CHAPTER - I

INTRODUCTION

1.1 SPORTS TRAINING

Sports training is the process of bringing a person, to an agreed standard of proficiency, by practice, following a set of instructions, and extending over a long period. For best result the system of training has to be based and conducted on scientific basis.

1.2 STRENGTH TRAINING

The expression of muscular strength is a fundamental property of human performance. The magnitude of the empirical and scientific literature devoted to strength development and evaluation makes it clear that a key aspect to the design of proper resistance training is the systematic inclusion of various testing modalities to evaluate the quality of the program. The evaluation of physiological responses and adaptations (e.g., cardiovascular, endocrine, neuromuscular, metabolic) associated with force production has allowed us to gain greater understanding of the various systems under conditions of high-threshold motor unit recruitment. In evaluating the effects of training, muscular fatigue, injury rehabilitation, muscular balance, or the functional abilities of different individuals, strength testing provides important information regarding human performance.
1.3 IMPORTANT OF STRENGTH TRAINING

The most important reason for monitoring strength performance is to assist in the evaluation and progression of resistance-training programs. Presently, most segments of the population perform resistance training, from children to the elderly, and the American College of Sports Medicine (1998, 2002) recommends resistance training for inclusion in general health and fitness exercise programs in adults. The programs, as well as the goals for training, are diverse. The amount of strength development depends on the initial level of muscular fitness, exercise prescription, time available, and objectives of the program. Regular assessment of muscular strength enables proper evaluation of the exercise prescription and modifications when appropriate.

The rate of strength increase differs considerably between untrained and trained individuals, with trained individuals showing much slower rates of improvement. A general review of approximately 150 studies revealed that increases in muscular strength, on average, are approximately 40% in untrained individuals, 20% in moderately trained individuals, 16% in trained individuals, 10% in advanced individuals, and 2% in elite individuals over periods ranging from 4 weeks to 2 years (American College of Sports Medicine, 2002). Although the training programs, durations, and testing procedures of these studies differed considerably, these data clearly show a specific trend towards slower rates of progression of strength development with training experience.
This has recently been shown by meta-analysis of 140 studies (Rhea, Alvar, Burkett, & Ball, 2003). In this study, statistically significant effect size (ES) differences were observed between resistance-trained individuals and untrained individuals for training intensity (ES range of 0.65 to 1.80 for trained versus 1.60 to 2.80 for untrained), frequency (ES range of 0.70 to 1.40 for trained versus 1.20 to 1.90 for untrained), and volume (ES range of 0.47 to 1.17 for trained versus 1.16 to 2.28 for untrained).

1.4 TYPES OF STRENGTH AND THEIR TRAINING SIGNIFICANCE

Training involves various types of strength, each having certain significance for some sports and athletes. General strength is the foundation of the entire strength training program. It must be the sole focus of the early training phase of anatomical adaptation. Anatomical adaptation is devoted to the development of the overall strength of the core and limbs. The development of a good base of aerobic endurance is also stressed in this phase along with muscle balance and injury prevention. Anatomical adaptation, as the name implies, prepares the body for the more difficult phases that follow. A low level of general strength may limit the overall progress of an athlete. It leaves the body susceptible to injury and potentially even asymmetrical shape or a decreased ability to build muscle strength. Specific strength is the strength of only those muscles (mainly the prime movers) that are particular to the movements of a selected sport.
As the term suggests, this type of strength is each sport. Thus, any comparison between the strength levels of athletes involved in different sports is invalid. Specific strength training should be progressively incorporated towards the end of the preparatory phase for all advanced athletes. Maximum strength refers to the highest force that can be performed by the neuromuscular system during a maximum contraction. It constitutes the heaviest load an athlete can lift in one attempt and is expressed as 100 percent of maximum or 1-repetition maximum (1RM). For training purposes, athletes must know their maximum strength for each exercise because it is for calculating loads for every strength phase.

Power is the product of two abilities, strength and speed, and is considered to be the ability maximum force in the shortest time. Muscular endurance is defined as a muscle's ability to sustain work for a prolonged period. It is used largely in endurance-related sports and has a positive transfer to cardiorespiratory endurance. Absolute strength refers to an athlete's ability to exert maximum force regardless of body weight. Absolute strength is required to reach very high levels in some sports (shot put and the heavies: weight categories in weightlifting and wrestling). Increases in absolute strength parallel gaining body weight in athletes following a systematic training program. Relative strength represents the ratio between absolute strength and body weight.

