INTRODUCTION
CHAPTER - 1

INTRODUCTION

Health and physical fitness have maintained the motto of a man from ancient times. The marked deterioration in health and physical activity has been caused by mechanization. Now-a-days people become almost sedentary and physically inactive because of very limited movement caused by scientific innovation. Physical inactivity can have serious implications on people’s health, said the World Health Organization. Approximately two million deaths per year are attributed to physical inactivity, prompting World Health Organisation, henceforth know as WHO to issue a warning that a sedentary lifestyle could very well be among the 10 leading causes of death and disability in the world. Sedentary lifestyles increase all causes of mortality, double the risk of cardiovascular diseases, diabetes, increase the risk of colon cancer, high blood pressure, osteoporosis and lipid disorders. The main root cause for all these is believed to be caused by obesity. 60 to 80 percentages of people in the world from both developed and developing countries suffer from obesity because of sedentary lifestyles, making it one of the serious and insufficiently addressed public health problems of our time.

All obesity is not the same. Recent studies suggest that it is not only the relative body fat related to an increased risk of CVD, but the distribution of that fat must also be considered. Individuals with a large waist circumference, compared to hip circumference are at high risk of sudden death. People having ratios of waist to hip circumference >0.95 for men and >0.8 for women are
associated with the CVD risk factors of insulin resistance, high cholesterol, hypertension, and such individuals are treated even if they are only on the borderline obese. Obesity and overweight is a significant public health problem leading to chronic diseases and health conditions such as heart disease and diabetes (Jakicic et al. 2002). One in five people not only exceed ideal weight, but also meet the clinical criteria for obesity. Therefore, weight loss may be an important consideration in reducing these morbidity factors.

The need for treatment far exceeds the capacity of the health care system to provide care on an individual basis. Moreover, the most effective method for the delivery of treatment and the best ways to induce and sustain client adherence to such a programme, remains elusive. Obesity stands in the ignominious position of being the only epidemic in the latter decades of the twentieth century and into new millennium that clinicians, academicians, and investigators alike seems to have virtually ignored. With the ever increasing prevalence of obesity and its related diseases, the burgeoning expansion of health care delivery in outpatient care, and the growing emphasis on health promotion, it is imperative that academicians in all roles give their long overdue and concerted attention to grappling with this unrelenting epidemic. In fact, though exercise has been found to have many benefits in the treatment of obesity, competitive nature of the present living conditions is keeping the obese people from participating in physical exercises. The main reason behind the lack of participation of such obese people in physical activity could be accommodated to lack of time, as the nature of the traditional exercise prescription takes a lengthy session of 30 to 40 minutes. So the timely need is
to modify the existing traditional exercise prescription into an exercise programme that underlies the life style of people and thus increasing the rates of adoption and compliance as far as exercise prescription towards the treatment of obesity is concerned.

Having this concept, when attempting to trace the means and methods, it was found from the recent studies that accommodating several short bouts of moderate to vigorous activity each day may improve adherence to the programme. The findings of these explained that aerobic fitness levels can improve with as little as 10 minutes duration-provided exercise if performed often, meaning 2-3 times a day, 5 days a week. The American College of Sports Medicine also recommends 3-5 days a week for most aerobic exercise programmes. Besides it was found from some of the research studies that combining resistance exercise with aerobic exercise is a viable source to reduce the general obesity, central obesity and to increase the essential body mass. By this conjecture, as the main objective, the investigator has designed the three modes of treatment using cardio aerobic circuit namely continuous long bout, multiple short bouts and multiple short bouts with resistance exercises to find out its effect on obesity and development of health related physical components (muscular endurance, flexibility and cardio vascular endurance) and physiological factors.

1.1 OBESITY

Obesity is the term used for extreme overweight. It is defined as a significant increase above the ideal weight (that which maximizes life expectancy) caused by the accumulation of fat so that health is adversely
affected. Obesity is a heavy accumulation of fat in the body's fat cells to such a serious degree that it rapidly increases the risk of obesity-associated diseases and mortality. The fat may be equally distributed on the body, on the stomach (apple-shaped) or on the hips and thighs (pear-shaped). Being obese and being overweight is not exactly the same thing. An obese person has a large amount of extra body fat, not just a few extra pounds. The WHO defines obesity as a Body Mass Index of >30. A person with a BMI above the 95th percentile (meaning the BMI is greater than that of 95% of people of the same age and gender) is generally considered overweight. With a BMI of more than 25, it is advisable to change lifestyles and lose weight, especially if it is stomach obesity (apple-shaped). The waist circumference may be used in order to determine if you are apple-shaped. Men with a waist circumference of more than 94cm (37in) and women with a waist of more than 80cm (31.5in) should not further increase their weight. An increased risk of obesity-related diseases is present with a waist circumference of more than 102cm (40in) for men and more than 88cm (34.6in) for women.

1.1.1 Causes of Obesity

Causes of obesity are generally found in the form of lack of physical exercise, genetic susceptibility, lifestyle, biological problems, psychological impacts, irregular vicious cycle, saturated foods and parental attitude. The roles of these in obesity are individually discussed in the following.
1.1.1.1 Genetic Factors

Numerous scientific studies have established that genes play an important role in tendency to gain excess weight. Studies published in the New England Journal of Medicine (Marry 2003) indicate that certain genetic processes are an important and powerful underlying factor in the development of obesity and binge eating. Genes - small parts of the DNA that people inherit from their parents and that determine traits like hair or eye color - can play an important role in this weight gain. Some of the genes direct body how to metabolize food and how to use extra calories or stored fat. Some people burn calories faster or slower than others do because of their genes. The body weights of adopted children shows no correlation with the body weight of their adoptive parents, who feed them and teach them how to eat. Their weight does have an 80 percent correlation with their genetic parents, whom they have never met. Identical twins, with the same genes, show a much higher similarity of body weights than do fraternal twins, who have different genes. People probably have a number of genes directly related to weight just as some genes determine eye color or height, others affect our appetite, our ability to feel full or satisfied, our metabolism, our fat-storing ability, and even our natural activity levels.

