CHAPTER 1

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Health according to World Health Organisation (WHO) is the state of complete physical, mental and social well being. The aim of the WHO is to attain the highest state of health by all people. Physical fitness, on the other hand is defined as the ability to carry out daily tasks with vigour and alertness, without undue fatigue and with ample energy to enjoy leisure time pursuits and to meet unforeseen emergencies. There is an optimum level of fitness for every body. (Clarke, 1976)

All physical movements incorporate motor and functional components like strength, speed, endurance and coordination. From the training point of view, a coach should prepare the athletes through these functional components which are more commonly referred to as biomotor abilities. The necessity and contribution of the biomotor abilities to the attainment of high performance standards are wider. (Bompa, 1983)

Fit people make a better sports world. Performance related physical fitness is associated with those ingredients and qualities like endurance, strength, speed and agility which are conducive to better performance in sports like endurance, strength, speed and agility. (Bucher, 1983)
The approach to physiological conditioning is basically the same for both sexes and they respond and adopt to training essentially in a similar manner. As long as the accepted principles of exercise training are followed similar fitness improvements occur in exercise programmes offered to the public and also to the controlled training experiments in laboratory conditions. (McArdle, et al., 1991)

Resistance training is one of the means for developing the optimum level of fitness. It is a broader term than weight training because resistance can be supplied by weights, machines, rubber stands and a number of other devices that resist the movement of the exercise. Resistance training is defined as a training aid to different sports using the weight or similar apparatus (Kirkley and Goodbody, 1978).

The resistance training is concerned with improving the condition of the body in terms of muscular strength, power and muscular endurance through the use of repetitive movement against a resisting load of some kind. Training will improve the performance ability of the athletes and players in a programme of exercise aimed to increase the skills and the energy capacities of a player for a particular game or sport. In spite of the importance of training for muscle strength, the wide acceptance of its significance and the profound knowledge of trainers and players in training remain unsystematic. The
difference between the dimensional structure of strength and its components are frequently ignored. Usually this is due to lack of time and proper training conditions as well as unwillingness to do exercise, carelessness and poor planning. It is apparent that the attention must be turned to the importance of strength training programme to improve the training quality, especially in view of the limited time available to players. (Payne, 1990)

ADAPTATIONS TO RESISTANCE TRAINING

Resistance training programme creates systematic process for eliciting physiological adaptations over time. The amount of physiological adaptation will depend upon the effectiveness of the exercise prescriptions used in the training programme. (Fox et al., 1988)

The effect of training is related to the type of exercise used, its intensity and the volume. With trained athletes, a higher volume of exercise is typically needed to continue the adaptation. The use of both eccentric and concentric components in machine stack plate or free weight resistance exercise may result in optimal increase in strength and muscle size. (Kraemer and Fleck, 1988)

Wide variety of alterations must take place to provide for increased strength, power and size of the muscle trained when starting a training
programme. The nervous system and the muscle tissue system are primary physiological systems involved with the needed adaptations for increased forced production. They carry on dramatic and complex interplay. The exact cause of the neural or muscle tissue component to dominate at the given stage of training remains unclear. But this is due to the configuration of the resistance exercise stimulus used in a programme. (Baechle, 1994)

**PHYSICAL VARIABLES**

During resistance training changes occur in physical variables such as muscular strength and muscular endurance. The extent of changes that occur due to relative resistance training has not been fully explored. So earnest attempt has been made to find out the effect of relative resistance training on muscular strength and muscular endurance.

**Muscular Strength and Endurance**

The strength of the muscle is determined mainly by its size with the maximum contractile force. The athlete who had enlarged his muscles through an exercise training programme likewise will have increased muscle strength (Guyton and Hall, 1996).

The increase in muscle bulk, bone mineral content, total contractile protein and energy generating compounds with heavy weight training occurs
without a parallel increase in capillarisation, mitochondrial volume and mitochondrial enzymes in the muscle cells. (McArdle, et al., 1991).

If the muscles that function under no load are exercised for hours on end there is increase in strength. At the other extreme, muscle that contract at more than 50 percent maximal force develop strength rapidly even if the contractions are performed only a few times each day. The experiments on muscle building have shown that nearly six maximal muscle contractions performed in three sets, three days a week give approximately optimal increase in muscular strength. In an untrained young person the muscle strength can be increased by about 30 percent during the first six to eight weeks of resistance training. In old age, many people become so sedentary that their muscles get atrophied tremendously. In these instances, muscle training often increases muscle strength by more than 100 percent. (Kendall, 1993)

The process of hypertrophy of the muscle due to light resistance training is directly related to increased vascularisation of the muscles, synthesis of cellular material, including the protein filaments that are the contractile elements (McArdle, et al., 1991).