Relative strength is important in sports such as gymnastics or those in which athletes are divided into weight categories (wrestling, boxing). For instance, a gymnast may not be able to perform the iron cross on the rings unless
the relative strength of the muscles involved is at least one to one. This means that the absolute strength must be at least sufficient to offset the athlete’s body weight. Gains in body weight change this proportion - as body weight increases, relative-strength decreases.

Strength reserve is the difference between absolute strength and the amount of strength required to perform a skill under competitive conditions. Strength gauge techniques used to measure rowers' maximum strength per stroke unit revealed values up to 233 pounds (106 kilograms) the mean strength per race was 123 pounds (56 kilograms) (Bompa, Hebbelinck and Van Gheluwe, 1978). The same subjects were found to have absolute strength in power clean lifts of 198 pounds (90 kilograms). Subtracting the mean strength per race (123 pounds or 56 kilograms) from absolute strength (198 pounds or 90 kilograms) results in strength serve of 75 pounds (34 kilograms). The ratio of mean strength to absolute strength is 1 to 1.6. Similarly, other subjects were found to have a higher strength reserve with a ratio of 1 to 1.85. Needless to say, the latter subjects performed better in rowing races, leading to the conclusion that an athlete with a higher strength reserve is capable of reaching higher performance levels.

Although the concept of strength reserve may not be meaningful to all sports, it is believed to be significant in sports such as swimming, canoeing, and rowing, as well as in jumping and throwing events.
1.5 STRENGTH TRAINING AND MUSCULAR ADAPTATION

Systematic strength training results in certain structural and physiological changes, or adaptations in the body. The level of adaptation is evidenced by the size and definition of the muscles. The magnitude of these adaptations is directly proportional to the demands placed on the body by the volume (quantity), frequency, and intensity (load) of training. Training benefits an athlete only as long as it forces the body to adapt to the stress of physical work. In other words, the body is presented with a demand greater than it is accustomed to, it adapts to the stressor by becoming stronger. When the load does not challenge the body's adaptation threshold. The training effect will be nil or at best minimal, and no adaptation will occur.

Different types of adaptation can occur. Periodization of strength offers a six-phase approach that follows the physiological rhythm of how muscles respond to strength training. Depending on the physiological makeup of the sport, a minimum of three of the six phases will be combined in sequence to form the periodization of strength. All periodization of strength models begin with phase 1. Four of the six possible phases are briefly discussed below. The remaining two phases competition and transition will be discussed in later chapters.

Phase 1: Anatomical Adaptation

The emphasis in the anatomical adaptation phase is "prehabilitation," with the hope of preventing the need for rehabilitation. The three main physiological objectives of this phase are to increase the oxidative capacity of the slow-twitch
muscle fibers; strengthen the tendons, ligaments, and joints, which are plausible through a high volume of training; and increase the bone mineral content and proliferation of the connective tissue that surrounds the individual muscle fibers. Regardless of the sport, cardiovascular fitness is improved, muscular strength is adequately challenged, and neuromuscular coordination for strength movement patterns is tested and practiced. An increase in the cross-sectional area of muscle is not the focus but can occur during this phase.

The anatomical adaptation phase is the foundation for the other phases of training. The name of the phase illustrates the fact that the main objective of strength training is not an immediate overload but rather a progressive adaptation of the athlete's anatomy.

**Phase 2: Hypertrophy**

One of the most visible signs of adaptation to strength training is the enlargement of muscle size, known as hypertrophy. Many of the principles used in hypertrophy training are similar to those used in bodybuilding. The two main physiological objectives of this phase are an increase in muscle cross-sectional area and an increased storage capacity for high-energy substrates and enzymes. The main difference between athletic hypertrophy and bodybuilding hypertrophy is the amount of load used in training. Bodybuilders train to exhaustion using relatively light to moderate loads, whereas athletes rely on heavier loads focusing on movement speed and rest between sets. Although hypertrophic changes occur in both fast-twitch and slow-twitch muscle fibers, more changes take place in the
fast-twitch fibers. Hypertrophy training provides a strong physiological precept to nervous system training when it produces chronic changes. When a muscle is forced to contract against a resistance, as happens in strength training, there is a sudden shift in blood flow to the working muscle.