1.1.1.2 Biological Problems

Some individuals are obese because of specific biological problems such as malfunctioning of thyroid or pituitary glands (Annette Nay, 1997). The hormones produced when one is under stress encourage the formation of fat cells. There may also be a link between so-called modern life and increasing
rates of overeating, overweight, and obesity. Some obesity is caused by thyroid malfunction (Harvard Medical School, 1992). The thyroid hormones regulate such functions as appetite and weight. When the hyperthyroid does not work properly, it causes weight gain and also makes it harder to lose weight. Sometimes it eliminates the person’s ability to feel satiated after eating. This causes excessive eating and obesity (Schwartz, 1985).

1.1.1.3 Life style and Environment

One of the most important factors in weight gain is a sedentary lifestyle. Computers, fast food, Television and other technological advances have made lives easier. People are much less active today than they used to be, with televisions, computers, and video games filling their spare time. Cars dominate our lives and fewer people walk or ride bikes to get somewhere. As lives become busier, there is less time to cook healthy meals; people eat at restaurants or buy quick foods at the grocery store or food market to heat up at home. All of these can contain more fat and calories than meals prepared from fresh foods at home. All these situations can contribute to weight gain; besides weight gain is influenced by changing social structure whereby fewer adults and children include physical activity as part of their daily routine.

1.1.1.4 Psychological problems

Psychologically sometimes emotions can fuel obesity as well. People tend to eat more when they are upset, anxious, sad, stressed out, or even bored. Then after they eat too much, they may feel bad about it and eat more to deal with those bad feelings, creating a tough cycle to break. Other obese people
may be able to trace their obesity to a neurochemical predisposition. A predisposition is generally caused from heavily abusing addictive foods. This type of abuse causes an elevation of psycho-stimulants in the brain. This results in an elevated mood change. Purposefully engaging in eating addictive foods continually can cause addiction (Lesieur & Blume, 1993; Sheppard 1993).

1.1.1.5 Irregular Vicious cycle

Studies have shown that the body engages in three cycles. The major part of acquisition time or when food is taken into the body occurs from noon to 8 P.M. Assimilation happens from 8 P.M. to 4 A.M. This is when the partially or fully digested food moves into the intestine to be distributed to meet the needs of the body. From 4 A.M. to noon the major part of elimination is taking place (Diamond & Diamond, 1985). Although these activities tend to overlap, the major part of these activities happen during their allotted time sequence if allowed to do so. When people eat late at night they push the acquisition time into the assimilation period. The assimilation period overflows into elimination time. This cuts the elimination time short. This is the most important part having to do with weight loss. The body wants to get rid of the extra food it did not need, but it does not have the time to do so. It copes by storing the excess waste and toxins around the thighs, buttocks, and stomach. The storage can be seen as fatty rolls, cellulite, dark circles under the eyes, bloating, gray or balding hair, and nervous outbursts (Diamond & Diamond, 1985).
Obese or overweight people tend not to do aerobic exercise. The lack of aerobic exercise makes one more prone to being overweight or obese (Bailey, 1991). They can eat the same amount of fats and calories but it adds up to more stored fat. A regularly-exercised body treats fat differently than an unexercised body does. When cholesterol (fat) comes through the bloodstream it enters the liver. The liver wraps strands of protein around the cholesterol so the body can use it. The fit body’s liver grabs the cholesterol and quickly wraps many strands of protein around it. This forms HDL or high-density cholesterol. HDL cholesterol is easily used by the body (Bailey, 1991). The unfit body’s liver is too tired to do much with the cholesterol. It slowly wraps a few proteins strands around the cholesterol and sends it back into the bloodstream. This cholesterol is called LDL or low-density cholesterol. LDLs are harder for the body to break down. LDL cholesterol is hard to get rid of. When the liver is finished with the cholesterol it sends it back into the bloodstream to find a fat storage cell. There are two enzyme systems within the fat cells; each with a different job to do. The first is a lypo-genesis enzyme. Its job is to capture LDLs or HDLs and glue them together so they are too big to get out of the storage cell. The second type of enzyme is the lypo-lysis. Its job is to unglue the cholesterol and release it for the body to use for energy. The exercised body has more lypo-lysis enzyme than lypo-genesis, whereas the unexercised body has the opposite (Bailey, 1991). When there are more enzymes binding cholesterol than those releasing it, the person has a lot of fat deposits. Once stored, these deposits are difficult to release for use. This is how the fat get
fatter and the thin stay thin even though they eat the same kinds and amounts of foods (Bailey, 1991).

1.1.1.7 Lack of Liquids

Generally overweight or obese people do not have enough liquids in their diet (Schwartz, 1985). The body needs at least eight cups of liquids each day to carry on the basic functions of the body (Medina, 1992). Any excess liquid helps to break down fats. Without the daily minimum of water, the body has difficulty in breaking down the fats in the diet and still meet the body’s other water needs (Medina, 1992). Ten to twelve cups can literally flush fats from the body (Medina, 1992).

1.1.1.8 Eating Disorders

Slow steady weight loss is the best way to take off weight (Callahan & Perry, 1993). Slow weight loss helps the individuals learn how to keep their eating under control by learning how to deal with stresses in healthy ways instead of covering them up with food. These individuals learn to adapt their diet to help them stay trim the rest of their lives, not just for the short time they are on the diet. These individuals generally do not go back to the bad eating habits they had which led them to obesity and/or addiction (Nay, 1998; Sheppard, 1993).

1.1.2 Obesity and Cardio Pulmonary System

Obesity is inversely related to anaerobic threshold (Naimark and Cherniak, 1960) and aerobic capacity. Obesity can increase the oxygen cost
and mechanical work of breathing (Dempsey, 1966). Obesity is associated with higher than normal levels of pulmonary ventilation, oxygen consumption, and carbon dioxide production. These values are particularly elevated during exercise (Holley et al, 1967). Pulmonary function is altered with increasing deposit of fat on the thoracic cavity and throughout the abdominal cavity. Lowered functional residual capacity in moderate and gross obesity is contributed to the decreased chest wall compliance resulting from the accumulation of fat in and around the abdomen, diaphragm, and ribs (Sakamoto et al, 1993).

