronchi and bronchioles, often because of excessive contraction of the smooth muscle itself.

Resistance to airflow in the bronchial Tree-

Under normal respiratory conditions, air flows through the respiratory passageways so easily that less than 1 cm of water pressure gradient from the alveoli to the atmosphere is sufficient to cause enough airflow for quiet breathing. The greatest amount of resistance to airflow occurs not in the minute air passage of the terminal bronchioles but in some of the larger bronchi near to the trachea. The reason for this high resistance is that there are relatively few of these larger bronchi in comparison with about 65000 parallel terminal bronchioles, through each of which only a minute amount of air must pass.

Yet in disease condition, the smaller bronchiole often do play a far greater role in determining airflow resistance, for two reasons;

1. Because of their small size, they are easily occluded;
2. Because they have a greater percentage of smooth muscles in the walls, they constrict easily.

Sympathetic dilatation of the bronchioles

Direct control of the bronchioles by sympathetic nerve fibre is relatively weak because few of these fibres penetrate to the central portion of the lung. However, the bronchial tree is very much exposed to circulating norepinephrine and epinephrine released into the blood by sympathetic stimulation of the adrenal gland medullae .Both of these hormones, especially epinephrine because of its greater stimulation of beta receptors, cause dilatation of the bronchial tree.

Parasympathetic constriction of the Bronchioles.

A few parasympathetic nerve fibres derived from the vagus nerves also penetrate the lung parenchyma. These nerves secrete acetylcholine and when activated, cause mild to moderate constriction of the bronchioles. When a disease process such as asthma has already caused some bronchiolar constriction, parasympathetic superimposed nervous stimulation often worsen this condition. When this occurs, administration of drugs that block the effects of acetylcholine, such as atropine, can sometimes relax the respiratory passage enough to relieve the obstruction.

Sometimes the parasympathetic nerves are activated by reflexes that originate in the lungs. Most of these begins with irritation of the epithelial membrane of the respiratory passageways themselves, initiated by noxious gases, dust, cigarette smoke, or bronchial infection.

Local secretary factors often cause Bronchiolar constriction

Several substances formed in the lungs themselves are often quite active in causing bronchiolar constriction. Two of the most important of these are histamine and slow reactive substance of anaphylaxis. Both of them are released in the lung tissues by mast cells during allergic reactions, allergic reactions caused by pollen in the air. Therefore, they play key roles in causing the airway obstruction that occurs in allergic asthma; this is especially true of the slow reactive substance of anaphylaxis.

Also, the same irritants that cause parasympathetic constrictor reflexes of the airways are smoke, dust, sulphur dioxide, and some of the acidic elements in smog-often act directly on the lung tissues to initiate local, non nervous reactions that cause obstructive constriction of the airways.

NON-RESPIRATORY FUNCTIONS OF RESPIRATORY TRACT

1. OLFACTION

Olfactory receptors present in the mucous membrane of nostril are responsible for olfactory sensation.

2. VOCALISATION

Along with other structures, larynx forms the speech apparatus .However, larynx alone plays major role in the process of vocalisation .Therefore it is called as sound box.

3. PREVENTION OF DUST PARTICLES

Dust particles, which enter the nostrils from air, are prevented from reaching the lungs by filtration action of the hairs in nasal mucous membrane. Small particles, which escape the hair are held by the mucous secreted by nasal mucous membrane. Those dust particles, which escape from nasal hairs and nasal mucous membrane are removed by the phagocytic action of macrophages in the alveoli.

4. DEFENCE MECHANISM

Lungs play important role in the immunological defence system of the body. Defence functions of the lungs are performed by their own defences and by the presence of various types of cells in mucous membrane lining the alveoli of lungs. These cells are leukocytes, macrophages, mast cells, natural killer cells and dendritic cells.

5. MAINTENANCE OF WATER BALANCE

Respiratory tract plays a role in water loss mechanism. During expiration, water evaporates through the expired air and some amount of body water is lost by this process.

6 REGULATION OF BODY TEMPERATURE

During expiration, along with water, heat is also lost from the body.

7. REGULATION OF ACID BASE BALANCE

Lungs play a role in maintenance of acid base balance of the body by regulating the carbon dioxide content in the blood.

8. ANTICOAGULANT FUNCTION

MAST CELLS in lungs secrete heparin. Heparin is an anticoagulant and it prevents the intravascular clotting.

PULMONARY CIRCULATION

PULMONARY VESSELS

The pulmonary artery extends only 5 cm beyond the apex of the right ventricle and then divides into the right and left main branches, which supply blood to the two respective lungs. The vessels are very thin and distensible, gives the pulmonary arterial tree a large compliance, averaging about 7ml/mm of Hg, which is similar to that of the entire systemic arterial tree. This large compliance allows the pulmonary arteries to accommodate about two thirds of the stroke volume output of the right ventricle.

BRONCHIAL VESSELS

Blood also flows to the lungs through small bronchial arteries that originate from the systemic circulation, amounting to about 1 to 2 % of the total cardiac output. This bronchial arterial blood is oxygenated blood, in contrast to the partially deoxygenated blood in the pulmonary arteries. It supplies the supporting tissues of the lungs, including the connective tissue, septa, and large and small bronchi.

BLOOD VOLUME OF THE LUNGS

The blood volume of the lungs is about 450 millilitres, about 9% of the total blood volume of the circulatory system. Approximately, 70 millilitres of this is in the pulmonary capillaries, and the remainder is divided about equally between the arteries and the veins.

Lung as a blood reservoir:

Under various physiological and pathological conditions, the quantity of blood in the lungs can vary from as little as one half normal up to twice normal. For instance, when a person blows out air so hard that high pressure is built up in the lungs such as when blowing a trumpet, as much as 250 millilitres of blood can be expelled from the pulmonary circulatory system into the systemic circulation. Also, loss of blood from the systemic circulation by hemorrhage can be partly compensated for by automatic shift of blood from the lungs into the systemic vessels.

BLOOD FLOW THROUGH THE LUNGS AND ITS DISTRIBUTION

The blood flow through the lungs is essentially equal to the cardiac output. Therefore, the factors that control cardiac output mainly peripheral factors also control pulmonary blood flow. Under most conditions, the pulmonary vessels act as passive, distensible tubes that enlarge with increasing pressure and narrow with decreasing pressure. For adequate aeration of the blood to occur, it is important for the blood to be distributed to those segments of the lungs where the alveoli are best oxygenated.

AUTOMATIC CONTROL OF PULMONARY BLOOD FLOW DISTRIBUTION

When the concentration of oxygen in the alveoli decreases below normal especially when it falls below 70% of normal, the adjacent blood vessels constrict during the ensuing 3 to 10 minutes, with the vascular resistance increasing more than fivefold at extremely low oxygen levels. This is opposite to the effect observed in systemic vessels, which dilate rather than constrict in response to low oxygen. It is believed that the low oxygen concentration causes some yet undiscovered vasoconstrictor substance to be released from the lung tissue; this substance in turn promotes

constriction of the small arteries. It has been suggested that this vaso-consrictor might be secreted by the alveolar epithelial cells when they become hypoxic.

This effect of a low oxygen level on pulmonary vascular resistance has an important function; to distribute blood flow to where it is most effective. That is, if some alveoli are poorly ventilated so that the oxygen concentration in them becomes low, the local vessels constrict. This cause the blood to flow through the other areas of the lungs that are better aerated, thus providing an automatic control system for distributing blood flow to the pulmonary areas in proportion to their degree of ventilation.

EFFECT OF INCREASED CARDIAC OUTPUT ON THE PULMONARY CIRCULATION DURING HEAVY EXERCISE

During heavy exercise, the blood flow through the lungs increases fourfold to sevenfold. This extra flow is accommodated in the lungs in three ways;

1. By increasing the number of open capillaries, sometimes as much as threefold.

2. By distending all the capillaries and increasing the rate of flow through each capillary more than two fold;

3. By increasing the pulmonary arterial pressure.

In the normal person, the first two changes together decrease the pulmonary vascular resistance so much that the pulmonary arterial pressure rises very little even during maximum exercise.

The ability of the lungs to accommodate greatly increases blood flow during exercise conserves the energy of the right side of the heart and prevents a significant rise in pulmonary capillary pressure, therefore also preventing development of pulmonary edema.

PRESSURES OF OXYGEN AND CARBON DIOXIDE IN THE LUNGS, BLOOD AND TISSUES

The gases can move from one point to another by diffusion and the cause of this movement is always a pressure difference from the one point to another by diffusion and that the cause of this movement is always a pressure difference from the first

point to the next. Thus, oxygen diffuses from the alveoli into the capillary blood because the oxygen pressure (pO_2) in the alveoli is greater than the pO_2 in the pulmonary blood. Then, in the tissues, a higher pO_2 in the capillary blood than in the tissues causes oxygen to diffuse into the surrounding cells.

Conversely, when oxygen is metabolised in the cells to form carbon dioxide, the intracellular carbon dioxide pressure (pCO_2) rises to a high value, which causes carbon dioxide to diffuse into the tissue capillaries. Similarly, it diffuses out of the blood into the alveoli because the pCO_2 in the pulmonary capillary blood is greater than that in the alveoli .Basically, then, the transport of oxygen and carbon dioxide by the blood depends on both diffusion and movement of blood.

UPTAKE OF OXYGEN BY THE PULMONARY BLOOD

The pO_2 of the gaseous oxygen in the alveolus averages 104 mmHg, whereas the pO_2 of the venous blood entering the pulmonary capillary at the arterial end averages only 40 mmHg because a large amount of oxygen has been removed from this blood as it has passed through the peripheral tissues. Therefore, the initial pressure difference that cause oxygen to diffuse into the pulmonary capillary is 104-40 or 64 mmHg.

TRANSPORT OF OXYGEN IN THE ARTERIAL BLOOD

About 98% of the blood that enters the left atrium from the lungs has passed through the alveolar capillaries and has become oxygenated up to a pO_2 of about 104 mmHg. Another 2% of the blood has directly from the aorta through the bronchial circulation, which supplies mainly deep tissues of the lungs and is not exposed to the pulmonary air. This blood flow represents “shunt flow” meaning blood that is shunted past the gas exchange areas. On leaving the lungs, the pO_2 of the shunt blood is about that of normal venous blood, about 40 mmHg. This blood combines in the pulmonary veins with the oxygenated blood from the alveolar capillaries; this mixing of the bloods is called venous admixture of blood, and it causes the pO_2 of the blood pumped by the left side of the heart into the aorta to fall to about 95mmHg.

DIFFUSION OF CARBON DIOXIDE FROM THE PERIPHERAL TISSUE CELLS INTO THE TISSUE CAPILLARIES AND FROM THE PULMONARY CAPILLARIES INTO THE ALVEOLI

When Oxygen is used by the cells, most of it becomes Carbon dioxide, and this increases the intracellular pCO_2. Because of the high tissue cell pCO_2, Carbon Di oxide diffuses from the cells into the tissue capillaries and is then carried by the blood to the lungs. In the lungs, it diffuses from the pulmonary capillaries into the alveoli. Thus, at each point in the gas transport chain, Carbon dioxide diffuses in a direction exactly opposite that of the diffusion of Oxygen. The major difference between the diffusion of Oxygen and Carbon Dioxide is Carbon Dioxide can diffuse about 20 times as rapidally as Oxygen. Therefore the pressure differences required to cause Carbon Dioxide diffusion are, in each instance, far less than the pressure differences required to cause Oxygen diffusion.

TRANSPORT OF OXYGEN IN THE BLOOD

Normally about 97% of the Oxygen transported from the lungs to the tissues is carried out in chemical combination with haemoglobin in the red blood cells .The remaining 3 % is transported in the dissolved state in the water of the plasma and cells. Thus, under normal conditions, Oxygen is carried to the tissue almost entirely by haemoglobin.

TRANSPORT OF CARBON DIOXIDE IN THE BLOOD

Transport of Carbon dioxide by the blood is not nearly so great a problem as transport of oxygen because even in the most abnormal conditions, Carbon dioxide can usually be transported in far greater quantities than can oxygen. However, the amount of Carbon dioxide in the blood does have much to do with acid base balance of the body fluids. Under normal conditions, on an average of 4 millilitres of Carbon dioxide are transported from tissues to the lungs in each 100 millilitres of blood.

RESPIRATORY EXCHANGE RATIO

The normal transport of Oxygen from the lungs to the tissues by each 100 millilitres of blood is about 5 millilitres, whereas normal transport of Carbon dioxide from the tissues to the lungs is about 4 millilitres. Thus, under normal resting conditions, only

about 82% as much Carbon dioxide is expired from the lungs as there is Oxygen uptake by the lungs. The ratio of Carbon dioxide output to oxygen uptake is called the respiratory exchange ratio(R), that is,

R= Rate of carbon dioxide output/Rate of oxygen uptake

For a person on a normal diet consuming average amounts of carbohydrates, fats, and proteins, the average value for R is considered to be 0.825.

REGULATION OF RESPIRATION

RESPIRATORY CENTRE

The respiratory centre is composed of several groups of neurons located bilaterally in the medulla oblongata and pons. It is divided into three major collections of neurons.

1. A dorsal respiratory group, located in the dorsal portion of the medulla, which mainly causes inspiration

2. A ventral respiratory group, located in the ventro-lateral part of the medulla, which can cause either expiration or inspiration, depending on which neuron in the group are stimulated

3. The pneumotaxic centre, located dorsally in the superior portion of the pons, which helps control the rate and pattern of breathing. The dorsal respiratory group of neuron plays the most fundamental role in the control of respiration.

11. Peakflowmeter

The simple, handy instrument by which person's maximum speed of expiration that is Peak expiratory flow rate is measured is called as Peak Flow Meter. The measurement of Peak expirtory flow was pioneered by Martin Wright, who produced the first meter specially designed to to measure this index of lung function. Since the original design of instrument was introduced in the late 1950s. And the subsequent development of a more portable, lower cost version have become available across the world[108.]

The Wrights Peak Flow Meter, introduced in 1959, is a simple device for the measurement of ventilatory function of the lung. A mini version is available which can be carried in ones pocket for bed side use.

The flow meter is a short cylinder made of plastic material. An indicator (pointer) moves in a slot alongside a scale with numbers on it which indicates litres/min. There is a handle provided near the mouthpiece. The end, opposite the mouthpiece, has holes in it for allowing air to exit from the apparatus.

Normal range=350-600 litres per minute.

This estimation is useful in in distinguishing reversible (eg-asthma) from irreversible (eg emphysema**).The measurement of the effect of training in athletes is yet another application of the Wright Peak flow meter.**

PEAKFLOWMETRY-

The PEF is a person's maximum speed of expiration, as measured with a Peak Flow Meter, a small, hand held device used to monitor a person's ability to breath out air. It measures the airflow through the bronchi and thus the degree of obstruction in the airways. **The rate of airflow at the peak of expiration is measured by this device**. **Peak expiratory flow rate is a measurement of how fast and how forcefully a person can blow out. This peak flow shows how well the lungs are working.**

As stated by Daniel R Neuspiel,

PEFR is the maximum flow rate generated during a forceful exhalation, starting from full lung inflation. Peak flow rate primarily reflects large airway flow and depends on the voluntary effort and muscular strength of the patient.

Peak flow rate usually correlates with FEV1.

Before doing Peakflowmetry, make sure, not eat a heavy meal before the procedure.

A PFM is small and light enough to be used almost anywhere. It's important to use the same PFM on a regular basis. The readings can vary between brands and types of meters. An important part of Peak flow measurement is noting peak flow zones. Peak flow zones are areas of measurement on a peak flow meter. The goal of the peak flow zones is to show early symptoms of uncontrolled asthma. Peak flow zones are set differently for each person. Your healthcare provider will help determine your peak flow zones. The 3 peak flow zones are noted by colour and include:

- **Green**. This means "go." The green zone is 80 to 100 percent of your highest peak flow reading, or personal best. This is the zone you should be in every day. When your measurements are in this zone, air is moving well through the large airways in your lungs. It means that you can do your usual activities and go to sleep without trouble.
- **Yellow.** This means "caution" or "slow down." The yellow zone is 50 to 80 percent of your personal best. Measurements in this zone are a sign that your large airways are starting to narrow. You may start to have mild symptoms, such as coughing, feeling tired, feeling short of breath, or feeling like your chest is tightening. These symptoms may keep you from your usual activities or from sleeping well.
- **Red.** This means "stop." The red zone is less than 50 percent of your personal best. Readings in this zone mean you have severe narrowing of your large airways. This is a medical emergency. You should get help right away. You may be coughing, very short of breath, wheezing while breathing in and out, or having retractions (the muscles between the ribs are working hard to help you breathe). You may also have trouble in walking and talking.

In most cases, Peak flow measurement follows this process:

- Before each use, make sure the sliding pointer on the Peakflowmeter is reset to the 0 mark.
- Hold the PFM by the handle.
- Stand up straight.
- Remove chewing gum, candy, or food from your mouth.

- Take a deep breath and put the mouthpiece in your mouth. Seal your lips and teeth tightly around the mouthpiece.
- Blow out as hard and as fast as you can. A “fast blast” is better than a “slow blow.”
- Note the number where the sliding pointer has stopped on the scale.
- Reset the pointer to 0.
- Repeat this 3 times. The 3 readings should be close together. If not, adjust your technique.
- If you cough during a measurement, repeat the measurement.
- Record only the highest of the 3 readings on a graph or in a notebook. Do not average the numbers together. The highest number is called your peak flow or personal best.
- Use the peak flow meter once a day, or as directed by your health care provider. Measure peak flows about the same time each day. A good time might be when you first wake up, or at bedtime.
- Clean and care for your meter as instructed.
- If you use a new peak flow meter, you will need to find your new personal best value on the new meter.
- Your healthcare provider may give you other instructions as needed.

Certain factors may interfere with the accuracy of peak flow measurement, such as:

- Coughing during the test
- Poor seal around the mouthpiece while performing the procedure
- A dirty meter
- Blocking the mouthpiece with your tongue
- Use of medicines that open the airways (bronchodilators)
- Use of a different type or brand of peak flow meter, as measurements may vary among brands and types of meters

Tell your healthcare provider if you take any medicines. This includes prescriptions, over-the-counter medicines, vitamins, and herbal supplements.

All procedures have some risks. The risks of this procedure may include:

- Having to take in deep breaths may make you feel dizzy or short of breath
- It may trigger coughing or wheezing

12. Vital Capacity-VC

It is the largest volume of air a person can expel from the lungs with maximum effort after first filling the lungs fully by a deepest possible inspiration. **It amounts to 3.5 to 5.5 litres, normally, the value being 20% lower in females. In general, vital capacities are larger in males, taller persons, and in younger adults.**

The VC is frequently determined clinically as an index of lung function and provide useful information about abnormal ventilation due to airway obstruction, mechanical interference with chest expansion and compression and strength of respiratory muscles.

The VC is maximum in standing position, less in the sitting position, and least in the supine position. This effect of posture is due to the following factors

1. In the sitting and supine positions, the muscles of respiration (both primary and accessory) cannot be employed as forcefully and effectively for the expansion and compression of lungs and chest.
2. In the supine position, the abdominal viscera push the diaphragm up and interfere with its movements. The mobility of the chest is also reduced by the contact of the back with the bed.
3. There is accumulation of more blood in the blood vessels of the lungs (especially veins) in the supine position. This decreases the total lung capacity and hence the vital capacity.

Factors affecting Vital Capacity

a. The net air capacity of the lungs.
b. Condition of the lungs
c. Magnitude of compressing factors that is contraction of respiratory muscles.

Associated with these factors, the following factors affect VC:

1. **Age-** The net air capacity is lower in young children. VC decreases in old age due to loss of elasticity of lungs and weaker compressing forces.
2**. Gender**- Males have larger chests, greater body surface area and greater muscle power.
3. **Net air capacity of lungs**

a. Volume of blood in the lungs e.g. pulmonary congestion reduces air capacity.
b. Condition of lungs, e.g. loss of elasticity, emphysema**.**

c. Destruction of lung tissue, e.g. carcinoma

d. Patency of lung passages, e.g. asthma reduces patency

e. Mechanical interference with expansion of lungs e.g. pregnancy

f. Posture- In supine position, the abdominal viscera push up against the diaphragm thus reducing the thoracic space.

4. **Magnitude of compressing forces**

1. Swimmers, divers, athletes, have stronger and better developed muscles.

2. Persons doing yogic breathing exercises have better developed respiratory muscles.

13. Pulmonary function tests

As stated in "A textbook of practical physiology" by C.L.Ghai, it is mentioned that pulmonary function tests are done to assess physical fitness and effects of physical training.

1. **Chest expansion Test**

Measure the chest expansion with a tape placed around the chest just below the level of nipples. The normal chest expands by 5-10 cm following a deep inspiration after a forceful expiration.

2. **Respiratory endurance test (40 mm Hg test) or Breath Holding Time (BHT)**

A BP apparatus is required for this test. Disconnect the rubber tube leading from the mercury reservoir to the BP cuff. Ask the subject to take a deep breath, pinch his nostril, and exhale into the tube and then raise the mercury to 40 mm level and to hold it there for as long as possible.

Normal= 40-70 seconds or more.

3. **Snider's test-** Hold a burning match stick about 12 inches in front of the subject's face and ask him to blow it out with a single forceful expiration.

4. **Peakflowmetry-** As described earlier, with the help of Peakflowmeter, the maximum force of exhalation i.e. FEV1 is measured.

13.a. Physiological description of the respiratory function tests:

The physiology of these Lung function test is described in few research papers. According to that[lxxxv],

"The absolute volume of forced vital capacity FVC is important because it is an index of the state of elastic properties of the respiratory apparatus, whereas the rate at which FEV1 is expelled from the lungs is predominantly a reflection of the flow resistive properties. Most lab assess flow resistance by an analysis of the volume of air expired in particular time,the most frequent one being that expired in the first second FEV1% . FEV1% is predominantly reflects resistance to air flow in airways that are greater than 2 mm in diameter.

The Peak expiratory flow rate is generally considered as a sensitive indicator of changes in elastic recoil pressure and or of the resistance of small airways. PEFR is subject to wide variability and is effort dependant.

During practice of forced breathing, lungs and chest were inflated and deflated to the fullest possible extent and muscles worked to their maximum capacity.

A significant increase in FEV1% could be due to strengthening of respiratory muscles and improvement in elastic properties of the lungs and chest incidental to regular practice of forced breathing. Additionally inflation near to total lung capacity is a major physiological stimulus for the release of lung surfactant and prostaglandins into alveolar spaces thus increasing compliance of the lungs and decrease bronchiolar smooth muscle tone.

1. Prolonged breath holding capacity indicates either decreased responsiveness of the respiratory centre to CO_2 or of some unconfirmed chemoreceptors as reported in subjects who regularly practice breath holding exercise.
2. Increased development of respiratory musculature, incidental to regular practice of pranayamic breathing, causes increased muscle endurance and delays the onset of their fatigue, thus allowing the breath holding for longer time."

As discussed in following paper[lxxxvi], Breath holding time is defined as the time taken by the person to hold his breath as long as he can. Normal breath holding time is 45-55 sec. Respiration can be voluntarily inhibited for some time, but eventually the voluntary control is overridden. During voluntary breath holding, tissues continue to use oxygen and produce CO_2. Therefore during breath holding, arterial pO_2 falls and pCO_2 rises, resulting in state of asphyxia. Since both of these factors are powerful respiratory stimulants, a point is reached where the respiratory drive become so strong that the person cannot hold the breath any longer. The point at which breathing can no longer be voluntarily inhibited is called the breaking point. Thus breath holding time is the time duration from the time of inhibition of breathing till the breaking point. The breaking point is generally reached when alveolar pO_2 is 56 mm of Hg and pCO_2 is 49. Either an increase in pCO_2 or a decrease in pO_2 can affect respiration through respiratory centres, thus influencing Breath holding time. The maximal BHT has been used in respiration as a measure of ventilatory response.

Respiratory efficiency can be increased by training. Respiratory efficiency tests facilitate the increase in the strength of the respiratory muscles.
Breath holding is a voluntary act, but normal subject appear appeunable to breathhold to
unconsciousness. A powerful involuntary mechanism normally overrides voluntary breath holding and causes the breath that defines the breakpoint. The central respiratory rhythm is present throughout breath holding.
BHT has been used in respiratory physiology as a measure of ventilatory response. It is directly proportional to the lung volume at the onset of breath holding, partly because this has a major influence on oxygen stores. When one hold someone's breathe at rest, a total of about 600 ml of O_2 is available and can be utilised. Normal maximal BHT is 30 to 60 sec. The arterial pO_2 then drops to about 75 to 50 mm of Hg and the pCO_2 rises from 45 to 50 mm of Hg. This elevated CO_2 pressure plays a greater role in forcing the individual to discontinue the breath holding than does the reduced O_2 pressure."