This transient increase in blood flow, known as short-term hypertrophy, temporarily increases the size and thickness of the muscle. Short-term hypertrophy is experienced during every strength training bout and usually lasts one to two hours following the training session.

Although the benefits of a single bout of strength training are quickly lost, the additive benefits of multiple training sessions leads to a state of athletic hypertrophy. Football players rely on athletic hypertrophy to improve speed, agility, and power. Athletic hypertrophy results from structural changes at the muscle level. Because it is caused by an increase in either the number or size of the muscle filaments, its effects are enduring.

This form of hypertrophy is desired for athletes using strength training to improve their athletic performance. This more challenging and effective form of hypertrophy is achieved by using relatively heavy loads to stimulate and recruit the fast-twitch motor units to a degree that elicits structural changes such as increased numbers of cross-bridges and increased myosin protein size and number. In this manner, muscular adaptations will result in a stronger muscular engine prepared to receive and apply nervous system signals.
Phase 3: Maximum Strength

The development of maximum strength is probably the single most important variable in most sports. The ability to increase maximum strength depends on the diameter of the cross-sectional area of the muscles involved, the capacity to recruit fast-twitch muscle fibers, and the ability to synchronize or simultaneously call into action all the primary muscles that are involved in the movement (Howard et al., 1985). These changes represent both structural and neural flow changes that occur as a function of using very heavy loads in excess of 90 percent 1RM in training. Eccentric training with loads greater than 100 percent of 1RM can also be used to elicit these adaptive responses. The popularity of maximum strength training is rooted in the positive increase in relative strength. Many sports such as volleyball, gymnastics, and boxing require greater force generation without a concomitant increase in body weight.

In fact, an increase in maximum strength without an associated increase in body weight characterizes the maximum strength phase as central nervous system training (Schmidtbleicher, 1984). A novice athlete will benefit from traditional maximum strength training methods such as performing high loads with maximal rest between sets (three to five minutes). The more experienced athlete must continually stress and engage the nervous system by altering the loads, sets, and methods used in training.

The physiological benefits of sport performance lie in an athlete's ability to convert gain in strength and possibly muscular size to the particular sport.
Building the foundation sets the stage, adding muscle generates force, and adapting the body to using heavy loads awakens the largest engines in the body (the fast-twitch motor units). Once the mind-muscle connection is linked, the physical requirements of the sport determine the next phase.

**Phase 4: Conversion**

Depending on the sport, following a maximum strength phase of training, the conversion to power, power endurance, or muscular endurance are the three fundamental options. Some sports require a combination of all three. Conversion to power or power endurance is accomplished by using relatively moderate to heavy loads (65 percent to 85 percent of 1RM) with the intention of moving the weight as quickly as possible.

Although still engaging the nervous system, such methods as ballistic training or upper- or lower-body plyometric training improve an athlete's high-velocity strength or the ability to recruit and engage the high-powered fast-twitch motor units. A strong foundation of maximum strength is a must to maximize the rate of force production. In fact, slow-velocity training such as maximum strength training has been shown to transfer to gains in power as the athlete attempts to move the weight as quickly as possible (Behm and Sale, 1993). Conversion to muscular endurance requires more than performing 15 to 20 reps per set. Depending on the demands of the sport, muscular endurance can be trained for short, medium, or long distances.
Importantly, muscular endurance training that can require as many as 4 reps per set must be trained concomitantly with aerobic training. Similar physiological training objectives apply to aerobic training and muscular endurance training. Recall that the body replenishes energy for muscular contractions by a combined effort of three energy systems: the anaerobic alactic, the anaerobic lactic, and the aerobic systems. Conversion to muscular endurance training primarily requires the heightened adaptation of the aerobic training system and secondarily that of the anaerobic lactic system. The main objectives of aerobic training include improvements in physiological parameters such as changes in heart efficiency; biochemical parameters such as increased mitochondria and capillary density, which result in greater diffusion and use of oxygen; and metabolic parameters, which result in a greater use of fat as energy and an increased rate of removal of lactic acid. Because many medium- and long-endurance sports require resistance to be applied against water (e.g., rowing and swimming), the benefit of adapting the neuromuscular and cardiovascular system physiologically, biochemically, and metabolically is invaluable. To maximize performance in muscular endurance sports, maximum strength training must be followed by a combination of aerobic training and light-resistance strength training to prepare the body for the demands of the sport.