1.1.3 Need of Physical Exercise and Parental Care in Obesity

The incidence of obesity in youth is very high all over the world and is increasing at an alarming pace in India. The prevalence of obesity in 30 to 40 percent of the population concerns about the failure of the health related physical education programme. Therefore, it is important to ensure that, in India, due attention should be given to the need of physical exercise and parental care on minimal health related fitness aspects on children. From the causes of obesity, the factors like genetics, lifestyle, hormonal problems, psychology problems, and biological problems and lack of physical exercises which are observed and discussed in the earlier part of this chapter, it was observed that other than the genetic roots, others are preventable. Such a preventable measure is to participate in physical activities. Because of competitive pressure and interest on the children’s future, parents concentrate mostly on their children’s academic aspects and rarely on fitness aspects. Besides, the educational authorities also expect the students to concentrate
mostly on academic pursuits with the aim of bringing laurels to the institute among the public, since education is becoming commercialized. Factors fostering the younger generation to become old earlier are easily accommodated to the weight gain, where by they have to suffer from very deadly diseases, which was also discussed under the head of obesity and health care in the earlier part of this chapter.

While unfolding the causes and effects of obesity, the need of the hour is for both physical educational personnel and parents to join together to evolve reliable and appropriate methods. In order to achieve this, from the field of physical education, they have to take steps to realize the importance of physical fitness and motivate the student to actively participate rather than being fostered on competitive sports. Likewise, parents also should ensure that their children do well in academics and also sensitize them about being fit and healthy.

1.1.4 Physical Exercise and its Value

The use of exercise as a medical treatment is an old concept, but one that did not start gaining acceptance until the 20th century. Today, exercise Scientists are exploring the limits of exercise as a therapy—as a medicine. According to Hippocrates (1849) “In a word, all parts of the body which were made for active use, if moderately used and exercised at the labor to which they are habituated, become healthy, increase in bulk, and bear their age well, but when not used, and when left without exercise, they become diseased, their growth is arrested, and they soon become old”. Medicine’s view of exercise did not progress much in the subsequent two millennia, and exercise was primarily
viewed as an activity for healthy people, but not for the chronically ill. The first recorded anecdote of exercise as a treatment for heart disease is thought to be from William Heberden, who wrote of a man with angina pectoris in 1772: “I knew of one who set himself the task of sawing wood for half an hour every day, and was nearly cured” (Heberden 1772).

Physicians of the 1800s were interested in the role of exercise in maintenance of health (McArdle, 2001). But the modern notion of exercise as a medical treatment is thought to have originated with Berryman (1995) who perceived exercise as a technique to rehabilitate people with disabling injuries. William Osler, opined that bed rest and baths at spas like Bad Nauheim were the optimal treatment for heart disease (Osler, 1909). Physicians of the 19th and early 20th centuries were confused by enlargement of the heart, having recognized that cardiac hypertrophy paradoxically occurs both in athletes and patients with heart failure. Only after decades of research did physicians become advocates of exercise as a method of rehabilitation for heart disease.

1.1.5 Physical Exercises Prescription Resemble with Drug Prescription

In today’s Centers for Disease Control and Prevention and the American College of Sports Medicine (CDC/ACSM) paradigm for exercise prescription, there are two default options for exercise programming: (a) anything a little beyond the patient’s current activity level; (b) recommending large muscle group activities for 30–40 minutes on four or more, preferably all, days of the week (stretching and strength training are mentioned in passing). The first alternative is often used as a starting point in patients with very low exercise tolerance; the second alternative is often used as a goal for maintaining overall
hardiness. These guidelines promote the notion of accepting the former if the patient cannot (or will not) achieve, because the vast majority of people need more activity than they are currently doing. This approach has probably been a step forward, but it must be recognized that it is a sociological compromise that falls far short of a true exercise prescription.

An exercise prescription, like any prescription, has a type and dose, a dosing frequency, duration of treatment, a therapeutic goal, and anticipated adverse effects. This is true, whether the exercise is simple stretching for range of motion, aerobic exercise for all around fitness, resistance training for strength or a more integrated type of functional exercise designed around activities of daily living. Generically speaking, any exercise prescription resembles a drug prescription. To prescribe exercise in the context of chronic disease, one needs to consider how the physiology of exercise training interacts with both the path physiology and medical management of the patient’s chronic disease(s). "Our current understanding of exercise prescription is limited for most chronic diseases"

Such an exercise prescription is useful in almost all chronic diseases. What we do not know is how to optimize specific kinds of exercise for most clinical conditions. In spite of our scientific progress, our current understanding of exercise prescription is limited for most chronic diseases, where exercise is viewed as a drug. Exercise programming for most conditions must still be achieved somewhat by empiricism and trial and error, and is thus as much an art as it is a science. Most doctors have very little knowledge of exercise or sports, and thus are not schooled in this art, so they do not prescribe exercise
and often fail to even recommend exercise to patients who need it the most (unpublished data). To make matters worse, a few doctors refer patients to exercise specialists, who often have insufficient knowledge of disease path physiology and do not have direct access to patients (H Perrault, personal communication, 2002). Our challenge today is to find a better clinical care paradigm in which doctors and exercise specialists (cardiovascular, pulmonary and musculoskeletal) work more closely together to provide medically directed exercise programmes that are appropriate for each patient. Sports medicine doctors, the few physicians who actually know something about both exercise and medicine, ought to be leading this transformation. For every injured athlete, there are a score of patients for whom exercise prescription should be the cornerstone of their medical management.

