PHYSICAL FITNESS AND PULMONARY FUNCTIONS IN SCHOOL CHILDREN

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CONTENTS

CHAPTER 1 INTRODUCTION

DR. G. B. DHANAKSHIRUR, DR.SUMANGALA PATIL

In ancient Vedas, importance of physical fitness has been emphasized by saying

" Shareermadhyam khalu dharma sadhanam"

i.e to achieve anything in life our body must be fit or healthy. Strong body is necessary for achieving anything in life.

The body fitness is achieved through sports. The history of which is probably as old as the history of man himself. In the ancient classic "Shrimat Bhagavatam", there are references of professional Wrestlers. Lord Krishna while still in his very early teens beat some of the greatest contemporary professional wrestlers in the court of the tyrant king Kamsa. Both the ancient Greeks and Romans were great sport loving people. They practiced Kangfu to protect themselves from the armed bandits. Animals in jungle perform various playful acts, teleology, perhaps, is this keeps them fit.[1]

Fitness at the Dawn of Civilization [2]

If several hundred years from now archaeologists were investigating our society, they would find endless examples of sport in the United States: stadiums, swimming pools, running shoes, hockey sticks, skis, baseball gloves, posters of sports stars, etc. Various forms of sport and physical education have been around since the late 1400's and have only gained momentum and recognition in the centuries that followed.[2]

Physical fitness history spans back to the dawn of man. At that time, formal exercise wasn't necessary because prehistoric man's way of life involved a great deal of exercise. During this era in physical fitness history, primitive man was constantly on the move as a hunter/gatherer. Because of this, there was no need to pursue physical fitness.[2]

In about 10,000 BC, man as a hunter/gatherer came to an end as human beings developed agriculture. It was during this period that man started to cultivate plants and domesticate animals for the purpose of food. It was also during this time that the plow was invented. The agrarian lifestyle during this period was the beginning of decreasing daily physical activity. There was still hard work involved in daily life and little emphasis was placed upon physical fitness.[2]

As man's innovation advanced, their natural activity levels decreased. In ancient China, Confucius recognized that physical inactivity was becoming a way of life and his teachings encouraged participation in regular activity. Because of this, Cong Fu was developed to keep the body in shape. Chinese also participated in other activities that were purely for the pursuit of physical fitness – such as wrestling and badminton.[2]

During this same period, the ancient Indian civilization was taking another route. Religious beliefs of the time discouraged the development of the body, emphasizing instead the development of the spirit. Yoga emerged as a means of reconciling these two things – moving the body in ways that opened up spiritual pathways.[2]

The Indian rulers like Shivaji Maharaj, Krishnadevaraya and Tamilnaadu emperors have started physical fitness training centers in their realms to train the youngsters to become physically fit. As realms were ruined, training programme came to an end.

Yet, physiology of exercise, in particular sports physiology is not a very old subject. Now, it is growing very fast. Probably, the reason for its rapid growth may be the patronage from the government, society and mass media network. The society hopes that prize winning in sports brings recognition to it. The modern sports have gained the demand due to their fierce competitions. Physical fitness and sporting activity are interdependent.[2]

Regular physical exercise is known to have beneficial effects on health. As diseases are related to lack of fitness, Americans realized that there is a need to counteract a sedentary lifestyle with planned physical activity through sports and formal exercise. This brought government's attention to the lack of fitness of its citizenry. This led to the establishment of minimum fitness standards in the country's public schools.[2]

One of the first men to recognize the importance of physical activity in school curriculum was Johann Bernard Basedow in Germany. He included gymnastics as part of the daily curriculum devoting up to three hours per day. Basedow required a specific uniform for his students so they could have unrestricted movement. He also offered a camp for two months during the summer for his students.

In 1810, Friedrich Jahn, “the father of gymnastics”, began working outdoors with his students using simple exercises and games sometimes taking long hikes. Jahn motivated to develop a system of physical training as his deep sense of patriotism. Germany had been defeated in the Napoleonic wars. So, he developed his system with a hope of creating strong, sturdy and fearless youth who would help secure Germany's freedom and could defend the Fatherland from outside forces. Charles Beck who was a student, friend and follower of Friedrich Jahn teamed up with a friend and they made their way to Switzerland, France and eventually America. George Bancroft who had opened the Round Hill School in America had been looking at and studying the German system and immediately hired Beck to teach Latin and Physical Education in the form of German gymnastics. So, Beck became the first official Physical Education teacher in America in 1825.[2]

“Survival of fittest” (Fit person will survive)

The above quotation indicates the importance of physical fitness. It is not only essential for an individual but also for the whole nation.

The nations which have realized the importance of physical fitness have started specific programmes. These programmes are aimed to hold up and build up the nationsS.

For those who strive to achieve and maintain a high quality of health, it must be recognized that physical activity is vital to optimal health. This is reaffirmed by numerous studies that have found an association between physical activity, health, longevity and an improved quality of life. In addition, the number of deaths related to sedentary living or obesity is approximately a half-million per year. Physical activity may impact quality of life in several ways: it can be used to improve self-image, self-esteem, physical fitness and health.

In our country, we are getting acquainted with the modern amenities at a very fast rate, so we are neglecting the natural physical activities. The present attractive education system has helped to improve the education standards. But the non active sedentary stressful life has made the youth physically unfit. Now the time has come to consider about the physical fitness and exercise in the adolescent age group. Realizing this fact, educationalists have recommended minimal physical exercise in the curriculum.[1]

CHAPTER 2 CARDIOPULMONARY FITNESS

DR. LATA MULLUR PROFESSOR

According to Sunderrajan (1983),[3] Physical fitness is an intrinsically individualized index. It expresses the individual's biopotential, comprising functional and metabolic components and growth factors built up and maintained by exercise.

According to H.S Harrison Clarke (1971),[4] physical fitness is defined as ability to carry out daily tasks with vigor and alertness without undue fatigue with ample energy to enjoy leisure time pursuits, to meet unusual situations and unforeseen emergencies.

Physical fitness is ability to last to bear up to withstand stress and to pressure under difficult circumferences where an unfit person would be ineffective or would quit.[4]

The positive health is the terminal goal of the health planners where the physical fitness is the means to achieve the targets.

Children and physical fitness

The physical growth in boys and girls more or less is equal up to adolescence. The peak growth velocity is achieved earlier in girls than the boys.