The physiology during Chest expansion**:**
It is discussed in following research paper[lxxxvii]-
"Muscle tension of the rib cage and mechanical properties caused by movement of the rib cage are important factors in air flow during inspiration and expiration. In addition, the thorax has an elastic structure that expands and contracts during breathing and interaction between the lung and chest cavity is a critical parameter representing the gas exchange ability of the lung. Further, the expansion and contraction of the lungs are affected by the capacity of the thorax, which is determined by the mobility of the skeletal muscles, the elasticity of the surrounding soft tissue and the intensity of the respiratory muscles. Research results have shown that tidal volume is more affected by movement of the rib cage than abdominal motion. Therefore the degree of chest expansion is considered to be closely related to respiratory function and an important element in representing respiratory function, 2 .Chest expansion at the axillary level represents the upper chest breathing pattern, which utilises a combination of upward and foreword chest movements or the pump handle movements, as well as upward and outward chest movements or the bucket handle movement.

Cigarette smoking affects the respiratory muscles through the influence of free radicals on the vascular system, leading to a reduction in respiratory muscle blood supply which adversely impacts respiratory function."

Physiology of Lung function tests are described also in the article[lxxxviii],

It was found that due to regular practice of Pranayama, there was a highly significant increase in Chest expansion, Breath holding time and PEFR. It can be explained on the following basis

"Usually breathing is not a conscious event and is regulated automatically by the nervous system through the respiratory centres located in the medulla oblongata and pons. These are the dorsal and ventral group of neurons located in the medulla, the pneumotaxic centre and the apneustic centre located in the pons. The activity of these respiratory centres is in turn modified by supra-pontine influences, in the conscious being. While the basic respiratory rhythm in normal situation is maintained by the impulses discharged by the dosal group of neurons, the pneumotaxic centre indirectly controls the duration of inspiration and helps in relaying the suprapontine impulses which promote voluntary inspiration and expiration.We believe that during daily practice of Pranayama the basic activity of the bulbopontine complex is modified in such a way as to slow down its rhythm. Thus after continous practice of Pranayama for few week, the bulbopontine complex is adjusted to the new pattern of breathing which is slower than its basal rhythm. Also by voluntarily prolonging the phase of inspiration and expiration, the respiratory muscles are stretched to their full extent and the respiratory apparatus is able to work to their maximal capacity represented by increased chest wall expansion and lung volumes.

Regular practice of slow and deep breathing exercises improves muscle strength and flexibility due to work hypertrophy.

Pranayama cleanses airway secretions.

Stimulation of pulmonary stretch receptors due to maximum inflation of the lungs reflexly relaxes smooth muscles of larynx and trachea-bronchial tree which

modulates the calibre of airways and reduces airway resistance. Thus opening of small airway and reduced airway resistance increases PEFR.

Increase in BHT-

In normal breathing after a particular degree of stretching or even before this, stretch receptors in alveoli are stimulated and send information to the respiratory centres so that exhalation sets in. But in Pranayama there is continuation of the phase of inhalation with strong voluntary control so that lungs are expanded considerably and the walls of the alveoli are stretched to the maximum extent. Thus the chest continues to get expanded under cortical control. The stretch receptors are thus trained to withstand more and more stretching. This helps in holding the breath for a longer time. As the duration of breath holding during Pranayama is gradually increased by practice, the respiratory centre is acclimatized to withstand higher and higher carbon dioxide concentrations in the alveoli and the blood. Also the subject keeps his voluntary muscles relaxed and immobile while at the same time exercising a close and continuous voluntary control over respiratory muscles, thus consciously and persistently overriding the usual excitatory stimuli to respiratory centres. Also the receptors get acclimatized to the increased concentrations of carbon di oxide gradually by regular practice of Pranayama.
In addition, increased development of respiratory musculature and endurance due to regular practice of Pranayama delays the onset of fatigue, thus allowing the breath holding for longer time."

14. Arterial pulse:

The arterial pulse is defined as the pressure changes transmitted in the form of waves through the arterial wall and blood column from heart to the periphery.

When heart contracts the blood is ejected into aorta with great force. It causes distension of this blood vessel and a rise in pressure. A pressure wave is produced on the elastic wall of the aorta. It travels rapidly from the heart and can be felt after a brief interval, at any superficial artery like radial Pulse at wrist.

The formation and transmission of pulse wave depends upon the elasticity of blood vessels. Thus, when the walls of the arteries are more distensible the pressure rise is less and so the transmission of pulse is less. When the arterial wall looses its elastic property and become rigid as in old age, the pressure rise is more and the transmission of pulse is also more.

Examination of Radial Pulse

Examination of pulse is a valuable clinical procedure. Pulse represents heart rate. By examining pulse, important information regarding cardiac function, such as rate of contraction, rhythmicity etc. can be obtained.

Usually the pulse is palpated on the radial artery, because it is easily approachable & placed superficially. Pulse is examined by placing the tips of 3 fingers, viz. Index, middle & ring finger on the artery. While examining the pulse, following features are observed:

1. Rate
2. Rhythm
3. Character
4. Volume
5. Condition of blood vessel wall
6. Delayed pulse.

1. In this study pulse rate is examined. The no. of pulse per minute is pulse rate. It has to be counted for minimum 1 minute. It is 72/min in adults. At birth it is 130-140/min. The conditions which alter heart rate also alter pulse rate. Pulse rate increases during exercise, pregnancy, emotional conditions, fever, anaemia &

hyperthyroidism. It decreases during sleep, hypothermia, hypothyroidism, incomplete heart block.

15. Arterial blood pressure: Arterial blood pressure is defined as the lateral pressure exerted by the contained column of blood on the arteries. The pressure is exerted when the blood flows through the arteries. Arterial blood pressure is expressed in 4 different terms.

1. Systolic blood pressure
2. Diastolic blood pressure
3. Pulse pressure
4. Mean arterial pressure.

In this study systolic & diastolic blood pressure is examined.

1. Systolic blood pressure: It is defined as the maximum pressure exerted in the arteries during systole of the heart. The normal systolic pressure is 120 mm of Hg. It ranges between **110 to 140 mm of Hg**
2. Diastolic blood pressure: It is the minimum pressure in the arteries during diastole of the heart. The normal diastolic pressure is 80 mm of Hg. It varies between 60 to 80 mm of Hg.

Physiological variations:

1. Age: Arterial blood pressure increases as age advances. Systolic pressure in different ages: in newborn 40 mm of Hg, Puberty 120 mm of Hg, at 50 yrs 140 mm of Hg, at 70 yrs 170 mm of Hg, at 80 yrs, 180 mm of Hg. Diastolic blood pressure in different ages: At puberty, 80 mm of Hg, at 50 yrs, 85 mm of Hg, at 70 yrs, 90 mm of Hg, at 80 yrs, 95 mm of Hg.
2. Gender: In females, upto the period of menopause, arterial pressure is low, upto 5 mm of Hg as compared to the males of the same age. After menopause, pressure in females becomes equal to the males of same age.
3. Body built: pressure is more in obese then in lean people.
4. Diurnal variation: in early morning pressure is slightly low, gradually increases & reaches maximum in the noon. Becomes low in the evening.
5. After meals: the arterial blood pressure is increased after meals for few hours due to increase in cardiac output.

6. During sleep: Usually the pressure is reduced up to 15 to 20 mm of Hg during deep sleep. However, it increases slightly during sleep associated with dreams.
7. Emotional conditions: During anxiety & excitement, BP is increased due to increase in adrenaline.
8. After exercise: after moderate exercise, systolic pressure increases by 20-30 mm of Hg above the basal level, due to increase in contraction & stroke volume. Normally, diastolic pressure is not affected by moderate exercise. This is because, it is dependent on peripheral resistance, which is not altered by moderate exercise. After severe muscular exercise, the systolic pressure rises by 40-50 mm of Hg above the basal level, but diastolic pressure reduces, because, peripheral resistance decreases in severe muscular exercises.

Factors maintaining Arterial blood pressure: there are some factors necessary for maintenance of blood pressure, called as local factors/mechanical factors or determinants of blood pressure. These factors are divided into 2 types:

1. Central factors: Pertained to heart
    a. Cardiac output
    b. Heart rate
2. Peripheral factors: pertaining to blood & blood vessels
    a. Peripheral resistance
    b. Blood volume
    c. Venous return
    d. Elasticity of blood vessels
    e. Velocity of blood flow
    f. Diameter of blood vessels
    g. Viscosity of blood

1. Central factors

a. Cardiac output- Systolic pressure depends mainly upon the stroke volume and cardiac output and is directly proportional to the stroke volume and cardiac output. Whenever the cardiac output is increased, the systolic pressure is increased and, when, cardiac output is less, the systolic pressure is reduced.. The cardiac output increases in in muscular exercise, emotional conditions etc. So in these conditions the systolic pressure is increased.

Cardiac output in turn depends upon blood volume, venous return, heart rate and force of contraction. Cardiac output is directly proportional to blood volume. When blood volume increases, ventricular filling is more, cardiac output is more and pressure rises. When the blood volume is reduced, the cardiac output is less and blood pressure falls..

Cardiac output is also directly proportional to venous return. When amount of blood returning to heart is more, ventricular filling is more, with distension of heart. The course of contraction of heart is directly proportional to length of muscle fibres. So when the force of contraction is more, cardiac output is more & systolic pressure rises.

b. Heart rate: moderate changes in heart rate do not affect arterial blood pressure much, but marked alteration in heart rate affects blood pressure by altering cardiac output.

2. Peripheral factors:

a. Peripheral resistance: this is the important factor to maintain diastolic pressure. Diastolic pressure is directly proportional to peripheral resistance. It is the resistance offered to blood flow at the periphery. When peripheral resistance is decreased, diastolic pressure is less & vice versa.

b. Blood volume: Blood pressure is directly proportional to blood volume. It maintains blood pressure through venous return & cardiac output. If the blood volume is more, there is increase in venous return & cardiac output, resulting in elevation of blood pressure. Decrease in blood volume causes fall in blood pressure.

c. Venous return: BP is directly proportional to venous return. When venous return is more, there is increase in ventricular filling & cardiac output resulting in elevation of blood pressure.

d. Elasticity of blood vessels: BP is inversely proportional to elasticity of blood vessels. Due to elastic property, blood vessels are distensible & able to maintain the pressure. If this property is lost, vessels become rigid & pressure increases, as in old age.

e. Velocity of blood flow: blood pressure is directly proportional to velocity of blood flow. If velocity is more, resistance is more, so pressure is more.

f. Diameter of blood vessel: blood pressure is inversely proportional to diameter of blood vessel. If diameter decreases, peripheral resistance increases, which increases the pressure.

g. Viscosity of blood: blood pressure is directly proportional to viscosity of blood. When viscosity is more, frictional resistance is more, increasing the pressure.

Regulation of arterial blood pressure: Arterial blood pressure varies even under physiological conditions, however immediately it is brought back to normal level, because of presence of organised regulatory mechanism of the body. Body has 4 such regulatory mechanisms.

9. Nervous mechanism: it is rapid among all mechanisms. It brings pressure back to normal within few minutes. Although it is fast acting, it operates for short duration, then adapts to new pressure. Hence it is short term regulation. This mechanism is conducted by vasomotor centre & impulses from periphery.
10. Renal mechanism: conducted by ECF volume & by RAA mechanism.
11. Hormonal mechanism: it is conducted by hormones causing vasoconstriction & vasodilatation. E.g. adrenaline, noradrenaline, vasopressin, histamine etc.
12. By local mechanism: conducted by local vasoconstrictors & local vasodilators.

Cardiovascular adjustment during exercise: types of exercise: exercise generally divided into 2 types depending upon type of muscle contraction
1. Dynamic

2. Static

1. Dynamic: this involves isotonic muscular contraction. It keeps joints and muscles moving. E.g. swimming, walking bicycling. In this type, heart rate, force of contraction, cardiac output & systolic BP increases. However, the diastolic pressure is unaltered or decreased, because, during this exercise, peripheral resistance is unaltered or decreased depending on severity of exercise.
2. Static exercise: It involves isometric muscular contraction without movement of joints. E.g. Pushing heavy objects. During this exercise, apart from increase in heart

rate, force of contraction, cardiac output & systolic BP, diastolic pressure also increases. It is because of increase in peripheral resistance during static exercise.
Severity of exercise: the cardio vascular & other changes in the body depend upon the severity of exercise. Based on it, it is classified in 3 types:

1. Mild
2. Moderate
3. Severe

1. Mild: very simple form of exercise of slow walking. Little or no change occurs in cardio vascular system during mild exercise.
2. Moderate: it does not involve strenuous muscular activity. So this type of exercise can be performed for a longer period. Exhaustion does not occur at the end of moderate exercise. E.g. fast walking & slow running.
3. Severe: It involves strenuous muscular activity. Severity can be maintained only for short duration. Complete exhaustion occurs at the end. E.g. fast running for a distance of 100 meters.

Effects of exercise on Cardiovascular system:

1. On heart rate heart rate increases during exercise. Even the thought of exercise increases heart rate, because of impulses from cerebral cortex to medullary centres, which reduces vagal tone. In moderate exercise, heart rate increases upto 180 bpm. In severe exercise, it reaches 240 bpm. The inceased heart rate is mostly due to vagal withdrawal.
2. On cardiac output: cardiac output increases upto 20 lit/min in moderate exercise & upto 35 litres/ min during severe exercise. The increase in cardiac output is directly proportional to amount of oxygen consumed during exercise. During exercise, cardiac output increases due to increase in heart rate & stroke volume. Heart rate increases due to vagal with drawl. Stroke volume increases due to increased force of contraction. vagal with drawl increases sympathetic activity leading to increase in rate & force of contraction.
3. On blood pressure: during moderate exercise, systolic BP is elevated. It is due to increase in heart rate & stroke volume. Diastolic pressure is not altered because peripheral resistance is not altered. In severe exercise, systolic pressure enormously increases but diastolic pressure decreases. It is because of decrease in peripheral

resistance. Decrease in peripheral resistance is due to vasodilatation caused by metabolites.

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I. METHODOLOGY (MATERIALS AND METHODS)

1. Area or place of the study: This study was conducted atAshtangAyurvedMahavidyalaya., Pune.

2. Type of study, phase of study and study design: This is a literature based open labelled, controlled study.

3. Sample size: In all 360apparently healthy individuals were to be enrolled in the study. The individuals were randomly divided into study (A) & control (B) groups. Excluding the drop outs from both Study and control groups, 193 subjects in study group and 186 subjects in control group were available for assessment.Males&femalessubjects were comparable.

4. Operational definitions:

a. Ucchhwas –

It is the karma of UdanaVayu.Ucchwas and Nishwasa are two phases of Shwasan. Ucchwas that is exhalation is done by UdanaVayu and Nishwasa by PranaVayu in the body. It is measurable by modern equipments like Spirometer, Peakflowmeter etc. In this study, it has been measured by some simple tests like Chest expansion, 40 mm of Hg test, Snider test and Peakflowmetry by which holding capacity of lungs, force of expiration has been checked.

b. UdanaVayu – It is one of the five types of Vatadoshas. There are many karmas of UdanaVayu as stated in the literature review. In this study, mainly Ucchwasa karma of UdanaVayu has been studied.

c.NadishodhanaPranayama- One of the traditional methods of breathing exercises. It is simple, less time consuming and economical method..

d. DoshaPrakriti- It is the dominance of one of the doshas from the birth which is very much habitual to the body. There are many types of Prakriti as stated in Ayurvedicsamhita, but here in this study, only DwiDoshajPrakritis have been considered. The Prakriti has been decided by the proforma attached, which is frequently used in MUHS journal.

e. Vyayamshakti- It is the strength of the person to perform physical exercise. It is one of the Dashavidhaparikshyabhavas stated by Charakacharya. There are three types of this viz. Uttam, Madhyam and Alpa according to their performance of doing exercise.Bala of a person is examined according to his or her exercise doing capacity.

f. Desha- According to Ayurveda, there are 3 types of Deshas viz. Jangal, Aanoopa, and Sadharandesha. The volunteers for this study are from Pune only and the experiment has been done in Pune, which is the Sadharandesha.

g. Kala- It is divided mainly in Aadankala and Visargakala. Aadankala includes Shishir, Vasant and Grishmarutu and Visargkala includes Varsha, Sharad and Hemantrutu.

h. Pulse Rate- The examination of the cardiovascular system is done from the palpation of the radial artery, commonly called the pulse. The Radial artery is palpated with the tips of three fingers compressing the vessel against the head of radius bone.The index finger (toward the heart) varies the pressure on the artery, the middle finger feels the pulse, while the distal finger prevents reflections of pulsations from the palmer arch of arteries.The normal pulse rate at rest averages about 72/min.

i. Blood Pressure- The vascular system is “overfilled” with the blood so that it is slightly stretched by the blood. As a result, the blood exerts an outward lateral force on the inside of the vessels; this force is known as blood pressure. Although blood exerts a force (pressure) throughout the vascular system, the term blood pressure refers to systemic arterial pressure.

Systolic blood pressure- The maximum pressure is reached during the maximum ejection phase of systole and is called the systolic pressure.

Diastolic blood Pressure- It is the minimum pressure reached in the arteries during diastole of the heart, i.e.just before the next systole.

Normal Blood Pressure- 120/ 80 mm of Hg.

5. Description and explanation of the procedures:

5.A. NadishodhanaPranayama to be practiced for 10 weeks.

Take the breathe or Prana first with left nadi that is Ida and release it from right nadi that is Pingala. Then breath is taken from right nadi that is Pingala and release it via left Nadi that is Ida. By doing this for more than three months, Nadishodhana is done.

प्राणंचेदिड्या पिवेन्नियमितं भूयोऽन्यया रेचयेत्पीत्वा।

पिंगलया समीरणमथो बद्ध्वात्यजेद्वामया ।

सूर्या चन्द्रमसोरनेन विधिनाभ्यासं सदातन्वतां

शुद्धानाडिगणा भवन्ति यमिनां मासत्रयादूर्ध्वतः ।।१० हठ्योग प्रदीपिकाद्वितीय उपदेश

With the help of the above verse, the NadishodhanaPranayama exercise has been designed.

a. NadishodhanaPranayama should be practiced empty stomach in the morning. Hot tea, coffee or milk can be permitted before half an hour.

b. The subject was asked to attain the Siddhasana with Dhyanmudra.

c. The subject was asked to keep his vertebral column straight. Head and neck in line with the column and the shoulder and the back stretched, Chin tipped slightly downwards.

d. The Facial muscles to be relaxed and eyes to be gently closed.

e. The thumb and ring finger of the right hand to be used for the process of the Pranayama. Thumb for closing right nostril and ring finger for left nostril.

f. First, right nostril to be closed with the thumb and deep and slow inhalation to be done with the left nostril.

g. Then immediately left nostril to be closed with the ring finger and slow and complete exhalation to be done with the right nostril.

h. Immediately inhale with the same nostril in the same manner and exhale through the left nostril.

i. This pair of inhalation and exhalation makes one avartana.

j. One normal breathe to be taken after every avartana.

Gradually increase the time duration of Inhalation and Exhalation.

k. 10 such repetitions had been practiced every day.

l. Total duration of exercise was 10 weeks.

m. This Pranayama is irrespective of Asana siddhi.

5.B. SOPs For Assessment Parameters

5.B.1. **Chest expansion-circumference of the chest**

1. A verbal consent of volunteer was taken.
2. The subject was asked to stand upright with a relaxed mind.
3. The measuring tape was held just below the level of nipples.
4. The subject was asked to exhale completely (deflated chest) and the reading was taken as 1.
5. An individual was now asked to inhale as much as possible and again circumference was taken (inflated chest) and recorded as reading 2
6. The difference between reading 2 and reading 1 was recorded.
7. The procedure was repeated for 3 times and mean of the difference was calculated.

Normal chest expands by 4 to 8 cm after deep inspiration.

5.B.2. 40 mm Hg Test-

1. The subject was asked to sit on a chair with a straight vertebral column.

2 .The subject was asked to take a deep breath.

3. Now he was asked to pinch his nostril by himself.

4. Then he was told to exhale into the tube of mercury Sphygmomanometer of Diamond company, raising the mercury to 40 mm level, and to keep there as long as possible.

5. At this stage by using stop watch the reading was taken.

6. The procedure was repeated for 3 times and mean was drawn.

Normal value - 30 to 40 sec.

5.B.3. Snider's Test-

1. The subject was asked to stand in upright position.
2. A burning match stick was held in front of his/her face.
3. The subject was now asked to blow out.
4. The distance at which he can blow successfully was measured.

The normal distance is 12 inches.

5.B.4. Peakflowmetry-

1 .The subject was asked to stand in upright position.

2. The mouthpiece was inserted into the Peakflowmeter and the pointer was moved to the zero end of the slot

3. The subject was asked to sit in a straight position.

4. Now he was asked to take a deep breath as possible.

5. Now he was asked to hold the meter lightly so that he did not obstruct the slot or the holes.

6. The individual was now asked to inhale as much as air possible and blow out forcefully into the Peakflowmeter

7. The displacement of the rider was noted.

8. The procedure was repeated for 3 times

9 .Every time the indicator was brought to zero by pressing the button located near the mouthpiece.

9. The highest value of the displacement was noted.

Normal Range- 350 to 500 lits/min

5.B.5. Vyayamshakti

In this study, Vyayamashakti of individual is decided by doing simple exercise of skipping .

1. Pulse rate and respiratory rate of a person is taken before the exercise.
2. The skipping exercise is done till heart rate increases.
3. Again the pulse rate and respiratory rate is measured.
4. The pulse rate and respiratory rate are measured after 2 minutes time interval.
5. The time required for regaining the original pulse rate and respiratory rate is noted.

a. Upto 3 mins for regaining-UttamVyayamshakti
b. Upto 6 mins for regaining –MadhyamVyayamshakti

c. Above 6 mins for regaining –AlpaVyayamashakti

5.B.6. Recording the Pulse Rate

1. The volunteer was asked to sit in a chair.
2. The subject's forearm should be slightly pronated and the wrist slightly flexed.
3. The radial artery is palpated with the tips of three fingers compressing the vessel against the head of radius bone.
4. The index finger varies the pressure on the artery, the middle finger feels the pulse, while the distal finger prevents reflexions of pulsation from the palmer arch of arteries.
5. The normal pulse rate at rest averages about 72/min. The rate is normally higher in children (90-110/min) and slower in old age (55-65/min.)

5.B7. Recording of Blood Pressure

1. Make the subject lie supine and allow 5 min. for mental and physical relaxation.
2. Open the lid of the apparatus. Release the lock on the mercury reservoir and check that the mercury is at the zero level.
3. Place the cuff around the upper arm, with the centre of the bag lying over the brachial artery. The cuff should neither be too tight nor very loose.
4. Place the chest piece of the stethoscope on the cubital space at the bifurcation of the brachial artery.
5. Inflate the cuff rapidly, by compressing and releasing the air pump alternately. Raise the pressure above 120 mm Hg.(sounds may be heard as the mercury column goes up.)
6. Lower the pressure gradually until a clear, sharp, tapping sound is heard.
7. The level at which the first sound (clear, sharp) is heard, is taken as the systolic pressure.
8. Continue to lower the pressure and note a change in the character of the sounds.
9. As the pressure falls, the character of the sounds changes, they first become murmurish, then clear and banging, until they suddenly become muffled and disappear.
10. The pressure at which the sounds become muffled marks the diastolic pressure.

Normal range (young adults)

Systolic blood pressure= 100-140 mm of Hg

Diastolic blood pressure=60-80 mm of Hg.

6. Preparation ofProforma(CRF):

तस्मादातुरं परीक्षेत प्रकृतितश्च, विकृतितश्च, सारतश्च, संहननतश्च, प्रमाणतश्च, सात्म्यतश्च, सत्त्वतश्च, आहारशक्तितश्च, व्यायामशक्तितश्च, वयस्तश्चेति, बलप्रमाणविशेषग्रहणहेतोः।। च.वि. ८-९४

A specialised case paper was designed to collect all the clinical data of the volunteers. It is attached as Annexure 2.

7. Description of Independant variables and Dependant variables:

A. Independent variables:

1. Age

2. Gender

3. Rutu

4. DoshaPrakriti

5. Vyayamshakti

B. Dependant variables:

Parameters to measure Bala of Ucchwasa of UdanaVayu are dependent variables.