One of the important measures of muscle performance is endurance. This depends on the nutritive support for the muscle, namely, the amount of glycogen that has been stored in the muscle before the period of exercise. The
resistance training hypertrophies muscle to an additional 30 to 60 percent. The hypertrophied muscle will have 50 percent increase in stored glycogen and 75 to 100 percent increase in stored triglyceride, 120 percent increase in mitochondrial enzymes and 60 to 80 percent increase in the ATP and phosphocreatine in a prolonged and systematic resistance training (Fisher and Jensen, 1989).

The strength and endurance are the key to success in sports and games. There is a vast need for every one involved in sports for better understanding of the importance of strength and endurance. Most coaches recognise that strength and endurance are valuable assets to athletic success (Hooks, 1974).

ANTHROPOMETRIC VARIABLES

Anthropometry is a branch of the science that deals with the measurement of size, weight and proportions of the human body. Anthropometric measures are used to predict body density and percentage of body fat. (Johnson and Nelson, 1974)

Percent Body Fat and Girth

According to MacDougall (1986), the resistance training programme results in an increase in muscle girth. In untrained persons a training duration of four weeks or more is needed to produce a significant increase in muscle
size while in previously trained individuals, a duration of few weeks is sufficient to increase muscle size.

Individuals engaged in resistance training over a period of eight to ten weeks exhibit remarkable muscular development with a greater amount of lean body mass (McArdle et al., 1991).

The changes in body composition induced by training are: a decrease in total body fat, a slight increase in lean body weight, and a small decrease in total body weight. These changes, particularly that of fat loss is more pronounced in obese men and women than the lean individuals (Fox and Mathews, 1981).

HAEMATOLOGICAL VARIABLES

During resistance training changes occur in the haematological variables such as haemoglobin and red blood cells.

Haemoglobin and Red Blood cells

The major function of blood is the transport of oxygen from the lungs to the tissues and carbon dioxide from the tissues to the lungs. The transport of oxygen is accomplished by haemoglobin, the iron-protein molecule carried by the red blood cells. The red blood cells also contain a large quantity of
carbonic anhydrase, which catalyses the reaction between carbon dioxide and water to facilitate the removal of carbon dioxide. The regular exercise results in increase in the number of red blood cells circulating in the blood. The improved oxygen carrying and waste removal capacity further increases workload capacity. (Lee, 1989)

The amount of haemoglobin, the haematocrit and the volume percentage of the red blood cells are critical factors in oxygen association. Both haemoglobin and haematocrit levels increase with maximum exercise, largely because of increased haemo concentration due to slight decrease of blood plasma volume. During exercise blood plasma shifts to the tissues, where it is needed to maintain water balance (McArdle et al., 1986).

Bevagerd and Shepherd (1967) have reported an increase in plasma volume and total haemoglobin with an increase in capillary density of the muscle due to endurance training.

**BIOCHEMICAL VARIABLES**

The resistance training produces biochemical changes in the cardiorespiratory system and other important alterations in blood composition, such as, blood cholesterol, blood glucose and triglyceride levels (Fox and Mathews, 1981).
Blood glucose

The blood glucose concentrations are maintained at a relatively constant levels at very low exercise intensities as a result of low muscle glucose uptake. The rate of glycogen depletion is related to exercise intensity. During moderate and high intensity exercises, muscle glycogen is more important energy source whereas during long duration low intensity exercises, liver glycogen is an important source of energy. During long duration exercises lasting more than 90 minutes the blood glucose concentration decreases even below 2.8 mmol/l. (Ahlborg and Felig, 1982).

According to Roberges (1991), very high intensity intermittent resistance exercise causes a substantial depletion of muscle glycogen within a relatively a few sets of exercises and muscle glycogen may become limiting factor for resistance training with more number of total sets resulting in larger amount of total work.

Total Protein, Albumin and Globulin

Proteins are extremely important in the structure and function of the tissues of the body. Like carbohydrates and lipids, proteins are constructed from relatively simple building blocks, but their structural possibilities are limitless. The major classes of proteins in the body include enzymes, which
control chemical activity, antibodies which protect against disease, haemoglobin, which carries oxygen in the blood and hormones, which are important in the control of the cellular functions. (Guyton and Hall, 1996).