The childhood between 6 to 12 years is an age comparison by competition (1st stage) and at the age of 12 to 15 years, the physique is changing (2nd stage). The third stage of growth is adolescence, where the gender identification is observed. But later year is a stage of separation. Maximum strength is obtained from approximately one year following peak period in growth of height and weight. Maximum aerobic capacity is obtained at this time.

Therefore, to achieve good fitness in children, sports programmes should be arranged accordingly. At 1st stage, priority of fun, recreation, skill development and opportunity for competition should be provided. At the 2nd stage, the exercise should be both competitive as well as more exhaustive than 1st stage, where as in the 3rd and 4th stages, the exercise should be severe enough to attain maximum fitness. Because at this stage, the muscle strength, cardio respiratory strength and endurance of the children are developed maximally.[5]

Physically fit have various advantages

1. Physical fitness increases the level of intelligence.
2. Physical fitness makes the children more extrovert, social, dependable, tolerant, active and competitive. Children with low fitness are emotionally unstable and defensive.
3. Physically fit children show better adaptability to stress, less neuromuscular tension and less fatigability.

Nutrition and Physical fitness [6]

Excess availability of food, low energy expending and highly mechanized life style increase body fat which is incompatible with the physical fitness. Therefore, active energy expending life is essential in order to achieve physical fitness.

It is necessary to include all energy substrates in the diet plus vitamins and minerals which provide the enzymes that catalyze energy production.

Life style and physical fitness

Regular active disciplined lifestyle will enhance physical fitness. Balance diet, exercise, work, relaxation and sleep will make the person happy and energetic.

PHYSICAL FITNESS PARAMETERS

1. Maximal Aerobic Power (VO_2 Max).

Fitness can be measured by volume of oxygen that can be consumed while exercising at one's maximum capacity.VO_2 Max is the maximum amount of oxygen in ml, one can use in one minute per kg of body weight. Those who are more fit have higher VO_2 Max and can exercise more intensely than those who are less fit.

Maximal Aerobic power is defined as the highest oxygen uptake, an individual can attain during exercise while breathing air at sea level.

Before puberty, girls and boys show no significant difference in Maximal Aerobic power.[7]

The maximal oxygen uptake increases during childhood and adolescence, as there is growth in all tissues of importance for strength and power.[7]

Maximal aerobic power is expressed in lit/min. It gives information about a person's potential for activity requiring a high aerobic power. It is highly correlated with the individual's Maximal stroke volume and cardiac output. It indicates person's potential to move the body during activity such as running, climbing upstairs etc for several minutes or longer.

Mean VO_2 Max for male athlete is 3.4lit/min. Training and regular physical activity can modify the maximal oxygen uptake. Top athletes in endurance events have a VO_2 Max that is about twice as high as that of an age matched average person.

Inactivity is another fact that decreases the functional range of oxygen transporting system. It decreases stroke volume and perhaps the efficiency of regulation of circulation during exercise.

An obese person due to overweight increases the energy cost of moving the body.

Vo_2 Max depends on chemical ability of muscular, cellular and tissue systems to use oxygen in breaking down fuels and combined ability of cardiovascular and pulmonary systems to transport oxygen to muscular tissue system.

Factors affecting VO_2 Max

Age :

The maximum oxygen uptake is not spared by the effect of ageing. The maximum oxygen uptake in lit/min rapidly increases during the growth stages of the early years and reaches its peak between 18 to 25 years. After the age of 25 years, the VO_2 Max declines steadily. By age 55 years, it is about 27% below the values reported for 20 years of age.

The effect of age has been extensively studied. It was shown by Robinson (1938)[8] and later by P.O Astrand (1956)[9] that maximal aerobic power increases during childhood to reach a peak in the late teens which is maintained until the mid twenties. The early increase is due to growth of muscles, heart and lungs and the later decline is due in large part to a gradual reduction in maximum cardiac efficiency with advancing age.

Sex :

Vo_2 Max values for men typically exceed scores for women by 15% to 30%, even among trained athletes. The apparent sex difference is due to gender related change in the body composition and hemoglobin content.[6,10]

Body composition:

It is estimated that 69% of the differences in VO_2 Max score among individuals can be explained by differences in body weight, 4% by differences in height and 1% by differences in lean body weight.[6]

State of training:

The VO_2 Max score must also be evaluated relative to the person's state of training at the time of measurement. An improvement in aerobic capacity with training ranges 6% to 20% above pretraining level.

Mode of exercise :

In various experiments where VO_2 Max was determined on the same subjects during different forms of exercise, the highest VO_2 Max was obtained with treadmill exercise. In the laboratory, the treadmill is the apparatus of choice for determining VO_2 Max.

In the field experiment or when funds are scarce, stepping or bicycle exercise is a suitable alternative. Stepping is a familiar form of exercise and is easily administered. Benches are simple to construct, do not require calibration and can be easily transported.

The simplest and most extensively applied way of testing the circulatory function capacity is to determine the heart rate/ pulse rate during and after exercise.

Harvard step test was developed during second World war as a scoring test to select the individuals according to their physical fitness by Brouha in 1943.[11]

Later on, this test was used for the cardiovascular fitness by American Alliance for Health, Physical Education, Recreation and Dance, (AAHPERD 956) for selection of sports in youth.[12]

The original Harvard Step Test (HST) has a 50 cm/20" height of bench, duration of 5min, with frequency 30 steps/min. So, only 1/3rd of subjects were selected.

It was observed that lower the number of heart beats during recovery, longer the work time and higher is the score. The original HST was only for highly physically active subjects, which was not suitable for normal healthy subjects of sedentary lifestyles in many countries as observed by Clarke HJ (1943).[13]

Several modifications of Harvard test were suggested. Clarke H.J (1943) used a bench of 16" high for college girls and found that the scoring formula could be applied without a change.[13]

Kaprovich[14] and his associates (1949) reduced the stepping rate from 30 to 24 per minute. This was done for two reasons,

1. This rate was easier for the subjects to maintain and
2. It was easier for the tester to keep the count without either pendulum or metronome.

A number of modified Harvard step tests had been recommended by number of workers either by lowering step's height, frequency of up and down/min or by altering the duration of exercise instead of maximum period of 5 min.[15,16,17,18]

The draw backs of original Harvard Step test was, it might produce acute local muscular fatigue and that the bench was too high.

