CHAPTER I

INTRODUCTION

Physical activity is important for fitness; it increases the functional capacity through improvements in maximal oxygen consumption ($V0_2max$), body composition, muscular strength and endurance, and flexibility. Exercise training is also an important component of preventive and rehabilitative programs designed to address metabolic and cardiovascular diseases, as well as orthopedic injuries and musculoskeletal disorders. Physical activity has been shown to substantially reduce the risk of several controllable and degenerative diseases and to improve both the quality of life and longevity.

Physical inactivity has been identified by the World Health Organization (WHO, 2009) as the fourth leading risk factor for global mortality which accounts for 5.5% of deaths globally. Physical inactivity is also well-known to be one of the major risk factors for heart diseases, cerebrovascular disease, diabetes mellitus, hypertension, some types of cancers and obesity in both men and women at any age. Thus, recognizing the strong inverse relationship between regular aerobic exercise and degenerative disease development, physical activity is recommended as an effective modality in both primary and secondary prevention (ACSM, 1991; Fletcher et al., 1995; Pollock & Wilmore, 1990).

1.1 HEALTH AND WELL BEING

Health means everyone achieving his or her potential to enjoy complete physical, mental and social wellbeing. Healthy people contribute to the health and quality of the society in which they live, work and play. Health is much more than an absence of disease or disability, and individual health, and that of the country, affects the quality of everyone's lived experience. Health is an essential resource for everyday life, a public good, and an asset for health and human development (WHO, 1986). Wellbeing is an integral part of this definition of health. It reflects the quality of life and the various factors which can influence it over the course of a person's life (WHO, 2012). Wellbeing also reflects the concept of positive mental health, in which a person can realize his or her own abilities, cope with the normal stresses of life, work productively and fruitfully, and be able to make a contribution to his or her community (WHO, 2001). Consideration of health and well-being requires a shift in focus from what can go wrong in people's lives, to focusing on what makes their lives go well (Aked, et al 2010).

1.2 SMOKING

Smoking is a major risk factor for cardiovascular morbidity and mortality, and is considered to be the leading preventable cause of death in the world. World Health Organization reported that 100 million people were killed due to smoking, worldwide, in the 20th century and by 2030

it could increase up to 10 billion deaths per year, approximately 80% of these deaths will occur in developing countries (WHO, 2008). Hindustan Times estimated that 23% of Indian male are smokers in 2012 (Hindustan Times, January 8th, 2014).

Smoking, either active or passive, can cause cardiovascular disease via a series of interdependent processes, such as enhanced oxidative stress, haemodynamic and autonomic alterations, endothelial dysfunction, thrombosis, inflammation, hyperlipidemia, or other effects (Ambrose and Barua, 2004).

1.2.1 HEALTH HARMS FROM SMOKING

Cigarette smoke is a complex mixture of chemicals. Some smoke Components, such as carbon monoxide (CO), hydrogen cyanide (HCN), and nitrogen oxides, are gases. Others, such as formaldehyde, acrolein, benzene, and certain N-nitrosamines, are volatile chemicals contained in the liquid- vapor portion of the smoke aerosol. Still others, such as nicotine, phenol, polyaromatic hydrocarbons (PAHs), and certain tobacco-specific nitrosamines (TSNAs), are contained in the submicron-sized solid particles that are suspended in cigarette smoke.

In view of this chemical complexity, cigarette smoke has multiple, highly diverse effects on human health. It is not unexpected that multiple chemicals in cigarette smoke can contribute to any single adverse health effect. Thus, hydrogen cyanide (HCN) may affect the human respiratory system by its toxic effects on the cilia that line the

respiratory tract. At the same time, hydrogen cyanide (HCN) may cross the placenta and have toxic effects on the growing fetus. In addition, hydrogen cyanide (HCN) also may cause nerve damage in cigarette smokers with optic neuropathy (Costagliola et al., 1989).