1. Chest expansion
2. 40 mm of Hg test
3. Snider test
4. Peakflowmetry
5. Pulse rate
6. Systolic Blood Pressure
7. Diastolic Blood Pressure

8. Inclusion and Exclusion criteria:

I. Criteria for Inclusion -

1. Volunteers apparently healthy.

2. Subjects of the age group of 18 to 40 years.

3. Subjects of both genders in equal numbers .

II. Criteria for exclusion-

1. Subjects of known case of any major illness like Diabetis, Hypertension, Asthma
.

2. Subjects of known case of any disease of respiratory system like Nasal polyps, DNS, Allergic rhinitis, Sinusitis, Asthma..

3. Subjects of known case of any major illness of the lungs like Tuberculosis, Pulmonary fibrosis.
4. Subjects of known case of any type of physical debility.
5. Subjects practising any type of breathing exercises regularly.
6. Subjects of known case of severe pain in abdomen, enlarged liver, delicate bowel.
7. Subjects of known case of abnormality of chest wall.

9. Calibration, validation and standardisation of the instruments and equipments:

A. **Peak flow meter/Pulmometer** made in association with FyneDyanamics Ltd., England Medicare equipment pvt Ltd Design no 2100423 Regd in ENGLAND, range 60 to 800 Lit/min (WRIGHTS SCALE) Peak Expiratory Flow Rate (PEFR)

The Peakflowmeter is a short cylinder made of plastic material. An indicator(pointer) moves in a slot alongside a scale with numbers on it which indicates litres/min.There is a handle provided near the mouthpiece. The end, opposite the mouthpiece, has holes in it for flowing air to exit from the apparatus.

Definition-The peak expiratory flow rate(PEFR) is the maximum or peak rate (or velocity),in litres per minute, with which air is expelled with maximum force after a deep inspiration.


EU
800
700
650
600
550
500
450
400
350
300
250
200
150
100
60
L/Min
EN
13826

B**. Sphygmomanometer-** Diamond company, standard type mercury manometer for 40 mm Hg test.

C. Match Box- Cycle brand match box for Snider's Test

10. Measures if any for preventing, controlling or minimizing errors: The readings have been taken for 3 times and average is drawn which has been considered as final reading.

11. Statistical component: To compare the results within a group (intra group) before and after doing NadishodhanaPranayama exercise, the paired t test and for comparison between study and control group (inter group) Z test has been applied.

12. Time utilisation calendar

1. Date of registration for Ph.D. - 25-04-2012

2. Duration for preparation of the study title & study protocol, in order to formulate the synopsis: 2 months

3. Date of submission of synopsis to the institutional ethics committee: 14-2-2012

4. Date of approval of the synopsis by institutional ethics committee: 25-04-2012

5. Date of approval of the synopsis: 25-04-2012

6. Date from which, the actual work started: 30-04-2012

7. Time was required per procedure: 30 mins

8. Time required for compilation and analysis: 1 and ½ yr

9. Total duration: 4 years

13. Study design

Plan of work

1. A specialized case paper is designed on the basis of data collected from literature search.
2. The study was conducted in batches of 60 at a time, of which 30 were included in study group and 30 were included in control group, randomly, with equal distribution of male and female genders (15 each)
3. This was repeated for 6 batches, so that there were 360 subjects included in this study.
4. All the included subjects had been signed the ICF in the prescribed format. (enclosed)
5. All the vital information, and information regarding Ucchwasbala was entered in case paper, by elicitation of following parameters.

a. Chest expansion for maximum capacity of lungs.
b. 40 mm Hg test for breath holding capacity.
c. Snider's test for power of generating force during expiration.
d. Peakflowmetry for assessment of forcefulness of expiration.

6. Group A individuals were subjected to NadishodhanaPranayama exercise as per protocol, daily for 10 weeks.

7. The NadishodhanaPranayama exercise was conducted daily in the morning, under the investigators observation.

8. There was one weekly off on Sunday.

9. Training was given first and then actual study was started.

10. Everyday 10 avartanas was practiced at a time.

11. Due to any personal, social or health problem, a maximum break of three consecutive days in the practice was tolerated, only once in the course. Otherwise the subject was not considered for final evaluation.

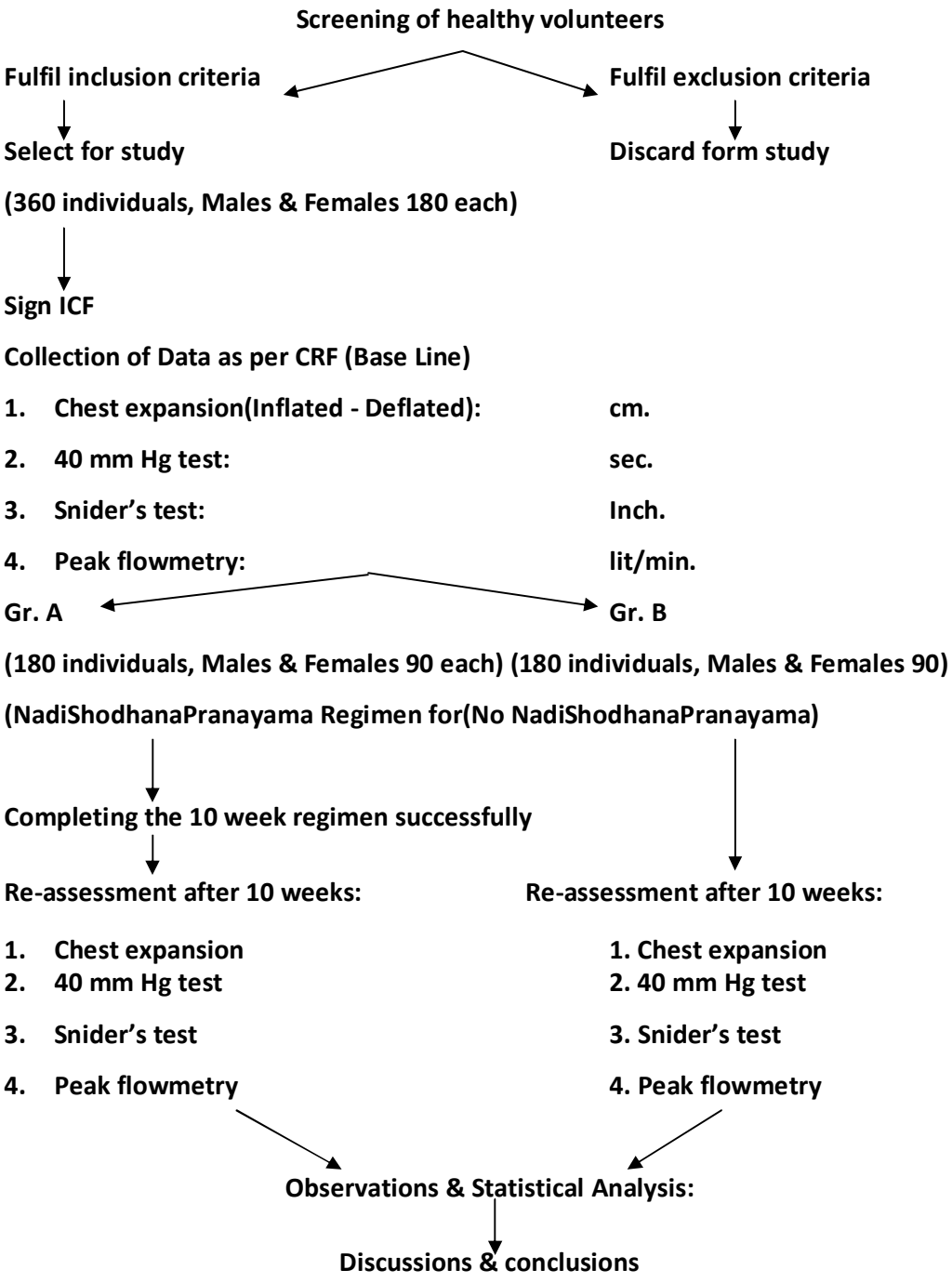
12. Group B individuals were not subjected to NadishodhanaPranayama.

13. At the end of 10 weeks, all the parameters were evaluated again.

14. The increase of more than 15% in the initial readings of any of the said parameters was considered as positive results.

15.In case proforma, rutu has been noted at that particular time of exercise and from the collected data, effect on ucchwasa karma in different rutus has been separated.

FLOW CHART



OBSERVATIONS

A. In this study, improvement of Uchchhwasakarma of all the subjects was assessed with 4 clinical parameters, viz.

1. Chest expansion
2. 40 mm Hg test
3. Snider test
4. Peak flow metry.

As described earlier, the increase of more than 15% in the initial readings of any of the said parameters was considered as positive results.

B. The critical assessment of all these parameters was also done in view of

1. Age

2. Gender

3. Rutu

4. Dosha Prakriti

5. Vyayamashakti

6. Pulse Rate

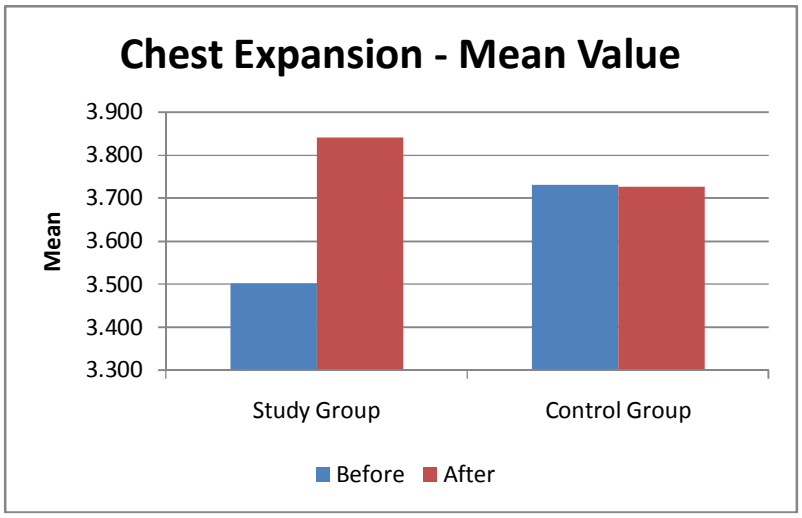
7. Systolic Blood Pressure

8. Diastolic Blood Pressure

A. OVERALL ASSESSMENT

1. Chest expansion test:

A. For whole population



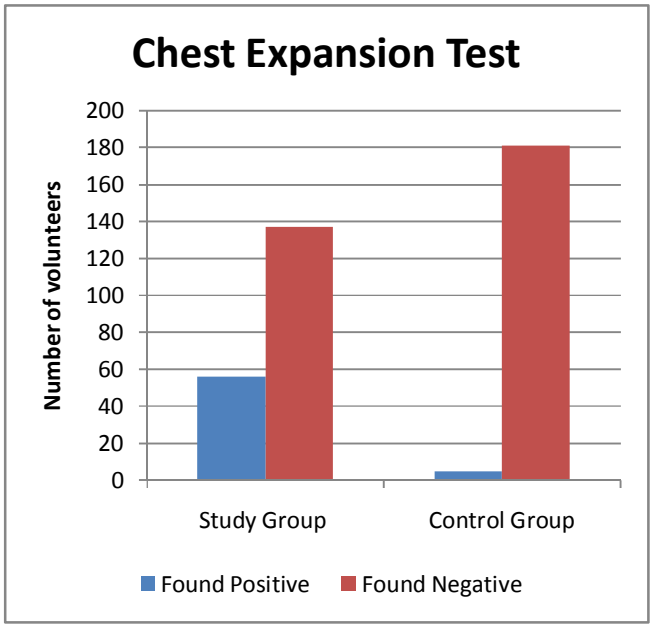
Chest Expansion - Study Group	
Mean Difference	0.338
SD	0.238
SE	0.017
Paired t calculated	19.685

From the above table, it is observed that the t score shows that there is statistically significant improvement in the chest expansion after Nadishodhana Pranayama in study group at 5% significance level.

Chest Expansion – Control Group	
Mean Difference	0.005
SD	0.173
SE	0.013
Paired t calculated	0.423

From the above table, it is observed that the t score shows that there is no statistically significant improvement in the chest expansion control group at 5% significance level.

B. Chest expansion comparison between study & control groups:



Chest Expansion Test	Study Group	Control Group
Found Positive	56	5
Found Negative	137	181
Total	193	186

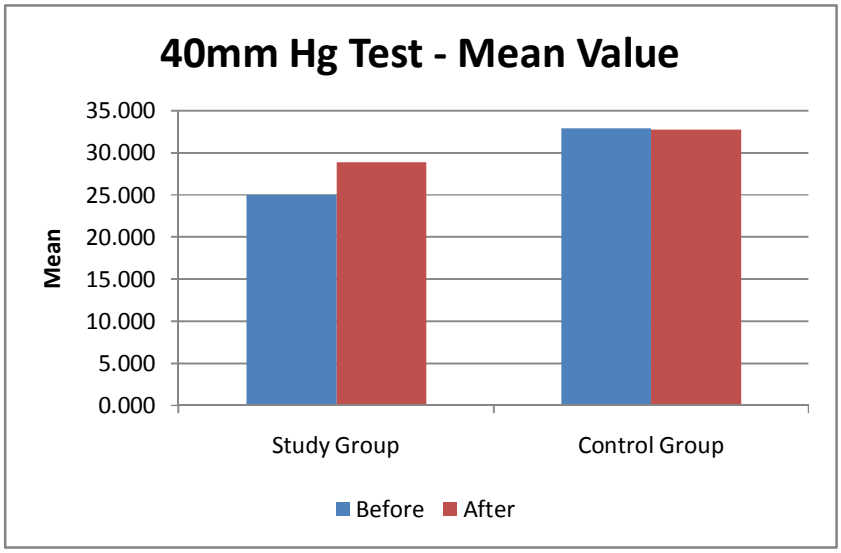
Chest Expansion (%)	Study Group	Control Group
Found Positive	29.016	2.688
Found Negative	70.984	97.312
Total	100.000	100.000

When study & control groups were compared, it was seen that 29% of the population in study group showed improvement as compared to 2.7% of control group.

So Nadishodhana Pranayama shows considerable improvement in chest expansion.

2. **40 mm Hg test:**

A. **for whole population**



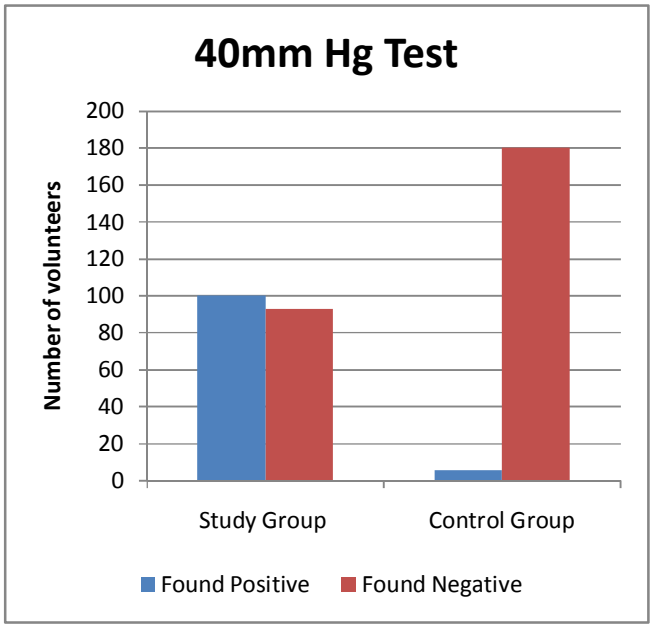
40 mm Hg Test - Study Group	
Mean Difference	3.881
SD	2.044
SE	0.147
Paired t calculated	26.375

From the above table, it is observed that the t score shows that there is statistically significant improvement in the 40 mm Hg test after Nadishodhana Pranayama in study group at 5% significance level.

40 mm Hg Test – Control Group	
Mean Difference	0.140
SD	1.798
SE	0.132
Paired t calculated	1.060

From the above table, it is observed that the t score shows that there is no statistically significant improvement in the 40 mm Hg test of Control group at 5% significance level.

B. **40 mm Hg test comparison between study & control groups:**



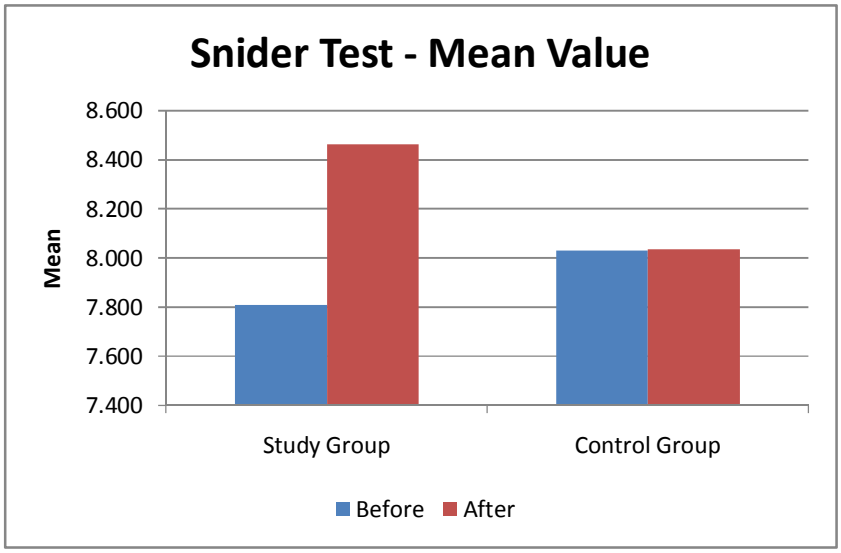
40 mm Hg Test	Study Group	Control Group
Found Positive	100	6
Found Negative	93	180
Total	193	186

40 mm Hg Test (%)	Study Group	Control Group
Found Positive	51.813	3.226
Found Negative	48.187	96.774
Total	100.000	100.000

When study & control groups were compared, it was seen that 52% of the population in study group showed improvement as compared to 3.2% of control group. So Nadishodhana Pranayama shows considerable improvement in 40 mm of Hg test.

3. **Snider test:**

A. **for whole population**



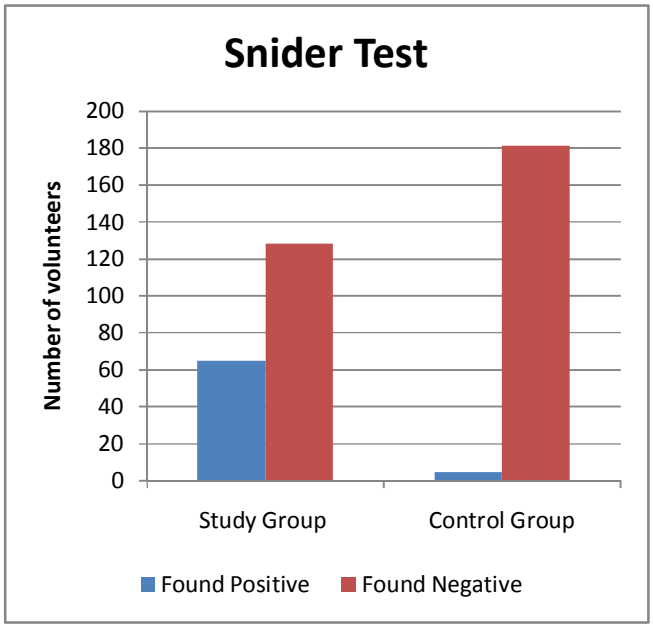
Snider Test - Study Group	
Mean Difference	0.653
SD	0.458
SE	0.033
Paired t calculated	19.827

From the above table, it is observed that the t score shows that there is statistically significant improvement in the Snider test after Nadishodhana Pranayama in study group at 5% significance level.

Snider Test – Control Group	
Mean Difference	0.006
SD	0.267
SE	0.020
Paired t calculated	0.302

From the above table, it is observed that the t score shows that there is no statistically significant improvement in the Snider test of control group at 5% significance level.

B. Snider test comparison between study & control groups:



Snider Test	Study Group	Control Group
Found Positive	65	5
Found Negative	128	181
Total	193	186

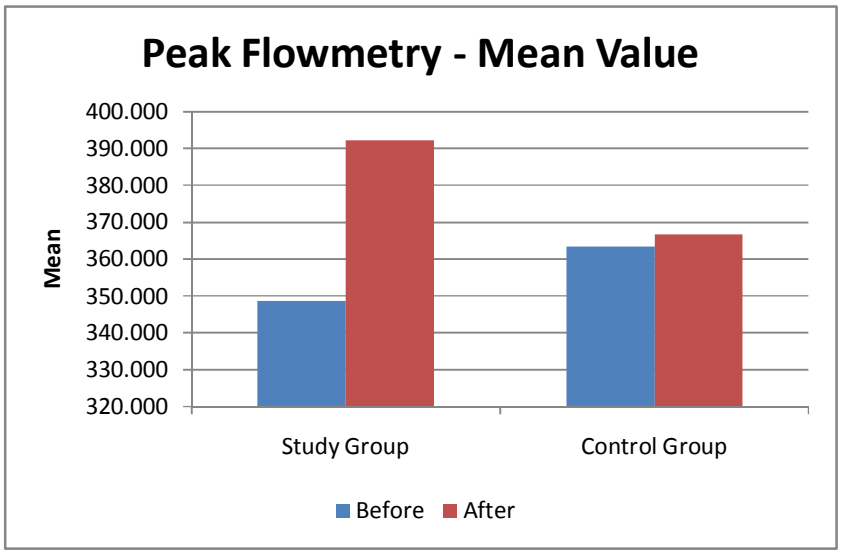
Snider Test (%)	Study Group	Control Group
Found Positive	33.679	2.688
Found Negative	66.321	97.312
Total	100.000	100.000

When study & control groups were compared, it was seen that 34% of the population in study group showed improvement as compared to 2.7% of control

group. So Nadishodhana Pranayama shows considerable improvement in Snider test values.

4. Peak flow metry:

A. for whole population



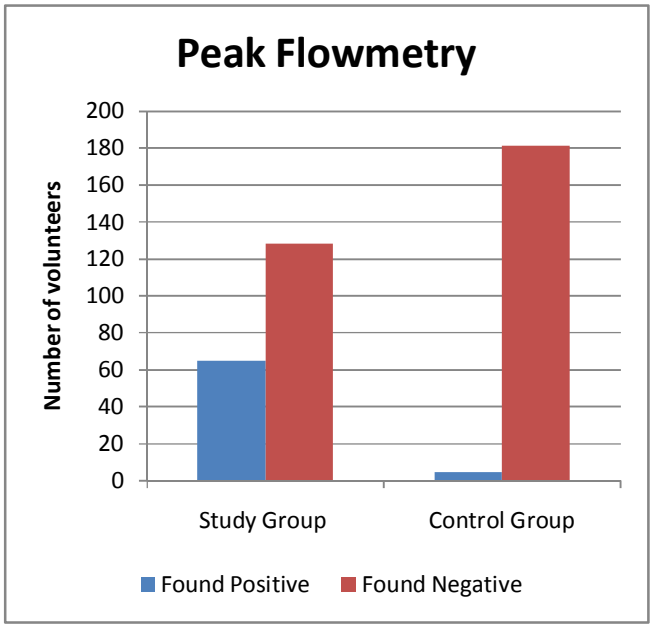
Peak Flowmetry – Study Group	
Mean Difference	43.685
SD	19.117
SE	1.376
Paired t calculated	31.746

From the above table, it is observed that the t score shows that there is statistically significant improvement in Peakflowmetry after Nadishodhana Pranayama in study group at 5% significance level.

Peak Flowmetry – Control Group	
Mean Difference	3.313
SD	13.157
SE	0.965
Paired t calculated	3.435

From the above table, it is observed that the t score shows that there is no statistically significant improvement in Peakflowmetry of control group at 5% significance level.

B.Peakflowmetry comparison between study & control groups:



Peak Flowmetry	Study Group	Control Group
Found Positive	103	9
Found Negative	90	177
Total	193	186

Peak Flowmetry (%)	Study Group	Control Group
Found Positive	53.368	4.839
Found Negative	46.632	95.161
Total	100.000	100.000

When study & control groups were compared, it was seen that 53% of the population in study group showed improvement as compared to 5% of control

group. So Nadishodhana Pranayama shows considerable improvement in Peakflowmetry.

5. **To summarise, Comparison of Control & Study groups:**

The collected data is continuous, randomly selected from the population and independent, **Z test for mean** is applied for comparison of data of study and control groups. This test gives the comparison of objective parameter of the volunteers in study and control groups at the end of study. 5% is the significance level accepted for this research study.

Parameter	Mean Difference	Standard Error	Z score
Chest Expansion	0.343	0.021	15.981
40 mm Hg Test	4.021	0.198	20.301
Snider Test	0.647	0.039	16.733
Peakflowmetry	40.372	1.692	23.865

From the above table, it is observed that the Z score shows significant improvement in all objective parameters of study group as compared to control group at 5% significance level.