Original evidence of validity for Harvard Test was based upon endurance in

Treadmill running, Maximum Heart Rate per minute and Blood Lactate level.

Effect on Cardio Vascular Endurance

It is increased due to various structural and functional changes in the heart and vessels.

1. Myocardial hypertrophy: Variable with age, sex, type of exercise, and intensity and duration of exercise. If produced at an early age, it may be long lasting.[19]
2. Cardiac output: It is increased due to increase in stroke volume, which is more due to hypertrophic heart.[20]
3. Bradycardia : It depends on several interdependent factors.
    a. Sympathetic tone: It is reduced. Training may increase myocardial concentration of Acetylcholine.[21]
    b. Parasympathetic tone: It is increased due to training.[22]
    c. Peripheral adaptations: They occur in skeletal muscles and peripheral circulation which will reduce the amount of stress from any absolute work load. Therefore, central sympathetic output is less and heart rate response is reduced.[23]
    d. Intrinsic heart rate: The uninfluenced discharge of sino-atrial node is reduced after training.[24,25]
4. Coronary circulation: It is increased according to demand.[26]
5. Efficiency of Blood flow: It is increased due to increased capillarization and hypertrophy of existing blood vessels. The resting blood flow does not change, but the blood flow debt during recovery is reduced. It means vascular bed opens to a greater extent during exercise.[27]

Pulse Rate During Exercise :

At the beginning of the muscular exercise, the pulse rate increases rapidly. The greatest rise takes place within one minute. Half of this increase occurs within 15 seconds, gradually a pattern is reached. If the exercise is intensive, the secondary rise may be observed. The change in pulse rate is individualized.

The pulse frequency shows a linear relationship to the amount of oxygen absorbed during the period of work.[28]

Respiratory Endurance:
It is increased due to increased number of functioning alveoli and their dilatation.

Capillary vascularisation and strength of respiratory muscles are also increased. As a result, there is an increase in both static and dynamic functions of the lungs and the diffusing capacity. The rate of respiration is reduced.[29]

Effect on Body Composition.
Total body fat reduces and lean body mass increases to some extent. Maximal oxygen uptake is proportional to body weight (lean body mass) and diminishes with advancing age. A peak in maximal oxygen uptake is observed between 15 to 20 years of the age. A gradual decline with advancing age is found in this group of the male individuals.[30]

Effect on Blood culture
The RBC count is increased and hemoglobin content too, by enhanced erythropoiesis. Daniel stated that during adolescence, developmental changes in hemoglobin or hematocrit are a function of the stage of sexual maturation in boys. Total hemoglobin is also related to maximum oxygen intake.[31]

Psychological Effects:
Regular exercise positively brings about an emotional stable mind. In a physically fit person, symptom alleviation of depression is greater. Moderate exercise is associated with enhanced cognitive function.[32]

Appropriate kind and amount of exercise constantly employed will develop muscular strength and endurance. In fact, properly directed exercise is the only means of aquiring the ability to engage in tasks demanding strong and sustained physical efforts.

CHAPTER 3 PULMONARY FUNCTION TESTS

DR. GIRISH KHODNAPUR

Pulmonary function testing is also a valuable tool for evaluating physical fitness of any individual. Conventionally, strength of respiratory muscles is evaluated by determining pulmonary function tests. There are various factors that influence the pulmonary function tests. The most important factors are age, height, weight, sex, race and proper physical training. Further more, individual factors such as environmental factors, socio-economic status, habits and differences in life style can also cause a change in values of pulmonary function tests.[33,34]

Evolution of pulmonary function tests:
Hutchison, a London Surgeon in 1846 in his classic treatise “On the capacity of lungs and Respiratory Function” introduced the concept of Spirometry. Recently with the inventions and evolutions, more sensitive and technologically excellent equipments such as Spirometer, Mini Wright's peak flow meter, Medspiror etc, are being developed. Eventually handy instruments are designed and made available. Accordingly, pulmonary function tests have become more easier and more practicable.

The following are some of the important landmarks in the evolution of pulmonary function tests. The founders of experimental Physiology were Erasistratus (280 B.C) and Galen (131-201) who demonstrated the role of diaphragm as a muscle of respiration, the functions of the phrenic nerve and function of intercostal and accessory muscles.[35] The barrier to the passage of blood imposed by the interventricular septum was recognized by Ibn-al-Nafis (1210-1289) and Servetus(1511-1553). They separately proposed that blood passes from pulmonary artery through the lung to the pulmonary vein.

Function of the diaphragm was further explored by Da vinci (1452-1519) who observed that during inspiration the lung expands in all directions following the movement of thoracic cage. The collapse which follows puncture of the pleura was described by Vesalius (1514-1564).

The need for fresh air was recognized by Galen who believed that it reacted with the blood in the left part and arteries to produce the vital spirit. Boyle (1627-1691) demonstrated that the constituents of air which supports combustion also supports life. The information about the lung which was necessary for the birth of respiratory physiology was available by 1667. The stroke output of lung bellows or vital capacity was first index of function to be investigated and it was measured in 1679. It was a fully developed test by the year 1946.

During the 18th century, role of the lung as an organ of gas exchange was observed by Lavoiser (1777) and others. They observed that it was the site of combustion. Measurement of residual volume by a gas dilution method was first performed by Davy (1800).

Thackarah (1831) showed that volume of air is less in women than in men and is reduced among the workers in flax and other occupations due to the inhalation of dust. The measurement was assessed finally on a quantitative basis by Hutchison (1846).[33] Spirometer was invented as early as in 1846 by Hutchison to measure lung volumes in various groups of people in London.[35]

Hutchison defined vital capacity as the greatest voluntary expiration following the deepest inspiration. He only designed a spirometer for the estimation of vital capacity related to height such that for every inch of height (from 5ft to 6 ft) eight additional inches of air at 60 degree F are given out by forced expiration. He also further showed that the vital capacity decreased with age and was reduced by excess weight and by disease of the lung.

Role of elastic recoil of the lung in causing expiration was demonstrated by Donders (1849).[33] Exchange of gas in the lung was intensively studied during the period of 1890. The techniques for analyzing gases were improved by Haldane and described in "Method of Air Analysis"(1899).

The relationship of vital capacity to breathlessness was described by Peabody (1915). He also compared the ventilation during the inhalation of carbon dioxide with that during exercise. The use of forced vital capacity was introduced by Strohl(1919).