Smoking is associated with an increased risk of all types of Heart disease, cancer and respiratory diseases are just a few of the physical and medical problems associated with smoking. Smoking causes poorer health outcomes in cancer patients and survivors (HHS, 2014). It may reduce fertility and is a known cause of erectile dysfunction in men (Cramer, et al., 1995). Cigarette smoking is a cause of diabetes and increases both the risk and the severity of rheumatoid arthritis (HHS, 2014). Hearing loss and vision problems, including cataracts, has been linked to smoking (Noorhassim & Rampal, 1998). Smoking also is a cause of age-related macular degeneration, a condition that leads to loss of vision in the center of the eye. Chronic coughs, increased phlegm, emphysema and bronchitis have been well-established products of smoking for decades. Smoking exacerbates asthma in adults and also impairs the immune system (HHS, 2014). Smokers are more susceptible to influenza and more likely to experience severe symptoms when they get the flu (Kark, et al., 1982). While many smokers believe that smoking relieves stress, it is actually a major cause. Smoking only appears to reduce stress because it lessens the irritability and tension caused by the underlying nicotine addiction (Parrott, 1999).

While most of the major health harms from smoking, such as lung cancer and heart disease, typically appear after years of tobacco use, many health problems can appear almost immediately, even among otherwise young and healthy kids. For example, cigarette smoking immediately increases heart rate and blood pressure, and the resting heart rates of young adult smokers are two to three beats per minute faster than nonsmokers.

1.2.2 CARDIORESPIRATORY EFFECT

Aerobic exercise challenges the body's ability to supply and handle oxygen. For example, when performing high-intensity aerobic exercise, mitochondrial reactive oxygen species' (ROS) grow in number. Reactive oxygen species' (ROS), if left unchecked, have the ability to cause genetic mutations. However, several enzymes, including superoxide dismutase are present to handle this oxidative stress caused by reactive oxygen species' (ROS). The body responds to chronic aerobic exercise by enhancing its ability to cope with reactive oxygen species' (Vollaard, Shearman and Cooper, 2005).

Smoking also induces an oxidative stress; however, smoking-induced oxidative stress also inhibits the body's ability to cope by suppressing the genes responsible for the antioxidant production (Garbin, et al. 2009). The net result of smoking-induced oxidative stress is vascular and arteriolar inflammation further impairing the oxygen-delivering capabilities of the body. By limiting oxygen delivery, cigarette smoking impairs the ability to generate energy through the

oxidative energy system. Smoking also impairs anaerobic energy provision by altering contractile proteins, creatine kinase, and other glycolytic enzymes (Barreiro, et al. 2010).

It is also associated with increased blood pressure, systemic vascular resistance, and heart rate. Nicotine is one factor that stimulates epinephrine and norepinephrine release from the sympathetic nerve terminals and the adrenal glands, which explains that acute cardiovascular effects may be due to adrenergic stimulation at the peripheral levels. Acute smoking affects the cardiorespiratory responses to both submaximal and maximal exercise, which can result in an increase of sympathetic dominance at lower levels of submaximal work (Fernhall, Mendonca and Pereira, 2011). Smoking has not only been shown to be associated with an increase in resting heart rate (HR), but also with a significantly diminished increase in HR during exercise (Benowitz, 2003 & Srivastava, Blackstone and Lauer, 2000).

Smoking blocks airway passages and has significant detrimental effects on lung tissue and the lungs' ability to operate at full strength. Research has shown that even second-hand smoke can have harmful effects on the lungs. During submaximal and maximal intensity exercise, individuals showed a significant difference in average and maximum power output of the lungs, as well as decreased average and maximum oxygen consumption following exposure to second-hand smoke. With the lungs functioning at lower level individuals will become exhausted more quickly during exercise and report an increased

perceived exertion following exercise (Flouris, et al. 2012 & Flouris, et al. 2010). Research looking at direct exposure to smoking has shown that moderate and heavy smokers have a decreased VO_2max. There tends to be a stronger correlation in men, and the decrease in VO_2max caused by smoking becomes more significant with age.