B. Critical analysis based on different variables:

Further critical analysis of the results of study group patients is done henceforth, based on different variables, to study the variations in patterns of effect of Nadishodhana Pranayama.

1. **Vaya (Age)**
2. **Linga (Gender)**
3. **Rutu (Season)**
4. **Dosha Prakriti (Constitution)**
5. **Vyayamshakti (Capacity of Exercise)**
6. **Nadi (Pulse Rate)**
7. **Systolic Blood Pressure**
8. **Diastolic Blood Pressure**

1. Age wise results

a. Age group 18-29 yrs

Parameter of Age 18 to 29 yrs	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.404	0.029	13.724
40 mm Hg test	4.597	0.252	18.256
Snider test	0.693	0.054	12.844
Peak Flowmetry	41.641	2.341	17.788

From the above table, it is observed that the unpaired t score shows there is significant improvement in all parameters in the age group of 18 to 29 yrs. of study group as compared to control group at 5% significance level.

Unpaired t score of 40 mm Hg test in the study group of person having age group from 18 to 29 years is 18.25, of Peakflowmetry is 17.78, of Chest expansion is 13.72 and of Snider test is 12.84.

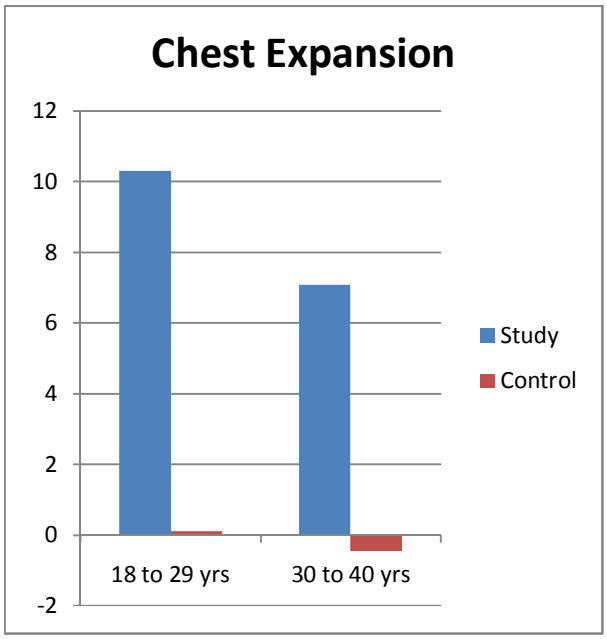
b. Age group 30-40 yrs:

Parameter of Age 30 to 40 yrs	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.260	0.028	9.291
40 mm Hg test	3.235	0.289	11.177
Snider test	0.583	0.052	11.227
Peak Flowmetry	38.553	2.334	16.516

From the above table, it is observed that the unpaired t score shows there is significant improvement in all parameters in the age group of 30 to 40 yrs. of study group as compared to control group at 5% significance level.

It is clear that all the parameters have shown good improvement in both the age groups. In an attempt to make a further critical observation, the percent improvement of all four parameters in both the age groups was calculated & the age groups were compared.

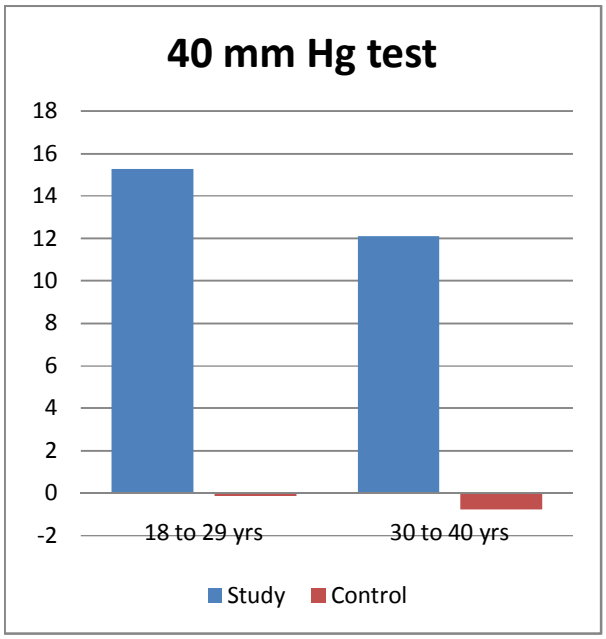
1. Age groups & Chest expansion:



% Improvement in Chest Expansion	18 to 29 yrs	30 to 40 yrs
Study	10.300136	7.071783937
Control	0.1022234	-0.461893764

It can be seen that lower age group individuals have shown better improvement in chest expansion, as compared with older age group.

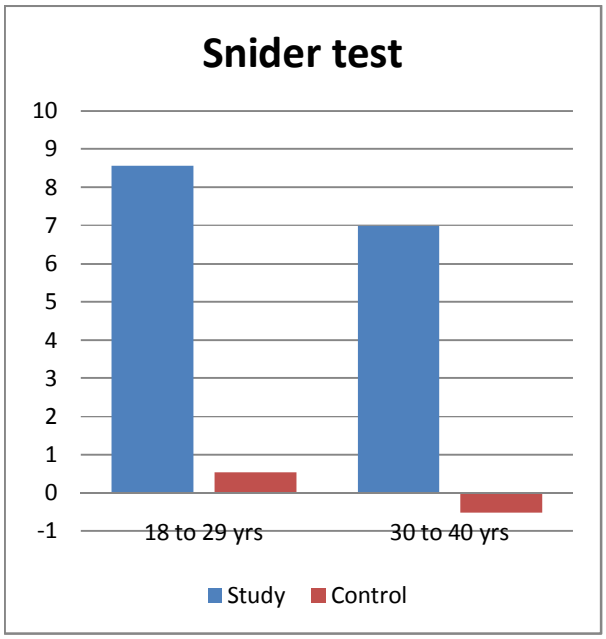
2. Age groups & 40 mm of Hg:



% Improvement in 40 mm Hg test	18 to 29 yrs	30 to 40 yrs
Study	15.25219	12.07323
Control	-0.14447	-0.79275

It can be seen that lower age group individuals have shown better improvement in 40 mm of Hg test, as compared with older age group.

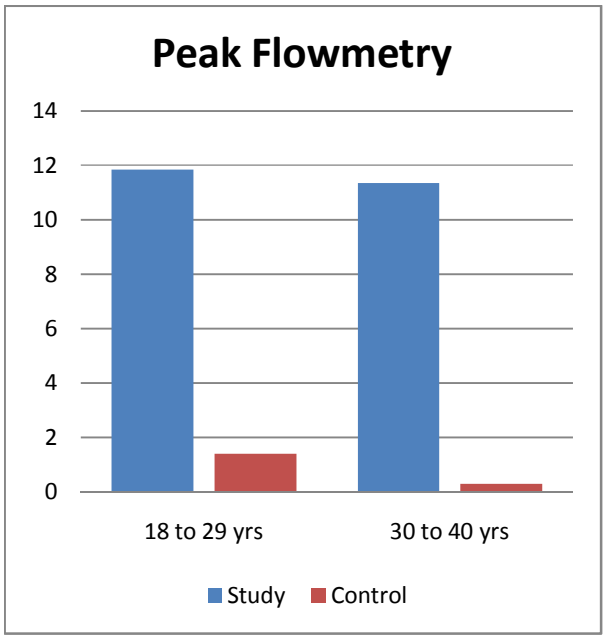
3. Age groups & Snider test:



% Improvement in Snider test	18 to 29 yrs	30 to 40 yrs
Study	8.557662	7.00205
Control	0.535651	-0.5168

It can be seen that, there is not much significant difference in Snider test in lower age group & older age group individuals.

4. Age groups & Peakflowmetry:



% Improvement in Peak Flowmetry	18 to 29 yrs	30 to 40 yrs
Study	11.82824	11.34676
Control	1.394189	0.276619

It can be seen that, there is not much significant difference in Peakflowmetry in lower age group & older age group individuals.

All the justifications behind these observations will be discussed in next chapter.

2. Gender wise results

a. Male gender:

Parameter – Gender – Male	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.345	0.031	11.125
40 mm Hg test	4.245	0.287	14.786
Snider test	0.575	0.056	10.327
Peak Flowmetry	39.462	2.439	16.180

From the above table, it is observed that the unpaired t score shows there is significant improvement in all parameters in male of study group as compared to control group at 5% significance level.

Unpaired t score of Male gender study group for Peakflowmetry is 16.18, for 40 mm Hg test 14.78, for Chest expansion is 11.12 and for Snider test is 10.32.

Peakflowmetry and 40 mm Hg test have shown good improvement in this group amongst the four respiratory tests.

b. Female gender:

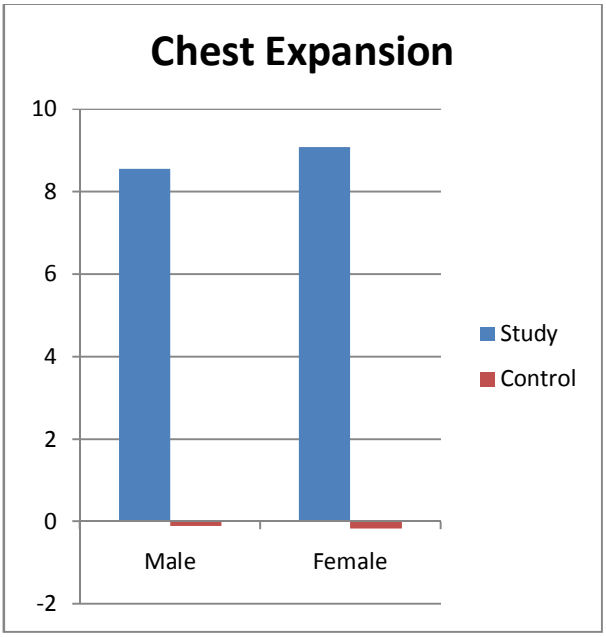
Parameter: Gender – Female	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.341	0.030	11.448
40 mm Hg test	3.623	0.266	13.629
Snider test	0.709	0.053	13.394
Peak Flowmetry	41.570	2.316	17.950

From the above table, it is observed that the unpaired t score shows there is significant improvement in all parameters in female of study group as compared to control group at 5% significance level.

Unpaired t score of Female gender group of study group for Peakflowmetry is 17.95, for 40 mm Hg test is 13.62, for Snider test is 13.39 and for Chest expansion is 11.44. **Peakflowmetry** has shown highest improvement amongst the four tests.

c. **Comparison between two genders:** It is clear that all the parameters have shown good improvement in both the genders. In an attempt to make a further critical observation, the percent improvement of all 4 parameters in both the genders was calculated & compared.

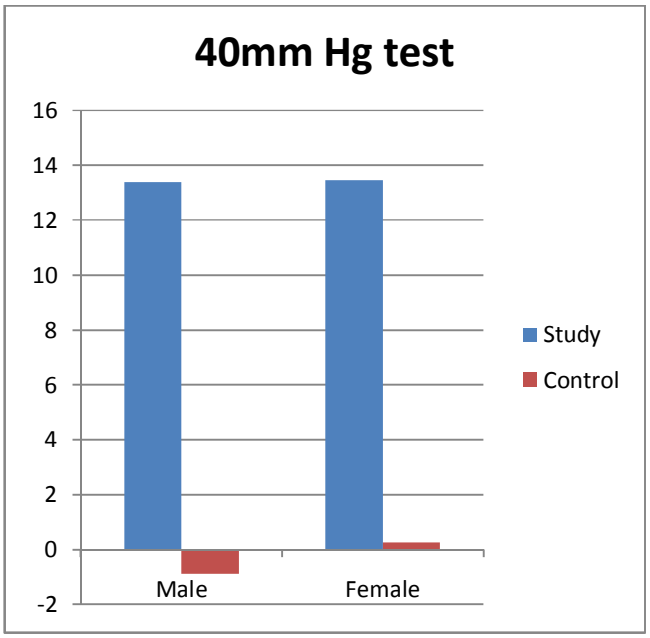
1. Gender & chest expansion:



% Improvement in Chest Expansion	Male	Female
Study	8.5527966	9.082944
Control	-0.1109878	-0.1804

On gender wise evaluation, it can be seen that there is no much significant difference in Chest expansion in males & females.

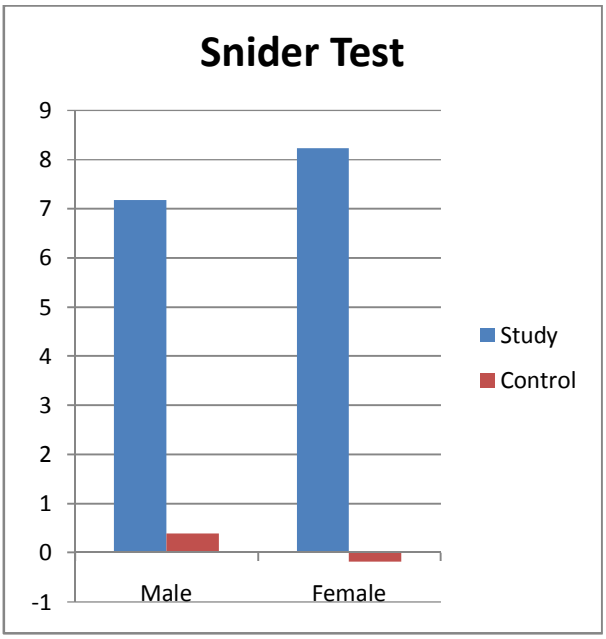
2. Gender & 40 mm of Hg test:



% Improvement in 40mm Hg test	Male	Female
Study	13.38028	13.45853
Control	-0.89186	0.244927

On gender wise evaluation, it can be seen that there is no much significant difference in 40 mm of Hg test in males & females.

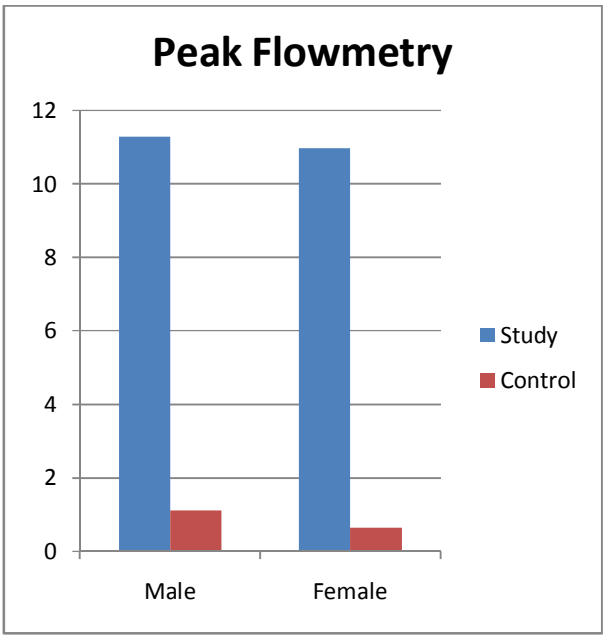
3. Gender & Snider test:



% Improvement in Snider test	Male	Female
Study	7.181136	8.230348
Control	0.395738	-0.17801

On gender wise evaluation, it can be seen that there is no much significant difference in Snider Test, in males & females.

4. Gender & Peakflowmetry:



% Improvement in Peak Flowmetry	Male	Female
Study	11.28291	10.96584
Control	1.116183	0.636435

On gender wise evaluation, it can be seen that there is no much significant difference in Peakflowmetry in males & females.

On gender wise evaluation, it can be seen that there is no much significant difference in any of the parameters in males & females.

All the justifications behind these observations will be discussed in next chapter.

5. Season (Rutu) wise results:

a. Shishir

Parameter	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.403	0.034	11.720
40 mm Hg test	4.308	0.371	11.615
Snider test	0.634	0.093	6.798
Peak Flowmetry	33.591	4.741	7.086

From the above table, it has been seen that unpaired t score of individuals in Shishir rutu for Chest expansion is 11.72, for 40 mm Hg test is 11.61, for Peakflowmetry is 7.086 and for Snider test is 6.79.

They have shown statistically significant improvement.

b. Vasant

Parameter	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.502	0.042	12.090
40 mm Hg test	4.422	0.503	8.798
Snider test	0.319	0.066	4.834
Peak Flowmetry	39.175	4.366	8.972

From the above table, it has been seen that, unpaired t score of individuals in Vasant rutu, for Chest expansion is 12.09, for 40 mm Hg test is 8.79, for Peakflowmetry is 8.97 and for Snider test is 4.83.

They have shown statistically significant improvement.

c. Varsha

Parameter	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.290	0.071	4.094
40 mm Hg test	3.397	0.532	6.389
Snider test	0.781	0.095	8.210
Peak Flowmetry	38.185	4.178	9.140

From the above table, it has been observed that unpaired t score of person of Varsha rutu group, for Peakflowmetry is 9.14, for Snider test is 8.21, for 40 mm Hg test is 6.38 and for chest expansion is 4.09.
They have shown statistically significant improvement.

d. Sharad

Parameter	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.340	0.051	6.631
40 mm Hg test	3.929	0.483	8.133
Snider test	0.714	0.107	6.672
Peak Flowmetry	47.073	3.520	13.372

From the above table, unpaired t score of person exercised in Sharad rutu, for Peakflowmetry is 13.37, for 40 mm Hg test is 8.13, for Snider test is 6.67 and for Chest expansion is 6.63.
They have shown statistically significant improvement.

e. Hemant

Parameter	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.325	0.044	7.307
40 mm Hg test	3.994	0.384	10.395
Snider test	0.540	0.076	7.145
Peak Flowmetry	39.008	3.308	11.792

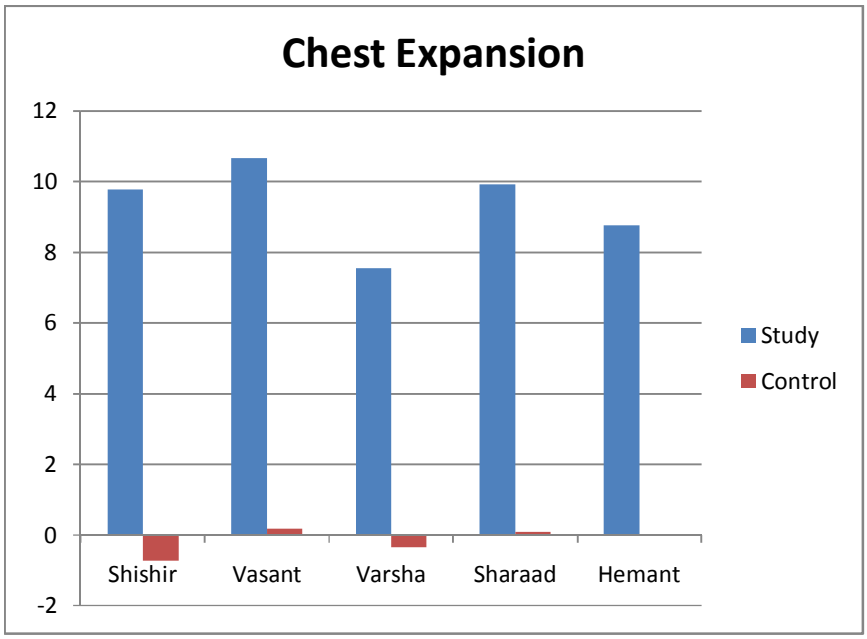
From the above table, unpaired t score of person exercised in Hemant rutu, for Peakflowmetry is 11.79, for 40 mm Hg test is 10.39, for chest expansion is 7.30 and for Snider test is 7.14.

They have shown statistically significant improvement.

It can be seen that the subjects have shown variable responses in various parameters depending on the season of exercise.

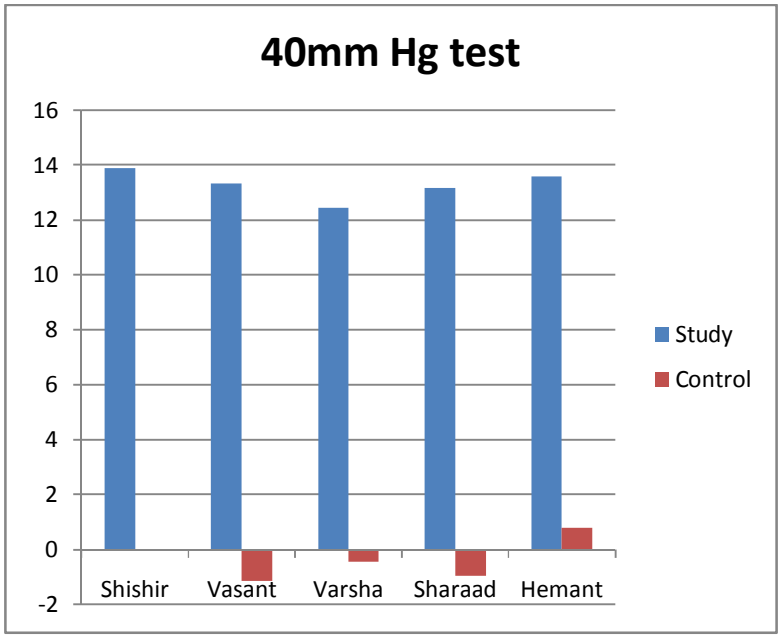
d. **Comparison of results in different rutus:** It is clear that all the parameters have shown good improvement in all the seasons. In an attempt to make a further critical observation, the percent improvement of all four parameters in all the seasons was calculated & compared.

1. Rutu &Chest expansion:



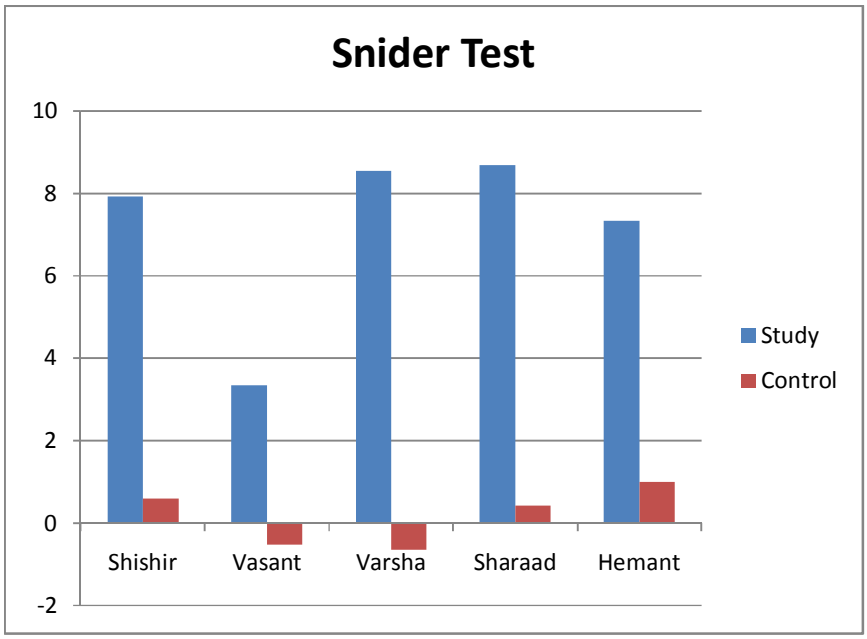
% Improvement in Chest Expansion	Shishir	Vasant	Varsha	Sharaad	Hemant
Study	9.7609562	10.66235864	7.5342466	9.927798	8.756174
Control	-0.7371007	0.164113786	-0.3589375	0.0819	0

2. Rutu & 40 mm of Hg test:



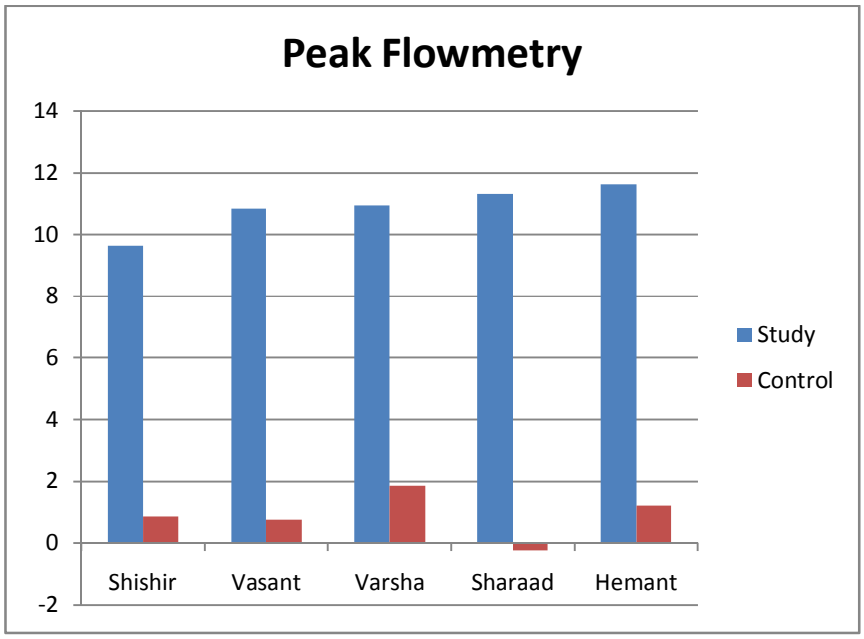
% Improvement in 40 mm Hg test	Shishir	Vasant	Varsha	Sharaad	Hemant
Study	13.87856	13.31658	12.44019	13.14879	13.56651
Control	0	-1.14734	-0.44014	-0.97345	0.78534

3. Rutu & Snider test:



% Improvement in Snider Test	Shishir	Vasant	Varsha	Sharaad	Hemant
Study	7.915921	3.345725	8.537926	8.690909	7.330567
Control	0.581395	-0.51849	-0.66007	0.416667	0.988217

4. Rutu & Peak flowmetry:



% Improvement in Peak Flowmetry	Shishir	Vasant	Varsha	Sharaad	Hemant
Study	9.617384	10.81673	10.92688	11.31007	11.61651
Control	0.869456	0.757238	1.867432	-0.24997	1.21214

Overall observations:

1. **Chest expansion** has shown good improvement in **Vasant & Sharad rutus and** least improvement **in Varsha rutu.**
2. **40 mm of Hg** shows good improvement in **all rutus**.
3. **Snider test** has shown good improvement in **Varsha & Sharad rutu** & least in **Vasant rutu**.
4. **Peakflowmetry** has shown good improvement in **Hemant & Sharad Rutu** & least **in Shishir**.
5. **Sharad Rutu** shows good improvement in **Peakflowmetry, Snider & Chest expansion.**

All the justifications behind these observations will be discussed in next chapter.

e. 4. DoshaPrakriti wise results:

a. VP- Vatapradhan Pittanubandhi Prakriti

Parameter – VataPittaPrakriti	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.334	0.048	6.980
40 mm Hg test	3.573	0.489	7.304
Snider test	0.662	0.092	7.210
PeakFlowmetry	45.418	2.960	15.345

From the above table, it is observed that the unpaired t score shows there is significant improvement in all parameters in VataPittaPrakriti volunteers of study group as compared to control group at 5% significance level.