Once the mind-muscle connection has been adapted to maximum performance, it is time to put the gains to the test. Unfortunately, most athletes and coaches work hard and strategically as the competitive season approaches and cease to train once the season arises. Maintaining the strong and stable base that
was formed during the precompetitive phases requires a continuation of training during the competitive season. Failure to plan at least two sessions dedicated to training the main systems involved in the sport will result in a decreased performance or early onset of fatigue as the season persists. Staying up is always easier than falling down and attempting to get on one's feet again. Periodization of strength is about planning phases to optimize physiological adaptation and planning to maintain the benefits for as long as the season lasts. When the season is over, serious athletes can take two to four weeks to regenerate their minds and bodies.

Stimulating the body for optimal performance takes time, planning, and persistency. Physiology is helpful in planning the program but an improvement in performance is achieved through the practical application of the many principles and methods of training inherent in the periodization of strength (Bompa, 2005).

1.6 PLYOMETRICS

“Plyometrics an eccentric contraction followed ‘immediately’ by a concentric contraction”. Plyometric refer to exercise that enable a muscle to reach maximal strength in as short a time as possible. Such exercise usually involves some form jumping but other modes of exercise exist. The elements ply and metric come from Latin roots for “Increase” and “measure” respectively; the combination thus means “measurable increase”. Plyometric utilize the force of gravity (e.g. you step off a bar) to store energy in the muscles (Potential energy). This energy is than utilise immediately in an opposite reaction (e.g. you immediately jump up, up
on landing). So the natural elastic properties of the muscle will produce kinetic energy. Elastic strength is the ability of muscle and connective for tissues (muscle sheath and tensions tissues) to rapidly exert a force in order to produce maximal power in linear, vertical, lateral or combination movements. Plyometric consists hopping, skipping, jumping and throwing activities designed to make one faster going from slow muscles to faster muscles that requires performing quick “explosive movement”.

These activities must allow for minimal contact with ground (Lower body) or the hand contact (upper body). Plyometric is best answer for these types of exercise needs. Plyometric is an exercise designed to enhance the athlete’s ability to blend speed and strength training. It is in effect, the king on the cake. When sound training principles are used Plyometric offer the mechanism by which an athlete can start quicker, change direction more, rapidly, accelerate faster and improve over all speed. Almost every athlete on a track and field team can benefit to some degree from Plyometric training. Every athlete in every event, attempts to move fast. The ability to generate power, the product of force and velocity is essential in sports. Plyometric is a form of training that has been advocated for sports in which success largely depends on power.

Plyometric training is an excellent way to develop both strength and power in the muscles involved in sprinting. It improves the explosive action of leaping from one foot to another because to the stretch shortening cycle. There fore Plyometric training improves stretch, power speed and jumping ability which has been proved by many researches. Free weights-barbells and dumbbells-are
generally inexpensive and allow multiple joint movements to be performed in more than one plane of motion. Using free-weight equipment requires greater proprioception, balance, and coordination than other modes.

The athlete must balance the weight while exerting force lift it in a pattern that will allow him or her to maintain balance. A type of training that combines isometric muscle actions with dynamic free-weight exercise is termed functional isometrics.

In this type of training, a power rack is utilized so that a barbell can be loaded and placed at a position 15 to 30 cm below a pair of cross-pins set at or near the sticking point (angle of weakest joint leverage) in a dynamic movement. The barbell is loaded to approximately 80% of the athlete’s IRM effort in the movement. The athlete lifts the barbell 15 to 30 cm, until the cross-pins impede further movement; he or she then performs an isometric muscle action lasting 7 to 10s, pulling or pushing the loaded bar against the pins.