Proteins are relatively complex molecules that have enzymatic and structural functions and are important in a variety of biosynthetic and bioenergetic reactions related to body growth, maintenance and repair and energy production. Because energy requirements take priority over tissue anabolic reactions, protein can also be used as an energy source if carbohydrate and fat in the diet are inadequate. An important function of skeletal muscle is to serve as a reservoir for protein, which can be broken down for energy when normal dietary intake is low as in the extreme case of starvation or marathon running (Sparge, 1979).

**Blood Cholesterol**

Cholesterol, a sterol, is the most familiar of all the derived lipids. Cholesterol synthesized from acetate in all animal tissues, is a precursor of cholic acid, vitamin D and the steroid hormones, including estradiol, progesterone, testosterone, and adrenal steroids. A high level of serum cholesterol and the cholesterol rich low density lipoprotein molecule are associated with an increased risk of coronary artery disease. Cholesterol
deposits on the inner lining of the medium and larger arteries results in athroposclerosis (McArdle et al., 1991).

Mobilisation of free fatty acids is important during aerobic exercise. As a consequence of anaerobic exercise, considerable mobilization of free fatty acids occurs resulting in body fat loss. The resistance exercise can beneficially alter blood lipid values and this is related to volume and intensity of training (Pollock and Wilmore, 1990).

The resistance exercises reduce blood cholesterol, low density lipoprotein and high density lipoprotein levels in the blood. These changes work together to reduce the risk of heart attacks and brain strokes (Grana and Kalenak, 1991).

**Blood Lactate**

One of the biochemical changes induced by repetitive high intensity resistance training is an increase in glycogen system capacity. This increase is evidenced by greater anaerobic capacity during high intensity exercise. The accumulation of lactate in the blood is greater following high intensity of intermittent exercise as in weight training and in many sports activities when compared to low intensity continuous exercise (Lehmann and Keul, 1986).
The multiple sets of resistance exercise, with increases in resistance to failure, resulting in higher blood lactate concentrations in trained individuals and that the time to failure and total work accomplished was greater in trained people when compared to untrained (Stone et al., 1987).

The present study was carried out to investigate the effects of relative isotonic resistance training on selected variables, namely, physical, anthropometrical, haematological and biochemical variables among nonathletes.

STATEMENT OF THE PROBLEM

The study under investigation involves the experimentation of resistance training at various relative intensities (40%, 60% and 80% of 1 RM) on selected physical, anthropometrical, haematological and biochemical variables among nonathletes.

HYPOTHESIS

It has been documented that systematic resistance training over a continuous period of time is bound to produce changes on physical, anthropometrical, haematological and biochemical variables (Fleck and Kramier 1987, Baechle, 1994 and McArdle et al., 1991). These changes are
subject to vary, depending upon the different types of resistance exercises used, its intensity and its volume. It was hypothesised that:

a) There would be no significant difference on selected physical variables, namely, muscular strength and muscular endurance due to relative isotonic resistance training.

b) There would be no significant difference in the selected anthropometrical variables, namely, percent body fat, chest circumference, thigh girth, forearm girth and upper arm girth (relaxed and flexed) due to relative isotonic resistance training.

c) There would be no significant difference among the selected haematological variables, namely, haemoglobin and red blood cells due to relative isotonic resistance training and

d) There would be no significant difference among the selected biochemical variables, namely, blood glucose, total protein, albumin, globulin, blood cholesterol and blood lactate due to relative isotonic resistance training.

SIGNIFICANCE OF THE STUDY

The present investigation will contribute significantly to the field of physical education and sports in the following ways:
1. The findings of the study would reveal the extent to which the resistance training improves muscular strength and endurance.

2. The findings of the study would reveal the extent to which the resistance training reduces the percent body fat and improves the girth.

3. The findings of the study would reveal the extent to which the resistance training improves haemoglobin level and red blood cell count.

4. The results of the study may help the physical educators, coaches and sports scientists to understand the response of biochemical variables, viz., blood glucose, total proteins, albumin, globulin, blood cholesterol and blood lactate to relative isotonic resistance training.