Unpaired t score of person of Vatapradhan Pittanubandhi Prakriti for Chest expansion is 6.98, for 40 mm Hg test is 7.30, for Snider test is 7.21 and for Peakflowmetry is 15.34. All are statistically significant.

b. PV- Pittapradhan Vatanubandhi Prakriti

Parameter – PittavataPrakriti	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.211	0.054	3.922
40 mm Hg test	3.723	0.490	7.601
Snider test	0.707	0.106	6.685
Peak Flowmetry	36.292	4.662	7.785

From the above table, it is observed that the unpaired t score shows there is significant improvement in all parameters in Pittavata Prakriti volunteers of study group as compared to control group at 5% significance level.

Unpaired t score of Pittapradhan Vatanubandhi Prakriti person for Peakflowmetry is 7.78, for 40 mm Hg test is 7.60, For Snider test is 6.68 and for Chest expansion is 3.92.

All are statistically significant.

c. VK- Vatapradhan Kaphanubandhi Prakriti

Parameter – VataKaphaPrakriti	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.417	0.064	6.483
40mm Hg test	4.581	0.552	8.300
Snider test	0.798	0.111	7.197
Peak Flowmetry	39.436	4.590	8.592

From the above table, it is observed that the unpaired t score shows there is significant improvement in all parameters in VataKaphaPrakriti volunteers of study group as compared to control group at 5% significance level.

Unpaired t score of person of Vatapradhan Kaphanubandhi Prakriti, for Chest expansion is 6.48, for 40 mm Hg test is 8.3, for Snider test is 7.19 and for Peakflowmetry is 8.59.

All are statistically significant.

d. KV-Kaphapradhan Vatanubandhi Prakriti

Parameter Kaphavata Prakriti	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.338	0.071	4.785
40 mm Hg test	4.115	0.482	8.531
Snider test	0.473	0.093	5.080
Peak Flowmetry	37.508	5.871	6.389

From the above table, it is observed that the unpaired t score shows there is significant improvement in volunteers of study group as compared to control group at 5% significance level.

Unpaired t score of Kaphapradhan Vatanubandhi person, for Chest expansion is 4.78.for 40 mm Hg test is 8.53, for Snider test is 5.08 and for Peakflowmetry is 6.38. All are statistically significant.

e. PK- Pittapradhan Kaphanubandhi Prakriti

Parameter – PittaKaphaPrakriti	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.355	0.050	7.103
40mm Hg test	3.993	0.461	8.656
Snider test	0.566	0.083	6.792
Peak Flowmetry	39.513	3.806	10.380

From the above table, it is observed that the unpaired t score shows there is significant improvement in all parameters in PittaKaphaPrakriti volunteers of study group as compared to control group at 5% significance level.

Unpaired t score of person of Pittapradhan Kaphanubandhi Prakriti for Chest expansion is 7.10, for 40 mm Hg test is 8.65, for Snider test is 6.79 and for Peakflowmetry is 10.38.

All are statistically significant.

f. KP- Kaphapradhan Pittanubandhi Prakriti

Parameter – KaphaPittaPrakriti	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.413	0.036	11.369
40 mm Hg test	4.270	0.440	9.712

Snider test	0.690	0.089	7.785
Peak Flowmetry	43.831	3.423	12.805

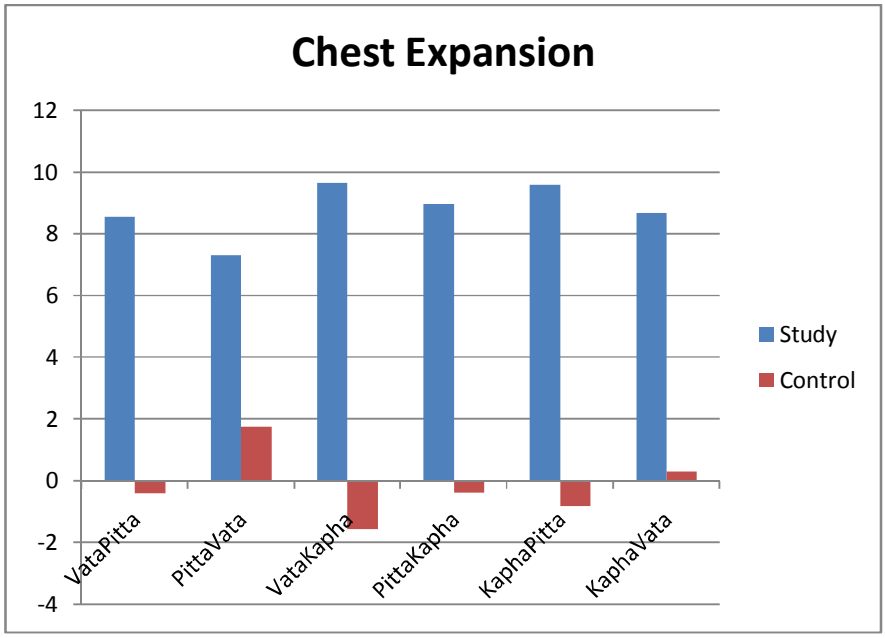
From the above table, it is observed that the unpaired t score shows there is significant improvement in all parameters in KaphaPittaPrakriti volunteers of study group as compared to control group at 5% significance level.

Unpaired t score of person of Kaphapradhan Pittanubandhi Prakriti for Chest expansion is 11.36, for 40 mm Hg test is 9,71, for Snider test is 7.7 and for Peakflowmetry is 12.80.

All are statistically significant.

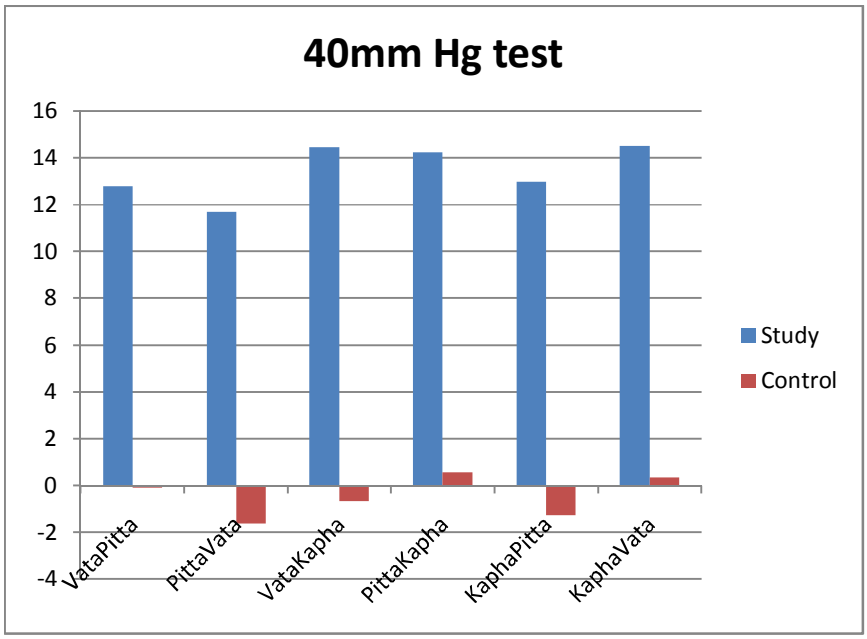
g. **On critical analysis of different Dosha Prakriti, following observations can be made:** It is clear that all the parameters have shown good improvement in all the DoshaPrakritis. In an attempt to make a further critical observation, the percent improvement of all 4 parameters in all the Prakritis was calculated & compared.

1. DoshaPrakriti & Chest expansion:



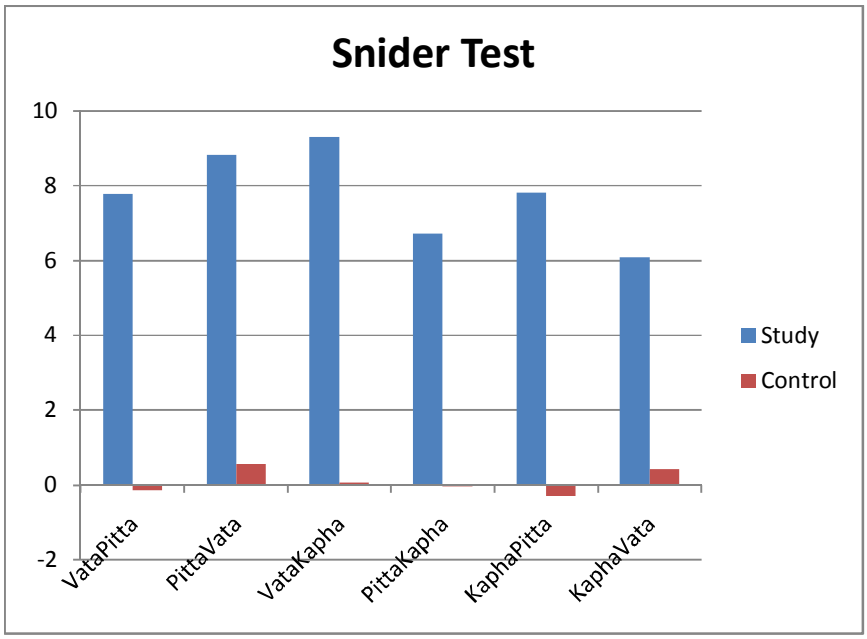
% Improvement in Chest Expansion	VP	PV	VK	PK	KP	KV
Study	8.544087	7.30593	9.642147	8.968307	9.589041	8.666667
Control	-0.398803	1.73611	-1.56695	-0.37618	-0.81411	0.298805

6. Dosha Prakriti & 40 mm of Hg test:



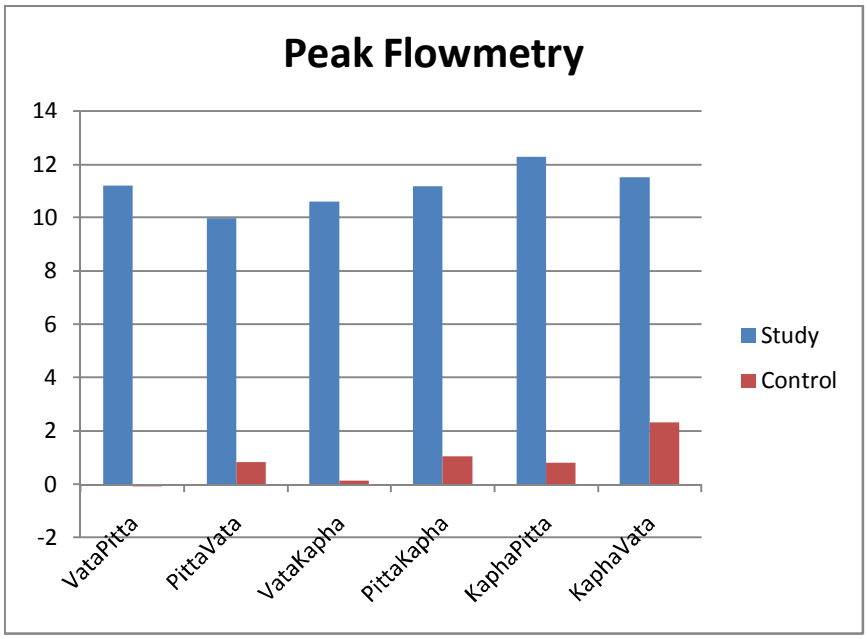
% Improvement in 40 mm Hg test	VP	PV	VK	PK	KP	KV
Study	12.77778	11.69811	14.42543	14.2358	12.97242	14.49275
Control	-0.10905	-1.6178	-0.65253	0.57020	-1.25294	0.337079

7. Dosha Prakriti & Snider test:



% Improvement in Snider test	VP	PV	VK	PK	KP	KV
Study	7.777097	8.829486	9.297344	6.721662	7.809727	6.074551
Control	-0.12987	0.562701	0.06502	-0.02923	-0.29268	0.425733

4.Dosha Prakriti & Peakflowmetry:



% Improvement in Peak Flowmetry	VP	PV	VK	PK	KP	KV
Study	11.18367	9.963871	10.58949	11.1644	12.25374	11.50183
Control	-0.06842	0.838652	0.141983	1.047881	0.828074	2.321726

Overall observations:

1. Chest expansion has shown good improvement in **Vata-Kapha & Kapha-Pitta** & least **in Pitta-Vata Prakriti**.
2. 40 mm Hg test has shown good improvement in **Kapha-Vata & Vata-Kapha** & least **in Pitta-Vata individuals**.
3. Snider Test has shown good improvement in **Vata-Kapha & Pitta-vata** individuals, & least in **Kapha-Vata** individuals.
4. Peakflowmetry has shown good improvement in **Kapha-Pitta & Kapha-Vata** individuals & least in **Pitta-Vata** individuals.
5. **Pitta-Vata** individuals have shown least improvement in all parameters **except Snider** test.

All the justifications behind these observations will be discussed in next chapter.

5. Vyayamshakti-wise results:

a. **Uttama Vyayamashakti:**

Parameter Uttam Vyayam	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.4391	0.0452	9.7200
40mm Hg test	4.7427	0.3405	13.9286
Snider test	0.6502	0.0798	8.1499
Peak Flowmetry	45.0874	3.7844	11.9141

From the above table, it is observed that the unpaired t score shows there is significant improvement in all the parameters of volunteers of study group as compared to control group at 5% significance level.

Unpaired t score of volunteers having Uttam Vyayamshakti for Chest expansion is 9.7, for 40 mm hg test is 13.92, for Snider test is 8.14 and for Peakflowmetry is 11.91.

All are statistically significant.

b. **Madhyama Vyayamashakti:**

Parameter Madhyam Vyayam	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.3343	0.0298	11.2027
40mm Hg test	3.9410	0.2802	14.0649
Snider test	0.6338	0.0537	11.7928
Peak Flowmetry	41.0283	2.3064	17.7892

From the above table, it is observed that the unpaired t score shows there is significant improvement in all parameters of volunteers having Madhyam Vyayamshakti
of study group as compared to control group at 5% significance level.
Unpaired t score of Madhyam Vyayamshakti volunteers of study group for Chest expansion is 11.20, for 40 mm Hg test is 14.06, for Snider test is 11.79 and for Peakflowmetry is 17.78.
All are statistically significant.

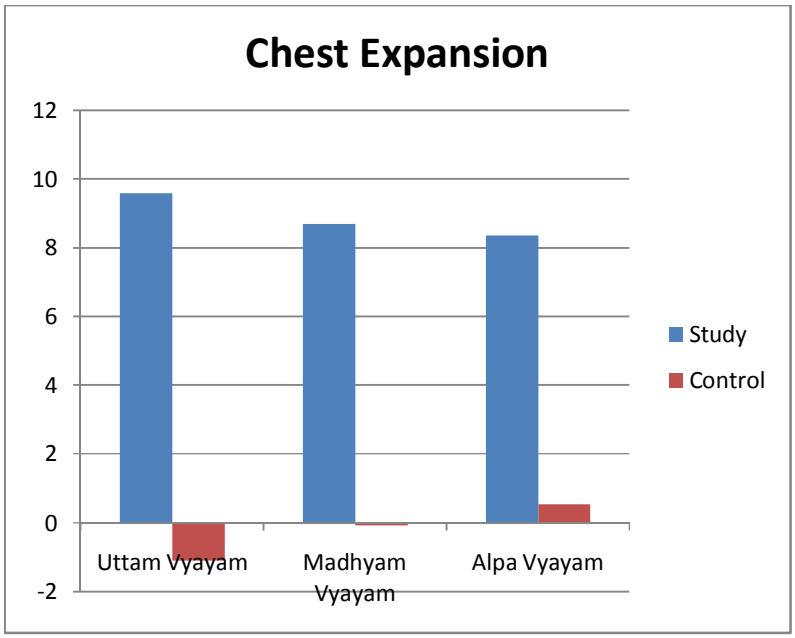
c. **Alpa Vyayama:**

Parameter Alpa Vyayam	Mean Difference	Standard Error	Unpaired t score
Chest Expansion	0.2836	0.0424	6.6966
40mm Hg test	3.6545	0.4183	8.7363
Snider test	0.6802	0.0796	8.5415
Peak Flowmetry	36.4958	2.7893	13.0841

From the above table, it is observed that the unpaired t score shows there is significant improvement in all the parameters of volunteers having Alpa Vyayamashakti of study group as compared to control group at 5% significance level.
Unpaired t score of Alpa vyayamshakti volunteers of study group for Chest expansion is 6.69, for 40 mm hg test is 8.73, for Snider test is 8.54 and for Peakflowmetry is 13.08.
All are statistically significant.

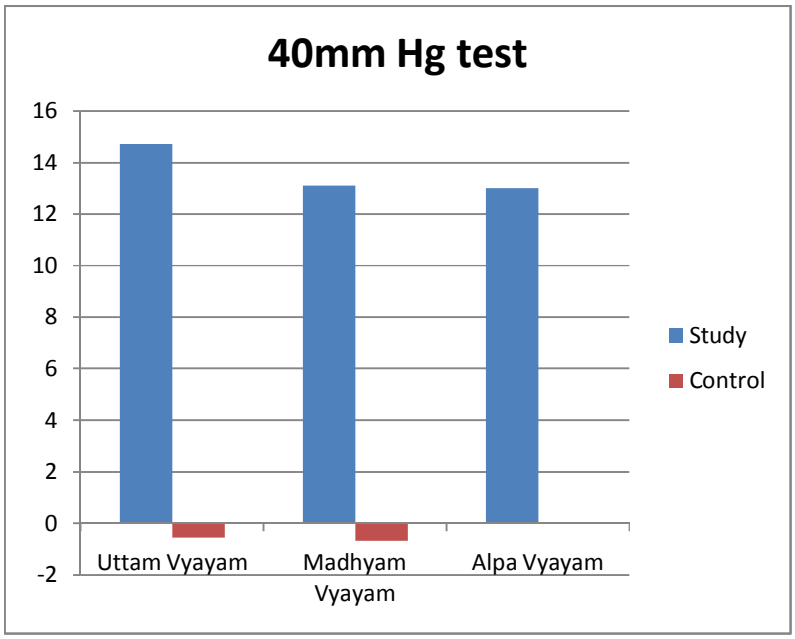
It is clear that all the parameters have shown good improvement in all the Vyayamashaktis. In an attempt to make a further critical observation, the percent improvement of all four parameters in all the three Vyayamashaktis was calculated & compared.

1. Vyayamashakti & Chest expansion:



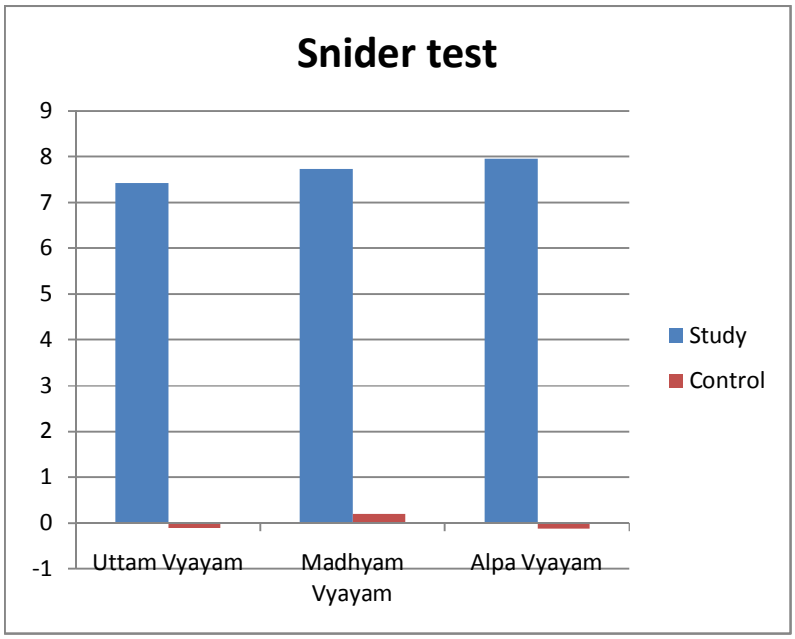
% Improvement in Chest Expansion	UttamVyayam	MadhyamVyayam	AlpaVyayam
Study	9.5756881	8.676671	8.341658
Control	-1.0848756	-0.08208	0.5386

2. Vyayamashakti & 40 mm of Hg test:



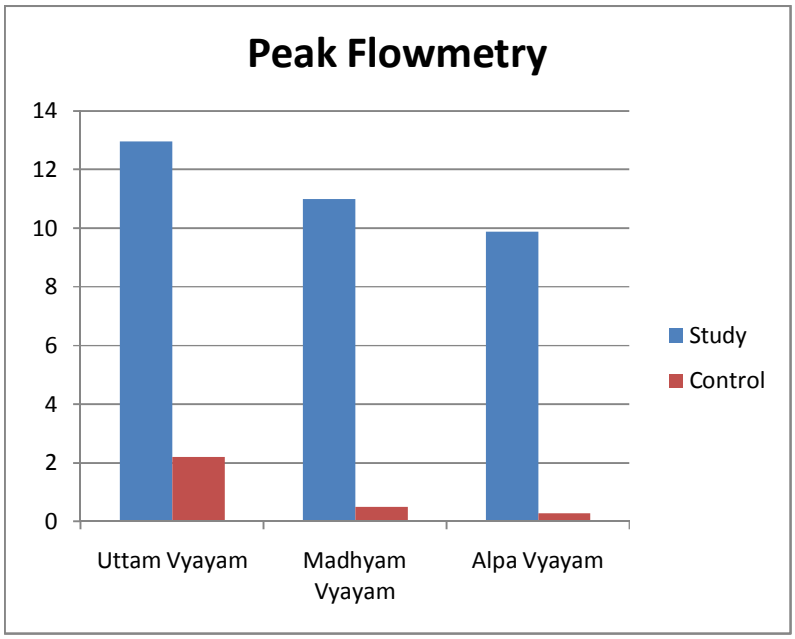
% Improvement in 40mm Hg test	UttamVyayam	MadhyamVyayam	AlpaVyayam
Study	14.714946	13.07213	12.99289
Control	-0.571837	-0.68901	0

3. Vyayamashakti & Snider test:



% Improvement in Snider test	UttamVyayam	MadhyamVyayam	AlpaVyayam
Study	7.4227373	7.727554	7.943017
Control	-0.1196888	0.202148	-0.13862

4. Vyayamashakti & Peakflowmetry:



% Improvement in Peak Flowmetry	UttamVyayam	MadhyamVyayam	AlpaVyayam
Study	12.956189	10.99395	9.883771
Control	2.2000572	0.49834	0.287628

Overall observations:

1. **Chest expansion** has shown good improvement **in Uttama Vyayamshakti** individuals & least in **Alpa vyayamshakti** individuals.
2. **40 mm Hg test** has shown good improvement in **Uttam vyayamshakti** individuals & least in **Alpa vyayamshakti** individuals.
3. **Snider Test** has shown good improvement in **Alpa vyayamshakti** individuals, & least **in Uttam vyayamshakti** individuals.
4. **Peakflowmetry** has shown good improvement in **Uttam vyayamshakti** individuals & least in **Alpa vyayamshakti** individuals.