This type of training elicits strength gains superior to either isometric of dynamic training alone. Perhaps the most common tools for assessing strength are free weight-barbells, dumbbells, Olympic-style weights, and related types of equipment. Interpreted broadly, free weights can also include body weight when used as resistance in callisthenic-type activity (e.g., push-ups, chin-ups, dips, body-weight squats). In strength tests using free weights, the velocity of movement is typically not controlled but could be determined through laboratory methods (e.g., video analysis) (Atha, 1981; Enoka, 1988; Hoffman, Maresh, &
Armstrong, 1992) intentionally attempting to decrease concentric lifting velocity or control velocity during testing may limit motor unit recruitment and result in less force production (Keogh, Wilson, & Weatherby, 1991). When a person performs more than one repetition (e.g., 5RM) in a strength test, each subsequent repetition may be slower (Mookerjee & Ratamess, 1999) until the individual is unable to complete another repetition (Knuttgen & Kraemer, 1987).

Demanding a specific power-output performance during multiple-repetition strength tests by implementing a specific time interval for the performance of the movement creates another type of strength test for a given number of repetitions. During free-weight strength testing, the movements involved can be somewhat similar to those found on the athletic field or in other areas of motor performance because constant external resistance that requires balance is involved.

1.7 FREE WEIGHT (BARBELL TRAINING)

Free weights present a number of different testing conditions compared with weight machines (Fleck & Kraemer, 1988; Nosse & Hunter, 1985). Free weight require greater motor coordination than do machines (Nosse & Hunter, 1985; Rutherford & Jones, 1986), primarily because the individual must control free weights through all spatial dimensions, whereas machines generally involve control through only one plane of movement (Fleck & Kraemer, 1988). This attribute can be an advantage or a disadvantage, depending on the motor function (e.g., frail elderly, those with neuromuscular disease, people with arthritis, and so on) may require machine-based testing initially until sufficient improvement in
physical function occurs. Another more practical reason for using free weights is their low cost and availability. The test specificity of free weights may be more appropriate for certain tasks being evaluated (Fleck & Kraemer, 1997; Rutherford & Jones, 1986). Test and training-mode specificity are vital for optimal expression of true strength gains. That is, using a free-weight testing modality is the most effective method for determining strength gains associated with free-weight training. Free weights also involve both concentric and eccentric muscle activity.

Eccentric muscle activity is not possible on some weight-training machines (e.g., typical hydraulic machines) or with some isokinetic (e.g., controlled constant velocity) dynamometers (Nosse & Hunter, 1985). Free weights almost always allow the desired range of motion, whereas other strength –testing modalities can be somewhat limited if it is not possible to get a proper fit between the individual and the machine configuration (Fleck & Kraemer, 1988).

1.8 UP HILL TRAINING

Hill running has a strengthening effect as well as boosting your athlete's power and is ideal for those athletes who depend on high running speeds - football, rugby, basketball, cricket players and even runners. To reduce the possibility of injury hill training should be conducted once the athlete has a good solid base of strength and endurance.

In hill running, the athlete is using their body weight as a resistance to push against, so the driving muscles from which their leg power is derived have to work harder. The technique to aim for is a "bouncy" style where the athlete has a good
knee lift and maximum range of movement in the ankle. They should aim to drive hard, pushing upwards with their toes, flexing their ankle as much as possible, landing on the front part of the foot and then letting the heel come down below the level of the toes as the weight is taken. This stretches the calf muscles upwards and downwards as much as possible and applies resistance which overtime will improve their power and elasticity. The athlete should look straight ahead, as they run (not at their feet) and ensure their neck, shoulders and arms are free of tension. Many experts believe that the "bouncy" action is more important than the speed at which the athlete runs up the hills.

Hill work results in the calf muscles learning to contract more quickly and thereby generating work at a higher rate, they become more powerful. The calf muscle achieves this by recruiting more muscle fibres, around two or three times as many when compared to running on the flat.

The "bouncy" action also improves the power of the quads in the front of the thigh as they provide the high knee lift that is required. For the athlete, when competing in their sport/event, it can mean higher running speeds and shorter foot strike times.

Hill training offers the following benefits:

- helps develop power and muscle elasticity
- improves stride frequency and length
- develops co-ordination, encouraging the proper use of arm action during the driving phase and feet in the support phase
- develops control and stabilisation as well as improved speed (downhill running)
- promotes strength endurance
- develops maximum speed and strength (short hills)
- improves lactate tolerance (mixed hills)

The benefits of short, medium and long hills are quite different and can be used at different times of the year. A short hill is one which takes no more that 30 seconds to run up and has an inclination between 5 and 15 degrees gradient.