1.1.6 Physical Training and Obesity

Physical training has been valued in the treatment of obesity for elevating mood, reducing hunger, and improving the likelihood of a successful outcome. Holm et al. (1978) reported a temporary suppression of the appetite after the initial bouts of a conditioning program (Mayer et al, 1956). Only modest changes in body composition have been reported in many of the studies that have investigated the effects of exercise on obesity. It is plausible that activity of higher intensity or longer duration could have resulted in a more dramatic fat loss. Unfortunately, obese people may not benefit from physical activity as readily as less obese individuals since they may be limited in their ability to exercise vigorously for substantial duration. In addition, physical activity accounts for only a fraction of the daily caloric expenditure for the
majority of the obese population. The implementation of an exercise program will raise this fraction only slightly. On the other hand, once an adequate exercise program is followed, less fit individuals, such as the mildly obese, can improve their fitness levels relatively faster than individuals of greater initial fitness. Exercise can play a very important role in the treatment of obesity when combined with a multifaceted approach (David and Nieman, 1991). Physical activity can improve health, decrease the loss of muscle mass, increase functional strength, and greatly improve the likelihood of achieving successful weight maintenance.

1.2 PHYSICAL FITNESS

Fitness is the capacity of heart, blood vessels, lungs and muscles to function at optimum efficiency (Mazzeo, 1985). Physical fitness is to the human body what fine tuning is to an engine. It is a physical state of well being that allows people to perform daily activities with vigor, reduce their risk of health problems related to a lack of physical activity and establish a base of fitness for participation in a variety of physical activities. It enables us to perform up to our potential. Fitness can be described as a condition that helps look, feel and do best (Daniel et al, 1993). More specifically, it is: "the ability to endure, to bear up, to withstand stress, to carry on in circumstances where an unfit person could not continue, and is a major basis for good health and well-being." People can only fulfill their potential when their bodies are healthy and fit (Robert, 1993). Unfortunately, many people in our society are not healthy and are not getting sufficient physical activity in order to become physically fit.
1.2.1 Present Trend of Physical Fitness

In the past, the normal routine of daily living required vigorous work and physical activity. Children did more walking to go from place to place and played outside more often. Today, concerns about safety prevent many parents from even allowing their children to play in their neighborhood. Machines, communication devices, computers, video games and other electronic conveniences have greatly diminished health enhancing levels of physical activity from our lives. Obesity has reached unprecedented levels among children and adults. Many children are not developing fitness habits nor do they value a physically active lifestyle. Sedentary behaviors have become commonplace. Thus the present trend of fitness among the early ages and middle ages is showing the dismal show.

1.2.2 Aerobic Fitness

"Aerobic fitness" refers to endurance, or the ability to sustain work for prolonged periods. The term "aerobic" implies that the oxygen necessary to accomplish the work is taken up by the individual during the activity. With longer exercise time, more aerobic metabolism is involved, and exercise lasting more than 12 minutes is mostly accomplished by aerobic metabolism. In aerobic work, oxygen is obtained from the air and is transferred from the lungs to the blood and then to the muscles via the circulatory system. Maximal oxygen uptake, or maximal aerobic power (VO₂ max) is the indicator of aerobic fitness. As VO₂ max increases, the level of aerobic fitness also increases (Fox, 1981)).
Aerobic fitness is dependent upon age and sex and it can be improved by training. It is highest at ages 18, 19 years in males and 15 to 20 years in females, and it decreases with age in adulthood. In general, males have higher \( \text{Vo}_2 \text{ max} \) than females (David and Coe, 1991). The main reason for this is that aerobic fitness is directly related to fat-free body weight, which consists mainly of the weight of muscles in the body, and on the average, males have a higher muscle mass than females. As with other physiological functions, there are large individual differences in \( \text{Vo}_2 \text{ max} \) of people of the same sex and age (Vivian, 1984). Some people show high \( \text{Vo}_2 \text{ max} \) without exercising because of genetic and other factors, while other people who exercise regularly do not show high \( \text{Vo}_2 \text{ max} \).

Aerobic fitness is a very important factor in growth and development during childhood and adolescence. It is also an important factor in the aging process. A high level of aerobic fitness during the growing years indicates good development of the muscles, bones, and cardio respiratory system. It is more important in this respect than body weight. In advanced age, aerobic fitness provides a measure of how fit one is physiologically. Good aerobic fitness is related to the ability to tolerate two common environmental stresses: heat and high altitude. Since aerobic fitness is a measure of the ability to sustain prolonged efforts, it determines the degree of fatigue that almost everybody experiences in daily life.

1.3 AEROBIC EXERCISES

The corner stone of improving health through exercise is developing the aerobic capacity. Aerobic exercise is any exercise that raises the heart rate to
the extent that it makes slightly breathless and sweaty e.g fast walking, jogging or cycling. Aerobic literally means 'with oxygen'. Aerobic system refers to heart, lungs, blood vessels and muscles (Bouchand, 1986). When exercising aerobically, fat burns as the main fuel. Aerobic capacity is based on how efficiently body can deliver oxygen to muscles and how much oxygen muscles can use for energy. Regular exercising at a specific level and for a certain time will help increase ability to take in, transport and use oxygen for exercise, so improving 'aerobic capacity'.

1.3.1 Aerobic Training and Heart Rate

Training results in an increase in the efficiency of oxygen transport within the body. By lowering the resting HR, and heart rates at sub maximal loads, the heart pumps more blood with every heart beat. This, and other physiological changes, increases the oxygen transport capability (Cyril et al, 1985). When an individual is tested before and after training, while performing exercise at the same load, a lower HR is shown after training because more blood (thus, oxygen) is delivered in each heart beat. Such HR differences during exercise can be used to predict aerobic fitness. Since a fit person shows a lower HR than an unfit one when exercising at the same load (same oxygen uptake) and the maximal HR for each age group is known, it becomes possible to extrapolate the oxygen uptake-HR curve to the maximal HR where it represents Vo$_2$ max.

1.4 Resistance Training

Resistance training is also known as Strength training. It is a common
component of sports and physical fitness programs for young people. Some adolescents and pre-adolescents may use strength training as a means to enhance muscle size and to simply improve appearance (Clayne, 1979). Strength training programs may include the use of free weights, weight machines, elastic tubing, or body weight. In addition to the obvious goal of getting stronger, resistance training programs may be undertaken to improve long-term health. Studies have shown that strength training, when properly structured with regard to frequency, mode (type of lifting), intensity, and duration of program, can increase strength in preadolescents and adolescents. In preadolescents, proper resistance training can enhance strength without concomitant muscle hypertrophy. Such gains in strength can be attributed to neuromuscular "learning", in which training increases the number of motor neurons that will fire with each muscle contraction. This mechanism helps to explain the strength gained from resistance training in populations with low androgen levels, including females and preadolescent males. Strength training can also augment the muscle enlargement that normally occurs with pubertal growth in males and females.