6. Effect on Pulse Rate:

Within the group – Study Group

H_0 : Nadishodhana Pranayama conducted in study group gives no significant result in selected objective parameter.

i.e. H_0 (Null Hypothesis):

Mean of objective parameter (Before) = Mean of objective parameter (After)

H_1 : Nadishodhana Pranayama conducted in study group gives significant result in selected objective parameter.

i.e. H_1 (Alternative Hypothesis):

Mean of objective parameter (Before) ≠ Mean of objective parameter (After)

Within the group – Control Group

All the volunteers are under daily schedule without *Nadishodhana Pranayama.*

H_0 : Volunteer of the control *group* gives no significant result in selected objective parameter.

i.e. H_0 (Null Hypothesis):

Mean of objective parameter (Before) = Mean of objective parameter (After)

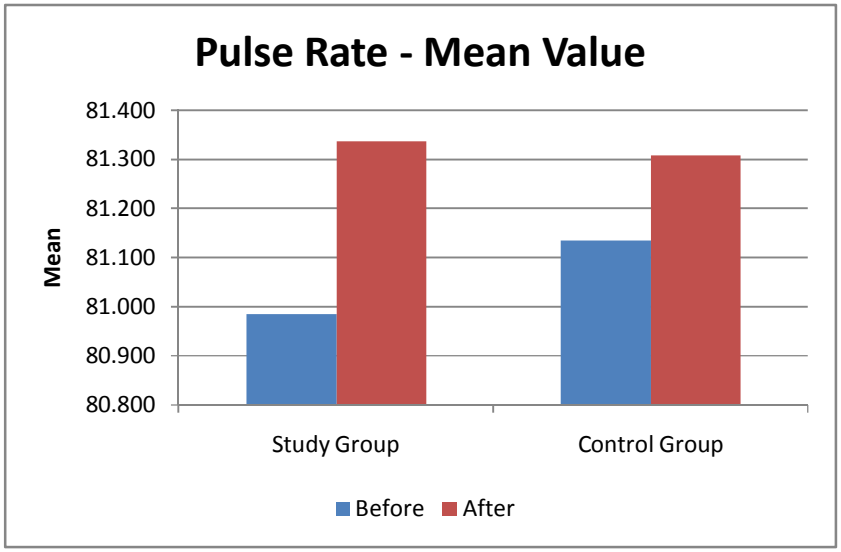
H_1 : Volunteer of the control *group* gives significant result in selected objective parameter.

i.e. H_1 (Alternative Hypothesis):

Mean of objective parameter (Before) ≠ Mean of objective parameter (After)

The collected data is continuous, randomly selected from the population, P**aired t test** is applied for comparison of data before and after study. This test gives the comparison of objective parameter of volunteers in study group before and after the study. 5% is the significance level accepted for this research study.

Pulse Rate



Pulse	Before	After
Study Group	80.984	81.337
Control Group	81.134	81.306

Pulse – Study Group	
Mean Difference	0.352
SD	3.298
SE	0.237
Paired t calculated	**1.484**

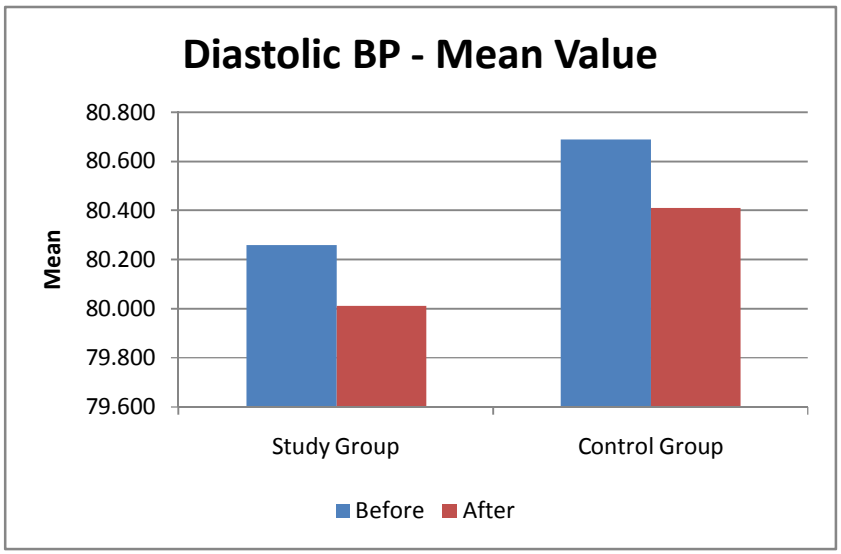
From the above table, it is observed that the t score shows there is no significant improvement in the Pulse Rate after *Nadishodhana Pranayama* in study group at 5% significance level.

Pulse – Control Group	
Mean Difference	0.172
SD	1.700
SE	0.125
Paired t calculated	**1.380**

From the above table, it is observed that the t score shows there is no significant improvement in the pulse rate in control group at 5% significance level.

7. Effect on Blood Pressure:

Diastolic BP



Diastolic BP	Before	After
Study Group	80.259	80.010
Control Group	80.688	80.409

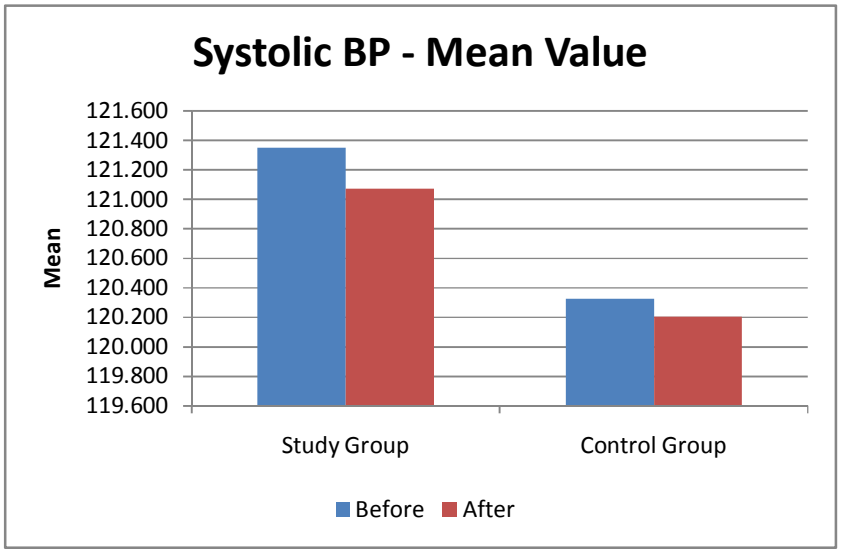
Diastolic BP – Study Group	
Mean Difference	0.249
SD	3.902
SE	0.281
Paired t calculated	**0.885**

From the above table, it is observed that the t score shows there is no significant improvement in the Diastolic BP after *Nadishodhana Pranayama* in study group at 5% significance level.

Diastolic BP – Control Group	
Mean Difference	0.280
SD	3.229
SE	0.237
Paired t calculated	**1.181**

From the above table, it is observed that the t score shows there is no significant improvement in the Diastolic BP control group at 5% significance level.

Systolic BP



Systolic BP – Study Group	
Mean Difference	0.280
SD	3.977
SE	0.286

Paired t calculated	0.977

From the above table, it is observed that the t score shows there is no significant improvement in the Systolic BP after *Nadishodhana Pranayama* in study group at 5% significance level.

Systolic BP – Control Group	
Mean Difference	0.118
SD	2.807
SE	0.206
Paired t calculated	0.575

From the above table, it is observed that the t score shows there is no significant improvement in the Systolic BP control group at 5% significance level.

DISCUSSIONS

Overall observations:

1. **Effect on Chest Expansion**

It is observed that the t score shows statistically significant improvement in the **Chest expansion** after Nadishodhana Pranayama in study group at 5% significance level.

29% of the population in study group showed improvement as compared to 2.7% of control group. Nadishodhana Pranayama shows considerable improvement in Chest expansion. Z score=15.981

As control group volunteers have not undergone the Nadishodhana Pranayama exercise, it can be concluded that the improvement in Chest expansion test in study group is attributable to Nadishodhana Pranayama exercise.

Paired t score of Chest expansion of study group is 19.685, which is statistically significant .So Chest expansion test in study group shows improvement after doing Nadishodhana Pranayama exercise.
The improvement in Chest expansion test is attributable to the increase in mobility of the skeletal muscle and elasticity of soft tissue.

Due to Nadishodhana Pranayama, there is shodhan of Ida Pingala nadi i.e channels in the chest region get cleared as explained in the literature review. So the gati of Vata dosha becomes regulated. The main Vayu related to Urasthan is Udana Vayu. So there is free flow of Udana Vayu in the chest region. As Prayatna is the function of Udana Vayu, it gives stimulation to mansa peshi i.e. skeletal muscles and respiratory muscles to move freely and forcefully. So activity of muscles increases results into improvement in the Chest expansion.

A study[i] taken up at Department of Agad Tantra, Department of Kaya Chikitsa, International Centre of Ayurvedic Studies, Shri Gulab Kunverba Ayurveda Mahavidylaya, Gujarat Ayurved University, Jamnagar, Gujarat, India, showed that at the end of 6 weeks Yoga training, chest wall expansion significantly increased ($p<0.05$) when compared to their pre-test values and post test control. It is likely that the improvement in chest wall expansion resulted from the increased respiratory muscle strength.

Another study[ii], taken up at S. Nijalingappa Medical College, Bagalkot, India, showed that the chest expansion of the participants significantly increased at end of 15 days of yoga practice, irrespective of age, gender and BMI.

One more study[iii], showed that the regular practice of Pranayama improves chest wall expansion and almost all lung functions. Pranayama improves the strength of expiratory as well as inspiratory muscles. The lungs inflate and deflate to fullest possible extent and muscles are made to work to maximal extent.

In a peculiar study[iv], showing the correlation between chest expansion & respiratory muscle weakness, it has been observed that, the expansion and contraction of the lungs are affected by the capacity of the thorax, which is determined by the **mobility of the skeletal muscles, the elasticity of the surrounding soft tissue and the intensity of the respiratory muscles**. Research results have shown that **tidal volume** is more affected by movement of the **rib cage than abdominal motion**. Therefore the degree of chest expansion is considered to be closely related to respiratory function and an important element in representing respiratory function,"

The observations of this research work support the observations of the previous research works published.

Thus, from all the observations & the previous research works, it can be concluded that Nadishodhana Pranayama definitely improves Chest wall expansion.

2. Effect on 40 mm Hg test

It is observed that the t score shows that there is statistically significant improvement in the **40 mm Hg** test after Nadishodhana Pranayama in study group at 5% significance level.

52% of the population in study group showed improvement as compared to 3.2% of control group. Nadishodhana Pranayama shows considerable improvement in 40 mm of Hg test. Z score=20.301

As paired t test score in study group for 40 mm Hg test is 26.375, it is statistically significant and it proves that 40 mm Hg test shows improvement after doing Nadishodhana Pranayama.

40 mm Hg test is principally related to

1. Stretching capacity of lungs
2. Holding capacity of lung
3. Elasticity of respiratory muscles.
4. Adequate blood supply

As discussed in benefits of Nadishodhana Pranayama in litreary review, one can get the above effects after doing Pranayama regularly. According to ayurvedic point of view also, due to Nadishodhana Pranayama, there is exercise of organs like Ura, Phuphusa, Nabhi which are the main seat of Udana Vayu. As a result of Pranayama exercise, they get better nourishment and become more powerful. As they all are seats for Udana Vayu, the strength of Udana Vayu also increases, and due to this holding capacity of breath also increases.

यथा ह्येनमसङ्घातमनवस्थितमनासाद्य प्रकोपणप्रशमनानि प्रकोपयन्ति प्रशमयन्ति वा, तथाऽनुव्याख्यास्यामः- वातप्रकोपणानि खलु रुक्षलघुशीतदारुणखरविशदशुषिरकराणि शरीराणां, तथाविधेषु शरीरेषु वायुराश्रयं गत्वाऽऽप्याय-यमानः प्रकोपमापद्यते वातप्रशमनानि पुनः स्निग्धगुरूष्णश्लक्ष्णमृदुपिच्छिलघनकराणि शरीराणां,तथाविधेषु शरीरेषु वायुरसज्यमानश्चरन् प्रशान्तिमापद्यते ।।७।। च.सू. १२ अध्याय

From the above reference, it is clear that status of Vayu depends upon the ashraya of the Vayu in the body it takes.

So when due to Pranayama exercise, the strength of chest region increases which is the main seat of Udana Vayu, it is possible from the above verse that strength of Udana Vayu also increases.

In a study[v] at Department of Physiology, L.T.M.Medical College, Sion, Mumbai, it is stated that, regular practice of Pranayamaic breathing improves ventillatary functions of the lungs as shown by improvement in FVC. MVV, PEFR; increase in the tolerance to CO_2 as shown by prolongation of BHT; and decreases the rate of respiration."

Another study[vi] at Medical College, Bagalkot, India, has observed that, at the end of 15 days regular yoga practice, the mean Breath Holding Time (BHT) is increased significantly."

One more study[vii] has documented in Journal of clinical and diagnostic Research that after doing Pranayama exercise regularly, there is statistically significant improvement in BHT. It has increased from 33+5.7735 to 58.6+12.78."

With the regular practice of Breath holding, the individual's central and peripheral chemoreceptors get adapted to the anoxia. This result is achieved by the body by causing hypometabolism. Thus resulting in prolonged hold and decreased urge to breathe. While doing this, in addition, the training of the stretch receptors in the respiratory muscles, chest wall and also walls of the alveoli support breath holding. Pranayama training causes an increase in the voluntary breath holding time. This may be due to acclimatization of the chemoreceptors to hypercapnoea.

Lung inhalation near to TLC is a major stimulus for release of lung surfactant into alveolar spaces which increases the lung compliance.

During Pranayama, there is slow and prolonged inspiration and expiration. It stretches elastin and collagen fibres interwoven among lung parenchyma. Hence these fibres elongate to a greater extent. During Pranayama, regular inspiration and expiration for longer duration would lead to acclimatization of central and peripheral chemoeceptors for both hypercapnoea and hypoxia. Acclimatization of the stretch receptors increases the synchronization between the lung tissue and cortex. Continuous Pranayama training causes increased breath holding time.

Another possible explanation for the role of yoga in improving the functioning of lungs and in reducing the mast cell degranulation could be as follows. The frictional stress from air flowing through narrowed airways, damages airway mucosa and thereby perpetuates airway inflammation and airway obstruction. Slow and gentle breathing in Pranayama may reverse the process by reducing the frictional stress and thereby stabilises the mast cell degranulation. Thus Pranayama improves the

ventilatory functioning of the lungs. Due to proper working of these organs, vital energy flows to maintain the normal homeostasis of the body and thus helps in prevention, and control of many respiratory diseases.

Thus from the observations of this study & the observations of previous research work done, it can be concluded that **Nadishodhana Pranayama causes improvement in 40 mm Hg test (by improving the breath holding capacity).**

3. Effect on Snider test:

It was observed that the t score shows statistically significant improvement in the **Snider test** after Nadishodhana Pranayama in study group at 5% significance level.

34% of the population in study group showed improvement as compared to 2.7% of control group. So Nadishodhana Pranayama shows considerable improvement in snider test values. Z score=16.733

As paired t score for snider test is 19.82, it is statistically significant and it proves that Nadishodhana Pranayama shows improvement in Snider test.
As this test is mainly concerned with forceful blowing, it depends mainly on the force of expiration. As stated earlier, due to Nadishodhana Pranayama, elasticity and strength of respiratory muscles increases, so expiratory force also get enhanced.
From ayurvedic perspective, due to Pranayama, any obstruction in the gati of Vata due to Kapha is removed. It also gives strength to the Pranavaha srotas which is related to Ucchwas and Nishwasaa. As Ucchwas karma is improved, the Snider test shows improvement after doing Nadishodhana Pranayama.
Snider's test is a crude form of Peakflowmetry, which measures force of expiration more accurately.
Thus it can be concluded that Nadishodhana Pranayama causes improvement in Snider test.

4. Effect on Peakflowmetry

It was observed that the t score shows statistically significant improvement in **Peakflowmetry** after Nadishodhana Pranayama in study group at 5% significance level.

53% of the population in study group showed improvement as compared to 5% of control group. So Nadishodhana Pranayama shows considerable improvement in Peakflowmetry. z score=23.865

As paired t score of Peakflowmetry of study group is 31.74, it is statistically significant and shows improvement in Peakflowmetry after Nadishodhana Pranayama.

In Peakflowmetry, force of expiration is chiefly measured. This force depends upon:

1. Strength of expiratory muscles
2. Contracting power of lungs
3. Elasticity of surrounding tissue.
4. Flexibility of chest wall.

Due to routine practice of Nadishodhana Pranayama, Slow and rhythmic exercise of exhalation and inhalation takes place. So strength of all these chest organs increases and ultimately power of expiration get enhanced.

In a study,[viii] published in Indian journal of ancient medicine and yoga Volume 5 number 3, July-September 2012, results showed that there was a significant increase in all pulmonary functions that is VC, FEV1, PEFR AND MVV.

Another study[ix], conducted at Department of physical education, SGGS Khalsa College Mahilpur, Punjab India & published in Journal of physical education and sport management vol 2(4),pp-44-47, August 2011, Issn 1996-0794@20-11 Academic journals showed that, Pranayama increases vital capacity, maximum voluntary ventilation, breath holding time, and maximal inspiratory and expiratory pressures.

One more study[x], at Gujarat Ayurved university, Jamnagar, Gujarat, published in IAMJ-23205091 has documented that, FEV1%, PEFR, FEF25-75% and MVV are found to be significantly improved after 2 weeks of Pranayama breathing exercises. FEV1, FVC and PIFR also showed a trend towards improvement although not

significant. Following the practice of Pranayama breathing exercises, significant improvements were seen in FEV1%, PEFR, FEF 25-75% and MVV. This indicates that there is some degree of broncho-dilatation, which is leading to better oxygenation of the alveoli. Endurance power of the lungs also improved as shown by improvement in maximum voluntary ventilation.
Yet another study[xi] conducted at Dept of physiology, Medical College, Manglore, published in Volume 18(no2, August 2005), page 10-16, ISSN O857-5754, showed significant improvement in Peak expiratory flow rate. It is an effort independent flow and is mainly dependent on lung volume. The 'NadishodhanaPranayama' involves using of lung spaces, not used up in normal shallow breathing. Therefore, **the increased Peak expiratory flow rate might be a consequence of small airway openings in lungs.**

One more study[xii] by Conducted at Nijalingappa Medical College, Bagalkot, India, which studied Effect on peak expiratory flow rate (PEFR), it was seen that the mean PEFR of all the participants, at end of 15 days regular practice of yoga, increased significantly.

Yet another study[xiii] has statistically shown that PEFR has been increased significantly at p value 0.001. PEFR denotes the force of exhalation. It is an expression of effort by respiratory muscles and the state of relaxation and constriction of the bronchial tree. PEFR is higher when bronchi are relaxed, dilated and respiratory system is working efficiently. The study showed improvement throughout but in early phases it was greater than later. The trend was similar in both men and women, but magnitude was double in men. The younger group benefited more. The benefit to older group was fluctuating and to lesser degree.
So it can be observed that Peak expiratory flow rate increases when airway obstruction or resistance is reduced. It may happened due to practising Nadishodhana Pranayama.

In a study[xiv] published in Indian journal of ancient medicine and yoga, Volume 5 number 3, July-September 2012, it has been put forth that, increase in PEFR may be due to rise in thoracic pulmonary compliances and bronchodilatation by training in Nadishodhana Pranayama. Stimulation of stretch receptors by inflation of the lungs reflexly relaxes smooth muscles of larynx and tracheobronchial tree modulating the

airway calibre and reducing airway resistance. The Pranayama involves using of lung spaces, these are not used in normal shallow breathing. So, increased PEFR may be due to small airway opening in the lungs.

From Ayurvedic perspective, Ucchwasa is the karma of Udana Vayu. So when the improvement in Peakflowmetry is seen, it means that bala of Ucchwas is increased that is strength of Udana Vayu is increased, as Ucchwas is the karma of Udana Vayu. When a person blows forcefully in the Peakflowmeter, Urasthan and Nabhisthan both are involved, which are the main seats of Udana Vayu. And also by practising Nadishodhana Pranayama, there is exercise of Urasthan and Nabhisthan. So it proves that by doing Nadishodhana Pranayama, strength of Udana Vayu definitely increases which can be seen in Ucchwas karma which is one of the important functions of Udana Vayu.

Thus, it can be concluded that, Nadishoshan Pranayama shows improvement in Peakflowmetry.

5. It can be said that, Nadishodhana Pranayama helps to improve all the components of respiration process. That is **Vital capacity (Chest expansion), Holding capacity (40 mm Hg test) & Exhalation (Snider & Peak flow metry).**

Nadishodhana Pranayama shows maximum improvement in Peak flowmetry and comparatively less improvement in Chest expansion.

All the four tests included in this study are related to respiration having different shades.

Chest expansion test is mainly related to vital capacity of the lungs. So inhalation and exhalation both are equally important for this test. This test is anatomy based that is structure dependant test. When improvement in this test is seen then the anatomical changes should responsible be bring out for this. It is a bit difficult to bring structural changes in course of 10 weeks. So there is comparatively less improvement in chest expansion.

Peakflowmetry has shown the highest improvement. The value of this test depends mainly upon the exhalation power. So mainly it is related to physiology of respiration. So as compared to Chest expansion, it has shown quite good improvement.

Breath holding time is related to retaining of air in the lungs for maximum time, i.e. mainly on the physiology. So after Peakflowmetry it has shown second highest improvement.

Snider test is also related with exhalation power like Peakflowmetry but Peakflowmetry is digital test. So manual error is less as compared to Snider test as this test can be affected by quantity of air in the room, error in measuring distance etc. So it might have shown the third highest improvement.

So it can be concluded that **Nadishodhana Pranayama helps to improve all the components of respiration process i.e. Vital capacity (Chest expansion), Holding capacity (40 mm of Hg test), and mainly Exhalation power (Snider test and Peakflowmetry).**

Critical observations based upon analysis of the results, based on different variables:

6.A. Age:

a. **Age group 18 yrs to 29 yrs:** It is observed that the unpaired t score shows significant improvement in all parameters in the age group of 18 to 29 yrs. of study group as compared to control group at 5% significance level.
Unpaired t score for age group of 18-29 years of study group is very significant that is for Chest expansion test it is 13.7, for 40 mm Hg test it is 18.25, for Snider test it is 12.84 and for Peakflowmetry it is 17.78 as compared to control group at 5% significance level. So it can be concluded that Nadishodhana Pranayama exercise have shown statistically significant improvement in age group of 18-29 years
b. **Age group 30 yrs to 40 yrs**: It is observed that the unpaired t score shows there is significant improvement in all parameters in the age group of 30 to 40 yrs. of study group as compared to control group at 5% significance level.
Unpaired t score of age group of 30-40 years of study group is very significant. For Chest expansion it is 9.29, for 40 mm of Hg test it is 11.17, for Snider test it is 11.22, and for Peakflowmetry it is 16.51 as compared to control group at 5% significant level.
So Nandishodhan Pranayama has shown statistically significant improvement in the age group of 30-40 years.

After percentagewise comparison between the two age groups of the population, it can be seen that the subjects of younger age group (18-29 yrs) have shown more improvement as compared with elder subjects of the age group 30-40, especially in parameters of Chest expansion & 40 mm of Hg test.

In Charak samhita, Charakacharya has made three age groups viz. Balyavastha, Madhyavastha and Jeernavastha. Balyavastha is further divided into two parts i.e. first part from 1 year to 16 years and second part from 16 years to 30 years. Madhyavastha is from 31 to 60 years and Jeernavastha is from 60 years onwards.