1.2.3 MUSCULOSKELETAL EFFECTS

The use of cigarettes and other tobacco products has also been found to be a contributing factor to age-related muscle atrophy, which is known as sarcopenia. When compared to non-smokers of similar backgrounds, those who did smoke had evidence of increased muscle tissue deterioration (Rom, et al. 2012). Type I fibers are specifically affected which would limit muscular endurance (Ide and Tabira, 2013). This loss of muscle mass can lead to less productivity during exercise in regards to energy output and respiration efficiency. Upper extremity muscles also serve as muscles of respiration, which should be taken into consideration while working to condition patients who are heavy smokers.

1.3 PHYSICAL FITNESS

Physical fitness as defined by the World Health Organizations is “the ability to perform muscular work satisfactorily”. Physical fitness is defined as the ability to perform moderate to vigorous levels of physical activity without undue fatigue and the capability of maintaining such ability throughout life (Wilmore, 1990).

A physically fit person will have the efficient body movement or neuromuscular co-ordination as it is often called and is also bestowed with the ability to perform a given task with a high degree of proficiency. The term fitness includes physical fitness, physiological fitness, and mental fitness, and cardiovascular fitness, social and spiritual fitness. Physically fit people are able to withstand fatigue for longer periods and are better equipped to tolerate physical stress. Many researchers strongly support the view that regular exercise helps to keep a strong and healthy heart and prevents cardiovascular diseases. A physically fit heart beats at a lower rate and pumps more blood per beat at rest. As a result of regular exercise, an individual's capacity to use oxygen is increased substantially. To develop and maintain physical fitness, vigorous effort by the individual is required. Cardiorespiratory endurance, strength, muscular endurance, flexibility, power and agility are the basic compounds of physical fitness. Physical fitness is considered as one of the most valuable assets and it has received a high priority in all thoughts and actions.

The ACSM position stand (1990) states that these adaptations can be stimulated through the safe, progressive application of the principle of overload, specifically the frequency, intensity, and duration of training, -and considerations of the mode of activity and the initial level of fitness. As a whole, the current guidelines have been well accepted and adopted for use in the general population.

Therefore, it is the responsibility of every country to promote physical fitness for its citizens, because physical fitness is the basic requirement for most of the tasks to be undertaken by an individual in his/her daily life. Accordingly the investigator makes an attempt to know the influence of submaximal and maximal aerobic exercise on selected musculoskeletal fitness and cardiopulmonary parameters.

1.4 AEROBIC EXERCISES

Aerobics refers to a “variety of exercises that stimulate heart and lung activity for a time period sufficiently long to produce beneficial changes in the body”. “Aerobic” basically means living or working with oxygen. The American College of Sports Medicine (ACSM) defines aerobic exercise as “any activity that uses large muscle groups, cane maintained continuously, and is rhythmic in nature." It is a type of exercise that overloads the heart and lungs and causes them to work harder than at rest. The heart is always able to deliver sufficient oxygen-rich blood to the muscles so that they can derive energy from fat and glycogen aerobically.

Aerobic exercises build stamina for sports and it also is the most important form of exercise for health, since it increases the efficiency of the heart, circulation and muscles. Aerobic exercise is the keystone of fitness by doing aerobics it increases the capillary network in the body.

1.5 SUBMAXIMAL AEROBIC EXERCISE

An exercise bout in which the energy requirement is greater than that which can be supplied aerobically at VO_2max is called submaximal exercise. Submaximal aerobic exercise is any physical activity where the intensity or workload of a particular exercise is increased at a steady rate, but only works the body up to 85 percent of the maximum heart rate. The human body is very adaptable. The greater the demands made on it, the more it adjusts to meet those demands. Over time, immediate, short-term adjustments translate into long-term changes and improvements. When breathing and heart rate increase during exercise, for example, the heart gradually develops the ability to pump more blood with each beat. Then, during exercise, it doesn't have to beat as fast to meet the cells' demands for oxygen. The goal of physical training is to produce these long-term changes and improvements in the body's functioning.