1.4.1 Combined Aerobic and Resistance Training

Resistance training provides numerous and important health benefits through multiple mechanisms that may reduce the risks for diabetes, heart disease, possibly some kind of cancers, and disabilities. There is much more extensive and long-standing evidence, however, about the benefits of aerobic training on cardiovascular fitness and disease risk reduction, particularly for reducing the risks of heart disease and for premature death from heart disease.
What has always been tricky for people primarily interested in resistance training is how to incorporate aerobic training into an overall program without undermining strength development or hypertrophy (gaining muscle mass). Docherty and Sporer (2000) have recently attempted in an extensive review article to advance the science by postulating specific physiological mechanisms affected by different training protocols that can predict when there will and will not be interference between aerobic and resistance training. They noted that aerobic training to increase maximum oxygen consumption and hence the body's ability to transport and use oxygen is dependent upon both a central component involving adaptations in the cardiopulmonary system and a peripheral component involving adaptations in muscle tissues. Central and peripheral adaptations are, in turn, dependent upon different mechanisms. It does appear that higher the intensity of the stimulus used to increase maximum oxygen consumption (e.g., high intensity interval training), the greater the increase in oxygen consumption. However, the location of the adaptation to aerobic training may shift depending upon the intensity of the stimulus. At lower levels of intensity, it appears that most of the adaptations occur centrally.

With higher intensity training, more adaptations occur peripherally. Docherty and Sporer (2000) noted that research suggests that training between 70% to 80% of VO\(_2\)max (70% to 80% of heart rate reserve; about 80% to 85% of maximum heart rate; just slightly below the anaerobic threshold) results in maximal contractile force in the heart and thus maximizes central adaptations important for health benefits. These findings are critical and suggest how concurrent training can be optimized. Aerobic training favorably influences the
health through central adaptations, there may be no reason to train at levels that will result in more peripheral adaptations. The ability to perform at higher levels does require training at high levels of intensity and specific peripheral adaptations, but such performance levels are not the goal of most people. Aerobic training at very high intensities through its effects on mechanisms associated with peripheral adaptations may be the cause of blunting of strength gains and hypertrophy when aerobic training is done along with resistance training.

Docherty and Sporer (2000) then discussed the mechanisms that appear involved in increasing strength and hypertrophy. The basic theory holds that high intensity aerobic training such as interval training affects specific mechanisms in peripheral adaptations such as those involved in increasing a muscle's oxidative capacity while a resistance training protocol for hypertrophy would try to increase protein synthesis and also stress the anaerobic energy system.

### 1.4.2 Effects of Resistance Training

The effect of resistance training on muscle fiber, muscle strength, blood pressure, heart rate, and body composition is as follows:

#### 1.4.2.1 Muscle Fiber Adaptations to Resistance Training

The increase in size of muscle is referred to as hypertrophy. The 'pump' one feels from a single exercise bout is referred to as transient hypertrophy. Hypertrophy refers to the increase in muscle size associated with long-term resistance training. Increases in the cross-sectional area of muscle fibers range
from 20% to 45% in most training studies (Staron et al., 1991). Muscle fiber hypertrophy has been shown to require more than 16 workouts to produce significant effects (Staron et al., 1994). In addition, fast-twitch (glycolytic) muscle fiber has the potential to show greater increases in size as compared to slow-twitch (oxidative) muscle fiber (Hather, Tesch, Buchanan, & Dudley, 1991).

1.4.2.2 Strength Adaptations to Resistance Training

The increases in muscular strength during the initial periods of a resistance training program are not associated with changes in cross-sectional area of the muscle (Sale, 1988). Changes in strength evidenced in the first few weeks of resistance training are more associated with neural adaptations (Moritani & deVries, 1979), which encompass the development of more efficient neural pathways along the route to the muscle. Long-term changes in strength are more likely attributable to hypertrophy of the muscle fibers or muscle group (Sale, 1988). The range of increase of strength is quite variable to the individual and may range from 7% to 45% (Kraemer, 1994). It should be noted that strength results appear to be velocity specific. Velocity specificity best characterizes the probability that the greatest increases in strength occur at or near the velocity of the training exercise (Behm & Sale, 1993).

1.4.2.3 Body Composition Adaptations to Resistance Training

Resistance training programs can increase fat-free mass and decrease the percentage of body fat. One of the outstanding benefits of resistance exercise, as it relates to weight loss, is the positive impact of increasing energy
expenditure during the exercise session and somewhat during recovery, and on maintaining or increasing fat-free body mass while encouraging the loss of fat body weight (Young & Steinhard, 1995). It is more likely that body composition is affected and controlled by resistance training programs using the larger muscle groups and greater total volume (Stone, Fleck, Triplett, & Kramer, 1991). Volume in resistance training is equal to the total workload, which is directly proportional to the energy expenditure of the work bout. Total volume is determined by the total number of repetitions (repetitions x sets) performed times the weight of the load (total repetitions x weight). An impressive finding to highlight with resistance training is that the energy expenditure following higher total volume workouts appears to be elevated, with an increase in fat utilization (due to a lower respiratory exchange ratio) during this period (Melby, Scholl, Edwards, & Bullough, 1993). The energy expenditure following the higher total volume workouts appears to be elevated, compared to other forms of exercise, and thus, further contributes to weight loss objectives. The evidence unequivocally supports the combined use of aerobic exercise and resistance training for optimal changes in body composition to successfully attain weight management goals.