As per this study, Inclusion criteria, involves individuals of 18 years to 40 years .The person between 16 years to 30 years can be considered in Balyavastha and person between 30 to 40 are in Madhyamavastha according to Charak samhita. More

improvement in all the four parameters in study group is seen mostly in individuals of age group of 18 to 29 years. Following may be the reasons:

a. One of the most important characteristics of Balyavastha is Kaphapradhanya (Kapha dominant age group)

Gunas and karmas of the Kapha dosha are

कफ गुण[xvi]
गुरूशीतमृदुस्निग्ध मधुर-स्थिरपिच्छिलः।
श्लेष्मणः प्रशमं यान्ति विपरीत गुणैर्गुणाः।। च.सू. १-६१
श्लेष्मा हि स्निग्ध-श्लक्ष्ण मृदु मधुरसारसांद्रमंदस्तिमितगुरुशीत विज्जलाच्छः।
च.वि. ८-९६

As the improvement in all the four parameters is mostly dependant on the strength of the muscles of the chest wall and elasticity of lungs. Kapha dosha is very much helpful in doing this task effectively. According, to Ayurvedic samhita, Kapha dosha is mostly related to functions of,

कफ कर्म[xvii]
श्लेष्मास्थिरत्वस्निग्धत्वसंधिबंधक्षमादिभिः। अ.हृ.सू. ११-३
संधिसंश्लेषण-स्नेहन-रोपण-पूरण-बृंहण-तर्पण-बल-स्थैर्यकृत् श्लेष्मा पंचधा प्रविभक्तः उदक कर्मणा अनुग्रहं करोति। सु.सू. १५-४

1) Regeneration

2) Forming bonds- sandhibandha

3) Giving stability-sthiratva

4) Providing power- bala

5) Giving flexibility to muscle tissues

6) Providing oiling to all body tissues- snigdhatwa

All these functios are done by Kapha dosha with the help of following gunas.

1. Snigdha[xvii]-

यस्य क्लेदने शक्तिःस स्निग्धः । (हे)
स्नेहमार्दवकृत् स्निग्धो बलवर्णकरस्तथा। सु.सू. ४६-५१६

स्निग्धं वातहरं श्लेष्मकारी वृष्यं बलावहम्। (भा.प्र।)

The property of providing oiling to the body is Snigdha.

2. Sthir[xviii]-

स्थिर-निश्चलः, चलप्रतिबंधकः। आ.श.कोश
अस्य धारणे शक्तिः। अ.हृ.सू. १-१८

The property of providing stability to the body is sthira.

3. Picchil[xix]-

दृढतर संयोगजनको गुणः। आ.श.कोश
द्रव्यस्य लेपने शक्तिः। (हे)

The property of sticking the things together is called Picchila.

4. Manda[xx]

मन्दोगुणः यात्राकरः।

The property of substance of minimizing the speed of action (prolonging) is Manda.

1. Guru[xxi]

द्रव्यस्य बृंहणे कर्मणि शक्तिर्गुरुः ।आ.श.कोश

The property which is the cause of accumulation of substance in the body is Guru.

2. Shlashna[xxii]

रोपणे श्लक्ष्णः, लेखने खरः । अ.हृ.सू. १/१८ हेमाद्री टीका

The property of healing is Shlshna.

7. Mrutsna[xxiii]

The property which joins the things together is Mrutsna.

The most important characteristics of this age group are

1. Shleshma -dhatuprayam- This age group is dominant in Kapha dosha. All these functions are mostly seen very pecularily in Balyavastha as stated by Charakacharya which is Kaphapradhan stage.

In the second group of Balyavastha, i.e. age group between 16 years to 30 years the characteristics are

1. Vivardhaman -dhatugunam (Ongoing developmental phase) - In this stage, the dhatus are not fully nourished. The process of transactions in the forming guna, and swaroopaa of dhatus is still going on. They have not got the stability fully gunataha and karmataha. So changes can occur in the structure and function of these dhatus easily.

On the other hand, the age group between 30 to 40 years is included under Madhyavastha as stated by Charaka. The characteristics of this stage are

1. Samatwagat bala (completion of nourishment)– As bala in this stage is fully developed and got the stability so it is very hard to bring change in the infrastructure of guna, swaroopa and karma of dhatus which are responsible for creating bala in the body.

2. Samatwagat sarva dhatu gunam (completion of development) –

As stated earlier, at this stage the dhatus are fully developed and nourished. With any external factors like physical exercise, or food or medicine, it is a bit difficult to bring the changes in the anatomical make up of any organ. However, gunas (qualities) of that particular dhatu can still be improved to some extent.

So, improvement in chest expansion, which is a structural change, is justified in younger age group.

Thus it is clear that the overall strength of dhatus, Dravyataha, gunataha and karmataha (structural, qualitative & functional) can be improved easily at the age group of 16-30 years i.e. second part of Balyavastha as stated by Charak as compared to 30-40 years i.e. Madhyavastha, where only qualititative & functional improvements can be achieved.

Urasthan is the main site of Kapha dosha. So Kapha which is carrying all the above mentioned gunas and karmas, gives strength to urasthan which is also the main site of Udana Vayu. So as per the refrence in Vatkalakaliya adhyaya, Udana Vayu also became compitant functionally and this is depicted in the Ucchwas karma of Udana Vayu in this study.

So it can be concluded that Nadishodhana Pranayama shows better improvement in 40 mm of Hg test, in age group of 18-29 years as compared to age group of 30-40 years.

In younger age groups, more improvement in other two parameters, i.e. Snider test & Peakflowmetry, was also expected theoretically. But in actual study the results in both the age groups were found similar.

One of the study[xxiv] has statistically shown that PEFR has been increased significantly at p value 0.001. PEFR denotes the force of exhalation. It is an expression of effort by respiratory muscles and the state of relaxation and constriction of the bronchial tree. PEFR is higher when bronchi are relaxed, dilated and respiratory system is working efficiently. The study showed improvement throughout but in early phases it was greater than later. The trend was similar in both men and women, but magnitude was double in men. **The younger group benefited more. The benefit to older group was fluctuating and to lesser degree.**

To justify this fact, further study is necessary.

6.B. Gender:

a. Male: It is observed that the unpaired t score shows there is significant improvement in all parameters in male of study group as compared to control group at 5% significance level.

Unpaired t score of male in study group is for chest expansion 11.12, for 40 mm Hg test 14.78, For Snider test 10.32 and for Peakflowmetry 16.18 as compared to male of control group at 5% significant level. So Nadishodhana Pranayama has shown good improvement in male gender of study group as compared to control group.

b. It is observed that the unpaired t score shows there is significant improvement in all parameters in female of study group as compared to control group at 5% significance level.

Unpaired t score of female gender in study group is for chest expansion 11.44. for 40 mm Hg test 13.62, for Snider test 13.39 and for peakflowmetry 17.95 as compared to female gender of control group at 5% significant level. So it can be concluded that Nadishodhana Pranayama exercise have shown good improvement in female gender of study group.

After percentagewise comparison between the two gender groups of the population, it can be seen that the subjects of both the groups have shown similar improvement.

Texts[xxv] mention that,.

एतच्चैव कारणमपेक्षमाणा हीनबलमातुरमविषादकरैर्मृदुसुकुमारप्रायैःउत्तरोत्तगुरुभिः
अविभ्रमैरनात्ययिकैश्चोपचरन्त्यौषधैः विशेषतश्च नारीः, ता हयनवस्थितमृदुविकृतविक्लवहृदयाः प्रायः सुकुमार्योऽबलाः परसंस्तभ्याश्च।

च.वि.८-९४ पान नं २७६

टीका - हृदयशब्देन हृदयस्यं मन इति ज्ञेयम्। मृदुविवृतम् अगम्भीरम्। विक्लवं स्तोकक्लेशाभिभवनीयम्, अनेन च दुर्बलचेतस्त्वमुक्तम्। परसंस्तभ्याः न स्वयमात्मानं सत्त्वबलात् स्तम्भयन्ति।

According to Ayurvedic text, women are described as sukumar and abala (delicate & weak) as compared to men. According to modern science also women are physically weak than men.

So more improvement in all the four tests involved in this study was expected in male volunteers. But actual results show that there is not much significant difference in the results of four tests done in male and female volunteers.

Few other studies have also documented similar observations.

In a study[xxvi], responses of regular practice of Pranayama are assessed with respect to age, gender and BMI revealed that both males and females responded similarly to the Pranayama practice. Similar observations in both the genders in respiratory parameters were also reported by previous study.

Another study[xxvii] Comparison of results between males and females shows similar response to Pranayamaic breathing."

After comparison of percent improvement in both the genders, there was not much significant difference in any of the parameters in males & females.

Thus, it can be concluded that Nadishodhana Pranayama shows improvement in all four parameters, irrespective of the gender of the participants.

6.C. Rutu:

It is observed that the unpaired t score shows there is significant improvement in chest expansion of study group as compared to control group at 5% significance level.

Unpaired t score of study group in **Shishir rutu** for Chest expansion 11.72, for 40 mm Hg test 11.61, for Snider test 6.79 and for Peakflowmetry 7.08 as compared to control group at 5% significance level. So Nadishodhana Pranayama exercise has shown improvement in study group in Shishir rutu as compared to control group at 5% significance level.

Unpaired t score of study group in **Vasant rutu** for Chest expansion 12.09, for 40 mm Hg test 8.79, for Snider test 4.83, for Peakflowmetry 8.97 as compared to control group at 5% significance level. So Nadishodhana Pranayama exercise has shown improvement in study group in Vasant rutu as compared to control group at 5% significance level.

Unpaired t score of study group in **Varsha rutu** for Chest expansion 4.094, for 40 mm Hg test 6.38, for Snider test 8.21, for Peakflowmetry 9.14 as compared to control group at 5% significance level. So Nadishodhana Pranayama exercise has shown improvement in study group in Varsha rutu as compared to control group at 5% significance level.

Unpaired t score of study group in **Sharad rutu** in study group for Chest expansion 6.63, for 40 mm Hg test 8.13, for Snider test 6.67 and for Peakflowmetry 13.37 as compared to control group at 5% significance level. So Nadishodhana Pranayama exercise has shown improvement in study group in Sharad rutu as compared to control group at 5% significance level.

Unpaired t score of study group in **Hemant rutu** for Chest expansion 7.30, for 40 mm Hg test 10.39, for Snider test 7.14 and for Peakflowmetry 11.79 as compared to control group at 5% significance level. So Nadishodhana Pranayama exercise has shown improvement in study group in Hemant rutu as compared to control group at 5% significance level.

When data showing percentagewise improvement was reassessed critically, it was seen that subjects have shown variable responses in all rutus in all parameters depending on the season of exercise.

1. Chest expansion test has shown good improvement in Vasant & Sharad rutus and least improvement in Varsha rutu.

2. 40 mm of Hg test shows good improvement in all rutus.

3. Peakflowmetry test has shown good improvement in Hemant & Sharad Rutu & least in Shishir.

1. **Vasant & Sharad** rutus are both ushna (hot) rutus coming after sheet (cold) rutu of Shishir & Varsha respectively. So, possibly expansion property shows its best activity in these Usna(hot) rutus.
Simple rule of physics, which says, heat expands & cold contracts, which is also advocated by Ayurveda, in the definitions of Sheeta & Ushna gunas, seems working in this case. Due to change of season from cold to hot, Stambhana (restriction) karma of sheeta starts reducing & Viksasna (expanding) karma of ushna guna starts functioning.

In Sharad rutu, prakopa of Pitta dosha takes place.

चयप्रकोपप्रशमा वायोर्ग्रीष्मादिषु त्रिषु ।
वर्षादिषु तु पित्तस्य, श्लेष्मणः शिशिरादिषु ।। अ.हृ.सू.१२/२४

Gunas of Pitta dosha[xxviii]-
पित्तमुष्णं तीक्ष्णं द्रवं विस्त्रमम्लं कटुकं च । च.चि. ८/९७

Karma of Pitta dosha[xxix]:

दर्शनं पक्तिरुष्मा च क्षुत्तृष्णा देहमार्दवम् ।
प्रभा प्रसादो मेधा च पित्तकर्माविकारजम् ।। च.सू. १८/५०

1. Tikshna
2. Ushna

Karmas of prakupit Pitta dosha[xxx]

पक्तिमपक्तिं दर्शनमदर्शनं मात्रामात्रत्वमूष्मणः प्रकृतिविकृतिवर्णौ शौर्यं भयं क्रोधं हर्षं मोहं प्रसादमित्येवमादीनि चापराणि व्दन्व्दानीति ।। च.सू. १२/११

In Sharad rutu, there is prakopa of Pitta dosha. Due to this, though there is not direct Ushna Guna in the climate, there is dominance of Ushna Guna.
Conversely, it is also observed that, chest expansion has shown comparatively less improvement in cold seasons i.e. Varsha, Hemant & Shishir.

As stated in the previous study article, by Sud Sushant, Sud Khyati S, Gujrath Ayurved University, Jamnagar, Effect of Pranayama on Pulmonary Functions- an Overview, "there are reported evidences of Pranayama that it increases chest wall expansion and lung volumes. The improvement of respiratory function and increased chest wall expansion were resulted from the increased respiratory muscle strength because of Pranayama effect. "

As stated previously, that in Varsha rutu, bala is very low as compared to other rutus. So exercises done in this rutu are not much fruitful to give strength to the chest wall muscles.

In addition, in Varsha rutu, there is Chaya (accumulation) of Pitta dosha and Prakopa (vitiation) of Vata dosha. As Vata dosha have following gunas

चयप्रकोपप्रशमा वायोर्ग्रीष्मादिषु त्रिषु ।
वर्षादिषु तु पित्तस्य, श्लेष्मणः शिशिरादिषु ।। अ.ह्व.सू.१२/२४

1 .Ruksha –
तस्य रौक्ष्याद्वातला रुक्षापचिताल्पशरीराः,
स्निग्ध - रूक्ष
स्नेहमार्दवकृत् स्निग्धो बलवर्णकरस्तथा ।
रुक्षस्तव्दिपरीतः स्याव्दिशेषात् स्तम्भनः खरः ।। सु.सू. ४६/५१६
क्लेदने स्निग्धः, शोषणे रुक्षः । अ.ह्व.सू. १/१८ हेमाद्री टीका

Due to the dominance of ruksha guna, in this season the bala accumulation in the body is not possible. Because the karma of ruksha guna is to scatter the particles. Lack of snigdha guna in this season also prohibit the production of bala as seen in the Vata Prakriti people, the sharir of that individuals are apachit, alpa .

2. Chala-

स्थिर - सर (चल)
धारणे स्थिरः, प्रेरणे चलः । अ.हृ.सू. १/१८ हेमाद्री टीका

Due to the Chala guna of Vata dosha, the rate, frequency and severity of movements are more. So degeneration is more in the body in this season. So it is very difficult to increase the bala of the body in these particular rutu. If movements are more, sharirapachaya is more. So bala that is already present in the body is used in daily regimen. So it is not possible to produce more bala and utilised it in the nourishment of mansa and asthi dhatu.

2.Khara:

श्लक्ष्ण – खर
श्लक्ष्णः पिच्छिलवज्ज्ञेयः कर्कशो विशदो यथा ।। सु.सू. ४६/५२१
रोपणे श्लक्ष्णः, लेखने खरः । अ.हृ.सू. १/१८ हेमाद्री टीका

Due to the dominance of khar guna, lekhan karma takes place very easily, brihan can not take place and increase in body strength is prohibited.

4. Laghu-

Due to Laghu guna, activities are more, movements are fast, so more consumption of energy, less accumulation of force or strength.

Besides this, in Varsha rutu, there is Prakopa of Vata dosha.

PrakupitaVata karma[xxxi]-

कुपितस्तु खलु शरीरे शरीरं नानाविधैर्विकारैरुपतपति बलवर्णसुखायुषामुपघाताय, मनो व्याहर्षयति, सर्वेन्द्रियाण्युपहन्ति, विनिहन्ति गर्भान् विकृतिमापादयत्यतिकालं वा धारयति, भयशोकमोह-दैन्यातिप्रलापाञ्चनयति, प्राणांश्चोपरुणद्धि । च.सू. १२/८

There are many symptoms due to Vataprakopa. But related to this subject is "बलमुपघाताय". So due to the effect of this rutu, balanasha is there naturally.

Udana Vayu is one of the main sources that produces bala in the body. If Vata dosha is vitiated in this season naturally, so this reflects in functions of Udana Vayu also. Ucchwas is important function related to shwasan (respiration) of Udana Vayu, which may not carried out so efficiently in this season.

Hemant and Shishir being cold seasons might be restricting the action of Chest expansion as discussed earlier.

So, it can be concluded that, Chest expansion shows better improvement in Sharad & Vasant rutus, & comparatively less improvement in cold seasons like Shishir, Hemant,Varsha rutus.

Of course, further deep study is necessary to support this conclusion.

2. 40 mm of Hg test has shown equal results in all seasons. Further study is necessary for justification of this observation.

- **Peakflowmetry has shown good improvement in Hemant & Sharad Rutu:**

It has been mentioned that[xxxii]

आदावन्ते च दौर्बल्यं विसर्गादानयोर्नृणाम्।
मध्ये मध्यबलं, त्वन्ते श्रेष्ठमग्रे च विनिर्दिशेत्।। च.सू.६-८
विसर्गस्यादौ वर्षासु, आदानस्यान्ते ग्रीष्मे, दौर्बल्यं प्रकर्षं प्राप्तम् मध्ये विसर्गश्च शरदि, आदानस्ये, मध्ये वसन्ते, मध्ये अन्ते विसर्गश्च हेमन्ते अग्रेच प्रथमे आदानस्य शिशिरे, श्रेष्ठं बलं विनिर्दिशेत् ।

Both Sharad & Hemant rutus have been included in Visarg kala by all the samhitakaar which is the bala gaining period. Especially in Hemant rutu, bala production is hightest because

1. Dominance of soumya guna.

2. Prasham of Pitta dosha and chaya of Kapha dosha

As stated in samhitas[xxxiii]

शीतेऽभ्यं वृष्टिघर्मेऽल्पं बलं मध्यं तु शेषयोः। वा.सू. ३-७
टीका - अत्र विसर्गाख्ये काले, सौम्यत्वात्, सोमभूयिष्ठात्, सोमो बलवान् तदाश्रितरात्रिवृद्धिदर्शनात्।
अरूणदत्त – यस्मात् अयं कालः सौम्यत्वात् हेतोर्बलं विसृजति-ददाति, अतो विसर्गाख्यः ।
..... यद्बलं विसृजत्ययम् ।
सौम्यत्वादत्र सोमो हि बलवान् हीयते रविः ।।५।। वा.सू. ३

Gunas of Kapha dosha

श्लेष्मा हि स्निग्ध-श्लक्ष्ण मृदु मधुरसारसांद्रमंदस्तिमितगुरुशीत विज्जलाच्छः।
च.वि. ८-९६
Which are helpful in increasing bala.

So bala is maximum and any strength giving food, exercise or medicine will show its optimum results in this season. This in turn also shows improvement in the bala of respiratory muscles in very good manner. Also, Udana is said to be synonym for bala.

So, it can be concluded that, Peakflowmetry shows good improvement in Hemant & Sharad Rutu.

6.D. Dosha Prakriti:

Unpaired t score of study group of Vatapradhan Pittanubandhi Prakriti (VP) for chest expansion 6.98.for 40mm Hg test 7.30, for Snider test 7.21 and for peakflowmetry is 15.34 as compared to control group at 5% significance level.

Unpaired t score of study group of Pittapradhan Vatanubandhi Prakriti (PV) for chest expansion 3.9, for 40 mm Hg test 7.60, for Snider test 6.68, for Peakflowmetry 7.78 as compared to control group at 5% significance level.

Unpaired t score of Vatapradhan Kaphanubandhi Prakriti (VK) persons for chest expansion 6.48, for 40 mm Hg test 8.30, for Snider test 7.19 and for Peakflowmetry 8.59 as compared to control group at 5% significance level.

Unpaired t score of Kaphapradhan vatanubandhi Prakriti (KV) individuals of study group for chest expansion 4.78, for 40 mm Hg test 8.53, for Snider test 5.08 and for Peakflowmetry 6.38 as compared to control group at 5% significance level.

Unpaired t score of Pittapradhan Kaphanubandhi Prakriti individuals (PK) of study group for chest expansion 7.10, for 40 mm Hg test 8.65, for Snider test 6.79 and for Peakflowmetry is 10.38 as compared to control group at 5% significance level.

Unpaired t score of individuals of Kaphapradhan Pittanubandhi Prakriti individuals (KP) of study group for chest expansion 11.36, for 40 mm Hg test 9.71, for Snider test 7.78 and for Peakflowmetry is 12.80 as compared to control group at 5% significance level.

So, all the Prakritis have shown statistically significant improvement in all four parameters.

On critical analysis of Prakritis, on percentagewise comparison and improvements, following observations could be made:

1. Chest expansion has shown good improvement in Vata-Kapha & Kapha-Pitta & least in Pitta-Vata Prakriti.

2.40 mm Hg test has shown good improvement in Kapha-Vata & Vata-Kapha & least in Pitta-Vata individuals.

3. Snider Test has shown good improvement in Vata-Kapha & Pitta-Vata individuals, & least in Kapha-Vata individuals.
4. Peakflowmetry has shown good improvement in Kapha-Pitta & Kapha-Vata individuals & least in Pitta-Vata individuals.
5. Pitta-Vata individuals have shown least improvement in all parameters except Snider test.

1. Chest expansion has shown good improvement in Vata-Kapha & Kapha-Pitta & least in Pitta-Vata Prakriti.

a. **Vatapradhana Kaphanubandhi individuals:** As mentioned earlier, Chest expansion is related mainly with mobility of skeletal muscles and elasticity of soft tissue.

When Vatapradhan Kaphanubandhi Prakriti is considered, there is dominance of Vata dosha. Therefore more influence of Vata dosha has been seen in that person. As mentioned in literature review, in Vatapradhan Prakriti, dominance of laghu, chala, shighra, sukhma guna has been observed. But these gunas are in hyper, uncontrolled state.When Nadishodhana pranayan has been done for 10 weeks, this vata dosha may be got controlled and regulated. And the effect has been seen in after Nadishodhana Pranayama results. As stated in HathayogaPradipika ,

"When Vata in the body is moving very fast, mind will be very unstable. So it is very necessary to aquire command over Vata.

चले वाते चलं चित्तं निश्चले निश्चलं भवेत् ।

योगी स्थाणुत्वमाप्नोति ततो वायुं निरोधयेत् ।।२।। हठ्योग प्रदीपिका द्वितीय उपदेश"

Due to controlled, chala and laghu guna mobility of skeletal muscles has been increased and due to Kaphanubandha, snigdha guna in the body is already in excess state which provides softness, and elasticity to the surrounding soft tissue of the chest.

Due to Kaphanubandha, excess Rukshata present due to Vatapradhanya which may become obstruction in the movements of muscular tissue is balanced, and there is free flow (gati) and increased expansion capacity due to increased elasticity (snigdhatwa) has been observed after Nadishodhana Pranayama. So this may be the

reason why Vatapradhan Kaphanubandhi Prakriti has shown good omprovement in Chest Expansion test.

b. **Kaphapradhan Pittanubandhi individuals:** have shown second highest improvement in chest expansion

As mentioned earlier, Kapha and Pittapradhan persons are uttambala and madhyambala respectively. So it is expected that the exercise of Pranayama will found more beneficial to Kaphapradhan and Pittapradhan persons. And the results found are the same.

Chest expansion is merely dependant on strength of the muscles, Muscles that is mansa dhatu according to ayurvedic paribhasha is the ashraysthan of Kaphadosha[xxxiv].

तत्रास्थनी स्थितो वायुः पित्तं तु स्वेदरक्तयोः ।
श्लेष्माशेषेषुतेनैवं आश्रयाश्रयिणां मिथः ।। अ.हृ.सु. ११/२६

As per the above verse, there is the direct relationship between ashray and ashrayee. When there is increase in ashray, ashrayee also increases and vice versa. So keeping in this mind, in KaphaPrakriti when there is kapabahulya, mansabahulya is also present in them. That's why these people are naturally bulky and fleshy. So when Pranayama exercise is given to them, the improvement in chest expansion is more prominently seen in them as compared to others. So due to the strong chest region (ura sthan) which is the main seat of Udana Vayu, Nadishodhana Pranayama exercise may have help to improve the Ucchwas karma of Udana Vayu.