The athlete's energy source on short hills is entirely anaerobic. The athlete should focus on a running technique which has vigorous arm drive and high knee lift, with the hips kept high, so that they are 'running tall', not leaning forwards.

1.9 CIRCUIT TRAINING

Circuit training is a method of physical conditioning that employs both apparatus resistance training and calisthenic conditioning exercise. It provides a means of achieving optimal fitness in a systematized controlled fashion. The intensity and vigour of circuit training are indeed challenging and enjoyable to the performer. This system produces positive changes in motor performance, general fitness, muscular power, endurance and speed. Circuit the trained first has to analyze what he specifically he can devise circuits to develop strength, power, skill under stress, stamina, endurance excreta. He should also consider the aim and objectives of the conditioning programme, the number of player to be involved, their age, sex, experience facilities and equipment on hand and as well as the
amount of time that can be spared. Circuit training program consists of a number of ‘station’ where a given exercise is performed usually within a specified time. Once the exercise is completed at one station, the trainee moves rapidly to the next station, performing another exercise also within a prescribed time period.

The circuit is completed once the exercises at all stations and performed. The exercise out the various stations consists mainly of weight resistance exercise, but running, swimming, cycling calisthenics and stretching exercise may also be included. Circuit training, therefore may be designed to increase muscular endurance, flexibility and if running swimming or cycling is involved to increase some cardio respiratory endurance as well. Circuits are designed to consists of between 6 and 15 stations requiring a total time of between 54 and 20 minutes to complete. Usually, each circuit is performed several times in on training session. Only 15 to 20 seconds rest should be allowed between stations. For the weight resistance stations, the road should be adjusted so that the working muscles are noticeably fatigued after performing as many repetitions as possible with in a designated times periods (30 seconds). The load should be increased periodically to ensure progressive over load. In addition, the sequence of exercises should be arranged so that no two consecutive stations consists exercise involving the same muscle group. Training frequency should be 3 days per week, with a duration of at least 6 weeks.
1.10 OBJECTIVES OF THE STUDY

The first objective of the present study was to find out the effects of different strength training on selected body composition, motor ability, physiological and hematological variables among men athletes.

The second objective of the study was to find out the superiority of effects of different strength training on selected body composition, motor ability, physiological and hematological variables among men athletes.

1.11 STATEMENT OF THE PROBLEM

The purpose of the study was to find out the effects of different strength training on selected body composition, motor ability, physiological and hematological variables on men athletes.

1.12 SIGNIFICANCE OF THE STUDY

1. This study would be very much useful and suitable for men athletes.

2. The study would be of great significance because it would provide an opportunity to the physical educators, coaches and the athletes as they would be able to scientifically understand and assess the changes in the performance variables due to different methods of strength training.

3. If the study is successfully completed, it would be scientifically accepted that the systematic training not only develops the performance variables of the students but also develops internal organs like respiratory system,
nervous system, circulatory system, excretory system, muscular system and endocrine system.

1.13 HYPOTHESES

The hypotheses formulated in the present study are as follows:

1. It was hypothesized that different strength training would have significantly improve selected body composition, motor ability components, physiological and hematological variables among men athletes.

2. It was hypothesized that plyometric training would have significantly improve selected body composition, motor ability components, physiological and hematological variables and would have greater than that of barbell, uphill and circuit training among men athletes.

3. It was hypothesized that barbell training would have significantly improve selected body composition, motor ability components, physiological and hematological variables and would have greater than that of uphill and circuit training among men athletes.

4. It was hypothesized that uphill training would have significantly improve selected body composition, motor ability components, physiological and hematological variables and would have greater than that of circuit training among men athletes.
1.14 DELIMITATIONS

The study was delimited to the following aspects:

1. Seventy five male athletes were randomly selected from Sports Authority of India, Netaji Subash Eastern Center, Kolkata as subjects for the study.

2. This experimental study was administered to only four experimental groups and one control group of 15 students each.

3. The age of subjects ranged from 18 to 22 years old only.

4. In this study, only four different strength trainings namely plyometric training, barbell training, uphill training and circuit training were administered to the groups.