1.4.2.4 Heart Rate Adaptations to Resistance Training

Heart rate is acutely elevated immediately following a work bout and affected by the amount of resistance, the number of repetitions and the muscle mass involved in the contraction (small vs. large mass exercises) (Fleck, 1988). Interestingly, in terms of chronic adaptations, there appears to be a reduction in heart rate from resistance training, which is considered beneficial.
(Stone et al., 1991). Long term adaptations observed in the research, from no change up to a 11% decrease in heart rate, may be explained by the differences in intensity, volume, rest between sets, use of small vs. large muscle mass, duration of study and fitness level of the subjects (David, 1975). Regular participation in aerobic exercise often results in a decrease in resting heart rate by 5 to 25 beats per minute. The lowered resting heart rate from exercise training is proposed to be due primarily to an increase in the parasympathetic nervous activity with a minor decrease in sympathetic nervous discharge (Katona, McLean, Dighton, & Guz, 1982; Smith, Hudson, Graitzer, & Raven, 1989).

1.4.2.5 Blood Pressure Adaptations to Resistance Training

More dynamic forms of resistance training, such as circuit training, that involve moderate resistance and high repetitions with short rests are associated with reductions in blood pressure. Studies have shown decreases in diastolic blood pressure (Harris & Holly, 1987) no change in blood pressure (Blumenthal, Siegel, & Appelbaum, 1991), and decreases in systolic blood pressure (Hagberg et al., 1984; Hurley, Hagberg, & Goldberg, 1988).

1.5 CIRCUIT TRAINING

Circuit training is a comparatively new addition in the field of Physical Training, making its appearance in the mid 1950's, with new varieties, such as Boxercise and Body Pump. Circuit training is a popular form of fitness session used by the army, navy, sports teams, squads of athletes/swimmers as well in health clubs and fitness centers. The aim of Circuit Training is a progressive
development of the muscular respiratory systems. (Circuit Training Exercise achieves all round fitness). Circuit training improves all round physical fitness, as opposed to fitness for a specific sport. It is generally assumed that a course of circuit training will improve both aerobic fitness and strength, thus making it a very useful conditioning method. It must be recognized that only through work (assuming adequate rest and nutrition are taken) can a muscular and respiratory system be improved on. Endurance training for which circuit training is a firm base to work from must be regular and sustained over a long period. Starting at a low level, appertaining from the standard of the class or individual, intensity should be gradually increased, with a progressive load being placed on the cardiovascular system.

Circuit training exercises are an excellent way to build strength and stamina simultaneously. In addition, resistance workouts heighten body awareness, upgrade coordination, reduce body-fat levels, and improve self esteem, all of which can contribute to improved performance of health and motor related.

1.5.1 Objectives behind the Cardio Aerobic Circuit-training programme

1 The circuit work will increase general work capacity by improving ability to tolerate increasing levels of muscular fatigue (stamina improvement).

2 Over time, the circuit training will have shorter and shorter rest intervals between exercises, thus maintaining elevated heart rates during the
circuit workouts and helping the person to upgrade cardiorespiratory capacity (stamina improvement).

3 Circuit efforts will enhance overall body strength, including the strength and resiliency of muscles, tendons, and ligaments, the integrity of joints, and the strength and density of supporting bone structures (strength improvement).

4 The circuits will improve movement skill and body awareness, because a person will perform exercises that utilise body weight as the primary form of resistance (skill improvement).

5 The circuit programme will increase lean muscle mass by a moderate amount and decrease body-fat levels through high levels of energy expenditure (body composition improvement).

1.5.2 Circuit Training for Women

Circuit Training has become increasingly popular among women. This type of training provides a one-stop total body exercise session, combining aerobic and strength training into a time efficient workout. Circuit Training reduces body weight and inches and is one of the most versatile methods of exercising (Frank, 1990). It provides excellent all round fitness, builds feminine lean muscle tone, increases strength and aerobic endurance. The benefits of Circuit Training can be summed up in a few words: “Maximum results in the minimum amount of time”.

26
1.5.3 Features of Circuit Training

The features of the circuit training are as follows: Circuit training is flexible and not a rigid one. Based on the availability of time, one can either reduce the number of circuit or extend the number of circuit in their circuit training programme. If one individual is short on time he can do one complete total-body workout in about 10 minutes. If one has time for a more challenging workout, he can do up to four circuits, completing up to a 45 minute workout. Whatever level of fitness, whether a person is merely a beginner, or highly obese he can work at a pace that is comfortable for him. The quick pace activity involved in circuit training is an excellent fat burner. Circuit training is psychologically rewarding and challenging, offering variety. Circuit training can be done at home or gym.

Fitness circuit training can significantly improve overall fitness. Circuit training has become increasingly popular with regular gym-goers; the reason being, that it provides a one-stop exercise session, combining cardiovascular activity, toning and resistance training. Circuit training is best for beginners and those of average fitness looking to tone up and get in shape (Hardyal Singh, 1984). There have been several reports recently, about the variety of benefits one can derive from attending circuit training even just once or twice a week. Studies have concluded that, depending on the structure and balance of the session, one can dramatically improve fitness level by taking part in circuit training exercises. The key to success lies in the formula of performing a set of exercises quickly and in rotation. One can significantly improve cardiovascular fitness level by exercising in short bursts of approximately 60 seconds each. If
one individual follows an aerobic work-station with a high repetition and strength station, then the individual will sustain a raised heart rate and therefore get the best possible results. Circuit training is excellent for developing good basic strength and body tone. The type of rotational activity involved in circuit training is an excellent fat burner.

The benefits of taking part in circuit training can be summed up in few words: “Maximum results in the minimum time”. It is probably one of the best methods of exercising, as it provides excellent all round fitness, tone and strength.