In 1925, Fleisch constructed Pneumotachograph. Jenson and Strombergen introduced maximal breathing capacity as a dynamic test of lung function in 1932. Jacobacus developed Bronchospirometry. Hermannsen first measured maximal voluntary ventilation. Maximum breathing capacity was introduced as a dynamic test of lung function by Tensen, Knipping and Stromberger (1932). Hermannsen calculated the equivalent minute volume from the Kymograph record maximum voluntary ventilation (MVV).

The role of changes in lung distensibility in causing breathlessness was explored by Christie (1934).[33] The use of the proportion of vital capacity which could be expired in the first one second (FEV1), as a guide to airways obstruction was introduced by Teffenman (1948) and Pinelli (1947) who called it "Capacite Pulmomaire Utilizable all effort."

This timed vital capacity is now generally referred as One Second Forced Expiratory Volume (FEV1). The usefulness of FEV1 was firmly established by Gaensler.[33]

The spirometer designed by Hutchison was a light bell shaped container immersed in water tank which forms a seal.[35] As the bell moves up during exhalation the pen moves down marking the chart. The disadvantage of this instrument is the inability to measure the Functional Residual Capacity (FRC) and Residual Volume (RV).

The snowbird workshop held in 1979 resulted in the first American Thoracic Society (ATS) statement on the standardization of spirometry.[36] This was updated in 1987 and again in 1994. A similar initiative was undertaken by the European community for steel and coal resulting in the first European standardization document in 1983.[37] This was then updated in 1993 as the official statement of the European Respiratory Society (ERS).[38]

According to Donald (1953), the Physician of last century who asked a patient with respiratory disease to whistle or blow a candle out was crudely assessing the maximum respiratory velocities. Donald suggested that "a simple whistle like instrument" might be developed and then might become a standard clinical tool.

In 1959, Wright and M. C. Kerrow[39] first described the use of Peak flow Meter for measuring PEFR with advantages over the pneumometer and Puff meter as it was simpler portable and had a lower resistance at higher flow rates. It was found to be convenient and reliable way of estimating ventilatory function and to produce results which co-relate with other recording methods.

In 1978, Wright described a mini Wright's Peak Flow Meter which has advantage of being economical and smaller than the original model[40] and other models make similar measurement. For example De Bone Whistle,[41] even economical but end point is less accurate.

Dubios et al in 1956 introduced a very different method of measuring functional residual capacity (FRC) by Helium dilution in a "closed circuit" in a system that does not allow gases to escape.

Dubois et al in 1956 introduced a very different method of measuring FRC by Plethysmograph.[42] Along with technology enhancements in various fields of Medicine, the Spirometer has undergone dramatic changes. With the advent of computerization, revolutionary changes have been brought in Spirometers which have become user friendly and accurate.

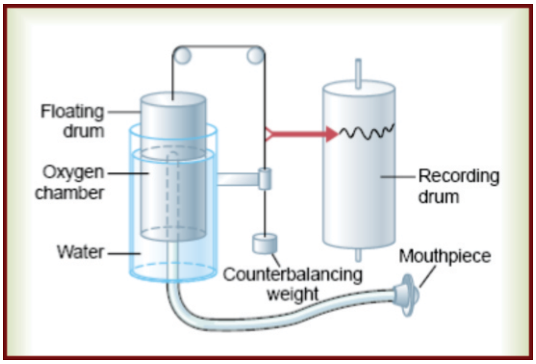

Fig. 1: Showing diagram of Spirometer[43]

SPIROMETER
PULMONARY FUNCTION PARAMETERS : [44,45,]

The static lung Function tests are.... Tidal Volume (VT), Inspiratory Reserve Volume (IRV), Inspiratory Capacity (IC), Functional Residual Capacity(FRC), Vital Capacity (VC) and Total Lung Capacity (TLC).

The dynamic lung function tests are ... Forced Expiratory Volume or Timed Vital Capacity (FEV or TVC), Maximum Ventilatory Volume or Maximum Breathing Capacity (MVV or MBC), and Peak Expiratory Flow Rate (PEFR).

The lung volumes and capacities (V_T, IRV, ERV, IC & VC) and also FEV and MVV can be measured by Spirometer. Peak Expiratory Flow Rate can be measured by mini Wright's Peak Flow Meter (WPFM).

FRC cannot be measured by simple Spirometer. It can be measured by Nitrogen wash out or Helium dilution method.

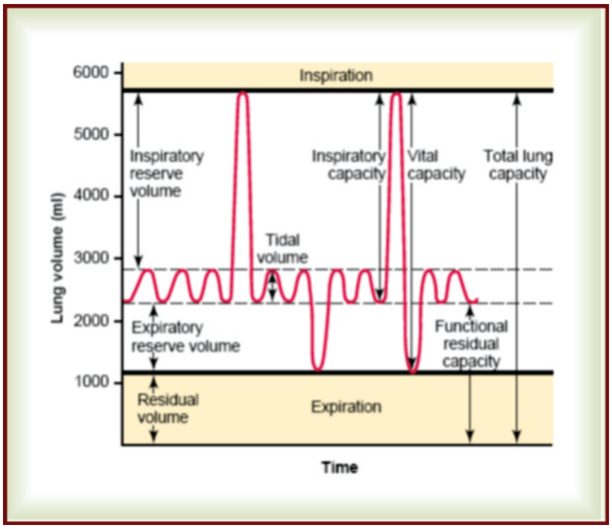

Figure 2: Diagram showing Lung Volumes and Capacities[43]

CHAPTER 4 PHYSICAL FITNESS & PULMONARY FUNCTIONS

Several studies well established that physical fitness & pulmonary functions of an individual are very necessary to carry out daily task.

Following studies have been done on cardiopulmonary physical fitness in healthy subjects.

Edward. L. Fox (1973)[46] in special communication concluded that Maximal Aerobic Power is single most valid measure of functional Capacity of Cardiopulmonary System. Their data were obtained from 876 healthy but untrained college male individuals in 17 to 19 years of age group.

P.K Dasgupta and A.K Das (1991)[47] in their article explained that high volume of VO_2 max in Athletes as a result of training may be due to some genetic endowment in them.