1.6 MAXIMAL AEROBIC EXERCISE

Maximal aerobic exercise is any physical activity or exercise capacity is the maximum amount of physical exertion that an athlete can sustain. An accurate assessment of exercise capacity requires that maximal exertion is sufficiently prolonged to have a stable effect on the circulation and that the pattern of athlete response is consistently above 85 percent when exertion is repeated. The highest intensity, greatest load, or long duration exercise of which an individual is capable is called maximal exercise.

An incremental exercise to maximum bout consists of a series of progressively increasing work intensities that continue until the individual can do no more.

1.7 MUSCULOSKELETAL FITNESS

Musculoskeletal fitness refers to muscular strength and muscular durance as well as to the flexibility of the joints. Muscular strength and muscular endurance are often used interchangeably, but they are the same. Muscular strength refers to the maximum force a muscle can exert in a single contraction. Muscular endurance refers to a muscle's ability to perform repeatedly without fatigue**.** In the context of physical activity, flexibility simply refers to the mobility of joints to bend through their full range of movement (ROM).

1.7.1 MUSCULAR STRENGTH

Muscular strength is the ability of a muscle or muscle group to exert maximal force against a resistance one time through the full range of motion. The emphasis on the full range of motion is important because any movement less than full range is counterproductive strength or endurance gains occur only in the range of motion exercised (National Association for Sport and Physical Education, 2011). Strong muscles are important for everyday activities, such as climbing stairs, as well as for emergency situations. They help keep the skeleton in proper alignment, preventing back and leg pain and providing the support necessary for good posture. Muscular strength has obvious importance in recreational activities.

1.7.2 MUSCULAR ENDURANCE

Muscular endurance is the ability of a muscle or muscle group to exert a submaximal force repeatedly over a period of time (National Association for Sport and Physical Education, 2011). In other words, it is the ability of the muscles to apply a submaximal force repeatedly or to sustain a submaximal muscular contraction for a certain period of time. It depends on such factors as the size of muscle cells, the ability of muscles to store fuel, and the blood supply to muscles. Muscular endurance is important for good posture and for injury prevention.

1.7.3 FLEXIBILITY

Flexibility is the ability to move the joints through their full range of motion. It depends on joint structure, the length and elasticity of connective tissue, and nervous system activity. Flexible, pain-free joints are important for good health and well-being. Inactivity causes the joints to become stiffer with age.

1.8 CARDIOPULMONARY PARAMETERS

When challenged with any physical task, the human body responds through a series of integrated changes in function that involve most, if not all, of its physiologic systems. When the body engages in exercise training several times a week or more frequently, each of these physiologic systems undergoes specific adaptations that increase the body's efficiency and capacity.

In order to supply the working muscles with the needed oxygen, the cardiovascular and respiratory systems must work together. The response of the respiratory system during exercise the parallel cardiovascular responses to dynamic aerobic activity, static exercise, and dynamic resistance exercise.

1.8.1 RESTING HEART RATE

Heart rate (HR) is the number of times that the heart contracts, usually expressed in a 1minute time frame and reported as beats per minute (bpm). There are no known or accepted standards for resting HR. Resting HR has been thought of as an indicator of cardiovascular endurance-it tends to lower as one become more aerobically fit. There are also no standards for exercise HR, but the HR response to a standard amount of exercise is an important fitness variable and the foundation for many cardiovascular endurance tests.

1.8.2 MAXIMAL OXYGEN CONSUMPTION (VO_2max)

Maximal oxygen consumption ($V0_2$ max) is determined by the capacity of the cardiovascular system to deliver oxygen to the working muscles and the capacity of the muscles to extract oxygen for oxidative metabolism. $V0_2max$, a function of maximal cardiac output and maximal arteriovenous oxygen difference, remains relatively unchanged throughout childhood and adolescence. Maximal oxygen consumption is defined as the greatest amount of oxygen utilization that occurs during dynamic exercise and is measured in either mL/kg/min or L/min.