5. The results of this study would help coaches and physical education teachers to design relative isotonic resistance training programmes for trainees, and

6. The study would also help as scientific literature to the physical educationist, coaches and athletes to identify and modify the method of resistance training based on physical, anthropometrical, haematological and biochemical responses.
DELIMITATIONS

The following delimitations were taken into consideration during this study:

1. Only volunteer male students of Madras Veterinary College were selected as subjects for this study.

2. The age of the subjects selected for the study was between 19 to 22 years and all the subjects were nonathletes.

3. All the subjects were residents in the same hostel and hence the nutritional status and day to day activities of all the subjects were similar.

4. The number of groups for the study was delimited to four with fifteen subjects in each group considered as adequate to draw meaningful conclusions.

5. The training was confined to the following resistance exercises:

   a) chest press  b) leg press  c) shoulder press and  d) arm curl. The chest press, leg press and shoulder press exercises were performed in a multigym whereas the arm curl exercise was performed by using free weights.
6. The dependant variables selected for the study were confined to the following parameters, namely, a) Physical: muscular strength and muscular endurance, b) Anthropometrical: percent body fat and girth, c) Haematological: haemoglobin and red blood cells and d) Biochemical: blood glucose, total proteins, albumin, globulin, blood cholesterol and lactate.

7. The duration of the experimental period was limited to 12 weeks and the training was conducted thrice a week which was considered adequate to cause changes in physical, anthropometrical, haematological, and biochemical variables and

8. Two sets for each resistance exercise were considered adequate to develop physical, anthropometrical, haematological and biochemical changes, since all the subjects were nonathletes.

LIMITATIONS

The uncontrollable factors associated with the study were accepted as limitations and the following were considered as limitations of the research study:

1. The heterogeneous characters of the subjects in hereditary and environmental factors were recognised as a limitation.
2. The investigator could not completely control the quantum of physical exertion, rest period, life style and other day to day activities of the subjects.

3. The growth and development of the subjects, if any, during the period of experimentation and its possible influence on the physical, anthropometrical haemotological and biochemical variables were considered as limitations.

4. The influence of vigorous academic activity of students could have discouraged or motivated the subjects during training and during the testing periods.

5. The influence of socioeconomic factors during the training programme was considered as a limitation and

6. The uncontrollable changes in climate and weather conditions such as atmospheric temperature, humidity and other meteorological factors during the training programme were regarded as limitations.

**DEFINITION OF TERMS**

Important terms that are frequently used in this investigation are defined below:
Training

In the words of Csamadi (1966) "training is a pedagogical process which makes possible the achievement of high standard performances without any physical or mental damage, through the planned systematic development of certain specific skills, physical capabilities and the adaptation of the organism." (p. 407)

According to Arnheim, (1985) training is defined as "a systematic process of repetitive, progressive exercise or work, involving the learning process and acclimation". (p.78)

Resistance Training

According to Payne (1990) "resistance training is concerned with improving the condition of the body in terms of muscular strength, power and muscular endurance, through the use of repetitive movements against a resisting load of some kind." (p.26)

Kirkley and Goodbody (1978) define resistance training as "a training aid to different sports using the weight or similar apparatus." (p. 2)
Isotonic Resistance Training

According to Bucher (1983) resistance training given for muscles function by contracting in such a manner that the muscle shortens and the ends are brought together (concentric) or the muscle lengthens and the ends go away from the center as in the beginning of a pull-up when one lowers oneself into a hanging position (eccentric or isotonic).

Nonathletes

Those individuals who have not undergone any systematic programme of conditioning or training and who have not represented their college in any game or sport, were considered as nonathletes.

Muscular Strength

Muscular strength is the force that a muscle or muscle group can exert against a resistance in one maximal effort (Baumgartner and Jackson, 1987)

Muscular strength is operationally defined as the force that a muscle or a muscle group can exert against a resistance in one maximal effort. In this study the muscular strength was assessed by 1 RM performance by each subject in chest press and was recorded in kilograms. (Chrusch, et.al. 2001)
Muscular Endurance

Muscular endurance is the ability of muscles to perform work. (Clarke, 1976) Muscular endurance is the ability of a muscle to work against a moderate resistance for a long period of time. (Mathews and Edward, 1976)

Muscular endurance is the ability of a muscle or muscle group to perform repeated contractions against light (sub maximal) load for an extended period of time. (Altug et al., 1987)

Muscular endurance is operationally defined as the highest number of repetitions that can be performed continuously and is assessed by the maximum number of repetitions at an intensity corresponding to 60% of baseline 1 RM in chest press and it was recorded as the number of maximum possible repetitions. (Chrush et al., 2000).