2. Pittapradhan Vatanubandhi subjects have shown the lowest improvement in Chest expansion: As mentioned previously, Pittapradhan persons have very loose and flabby mansa dhatu and Vatanubandh also adds to rukshatva and apachitatva of mansa dhatu.Also Pittapradhan and Vata pradhan persons are madhyabala and alpabala respectively.So this may be the reason why Pittapradhan Vatanubandhi persons have shown the lowest improvement in chest expansion. Exercise of Nadishodhana Pranayama may not have much fruitful to improve the ucchwas karma of Udana Vayu due to alpa mansa bala.That is though if strength of Udana Vayu has been increased due to Nadishodhana Pranayama, but if mansa dhatu is of less strength naturally due to Vata and Pitta then what will happen? While doing

chest expansion, forceful Udana Vayu will failed to inflate the chest to its fullest with mansa peshi having less bala. Same may be happened here, so the results are seen.

In all four tests, Chest expansion is the test related mainly with anatomical changes. It is a bit difficult to bring anatomical changes in fully grown volunteers in 10 weeks only. As mentioned previously, Vatapradhan Kaphanubandhi and Kaphapradhan Pittanubandhi Prakriti has shown highest improvement and Pittapradhan vatanubandhi has shown lowest improvement in Chest expansion test. Overall Chest expansion improvement seen in all the volunteers is 29.01%.

So from above discussion, it can be concluded that, **Nadishodhana Pranayama shows good improvement in Chest expansion of Vatapradhana Kaphanubandhi & Kaphapradhana Pittanubandhi Prakriti & least improvement in Pittapradhan Vatanubandhi Prakriti.**

2. 40 mm Hg test, Kaphapradhan vatanubandhi and Vatapradhan Kaphanubandhi Prakriti have shown highest improvement and Pittapradhan Vatanubanhi Prakriti lowest improvement:

2. a. Kaphapradhan vatanubandhi and Vatapradhan Kaphanubandhi have shown highest improvement in 40 mm Hg test.

As mentioned in Literature review, 40 mm hg test mainly depends upon

1. The stretching and holding capacity of lungs

2. Elasticity of chest muscles.

In Kaphapradhanya, Sthir, Shlakhna, Sara, Mrudu, Manda, Stimit, Snigdha, Picchil etc gunas (virtues) are predominant. Due to these gunas, Kaphapradhan Prakriti people are strong and stout. They have Upachit (very well nourished) and Paripurna (accomplished) body structure. According to Vaghbhatacharya, they have 'Pruthu-peena vaksha' (strong and stout chest region). It is the main seat of Udan Vayu. These people also are mansal (fleshy). So all these virtues facilitates Nadishodhana Pranayama exercise to show improvement in 40 mm Hg test wcich is mainly dependant upon the expanding capacity of lungs.

As anubandha is vata, and vata is composed of Vayu and Aakasha, this combination helps to create more avakash (space) to accommodate more and more air in the elastic lungs during holding in 40 mm Hg test.

2.b. Vatapradhan Kaphanubandhi Prakriti also have shown second highest improvement in 40 mm Hg test:

In Vata Prakriti people, sahaja bala is less that is these people are alpabala. So there is more scope to increase the bala. So anything which increases its bala, if it is worked out by them will definitely show the fast results. And here anubandha is Kapha which is very much helpful to increase the strength. So by doing Nadishodhana Pranayama in Vata Prakriti people, the strength or Uccwas bala has been increased as seen in results.

It seems that laghu, chala, shighra and sukhma guna of vata when gets combined with sthir,shlaksna, guru and snigdha guna of Kapha, it definitely shows improvement in 40 mm Hg test.

Thus, from above discussions, it can be concluded that **Nadishodhana Pranayama daily for 10 weeks shows good improvement in 40 mm of Hg test in Kaphapradhan Vatanubandhi Prakriti & Vatapradhana Kaphanubandhi Prakriti & least improvement in Pittapradhan Vatanubandhi individuals.**

2.c. PittaVata Prakriti individuals have shown least improvement in 40 mm of Hg test. The justification for this is already discussed previously.

- **Snider test test has shown highest improvement in Vatapradhan Kaphanubandhi Prakriti and lowest improvement in Kaphapradhan Vatanubandhi Prakriti:**

Snider's test is the test related mainly with maximum blowing that is expiration.As discussed previously that Vatapradhan Kaphanubandhi Prakriti has all the virtues which may stimulate the improvement in bala of Ucchwasa of Udan Vayu (expiration) which in turn improves the Snider's test.

Snider's test has shown least improvement in Kaphapradhan vatanubandhi Prakriti.

As stated in discussion of 40 mm Hg test, that Kaphapradhan vatanubandhi Prakriti shows very good improvement. But it is exception in Snider's test and more keen study should be done.

These volunteers are of Kaphapradhan Vatanubandh Prakritii. As the gunas of Vata are mentioned previously, due to chala, ruksha, laghu, khara guna, the results which are expected in Kaphapradhan volunteers are opposed by this Vatanubandha. The energy /force/strength created by that Kaphapradhan volunteers by Pranayama exercise may be compensated by that Vatanubandh and the results may be nullified. So by doing Nadishodhana Pranayama, the expected improvement in the Ucchwas karma of Udana Vayu was not seen due to Vatanubandha.

Thus, it can be concluded that, **Nadishodhana Pranayama daily for 10 weeks shows good improvement in Snider test in Vatapradhan Kaphanubandhi Prakriti & least improvement in Kaphapradhan Vatanubandhi individuals.**

4. Peakflowmetry has shown good improvement in Kapha-Pitta & Kapha-Vata individuals & least in Pitta-Vata individuals:

4.a.When Kaphapradhan Pittanubandhi Prakriti is considered, it means the person has characters of Kapha Prakriti predominantly, followed by characters of Pittaj Prakriti. As the Characters of Kapha Prakriti mentioned by different samhitas are

चरक-

कफ प्रकृति –

तस्य स्नेहाच्छलेष्मलाः स्निग्धाऽगाः

श्लक्ष्णत्वात् श्लक्ष्णाऽगाः

सारत्वात् सारसंहतस्थिरशरीराः,

मन्दत्वान्मन्दचेष्टाहारव्याहाराः,

त एवं गुणयोगाद् श्लेष्मला बलवन्तो..... भवन्ति। च.वि.८/९६

कफ प्रकृति –

वाग्भट –

अल्पं स भुडते बलवानस्तथाऽपि।

दीर्घसूत्रः चिरकारी।

As the above verse says

1. KaphaPrakriti people are balawan by birth that is they are having sahaj bala.

2. They are having very stable, stout and powerful fleshy body texure. Obviously they respond to the exercise well & show excellent improvement.

3. About their diet, it has been mentioned in Ashtang Hridaya that they eat a little food but they are very strong.

4. Due to the dominance of Manda guna, theses people have very less body movements, therefore less energy loss during their daily functioning.

5. Their mind is also very stable so once they decide to do certain things; they always do it within decided time.

So Prakrut bala of these volunteers is already good and by doing Nadishodhana Pranayama, all the channels get purified and Udana Vayu can move in its upward direction more freely and forcefully.

So, all these virtues are very helpful to show the improvement in the results of four tests as compared to Pitta Prakriti and Vata Prakriti people.

So by above gunas, it can be assumed that these Kaphapradhan Pittanubandhi people have done the exercise more powerfully and more sincerely which is depicted in their results.

4.b. Kaphapradhan Vatanubandhi volunteers have shown second highest improvement in Peakflowmetry.

As discussed previously, this Prakriti has shown very good improvement in 40 mm Hg test also.

4.c. Pittapradhan Vataanubandhi individuals have shown least improvement in Peakflowmetry.

When Pittapradhan Vatanubandhi is considered, it means dominance of Pitta dosha, more characters of Pataj Prakriti and less of vata Prakriti. So according to this,

As described in the Samhitas

पित्तप्रकृती –
चरक-
पित्त – तैक्ष्ण्यात् .....क्लेशासहिष्णवे।
द्रवत्वात् शिथिलमृदुसन्धिमांसाः
त एवं गुणयोगाद् पित्तला मध्यबला .....भवन्ति ।।९७।। च.वि.८

1 .Pitta Prakriti people are Madhyabala people.
2. These people have medium, very soft, tiny body frame.
3. These people have very soft, loose and fluffy joints and flesh.

As the parameters that have applied in this study that is chest expansion, 40 mm of Hg test, Peakflowmetry and Snider's test are mainly related to thoracic muscle strength, and when virtues of Pitta Prakriti are observed ,the results found are very much relevant to the scenario. And also there is anubandha of Vata dosha which having the immense character of loosing bala due to its rukha, chala, and khara guna. So combination of both Prakriti may prohibit Udana Vayu to improve its Ucchwas karma by doing Nadishodhana Pranayama.

वात-

तस्य रौक्ष्याद्वातला रुक्षापचिताल्पशरीराः,

लघुत्वात् लघुचपलगतिचेष्टाहारव्याहारः, शीघ्रत्वात् शीघ्रसमारम्भक्षोभविकाराः,

त एवं गुणयोगाद्वातलाः प्रायेणाल्पाबलाश्च ....भवन्ति ।।९८।। च.वि.८

तत्र वातप्रकृतिः .....

अघृतिः ..... ।।

द्रुतगतिः ..... अनवस्थितात्मा ।।६५।।

अव्यवस्थितमतिः ..... ।।६६।।

टीका - अनवस्थितात्म च चलचित्तः ।

अव्यवस्थितमतिः अनवस्थित बुद्धिनिश्चयः ।

वातप्रकृती – चलधृतिस्मृतिबुद्धिचेष्टा

न दृढा न जितेन्द्रिया वा.शा.३

1. Vata Prakriti people have very less sahaj bala.
2. These people have very thin, unstable, malnourished and bony body frame.
3. All actions of these people are very fast so more energy loss.
4. The mind of these people is very unstable so can't do any work sincerely.
5 .Very poor control on mind.

Due to all these virtues of Vata Prakriti people, it seems that the exercise of Pranayama will not be much beneficial for these people. Chala Guna of Vata might be playing key role in the results observed.

6.E. Vyayamashakti:

1. Unpaired t score of Uttama vyayamshakti persons in study group for chest expansion 9.72, for 40 mm Hg test 13.92, for Snider's test 8.14 and for Peakflowmetry 11.91 as compared to control group at 5% significance level.

So it can be concluded that Nadishodhana Pranayama has shown improvement in Uttama vyayamashakti persons of study group as compared to control group.

1. Unpaired t score of person of Madhyam vyayamshakti of study group for Chest expansion 11.20, for 40 mm Hg test 14.06, for Snider test 11.79 ,and for Peakflowmetry 17.78 as compared to control group at 5% significance level.

So Nadishodhana Pranayama has shown improvement in Madhyam vyayamshakti person in study group as compared to control group.

2. Unpaird t score of alpa vyayamshakti person of study group for chest expansion 6.69, for 40 mm Hg test 8.73, for Snider test 8.54 and for Peakflowmetry is 13.08 as compared to control group at 5% significance level.

So Nadishodhana Pranayama has shown improvement in Alpa Vyayamshakti people of study group as compared to control group.

On critical analysis of different Vyayamashaktis, on percentagewise improvements, following observations could be made:

Vyayamwise results:

1. Chest expansion has shown good improvement in Uttama Vyayamshakti individuals & least in Alpa Vyayamshakti individuals.
2. 40 mm Hg test has shown good improvement in Uttam vyayamshakti individuals & least in Alpa vyayamshakti individuals.
3. Snider Test has shown good improvement in Alpa vyayamshakti individuals, & least in Uttam vyayamshakti individuals.
4. Peakflowmetry has shown good improvement in Uttam vyayamshakti individuals & least in Alpa vyayamshakti individuals.

आ.र. - आयासमात्रफलं शारीरं कर्म व्यायामः ।
अयथाबलमारम्भः साहसम् ।
न हि व्यायामादि अतिभजनपर्याप्त्म पुंसां बलमस्ति ।

बलं व्यायामशक्त्या परीक्ष्येत ।च.वि.८
लाघवं कर्मसामर्थ्य दीप्तोऽग्निर्मेदसः क्षयः ।
विभक्तघनगात्रत्वं व्यायामादुपजायते ।। वा.सू. २-१०
बलवृद्धिकर भाव
बलवृद्धिकरास्त्विमे भावा भवन्ति। तद्यया - बलवत्पुरुषे
देशे जन्म बलवत्पुरूषे काले च, सुखश्च कालयोगः, बीजक्षेत्र
गुणसंपच्च, आहारसंपच्च, शरीरसंपच्च, सात्म्यसंपच्च,सत्त्वसंपच्च,
स्वभावसंसिद्धिश्च, यौवनं च, कर्म च, संहर्षश्चेति।।१३।। च.शा.६-१३

कर्म व्यायामादिकर्म इत्यर्थः, व्यायामादिकर्माभ्यासात् हि बलं भवति। चक्रपाणि टीका
व्यायामशक्तितश्चेति व्यायामशक्तिरपि कर्मशक्त्या परीक्ष्या।
कर्मशक्त्या ह्यनुमीयेत बलत्रैविध्यम्।।१२१।। च.वि.८

टीका- कर्म भारवहनादि, तत्र शक्तिः कर्मशक्तिः ।
टीका - स शरीरायासजननं कर्म व्यायाम उच्यते ।

In short,

1. Uttam Vyayamshakti individuals have shown excellent improvement in all four parameters except Snider's test.

The % improvement of Uttama vyayamshakti person in study group for Chest expansion test 9.57 %, for 40 mm Hg test 14.71%, for Snider's test 7.42% and for Peakflowmetry is 12.95%.

बलं व्यायामशक्त्या परीक्ष्येत । चरक
As per the above verse, bala of the person is examined by the capacity of doing exercise. Person having the Uttam vyayamshakti has possibility of having uttam bala if other factors are supporting like age, profession etc. In the same way, the matter of madhyam and alpa vyayamshakti.

In this study, it is observed that persons having uttam vyayamshakti have shown excellent improvement in all the four parameters, except Snider Test.

Uttama vyayamashakti people have shown highest improvement in Chest Expansion, test.

The reason may be

1. Uttama vyayamshakti person possesses Uttama bala as per the verse (balam vyayamshaktya parikhet). In Nadishodhana Pranayama exercise, Prana and Udana Vayu involved as deep ucchwas and deep Nishwasa is done in this process.Due to this:

a. Strength has been given to Prana and Udana Vayu due to consistently exercising the Nadishodhana Pranayama.
b. The strengthening of muscles of thorax also done, as this exercise is related to chest region.
c. Regulation of all types of Vata dosha done in this exerise, because Rechaka (deep expiration) and Puraka (deep inspiration) are the phases of this exercise.
d. As a result cheshta which is one of the Vata karma is improved.
e. Due to this there is free and powerful movements of mansa peshi which results in improvement in of all four parameters.

2. Alpa vyayamshakti individuals have shown less improvement in all parameters except Snider's test.

% improvement in Alpa vyayamshakti person in study group for Chest expansion is 8.34%, for 40 mm Hg test 12.99%, for Snider's test 7.94% and for Peakflowmetry 9.88%. It is less as compared to Uttama and Madhyama vyayamshakti persons.

As Alpa Vyayamshakti person possesses alpa bala, the force of doing Nadishodhana Pranayama is less.As these respiratory parameters depends mainly on expiratory force,the bala required for doing these test(expansion of chest) is less in this people.So more efforts are needed to improve the functioning of respiratory system. But stamina requires to do the exercise is poor, the resultant improvement is not much seen in these fellows.

So it can be concluded that **Nadishodhana Pranayama daily for 10 weeks shows good improvement in individuals of Uttam Vyayamshakti in Chest expansion, 40 mm of Hg test & Peakflowmetry test.**

6.F. Effect of Nadishodhana Pranayama on Pulse Rate and Blood Pressure:

When observation has been done of pulse rate and blood pressure before and after doing Nadishodhana Pranayama in study group and control group, the results found are

1. It is observed that the t score shows there is no significant improvement in the Pulse Rate after Nadishodhana Pranayama in study group at 5% significance level.

2. It is observed that the t score shows there is no significant improvement in the pulse rate in control group at 5% significance level

3. It is observed that the t score shows there is no significant improvement in the Diastolic BP after Nadishodhana Pranayama in study group at 5% significance level.

4. It is observed that the t score shows there is no significant improvement in the Diastolic BP control group at 5% significance level.

5. It is observed that the t score shows there is no significant improvement in the Systolic BP after Nadishodhana Pranayama in study group at 5% significance level.

6. It is observed that the t score shows there is no significant improvement in the Systolic BP control group at 5% significance level.

So from the above statitistical results, it can be concluded that there is no drastic or notable change observed on blood pressure or pulse rate before and after doing Nadishodhana Pranayama.

As stated in literature review, in the types of exercises, these Nadishodhana Pranayama exercise is catagorised in Mild type of exercise, because no “external work” is done in this exercise.External work is the shortening of muscle fibres against load like in swimming, bicycling etc.So the changes observed on the cardiovascular system are negligible **. Systolic blood pressure** increases or decrases when **cardiac output** increases or decreases which is again depends upon **Heart rate and stroke volume**. **Diastolic Pressure** is also directly proportional to **peripheral resistance**. Likewise Moderate and Severe Exercises, this Nadishodhana Pranayama exercise may don’t have much effect on CVS.

One of the articles[xxxv] supports this observation, which concludes that, "In normal person, yogic breathing exercises does not show much effect on CVS."

One another study[xxxvi], There was no significant change in SBP, DBP or MAP in either of the groups. All subjects in our study were normotensives. The reason for this might be twofold: one all the subjects in the study were **normotensives,** and two, the short period of study, *i.e.* 7 days. "
As stated in the above study, one thing is important that this study has been carried on **Healthy persons.** As stated in Literature review, Normal range of systolic BP is from 110 to 140 mm of Hg and diatolic BP is from 60 to 80 mm of Hg. Many physiological changes are occurring in Blood pressure and pulse rate in different time span like in the morning, after the meals, at sleeping time etc.So changes in Pulse rate and Blood pressure within Physiological range is considered as a normal or physiological change, which has been observed in this study.

As stated[xxxvii] in the "Essentials of Medical Physiology "by K.Sembulingam, during the beginning of expiration, arterial blood pressure increases slightly, i.e. by 4 to 6 mmHg, and it decreases during later part of expiration and during inspiration. It is because of two factors

1. Radiation of impulses from respiratory centres towards vasomotor centre at different phases of respiratory cycle.

2. Pressure changes in thoracic cavity leading to alteration of venous return and cardiac output.

So, slight increase in blood pressure and pulse rate during Nadishodhana Pranayama is negligible.

In another study[xxxviii], the readings of Pulse rate and blood pressure has been taken taken immediately after doing Nadishodhana Pranayama.
The changes in the initial and later readings after doing Nadishodhana Pranayama of Pulse rate and BP have been observed immediately.
One another study[xxxix] candidates have undergone two hours daily yoga programme for fourteen days. It was found that, there was significant reduction in resting pulse rate, Systolic blood pressure, Diastolic blood pressure and Mean Arterial blood pressure.

In this study, the readings are taken immediately after and before doing Pranayama. Another study[xl], Effect of Nadishodhana Pranayama on Cardiovascular functions. Sachit Goel, Varun Malhotra, Neera Goel, Jay Prakash, fall in HR, SBP AND RPP after 10 min of Pranayama among study subjects were noted.
In both the studies, the readings of Pulse and BP has been taken immediately after doing Nadishodhana Pranayama.
As stated previously,
1. The nervous mechanism is rapid amongst all the mechanism involved in the regulation of arterial blood pressure. When the areterial pressur alters, the nervous system brings the pressure back to normal within some minutes. Although the nervous mechanism is quick in action, it operates only for a short period and then it adapts the new pressure. It is called as short term regulation.
2. Baroreceptor mechanism- The baroreceptors are the receptors, which give response to change in blood pressure. Both the carotid and aortic baroreceptors are stimulated by the rising pressure and it helps to bring the pressure to normal.
So if BP and Pulse rate have been **taken immediately**, one can found changes in them in healthy person. After some minutes, the regulatory system show its results, trying to bring the pressure at normal level.
In present study, the pulse and BP was taken before starting the Nadishodhana Pranayama exercise and after finishing the study after 10 weeks. So this may be the reason of slight changes in BP and pulse before and after exercise.

In yet another study[xli], it is mentioned that," Nadishodhana Pranayama might have no any longer effect on peripheral vascular resistance or it has some roles, **but it may need practice for longer periods."**

So it can be concluded that, in this study, as Nadishodhana Pranayama has been done only for ten weeks, it may not be showing considerable effects on Pulse rate & Blood pressure. If it is carried out for more days, then the remarkable results might be observable.
In one more study[xlii], it is mentioned that, the readings of Pulse and BP should be taken daily while doing Nadishodhana Pranayama to observe the changes keenly. In this study, Psychophysiological effects of Nadishodhana Pranayama, Dr.Swami Nirmalananda Sarswati, Pranayama has been done for 6 months.

"The measured effects on CVS shows that, they remained within normal limits through out the experiment. **During the initial phase, the Pulse rate increases and at the end of the phase it approached to pre level.** The pattern was similar in both gender groups and the age specific changes were not remarkable.

For Systolic BP, like pulse rate, the long term effect of the practice was that, it **increased during early phase, but started declining steadily**. The immediate effect of the practice was to decrease SBP in the whole group.

Diastolic BP showed very little change throughout the experiment and there was no detachable pattern of change

The overall effect on CVS was stimulation during early phases as subjects were trying to achieve a predetermind pattern of breathing. As their bodies adjusted to this pattern, balance developed within the autonomic nervous system . The pulse rate and BP had already come down due to other purificatory factors like Pranayama ,diet etc.**Nadishodhana Pranayama is a balancing and not a calming practice. It will neither suppress its normal tone nor stimulate parasympathetic tone.Hence in relaxed, healthy, young adults the practice did not have any significant effect on the CVS."**

So from the above discussion, it is clear that daily monitoring of pulse rate and BP is necessary which was not done in this study, as only end results are observed. And as per above discussion, the Pulse and BP rises initially and becomes normal after few days due to adjustment of the body.

One more important factor is that to see the effect on Pulse rate and Blood Pressure,the study should be done in Pathological volunteers.

In this regard a study[xliii] was done on patients related to cardiac problems. The result of this study confirms that Pranayama will assist in decreasing the BP, Pulse rate and symptoms among hypertensive patients.

Another article[xliv], states that, Pranayama leads to better control of BP in mild hypertensive patients."

As stated in the article[xlv], Psychophysiological effects of Nadishodhana Pranayama. Dr.Swami Nirmalananda Sarswati, " Nadishodhana Pranayama is a balancing and not a calming practice. It will neither suppress its normal tone nor stimulate

parasympathetic tone. Hence in relaxed, healthy and young adults, the practice did not have any significant effect on the CVS.

So the results will be depicted more sharply on Hypertensive patients as compare to Healthy ones."

So from the above discussion and studying the previous articles, it can be **concluded that Nadishodhana Pranayama exercise does not show any remarkable effect on Pulse Rate and Blood pressure of Healthy person in 10 weeks.**

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CONCLUSION

10 aavartanas of NadishodhanaPranayama daily for 10 weeks shows improvement in Uchchhwasakarma of UdanaVayuin healthy volunteers, in all 4 parameters, viz. Chest expansion, 40 mm Hg test, Snider test and Peakflowmetry.

SCOPE FOR FURTHER RESEARCH

1. In this project, out of many karmas of Udanvayu, effect of NadishodhanaPranayam exercise has been studied only on Ucchwas karma by using respiratory parameters. Effect of NadishodhanaPranayama on the remaining karmas like Vakpravritti (speech), Prayatna, Urja, Bala, Varna, Smruti etc. can be studied by using different parameters and NadishodhanaPranayama exercise can be made more effective tool to improve the concerned particular function of Udanvayu. e.g. If by practising NadishodhanaPranayama exercise, Vakpravritti has been improved, then daily practice of this exercise can be suggested to the professionals like teachers, singers, consultants etc. where there is overuse of speech. If smruti is improved then it can be suggested to intellectual people.

2. Like NadishodhanaPranayama exercise, effectiveness of other methods of Pranayama like OmkarPranayama, BhasrikaPranayama, Suryanamaskaretc can be studied on the functions of UdanVayu.

3. In this project, Peakflowmeter has been used as a main parameter to asses the ucchwas karma of Udanvayu. By using this instrument, improvement in ucchwasbala (exhalation power) has been seen. So to know the status of Udanvayu in the body, Peakflowmeter can be used on OPD level basis with other examinations.Further research should be done on this topic.

4. In this project it has been proved that, Ucchwasbala of Udanvayu can be improved by NadishodhanaPranayama exercise. As per the karmas of Udanvayu, Bala is one of the important functions of Udanvayu. Udanvayu itself is Bala, as stated in Vaghbhata, 'Udanobalamuchyate.'So whether this bala is related to sarvadehikbala, manasabala or ucchwasabala will be the topic for the further research.