1.8.3 CARDIOVASCULAR AND RESPIRATORY SYSTEM

The primary functions of the cardiovascular and respiratory systems are to provide the body with oxygen (O_2) and nutrients, to rid the body of carbon dioxide (CO_2) and metabolic waste products, to maintain body temperature and acid-base balance, and to transport hormones from the endocrine glands to their target organs (Wilmore and Costill, 1994). To be effective and efficient, the cardiovascular system should be able to respond to increased skeletal muscle activity. However, as the rate of muscular work increases, these two systems will eventually reach their maximum capacities and will no longer be able to meet the body's demands.

1.8.4 CARDIOVASCULAR RESPONSES TO EXERCISE

The cardiovascular system, composed of the heart, blood vessels, and blood, responds predictably to the increased demands of exercise. With few exceptions, the cardiovascular response to exercise is directly proportional to the skeletal muscle oxygen demands for any given rate of work, and oxygen uptake (VO_2) increases linearly with increasing rates of work.

The maximum oxygen the body uses during exercise to get exhausted is referred to as VO_2max, or estimation of the maximum consumed oxygen. The maximum consumed oxygen, is one of the best predictors for cardiorespiratory endurance and also aerobic preparation. As the individuals need for energy is engaged with the body size, so the maximum energy consumption (VO_2max) is also

expressed as the body weight. The regular aerobic physical activity causes an increase in VO_2max and indirectly decrease most of disease affection (Blair, et al, 2001).

Aerobic exercise requires more energy and, hence, more oxygen (and thus the use of the term aerobic, with oxygen) than either static or dynamic resistive exercise. How much oxygen is needed depends primarily on the intensity at which the activity is performed and secondarily on the duration of the activity. Aerobic training reduces resting heart rate. An untrained individual may have a resting heart rate of 60–80 bpm on average. However, Aerobic training reduces resting heart rate to <60 bpm and some elite endurance athletes have a resting heart rate of <35 bpm (Wilmore and Costill, 1999). The reduced resting heart rate is due to greater parasympathetic or reduced sympathetic nervous system stimulation. Aerobic training leads to a reduced heart rate response to submaximal exercise and a quicker recovery of heart rate immediately after exercise.

VO_2max is the gold standard of aerobic fitness and increases during training due to increases in SV (and Q_C) and a small increase in the A-VO_2 difference (up to 20 ml, or15%) (McArdle, Katch and Katch, 2007). Aerobic training is the preferred mode of exercise for increasing VO_2max. Aerobic training leads toVO_2max increases of 10%–30% during the first 6 months (Brawner, Keteyian and Saval, 2010).

1.8.5 RESPIRATORY RESPONSE TO EXERCISE

Among body's functioning system, respiratory system is of special value. Because of an important and prominent role of this system in metabolism and providing the requested energy for different body's tissue and organ, so it is influenced seriously by short &long term exercises (Wilmore, et al, 2008).

After regular and intense exercises, most of the coaches prepare the athletes for participating in seasonal competitions. One of the exercises which the coaches make use of in preparing them is aerobic and anaerobic intermittent exercise. With performing intermittent exercises, the related factors of physical preparation could be considerable increase or develop, and so help to promote the efficiency of different body systems as respiratory system that is of great importance in physical preparation (Courteix, et al, 1997). Some of the researchers are in believing that the intermittent exercises in addition to increasing the level of VO_2max influence some of pulmonary capacities and volumes. The reason could be the result of increase in respiratory muscle strength and pulmonary performance.