Training increases VO_2 max by increasing Cardiac Output secondary to high Stroke Volume and an increase in Arterio-Venous (AV) Oxygen difference. It appears that physical training increases VO_2 max by about 50% due to an increase in cardiac output and rest 50% due to increased extraction of Oxygen by working muscles which is reflected by increased AV difference.[48]

S.K.Das, S.Mahapatra, G.Bhattachaeryaand D.Mukherjee (1993)[49] in their study on 140 subjects with age group 20 to 25 years (78 male individuals and 62 female individuals) with modified Harvard's Step Test, observed that Mean PFI was 103+12(%) in male individuals and 84+07 (%) in females individuals.

P.K.Dasgupta, A.K.Makhopadhayay and A.K De (2000)[50] conducted a study in 17 subjects grouped under 2 groups and VO_2 max determined during gradual exercise in tread mill at 11 km/hr, Oxygen pulse by Oxygen consumption in ml/min by Heart Rate. In their study, they observed that several factors like heredity, environment, diet, training, hormone status, socio economic status, psychological trait etc contribute to the performance of sportsman. [51,52] And also they saw that training increases both Stroke Volume and Oxygen extraction by tissues.

Thierry Busso et al (2002)[53], in their study showed the reduction in recovery time increases between training sessions, yielded a progressive increase in the magnitude and duration of fatigue induced by each bout of training stimulus and also lead to a decrease in resultant adaptation. Reduced adaptation to training loads could arise from lower tolerance to exercise from higher fitness level or from a limitation on the body's capacity to adapt to greater training loads.

Satipati Chatterjee, Pratima Chatterjee and Amit Bandyopadhyaya (2004)[54], in their study evaluated cardiopulmonary fitness in terms of VO_2 max in obese boys of West Bengal of India. 49 Obese of 10 to 16 years age range were studied against 70 Non Obese counterparts.

They observed absolute VO_2 max was higher among Obese group because of higher values of Body Mass and Lean Body Mass, but VO_2 max per Kg of Body Mass was significantly higher among no obese groups (Obese 39.6+2.6 Vs Non obese 48.4+ 1.8 ml/kg/min). The VO_2 max per unit of Body Surface Area was significantly higher in obese group. They concluded that reduced oxygen utilization by adipose tissue during exercise reduces the overall VO_2 max.

Ravi Sankar P, Madanmohan, Kaviraja Udupa and E. Sankaranarayan Prakash (2005)[55] conducted their Study in apparently healthy 145 (105 male individuals and 40 female individuals) subjects aged 14 to 18 years. Data were showing correlation between BMI and BP indices, handgrip strength and handgrip enduarance, in underweight, normal weight, and overweight, adolescents.

Both systolic and Diastolic blood pressures were highest in overweight and least in underweight male subjects. In female subjects, Diastolic blood pressure alone showed statistically significant. Positive correlation was seen between BMI and HGS. Positive correlation was also seen between BMI and SBP in overweight female individuals.

They concluded that there is gender difference in correlation between BMI and BP indices especially in underweight and overweight subjects

Following studies have been done on pulmonary function tests in healthy subjects.

A study on Peak expiratory flow rate of residential and non-residential school children showed that, the children from Sainik school had the higher values of lung functions related by PEFR in comparison to non-residential school children.[56]

Choudari D, Aithala M, Kulkarni VA (2002) [57] did study on Maximal expiratory pressure in Residential and Non-Residential school children, observed that the children from Sainik school who underwent routine physical exercise, had higher values of maximal expiratory pressure in comparison to non-residential school children. This might be attributed to greater physical activities in children of Sainik school leading to greater Aerobic fitness.

Vijayan VK, Reetha AM, Kuppurao KV, Venkatesh P, Thlakavathy S (2000)[58] studied on Pulmonary function in normal south Indian children aged 7 to 19 years, observed that the height influences the prediction equation in males to a great extent, whereas age and weight had greater influence in girls. Regression equations were derived for boys and girls for predicting normal pulmonary functions for children in South India. The pulmonary function measurements in South Indian were similar to those reported for subjects from Western India and lower than those reported for Caucasians.

A study was conducted on Environmental and social factors as determinants of respiratory dysfunction in junior school children in Moscow comprising of 539 children aged 6-12 years who attended school and lived in one of three districts of Moscow with varying ambient pollution levels. It was concluded that children from areas of high environmental pollution had lower lung capacity.[59]

In a cross-sectional study in 861 healthy Danish schoolchildren aged 6-17 years, Peak Expiratory Flow (PEFR) was measured by using a mini Wright's peak meter. A strong correlation was found between PEFR and height, age and sex. Among healthy children without previous asthma, earlier episodes of recurrent wheezing were reported in 8.8%. A significantly lower PEFR was found in this group.[60]

A study on prediction equation for lung functions in South Indian children, observed that Lung volumes and flow rates were lower than North Indian and foreign boys. The decrease in lung functions in South Indian boys were due to their sea level dwelling, dietary habits and comparatively lower anthropometric measurements.[61]

A study was on Lung function in Malay children to measure the Peak expiratory Flow, FVC & FEV1 in primary school children aged 7-12 years. They found that PEFR was correlated with age & height of the subjects. But, FVC & FEV1 were correlated with height only. It was concluded from the study that before puberty lung indices increase with both age & height.[62]

A study on Peak Expiratory Flow Rate in 345 healthy South Indian school children aged 4-15 years, observed that PEFR increased progressively with age & showed a very good correlation with height, age & weight in both sexes. Their results showed that highest correlation was obtained between PEFR & height & weight. They constructed a nomogram from the linear regression using PEFR as the dependent & height as the independent variable. It was found that 75% of the variability in PEFR could be explained by height alone.[63]

Shivesh Prakash et al conducted a study on 20 randomly selected subjects belonging to Athletes, Yogi's and sedentary groups using a COSMED /micro Quark spirometer based on ATS Recommendations and observed the following:[64]

1. The groups differed significantly in FEV1 (p=0.047) and PEFR (p=0.022).
2. The highest Mean FEV1 (96.25%) and PEFR (116.77%) were observed in Yogi's.

3. Lowest FEV1 and PEFR values were observed amongst the sedentary workers and Athletes respectively.
4. Comparison of Athletes with sedentary workers revealed significantly higher FEV1 (p=0.038, 95%, 14.6; 4.2) and FEV1/FVC (p=0.02, 95% C1; 7.5; 0.6) parameters amongst the Athletes.