1.6 CARDIO-AEROBIC CIRCUIT TRAINING

Cardio-aerobic Circuit Training is an excellent way to simultaneously increase one’s cardio respiratory capacity and muscular strength and endurance. This training also increases lean body mass by a moderate amount and decrease body fat levels through high levels of energy expenditure (body composition improvement). Cardio workouts help to beat boredom, boost the cardio respiratory endurance. The circuit training format utilizes a group of exercises that are completed sequentially (one exercise after another). Each exercise is performed for a prescribed time period before moving on to the next exercise. The exercises within each circuit are separated by a shorter rest interval, and each circuit is separated by a shorter rest period thus maintaining elevated heart rates during the circuit workouts and helping the individual to upgrade his cardio respiratory capacity. The total number of circuits performed during a training session may vary from two to six depending on one’s training level.
1.7 CARDIO-AEROBIC CIRCUIT TRAINING WITH RESISTANCE EXERCISES

Since the consensus of past research suggests that cardio aerobic circuit training only moderately improves aerobic fitness, changes also have taken place in body composition. From the earlier studies it was observed that high level changes in body composition, very specifically from the obese persons adding the resistance exercises with aerobic circuit training would have significant changes in body composition of obese persons. Combination of cardio aerobic exercise and resistance exercise is the best training to lose body weight. Generally speaking, aerobic training offers more immediate weight loss benefits than anaerobic exercise, although resistance training also plays a valuable role in normalizing weight levels. On balance, the best weight loss exercise programme combines both cardio aerobic and resistance exercise. Earlier researchers more recently have experimented with circuit weight sessions that include greater aerobic activity content. Circuit training comprising weight-training exercises of moderate loads performed with short rests produces small aerobic fitness gains, moderate strength gains and a reduction in body fat accompanied by lean body mass increase. Circuits with longer rests have no aerobic benefit.

The resistance work involved in the circuits encourages muscle-mass development, and thus any fat loss is replaced equally by muscle gain. This makes it easier to maintain the lower body fat or reduce body fat even further because the increase in lean body mass pushes up basal metabolic rate and overall calorie expenditure. These body-composition changes would support
the use of circuit weight training routines in a health and fitness setting where toning up, but not losing weight, was the major goals. This is a major benefit of cardio-aerobic circuit training with resistance exercises, especially for those who want to get in shape and tone up their muscles. With cardio-aerobic circuit training, a decrease in relative fat mass has led to a decrease in total weight with little change in lean body mass.

1.8 OBJECTIVE OF THE STUDY

The main objective of the study was to find out the effects of the three modes of treatment using cardio aerobic circuit, namely, continuous long bout, multiple short bouts and multiple short bouts with resistance exercises, on obesity, development of health physical fitness components (muscular strength and endurance, flexibility and cardio vascular endurance), body composition indices (percent body fat, lean body mass, body weight and waist circumference) and selected physiological variables (maximum oxygen consumption, resting heart rate, resting systolic blood pressure and resting diastolic blood pressure) of obese women.

1.9 STATEMENT OF THE PROBLEM

The purpose of the study are:

1. To assess the effectiveness of twelve weeks of cardio aerobic circuit training based continuous long bout, multiple short bouts and multiple short bouts with resistance exercises on health physical fitness components, body composition indices and selected physiological variables of obese women.
2 To compare the effects of cardio aerobic circuit training based continuous long bout, multiple short bouts and multiple short bouts with resistance exercise on the development of health related physical fitness components, body composition indices and selected physiological variables of obese women.

3 To determine if 10 minutes multiple short bouts of cardio-aerobic circuit training per day (3 x 10 minutes) was as effective as 30 minutes continuous long bout cardio aerobic circuit training per day (1 x 30 minutes) for improving the health physical fitness components, body composition indices and selected physiological variables of obese women.

4 To determine if multiple short bouts of cardio aerobic circuit training with resistance exercises was an effective as continuous long bout cardio aerobic cardio aerobic circuit training in developing the health fitness components and body composition indices and selected physiological variables of obese women.

5 To determine if multiple short bouts of cardio aerobic circuit training with resistance exercises was an effective as multiple short bouts of cardio aerobic cardio aerobic circuit training without resistance exercises in developing the health fitness components and body composition indices and selected physiological variables of obese women.
1.10 HYPOTHESES

The formulated hypotheses of the study are as follows.

1. It was hypothesized that there would be a significant mean difference among the cardio aerobic circuit training based continuous long bout, multiple short bouts and multiple short bouts with resistance exercises on health physical fitness components, body composition indices and selected physiological variables of obese women.

2. It was hypothesized that the training programmes of cardio aerobic circuit training based continuous long bout, multiple short bouts and multiple short bouts with resistance exercises would have significant developmental effects on health fitness components, body composition indices and selected physiological variables of obese women.

3. It was further hypothesized that multiple short bouts of cardio-aerobic circuit training may have similar effects as one continuous long bout cardio-aerobic circuit training with regard to the development of health fitness components, body composition indices and selected physiological variables of obese women.

4. It was also hypothesized that multiple short bouts of cardio-aerobic circuit training with resistance exercises programme would be better than the multiple short bouts of cardio-aerobic circuit training with out resistance exercises in the development of health fitness components, body composition indices and selected physiological variables of obese women.
It was further hypothesized that multiple short bouts of cardio-aerobic circuit training with resistance exercises would be better than the continuous long bout cardio-aerobic circuit training with regard to the development of health fitness components, body composition indices and selected physiological variables of obese women.

1.11 DELIMITATIONS

The study was delimited in the following aspects:

1. The study was delimited to sixty obese women students studying in Nirmala College for women and Bishop Appaswamy College of Arts and Science, Coimbatore.

2. The subjects were assigned at random to one of the four groups (n= 15) in which, Group I had undergone 30 minutes continuous bout of cardio-aerobic circuit training, Group II had undergone three 10 minutes multiple short bouts of cardio-aerobic circuit training, Group III had undergone three 10 minutes multiple short bouts of cardio-aerobic circuit training combining with resistance exercises and Group IV acted as control.

3. The age of the selected obese women ranged from 18 to 25 years.

4. The criterion variables selected were delimited to health fitness components such as muscular strength and endurance, flexibility, cardio-vascular endurance and body composition indices such as percent body fat, lean body mass, body weight and waist circumference,
physiological variables such as maximum oxygen consumption, resting heart rate, resting systolic blood pressure and resting diastolic blood pressure.

5 The duration of the training period was delimited to 12 weeks.

6 The data was collected prior and after the 12 weeks of training programme.

1.12 LIMITATIONS

The limitations of the present study are as follows.

1 Certain factors like, lifestyle, daily routine work, diet and other factors which may have an effect on the results of the study were not taken into consideration.