The kind of exercise activates the systems that they provide oxygen to body cells and by it the oxygen prepared to active muscles through blood flow. For establishing this kind of cellular aerobic metabolism, the intensity of training should be in at least and long term. Follow the aerobic exercise is created the good and useful changes, in lungs, heart and blood vessels. In other words, with doing

aerobic exercises, the body transferred more O_2, CO_2 inside and outside of the lungs respectively, and to better done transfer of oxygen to fibers finally (Paluska, 2000).

The lung function decline is less pronounced in smokers who engage in moderate to high intensity physical activity (Garcia-Aymerich, et al, 2007). Forced vital capacity is the volume of the air that can be expired rapidly with a maximum force following a maximum inspiration. Forced expiratory volume in one second is the volume expired in the first second of maximal expiration after a maximal inspiration and is a useful measure of how quickly full lungs can be emptied. Estimation of FEV1 is the most commonly used screening test for airway diseases. Normally FEV1 is about 80% of the FVC; useful in distinguishing between restrictive and obstructive diseases. MVV correlates with the respiratory muscle performance. Research indicates that men who remained in the active lifestyle during the follow-up (19 months) showed 50 ml improvement in their FEV1 and 70 ml in their FVC, whereas subjects who remained in sedentary life style had 30 and 20 ml reduction in their FEV1 and FVC, respectively (Garcia-Aymerich, et al, 2007).

1.9 OBJECTIVE OF THE PRESENT STUDY

The primary objective of the present study was to motivate smokers to participate in aerobic exercise (the best type of exercise that improves the functional capacity of the musculoskeletal fitness and cardiopulmonary system) aiming to raise awareness of the benefits of a physically active lifestyle for both physical and mental

health and the benefits of quitting smoking on their health. Smoking not only affects a person's health, it affects their well-being, their personal life and the health of people around them. Chronic smoking causes a decrease in the capacity of the circulatory and respiratory system for muscular work.

The objectives of this study are:

1. Examine the influence of submaximal and maximal aerobic exercise on musculoskeletal fitness and implications for developing effective intervention programs for smokers and intend to raise awareness of the benefits of a physically active style of physical health and the benefits of quitting smoking on their health.
2. To investigate the influence of submaximal aerobic exercise and maximal aerobic exercise performance of cardiopulmonary functions of smokers will aid in understanding the mechanisms of how physical activity improves the quality of life and promote healthy behaviors and prevent unhealthy ones apply also to the effectiveness of intervention programs.
3. To know the how far the submaximal aerobic exercise and a maximal aerobic exercise would helpful for the development of musculoskeletal fitness and cardiopulmonary parameters of active smokers.

1.10 STATEMENT OF THE PROBLEM

The present study was to examine the influence of submaximal and maximal aerobic exercise on selected musculoskeletal fitness and cardiopulmonary parameter among active smokers.

1.11 HYPOTHESES

The following hypotheses set for the present investigation.

1. It was hypothesized that there would be a significant improvement in selected musculoskeletal fitness and cardiopulmonary parameters of active smokers due to the impact of submaximal aerobic exercise.

2. It was hypothesized that there would be a significant improvement in selected musculoskeletal fitness and cardiopulmonary parameters of active smokers due to the impact of maximal aerobic exercise.

3. It was hypothesized that maximal aerobic exercise would be better in improving on selected musculoskeletal fitness and cardiopulmonary parameters of active smokers than the submaximal aerobic exercise.

1.12 SIGNIFICANCE OF THE STUDY

1. The findings of the study help to examine the lifestyle risk factors on musculoskeletal fitness and cardiopulmonary ventilator parameter among active smokers.

2. The results of the study help the health professionals to prescribe the mode of exercise, whether submaximal or maximal aerobic exercise for total health and wellbeing.
3. This study helps the individuals to maintain normal health by avoiding risk factors.
4. This study gives wide suggestion for unhealthy lifestyle of the smokers.
5. This study helps to describe the changes on musculoskeletal fitness and cardiopulmonary ventilation parameter among active smokers due to lifestyle risk factors.