Comparison of Yogi's with sedentary workers revealed significantly higher FEV1 (p=0.036, 95% C1;16.15, 0.06) PEFR (p=0.037, 95% C1; 19.0; 0.6) among the Yogi's.

There are no significant differences in the other parameters mentioned. Lung functions of Yogi's and Athletes were similar expect for PEFR which was significantly higher among Yogi's. (p=0.019, 95% C1, 20.5; 1.08).

The lung Function tests, like other physiological tests must be of the utmost importance for measuring the fitness of an individual from a Physiological point of view. The Pulmonary Function Capacitors of normal sedentary individuals have been studied extensively in India [65,66,67,68,69] in the context of an athletic population by Singh, Rao and Gupta et al. Such studies are scanty and have also been carried out by the researchers on a small sample by Malhotra et al, De et al.[70,71]

Pande J. N et al (1997)[72] recorded PEFR in children (6 to 17 years, n=183) from Urban Delhi school and from another school (n=523) in Nellore, AP. The Study showed that Age, Sex, Height and Weight were independent predictors of PEFR in children from Nellore.

For boys from Delhi, Age, Sex and Height were independent predictors for PEFR, while for Delhi girls, Height recorded, PEFR from both regions of the country were lower than those reported from American white children.

Rajesh Sharma, Anil Jain, Achala Arya and B.R Choudari (2002),[73] in their study evaluated that PEFR in a group of rural school going children from Ajmer Dist of Rajasthan and compared the values with available from North India.

They conducted a study on 203 subjects (163 male individuals and 140 female individuals) aged 5 to 14 years, mostly from low socio-economic group were chosen. The Mean Height was 128+3.8 cms, Mean Weight 25.61 kg and PEFR measured ranged from 92 to 460 lit/min.

Emerson and Green (1921)7[4] published one of the first scale studies on vital capacity values in children. Their methods were acceptable. Yet, their values were considerably small. This fact was noted by Edward and Wilson[75] and by Ferris et al. (1952).[76] But, no full explanation could be given for their discrepancy.

Lange et al (1984),[77] observed in longitudinal study of Lung Volumes and growth in both Athletes and Non Athletes. It revealed that Lung Volumes and growth increased with Body Height.

In an another study conducted by S. C Lakhera, T. C Kain and P. Bandopadhayay (1994)[78] in 25 subjects (14 male individuals and 11 female individuals) of 13 to 17 years age group with 1 year training. They concluded that boys had slight higher Lung Function Values in comparison to those of girls. Males had significant effect on Lung Volumes and Capacities. Adolescent habituated to high level of physical activity, has an average greater level of Lung Volumes. These were compared with Age, Body Size of same age group. Therefore, training may be of greater importance in determining the ultimate dimensions of lungs. They also concluded that running training during growth may help in developing a reduced resistance to expiration and a greater endurance in respiratory muscles.

S. K. Malik and S K Jindal (1985),[79] in their study on 441 male individuals observed a linear relationship of Lung Functions with Age, Height and Body Surface Area. Lung Functions based on Age and Height were identical to those based on Age and Body Surface Area. They observed that the nomograms available in literature were largely from Western Countries and were not strictly applicable in Indian children because of ethnic and environmental factors.

Avinash Kumar et al in (1992),[80] observed in their study conducted on 177 male healthy children between age group of 10 to 18 years that there was a linear relationship for lung functions with age, height, weight and BSA. The values when compared with South Indian students were higher but closer to other North Indian students.

R Hari Kumaran Nair, et al (1997)[81] conducted a study on study on 109 South Indian school boys in the age group of 5 to 16 years on Lung Functions (VC, IC, FVC, $FEV_{0.5}$, FEV_1, PEF, PEF0.2 to 1.2, FEF25 to 75%, FEF75 to 85%, PIF, FMFT, MVV_{IND}, PEF at 25%, 50% and 75% of FVC, PIF at 75%, 50%, 25%).

They observed that the entire lung functions except FEF 75 to 85% and the Ratio between different Lung Volumes showed positive correlation with Age, Height and Weight.

The values obtained were, Age group 14 to 16 years (n=42), Mean Height (cms) 159.21+6.25, Mean Weight (kgs) 44.64+6.84, VC (lit) 2.45+0.41, IC(lit) 2.31+0.50, FVC (lit) 2.42 +0.50 and PEF (lit/min) 260.85 +56.44.

Peak expiratory flow rates (PEFR) were studied by Parmer et al (1977) in North Indian (Chandigarh) school children both girls and boys between 6 to 16 years of age.[82]

The values showed positive correlation with age, height and weight. Singh and peri (1978) have used Wright Peak Flow meter to record the flow rates in children and adults of Tamilnadu.[83] The volume of air which a man can inhale during a single deep breath was measured by Borelli.

Following studies have been done on pulmonary function tests and cardiopulmonary physical fitness in healthy subjects.

A. K. Ghosh et al stated that the Physically trained individuals may have higher ventilator capacity as well as FEV1.[84] This might have been brought about by the fact that physical training not only improves the strength of skeletal limb and cardiac muscle, but also improves the accessory muscles for inspiration and expiration as stated by Stuart and Collings et al.[85] This denotes that the efficiency of the respiratory muscles may account for a high value of FEV1.

The vital capacity, maximum voluntary ventilation (MVV) and FEV1, were higher in Physically trained sportsperson than in the normal sedentary control individuals. This was observed in the study conducted by A. K. Ghosh, M.Sc., Ph.D; A.Ahuja, MB; BS and G.L.Khana, M.Sc., National Institute of Sports, Patiala, India, Pulmonary capacitors of different groups of sportsmen in India.[86]