2 No attempt has been made to control the factors like air resistance and atmosphere during training and testing period.

3 The difference in socio-economic status and educational background of the obese female students that might have influenced on their training program were not taken into consideration.

4 The knowledge of the subjects in exercise science and their previous experience in doing physical activities were not taken into consideration.

5 Subjects were motivated verbally during testing and training periods, but the impact of individual motivation was not taken into account.
6 The influence of psychological factors like stress and other factors during the testing and training periods was taken into consideration.

7 The heredity of the subjects and its influence on the selected criterion variables were not taken into consideration.

1.13 SIGNIFICANCE OF THE STUDY

1 The findings of the study may reveal the extent to which the practice of cardio-aerobic circuit training in multiple short bouts has similar effects as one continuous long bout with regard to the development of health physical fitness components such as muscular strength and endurance, flexibility, cardio-vascular endurance and body composition indices such as percent body fat, lean body mass, body weight and waist circumference); and selected physiological variables such as maximum oxygen consumption, resting heart rate, resting systolic blood pressure and resting diastolic blood pressure of obese women.

2 This study would also help to provide a scientific base and guidance to the physical educationists, coaches, sports scientists, exercise physiologists, and fitness leaders to identify the best weight loss (body composition) exercise programme (body composition) and simultaneously that helps to develops health physical fitness components and physiological efficiency of body of obese women.

3 Findings of this study would give a basic knowledge to the exercise physiologist and fitness leaders to envisage and conduct further research in various training methods, training programs, training intensity and
training load to prevent the various cardiac risk factors of obese females.

4. The results of this study would add to the quantum of existing body of knowledge in the area of training methods, fitness and wellness, exercise physiology and exercise science.

1.14 OPERATIONAL DEFINITIONS AND EXPLANATIONS

Continuous Long Bout Cardio-Aerobic Circuit Training

Continuous Long Bout Cardio – Aerobic Circuit Training (CLBCACT) refers to a group of exercises that were completed sequentially in a circuit workout (one exercise after another). Each exercise was performed for a period of 30 seconds before moving on to the next exercise. The exercises within each circuit is separated by a 30 second Jogging interval, and each circuit was separated by a shorter rest period thus maintaining elevated heart rate during the circuit workouts and helping the subjects to upgrade their cardio vascular capacity. This circuit workout was done once in a day (morning). The duration of the training session is 30 minutes and practiced five days in a week for about twelve weeks.

Multiple Short Bouts Cardio Aerobic Circuit Training

Multiple Short Bouts Cardio Aerobic Circuit Training (MSBCACT) refers to a course of circuit training which comprised 10 calisthenics type of exercises selected for this training purpose. Each exercise was performed for a period of 30 seconds before moving on to the next exercise. The exercises
within each circuit was separated by a 30 second Jogging interval, and each circuit is separated by a shorter rest period thus maintaining elevated heart rate during the circuit workouts and helping the subject to upgrade his cardiovascular capacity. This circuit was done three times in day i.e., morning, afternoon and evening and the duration of the training sessions was 10 minutes (3 x 10 = 30).

**Multiple Short Bouts Cardio Aerobic Circuit with Resistance Exercise**

Multiple Short Bouts Cardio Aerobic Circuit with Resistance Training refers to a course of circuit training which comprised 5 calisthenics type of exercises (Aerobic exercise) selected for this training purpose. Each exercise is performed for a period of 30 seconds before moving on to the next exercise. The exercises within each circuit are separated by a 30 seconds Jogging interval. This was followed by a five station weight circuit exercise selected for this training purpose. Each exercise was performed for a period of 30 seconds in a single set fashion at 50% to 60% of maximum heart rate with 30 second of Jogging between each station to increase the aerobic content. This workout was done three times a day i.e. morning, noon and evening and the duration of each session of a day was 10 minutes (3 x 10).

**Health Fitness**

Health Fitness is defined as “the ability to carry out the daily task with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure time pursuits and to meet unforeseen emergencies” (Jerrold et al, 1986)
Muscular Strength and Endurance

Muscular Strength and endurance refers to the ability of a muscle or of muscles to perform repeated contractions against a light load for an extended period of time (Fox et al., 1988).

Flexibility

Flexibility is the range of movement about a joint. Individual difference in flexibility depends upon physiological characteristics that influence the extensibility of the muscle and ligaments surrounding a joint (Fleishman, 1964).

Cardio Vascular Endurance

Cardio vascular endurance is referred as the ability of the lungs, heart and blood vessels to deliver the adequate amount of oxygen and nutrients to the cells to meet the demands of prolonged physical activity (Harvey et al., 1987).

Body Composition

Body composition is the component part of the body or otherwise it refers to fat and muscle weight.

Lean Body Mass

The lean body mass (LBM) is defined as total body weight less the weight of subcutaneous fat. Lean body mass was determined by use of the
following equation: LBM (kg): Total Body weight (kg) - Total weight of fat (kg)

**Maximal Oxygen Uptake (VO₂ Max)**

The maximal oxygen uptake can be defined as the maximal amount of oxygen that can be consumed per minute during the maximal exercise and it is abbreviated as Vo₂ Max (Larry Shaver, 1981).

**Resting Heart Rate**

Morehouse and Miller (1976) have defined resting heart rate as the distension of the arterial walls at the beginning of systolic ejection of blood which is not confined to aorta but travels down the arteries as a wave followed by a wave of recoil. The arteries that lie close to the body such as radial artery of the wrist, the arrival of the wave of distension and subsequent recoil may be felt as a distinct throw pulse which offers a convenient method of counting the pulse rate.

**Blood Pressure**

Blood pressure is the pressure in blood vessels that the blood exerts against the wall of vessels (Laurence, et al. 1967),

**Systolic Blood Pressure**

Systolic blood pressure is the pressure in the heart and blood vessels during contraction phase of this cardiac cycle (Mc Ardle et al.1985).
Diastolic Blood Pressure

Diastolic blood pressure is the minimum level of arterial blood pressure falls in the time between successive heart beats (Strikic, 1981).