Percent Body Fat

The percent body fat is defined as the amount of fats or lipids stored in the fat cells (adipocytes) of the body and is expressed in percentage. (Fox and Mathews, 1981)

The percent body fat is operationally defined as the amount of fat present in the body, estimated by measuring the skinfold thicknesses of chest,
abdomen and thigh in millimeters using the skinfold calipers and was expressed in percentage as per the index table of Pollock, et al., (1980).

Girth

Girth is an important anthropometric measurement and is defined as the circumference measured in the horizontal plane (Jacson, et.al., 1978).

Girth is operationally defined as the circumference measured in the horizontal plane using Gulich tape, at the bulkiest part of the muscle without applying too much pressure, and was expressed in centimeters.

Haemoglobin

Haemoglobin may be defined as a protein (globin) united with a pigment (hematin) and contains iron. (Astrand and Rodahi, 1977)

According to Strukie, (1981), it is the “iron containing oxygen carrying pigment in the erythrocyte. It loads up with oxygen in the lungs and unloads it's oxygen to the tissue.” (p. 186)

Haemoglobin is operationally defined as the amount of haemoglobin present in the blood expressed in g/dl and was estimated by acid hematin method using Sahle's haemocytometer.
Red Blood Cells

Karee (1975) has defined red blood cells or erythrocytes as “small circular biconcave discs, so called because they are concave on both sides. They are about 50,000,000 red cells in a cubic millimeter of blood. They are pale buff colony which enclose mass of haemoglobin.” (p.165).

The red blood cells were operationally defined as the concentration of the red blood cells as determined by haemocytometer and was expressed in millions per cubic mm of blood.

Glucose

Glucose, also called destrose or blood sugar, is formed as a natural sugar in food or is produced in the body as a result of digestion of more complicated carbohydrates. Glucose can be used directly by the cell for energy, stored as glycogen in the muscles and liver, or converted to fats for energy storage. (McArdle, et al., 1991)

Glucose is a principal sugar that circulates in the blood at a constant level and it is used by the muscles during the activity. (Perrot, 1974)
Blood glucose was operationally defined as the concentration of glucose in blood expressed as mg/dl and was determined by the O-Toluidine method of Winckers and Jacobs (1971).

**Total Protein, Albumin and Globulin**

A protein is a compound of high molecular weight consisting primarily of chains of amino acids unified in a peptide linkage. Plasma proteins represent a heterogeneous group of chemical compounds. Evaluation of the molecular weights of plasma proteins lends further support to their heterogeneous characteristics. Albumin which is the smallest has the molecular weight of approximately 69,000, alphaglobulin 200,000, betaglobulins 150,000, gama globulins 150,000 – 30,000 fibrinogen 400,000. The chief function of albumin is concerned with maintenance of osmotic pressure of blood, globulin, in production of anti bodies and fibrinogen, in clotting mechanism. (Coles, 1980).

Total protein and albumin were operationally defined as the concentration of serum total proteins expressed in mg/dl and was determined by the Modified Biuret and Dumas method.
Albumin was operationally defined as the concentration of serum albumin expressed in mg/dl and was determined by the modified Biuret and Dumas method.

Globulin was operationally defined as the concentration of serum globulin expressed in mg/dl and was determined by subtracting serum albumin from total protein. (Cole, 1980).

**Cholesterol**

The term cholesterol is derived from the Greek word, "Chola" meaning bile and "stereos" solid. Highly purified cholesterol is a white powder at room temperature. Cholesterol is a member of the class of lipid called steroid, which are derivatives of the tetracyclic hydrocarbon perhydrocyclopentabben Zuba, 1984).

Blood cholesterol was operationally defined as the concentration of serum cholesterol expressed as mg/dl and was determined by the Wybenga and Pileggi method (1970).
Blood Lactate

Lactic acid is the major end product in muscle in anaerobic glycolysis. Muscle tissue is capable of resynthesizing glucose from lactate. This conversion takes place entirely in the liver (Deb, 1988).

Lactic acid is the end product of glycolysis and would accumulate unless removed from the cell or oxidized. Lactic acid is removed by the blood and carried from muscle to other organs, where it can be oxidized. It can also be oxidized in muscles by reverting to pyruvate and entering into the citrate cycle during periods when muscles have an ample supply of oxygen (Awapara, 1988).

Blood lactate was operationally defined as the concentration of the plasma lactate expressed as mg/dl and was determined by the calorimetric method of Barker and Summerson (1941).