BIBLIOGRAPHY

1. Sujit K, Choudari. Text book of Concise Medical Physiology. 3rd Ed. Calcutta: New central book agency Ltd; 2000: p.404.
2. http://exercise.lovetoknow.com/Physical_Fitness_history.
3. Sunderrajan GS. Medical aspect of loss and gain of physical fitness. Report and Papers on Orientation Course in Scientific Aspects of Physical Fitness 1983; 7-11.
4. Clarke HH. Basic understanding of physical fitness. Physical fitness Research Digest series 1971;1:2.
5. Pansare MS. Physiology of Fitness. Medical J of Western India 1986;14;18-20.
6. McArdle WD, Katch FI, Katch VL. Energy transfer in the body. In: Text book of Essential of Exercise Physiology. 1st ed. Philadelphia. Lea and Febiger; 1994: p.271.
7. Pansare MS, Vaidya SM, Aundhkar VG, Pradhan SG. Comparative study of nutritional status, Health status and physical fitness in tribal and urban girls of Maharastra. 'SNIPES' J Patiala 1986;8(4):44-47.
8. Robinson S. Experimental Studies of Physical fitness in relation to age. Arbeits Physiol 1938;10(29):251-323.
9. Astrand PO. Human Physical Fitness with special reference to sex and age. Physiol Rev 1956;36:307-335.
10. Drinkwater BL. Physiological response of women to exercise. In exercise and sports Science Reviews 1973;1:45-71.
11. Brouha HCW, Graywel A. A step test, simple method of measuring physical fitness for hard muscular work in adult men. Rev Lond Biol 1943;2:89-91.
12. Reston VA. AAHPERD: Guidelines for physical fitness maintenance and development Lifetime health-related physical fitness test manual. 1980: Chapter 3.
13. Clarke HL. A Functional Physical Fitness Test for College Women. J Health and Phys Educ 1943;14:358.

14. Kaprovich PV . Physiology of muscular exercise. JAMA 1949;30:1198.
15. Keen EN, Sloan AW. Observation on Harvard step Test. J Appl Physiol 1958;13:341-343.
16. Sloan AW. A modified Harvard test for women. J of Appl Physiol 1959;14:985.
17. Das S. Determination of PFI with modified HST in young men and women. Ind J Physiol and Allied Sci 1993; 47 (2): 13-73.
18. Maritz JS, JF Morrison, J Peter, NB Strydom. A practical method of estimating an individual maximal oxygen uptake. J Ergonomics 1961;4:97.
19. Saltin B, Grimby G. Physiological Analysis of Middle aged and old former athletes. Comparison with still active athletes to the same ages. J Circulation 1968;38:1104-1115.
20. Rushmer R T. Cardiovascular Dynamics. 3rd ed. Philadelphia: WB Saunder CO; 1970: p.70-112.
21. Ekolom B, Kilbom A, Soltysiak J. Physical Training, Bradycardia and Autonomic nervous system. Scan J Clin Lab Invest 1973;32:251-256.
22. Clarke DH. Exercise Physiology. New Jersey: Englewood Cliffs;1975.p.306.
23. Saltin BN, Costil DL.The nature of training Response, Peripheral and Central Adaptations to one legged Exercise. J Acta Physil Scand 1976;96:289-305.
24. Lewis SG, Nylander E, Gad P. Non autonomic components in bradycardia of endurance trained men at rest and during exercise. J Acta Physiol Scand 1980;109:297-305.
25. Sutton JR, Cole A, Gunning J. Control of Heart Rate in Healthy Young Men. J Lancet 1976; 2: 1398-1400.
26. Arlie VB. The circulation of a Marathoner. J of Sports Medicine and Physical Fitness 1963;3:80.
27. Vanderhoof ER, Imig CJ, Hines HM. Effects of muscle strength and endurance development on blood flow. J Appl Physiol 1961;16:873.
28. Astrand PO, Rodahl K. Text book of work physiology. 4th ed. UK: Amazon co; 1970; Chapter 8: p. 373-376.
29. Fox E. Physical Training Methods and Effects. J Ortho Clin N Am 1971;8(3):545.
30. Jack HW, Howard GK. Aerobic exercise and endurance improving fitness for health benefits. J physician and sports Medicine 2003;l31(5).
31. Daniel WA. Hematocrit: maturity relationship in adolescence. J

Pediatrics 1973;52:388.

32. Stamford BA, Manbacher W, Fallica A. Effects of daily Physical Exercise on the Psychiatric state of Institutional Geriatric and Mental Patients. J Res Q 1974;45:34-41.
33. J. E. Cotes : Lung Function – Assessment and application in Medicine, 2nd Edition,2-10.
34. Lindiquit CH, Reynolds KD, Goron ML. Socioeconomic determinants of physical activity among children. Prev Med 1999; 29(4):305-312.
35. West JB. Mechanics of breathing. In: Best and Tailor's Physiological Basis of Medical Practice. 12th ed. USA: Williams and Wilkins; 1990: p.523.
36. Renzetti AD. Standardization of Spirometry. J Am Rev Respir Dis 1979;119;831-838.
37. Quanjer PH. Standardized Lung Function testing: European Community for coal and steel. J Bull Eur Physio Pathol Respir 1983;19(5):1-95.
38. Quenjer PH. Lung Volume and Forced Ventilatory Flows: Standardization of Lung Function Tests. Eur Respir J 1993;6(16):5-40.
39. Wright BM, Kerrow C B. Maximum Flow Rate as measure of Ventilatory Capacity. J British Med 1959; 1: 1041.
40. Wright BM. A Miniature Wright Peak flow meter. J British Med 1978; 2: 1627-1628.
41. DeBone ER. A Whistle for testing lung function. J Lancet 1963; 2: 1146 – 1147.
42. West JB. Mechanics of breathing. In: Best and Tailor's Physiological Basis of Medical Practice. 12th ed. USA: Williams and Wilkins; 1990: p.523.
43. Guyton AC, Hall JE. Pulmonary ventilation. In: Text book of Medical Physiology.11th ed. Philadelphia: Elsevier; 2006: p. 475.
44. Ganong WF. Pulmonary function. In: Review of medical physiology. 22nd ed. Singapore: Mc Graw Hill; 2005: p.53.
45. Bhasin RC. Using mini peak flow meter a simple airway moniter. Respo Med J Assoc Physicians India 1984; 2(11): 987-89.
46. Edward LF. A Simple, accurate technique for predicting maximal Aerobic Power. J of Appl. Physiol 1973;35:6.
47. Dasgupta PK. Assessment of Cardiopulmonary efficiency in Athletes and Non Athletes. Ind J Physiol Pharmacol 1991; 35(4): 245-248.
48. Wilmore JH, Costill DL. Physiology of sports exercise. 2nd ed.

Champaign IL: Human kinetics;1999:236.