The following variables were selected in this study.

A. DEPENDENT VARIABLES

Body Composition Variables

- Percent Body Fat
- Body Mass Index
- Lean Body Mass

Motor fitness Variables

- Speed
- Explosive Power
- Speed Endurance
**Physiological Variables**

- Anaerobic Power
- VO2 Max
- Resting Pulse Rate

**Hematological Variables**

- Hemoglobin
- Red Blood Corpuscles

**B. INDEPENDENT VARIABLES**

Experimental Group A : Plyometric Training
Experimental Group B : Barbell Training
Experimental Group C : Uphill training
Experimental Group D : Circuit Training
Group E : Control Group

**1.15 LIMITATIONS**

Certain factors like habit, life style daily routine work, climatic conditions and effect on the result of this study will not be taken in to consideration while interpreting the result.

In this study the following factors were considered as limitations of the study and may be taken consideration in interpreting the results.

- The previous experience of the field of sports and games which might be influencing on the training and data collection were not considered.
• Psychological factors, food habits, rest period and life style could not be controlled.

• The weather condition such as atmospheric temperature humidity and meteorological factors during test and training period were also not considered.

• Though the subjects were motivated verbally no attempt was made to differentiate the motivation level during the period of training and testing.

1.16 MEANING AND DEFINITION OF THE TERMS

Plyometric training

“Plyometrics” is defined as exercises that produce an over load of isometric type muscle action which involves the stretch reflex in muscles.

Barbell training

It is the training with an apparatus used for weight lifting consisting of a bar with replaceable, disk shaped weights to the ends.

Uphill training

Exercises like uphill runs, where one can run hard and quickly move upward a hill.
**Circuit training**

Circuit training is a form of conditioning combining resistance training and high-intensity aerobics. It is designed to be easy to follow and target strength building as well as muscular endurance.

**Percent Body Fat**

A person's body fat percentage is the total weight of the person's fat divided by the person's weight and consists of essential body fat and storage body fat.

**Body Mass Index**

The body mass index (BMI), or Quetelet index, is a heuristic proxy for human body fat based on an individual's weight and height.

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BMI = \frac{\text{mass (kg)}}{(\text{height(m)})^2}
\]

**Lean body mass**

Body weight that does not include fat tissue.

**Speed**

Speed as the capacity of the individual to perform successive movement of the same pattern at a fast rate, Barrow (1973).

**Explosive Power**

Explosive power is defined as the capacity of the individual to release maximum force in the shortest period of time (Hardayal Singh, 1991). Explosive
is the ability to release the maximum muscular force in an explosive manner, in the shortest possible time.

**Speed Endurance**

It is ability to overcome high speed with under condition of fatigue.

**Resting Pulse Rate**

Measurement of heart rate when an organism is under physical and mental rest can be termed as resting pulse rate, *More house and Miller (1976)*. Training has very pronounced effect on heart rate, even at rest. In highly trained athletes of either sex resting heart rate may be as low as or lower than 40 beats per minute.

In contrast resting heart rates for untrained but healthy individuals may be as high as 90 beats per minute, A relatively slow heart rate, compld with a relatively large stroke volume indicates an efficient circulary system, *Fox et al (1982)*.

**VO₂ Max**

VO₂ max is the maximal oxygen uptake and highest oxygen value per unit time that the human body is capable of when breathing air (*Morehouse and Miller 1976*).

According to *Clarke (1975)* special attention should be directed to the concept of maximal oxygen uptake (VO₂ or maximal aerobic power), currently so prominent in the exercise physiology literature. It involves an increase in high oxygen uptake to highest level of severity, where by the ability of the individual to utilize the greatest amount of oxygen is reached.
**Anaerobic Power**

The maximal rate at which energy can be produced for short periods of time. Anaerobic power is the amount of work performed using primarily anaerobic energy systems.

**Hemoglobin**

*Hemoglobin* is the iron-containing oxygen transport metallo protein in the red blood cells of all vertebrates.

**Red Blood Corpuscles**

Red blood cells (also referred to as erythrocytes) are the most common type of blood cell and the vertebrate organism's principal means of delivering oxygen \((O_2)\) to the body tissues via the blood flow through the circulatory system.