1.13 DELIMITATIONS

1. One hundred and twenty two smokers are selected randomly in the age group of 30 to 35 years. From the 122 smokers, finally sixty active smokers are defined as those who have smoked 5 or more cigarettes per day for at least three smoking years.
2. All the subjects are male working in the information technology sectors Chennai, city.
3. Standardized questionnaire was issued to each subject to discover the lifestyle risk factors.
4. The criterion variables selected for the study are

Musculoskeletal fitness

1. Muscular Strength
2. Muscular Endurance
3. Flexibility

Cardiopulmonary Parameters

1. Resting Heart rate (RHR)
2. Maximal Oxygen Uptake (VO_2 MAX)
3. Forced vital capacity (FVC)
4. Forced Expiratory Volume in one second (FEV1)
5. Maximal Voluntary Ventilation (MVV)

1.14 LIMITATIONS

1. The heterogeneous characters of the subjects in hereditary and environmental factors were recognized as a limitation.
2. All the questions and exercise program were explained by the research scholar, so that the times taken by the subjects to respond the questions were recognized as limitations of the study.
3. The uncontrollable changes in climatic conditions such as atmospheric temperature, humidity and other meteorological factors during the test are considered as limitations.
4. The quantum of physical exertion, lifestyle and physiological stress and other factors that affect the metabolic functions was also considered as limitations.

1.15 MEANINING AND DEFINITION OF THE TERMS

1.15.1 MUSCULAR STRENGTH

Muscular strength relates to the ability of the muscle to exert force. In other words, it is the maximal one effort force that can be exerted against a resistance or the maximum amount of force that one

can generate in an isolated movement of a single muscle group (ACSM's, 2005).

1.15.2 MUSCULAR ENDURANCE

Muscular endurance relates to the muscle's ability to continue to perform without fatigue (ACSM's, 2005). In other words, it is the ability of the muscles to apply a submaximal force repeatedly or to sustain a submaximal muscular contraction for a certain period of time.

1.15.3 FLEXIBILITY

Flexibility is the functional capacity of the joints to move through a full range of movement (*ACSM's, 2005*). Flexibility is specific to each joint of the body. Muscles, ligaments, and tendons largely determine the amount of movement possible at each joint.

1.15.4 RESTING HEART RATE (RHR)

Heart rate (HR) is the number of times that the heart contracts, usually expressed in a 1minute time frame and reported as beats per minute (bpm). There are no known or accepted standards for resting HR. Resting HR has been thought of as an indicator of cardiovascular endurance it tends to lower as one become more aerobically fit (ACSM's, 2008).

1.15.4 MAXIMAL OXYGEN UPTAKE (VO_{2MAX})

VO_2max is defined as the highest oxygen uptake (VO_2) an individual can attain during exercise engaging large muscle groups while breathing air at sea level (Astrand and Rodahl 1986). VO_2max is

a measure of the body's ability to transport oxygen from the ambient air to the working muscles and to use the available oxygen.

The maximal oxygen uptake (VO_2max) can be defined as the maximum integrated capacity of the pulmonary, cardiovascular and muscular systems to uptake, transport and utilize O_2, respectively (Poole et al., 2008).

1.15.6 FORCED VITAL CAPACITY (FVC)

Forced vital capacity is the maximal volume of air expired after maximal inspiration (3,200 ml in women and 4,800 ml in men) (Nicholas Ratamess, 2012).

1.15.7 FORCED EXPIRATORY VOLUME (FEV1)

Forced expiratory volume is the volume of air maximally expired forcefully in 1 second after maximal inhalation. Often expressed relative to forced vital capacity and are typically 85 % (Nicholas Ratamess, 2012).

1.15.8 MAXIMAL VOLUNTARY VENTILATION (MVV)

Maximum voluntary ventilation is the Maximum volume of air breathed rapidly in 1 minute (80–120 Lmin−1 in women and 140–180 L min−1 in men) (Nicholas Ratamess, 2012).