49. Das SK, Mahapatre S, Bhattacharya G, Mukherjee D. Determination of PFI with modified HST in young men and women. Ind J Physiol and Allied Sci 1993; 47(2): 73-76.
50. Dasgupta PK, Mukhopadhyay AK, Das AK. Study of Cardiopulmonary efficiency in different categories of runners. Indian J Physiol Pharmacol 2000;44(2):220-224.
51. Seidman D S, Doller E, Deuster P A. Androgenic response to lung term physical training. Int J Sports Med 1990; 421-424.
52. De AK, Debnath PK, Dey NK, Nagchoudhary J. Respiratory performance and grip strength tests in Indian school boys of different Socioeconomic status. Brit J Sports Med 1980;14: 45-148.
53. Thierry B, Henri B, Regis B, Leonard F, Jean RL. Effect of training frequency on the dynamics of performance response to a specific training about. J Appl Physiol 2002; 92: 572-580.
54. Chatterjee S, Bandyopadhyaya A. Cardiorespiratory fitness of obese boys. Indian J Physiol Pharmacol 2005;49(3): 353-357.
55. Ravisankar P, Madanmohan, Kaviraja U, Prakash S. Correlation between BMI and BP indices, handgrip strength and handgrip enduarance in underweight, normal weight, and overweight adolescents. Ind J Physiol Pharmacol 2005;49(4): 455-461.
56. Kulkarni VA, Aithala M, Choudari D. A study on Peak expiratory flow rate of residential and non-residential school children. J of Association Physiologists and Pharmacologists of India 2000; A11.
57. Choudari D, Aithala M, Kulkarni VA. Maximal expiratory pressure in Residential and Non-Residential school children. Indian Journal of Paed 2002; vol 69.
58. Vijayan VK, Reetha AM, Kuppurao KV, Venkatesh P, Thlakavathy S. Pulmonary function in normal south Indian children aged 7 to 19 years. Indian J Chest Dis Allied Sci 2000;42(3):147-56.
59. Eroshina K, Danishevski K, Wilkinson P, McKee M. Environmental and social factors as determinants of respiratory dysfunction in junior schoolchildren in Moscow. J Public Health (Oxf) 2004; 26(2):197-204.
60. Host A, Host AH, Ibsen T. Peak expiratory flow rate in healthy children aged 6-17 years. J Acta Paediatr 1994;83(12):1255-7.
61. Nair RH, Kesavachandran C, Sanil R, Sreekumar R, Shashidhar S. Prediction equation for lung functions in South Indian children. Indian J Physiol Pharmacol 1998;42(4):572.

62. Ismail Y, Azimi NN, Zurkurnain Y. Lung Function in Malay children. Medical J of Malasiya 1993;48(2):171-4.
63. Swaminathan S, Venketasan P, Mukunthan R. PEFR in South Indian Children. Indian J of Pediatric 1992;2:207-211.
64. Prakash S, Meshram S, Ramlekkar U. Athletes, Yogis and individuals with sedentary life styles, Do their lung functions differ? Indian J Physiol Pharmacol 2007; 51(1): 76-80.
65. Singh HD. Ventilatory Function tests, Normal Standards in Male Adults. Ind J.Med 1959;5:2483-6.
66. Singh HD. Peak Flow rate in Indians. Ind J Physiol Pharmacol 1967;11:129-130.
67. Kanos. Determination of Peak expiratory flow. Eur Respir J 1993; 6: 1347-52.
68. Gupta P, Gupta L, Ajmer RL. “Lung Functions in Rajasthan Subjects”. Ind J. Physiol. Pharmacol 1961;23 (1):9-14.
69. Jain S, Ramaiah KT. Normal Standard of Pulmonary Function Tests for healthy Indians 15-40 years old, comparison of different prediction equations. Ind J Med Resp 1969;57:1433-66.
70. Malhotra MS. Functional capacities and body compositions of Indian Athletes. Ind J Physiol Pharmacol 1972;6:55-62.
71. De AK. Physical efficiency test on Indian male Kabbadi Inter University Players. Brit J Sports Med 1982;16(1): 33-6.
72. Pande JN, Mohan A, Khilnani S, Khilani GC. PEFR in school going children. Indian J Chest Dis Allied Sci 1997; 39: 87-95.
73. Sharma R, Jain A, Arya A, Chowdhary BR. Peak Expiratory Flow Rate – School Going Rural children aged 5 to 14 years from Ajmer District. Indian J Pediatric 2002;39:75-77.
74. Emersonn PW, Green H. Capacity of the lungs of children. American Journal of Dis Child 1921; 22: 202.
75. Edward DJ, Wilson MG. An analysis of some of the factors of variability in the VC measurements of children. J Arch Int Med 1922; 30:638.
76. Ferris BG, Whitenberg JL. Maximum breathing capacity and VC of male children and adolescent. J Pediatrics 1952;91:659.
77. Lange. The growth of lung volume affected by Physical Performance capacity in boys and girls. European J Appl Physiol 1984;52: 380-84.
78. Lakhera SC, Kain TC, Bandopadhayay P. Lung function in middle distance adolescent runner. Ind J Physiol Pharmacol 1994;38(2):117-20.
79. Malik SK, Jindal SK. Pulmonary function tests in healthy children.

Indian J Pediatric 1985;22:677-81.

80. Kumar A, Manachanda BK, Singh KD, Lehal SS. Pulmonary function test is healthy male Punjabi Children of 10 to 19 year age. Indian J Chest Dis Aliied Sci 1992;34(4): 191-5.
81. Nair H, Keshavachandran C, Sanil R, Sreekumar R, Shashidar R. Prediction equation for lung functions in South Indian children. Ind J Physiol Pharmacol 1997;41(4):191-5.
82. Parmar VR, Kumar L, Malik SK. Normal Values of PEFR in Children 6-16yrs of age. Ind Paediat J 1977;14:591.
83. Singh HD, Peri S. Peak expiratory Flow rates in South Indian Children and adolescents. Ind Ped J 1978;6: 473-8.
84. Ghose AK, Ahuja MB, Khanna BL. Pulmonary capacities of different groups of sportsmen in India. Brit J Sports Med 1985;19(4):233.
85. Stuart DG, Collings WB. Comparison of vital capacity and maximum breathing capacity of athletes and Non-Athletes. J Appl Physiol 1959;14(4):507-9.
86. Ghosh A. K. Pulmonary capacities of different groups of sportsmen in india. Brit J Sports Med 1985;19(4):232-234.