Chapter I

INTRODUCTION

Ever since sport began, athletes have been trying to get the most out of their training. However, it was not until the last few decades, that levels of sport performance have exhibited a spectacular increase. Records that once were imaginary can now be regular. At the same time, the amount of training of modern competitors is considerably higher than that used in the past. This would not be possible without the concurrent evolution in training methodology. The necessity of superior performances in competition has impelled coaches to introduce increasingly effective and sophisticated training methods (Fleck, 1999).

Several sciences have contributed to the understanding of the effects of exercise on the body, and together have formed a science of their own, the science of training. This branch of science focuses on sports performance and aims to understand, measure and improve the effects of exercise on the body besides minimizing the prevalence of injury. (Fleck, 1999).

The strength approach to training of sports not only concentrated on the training procedures but also other contributing components so as to achieve optimum performance. This probably results in exploring the means to improve the performance level
besides identifying the negative factors on better performance. New
ventures are encouraged to improve the performance and attempts
are made to ensure enhanced ability of the players and athletes.

During competition, the subject is expected to withstand
several stressful stimuli, while performance can be influenced by
numerous internal factors (physiological, biochemical, technical and
tactical) and external factors (climatic, traveling, and financial).
Training has to be structured in a way that simulates these
conditions and prepares for the actual event. For optimal
performance, therefore, competitors must be experts in the technical
side of their event, be psychologically prepared to handle the
enormous stress of critical situations, and be free from injury; they
must also be physically ‘fit’ (Fleck, 1999).

Physical fitness is served by individual sciences such as
pediatric and adult physiology, biochemistry, biomechanics and
sports medicine, and it can be defined as the individual’s ability to
meet the demands of a specific task. It primarily consists of elements
of aerobic and anaerobic fitness, muscular strength and flexibility.
Regardless of the performance level, sex and age, all competitors use
one or more of these elements of fitness during their daily practice.
For example, in an endurance event such as the marathon, aerobic
capacity is the most important element for success, whereas in
sprinting events, such as the 100 mts, anaerobic power
predominates. Consequently, training programs have to address the most important elements of physical fitness for each individual sport \textit{(Fleck, 1999)}.

The word “training” has been a part of human language since ancient times. It denotes the process of preparation for some tasks. These processes invariably extend to a number of days and even months and years. The term ‘Training’ is widely used in sports. There is however, some disagreement among sports coaches and sports scientists regarding the exact meaning of this word. Some experts, exceptionally belonging to sports medicine, understand sports training as “basically doing physical exercises”. Several terms such as strength training, interval training, technical and tactical training are used in training, and these training reflect this line of thinking \textit{(Fleck, 1999)}.

Training plan has existed, though in a crude form, since the ancient times and was used for the Olympic Games or military purposes. The Greek athlete Milon from the city of Croton was the first known competitor who perhaps unwittingly, implemented the principle of periodization as early as the 6th Century BC. determined the training cycles by carrying a bull calf on his back each day until the animal reached maturity. As levels of a particular fitness component increases, a higher quality of exercise stress is needed to create overload and lead to physiological adaptations \textit{(Fleck, 1999)}. 
High sports performances through sports training can be achieved by a scientific and systematic use of training means. Training means are various physical exercises and other objects, methods and procedures which are used for the improvement, maintenance and recovery of performance capacity and performance readiness. Any material or immaterial object, method or measure which can be used to achieve the aims of training can be called a training means.

Physical exercises are the principal means of training. Without physical exercises the sports training cannot lead to improvement of sports performance. The other means are used in addition to physical exercises to increase the total effect of physical exercises. These means can be used along with physical exercises or separately as per requirement.

Training is a systematic athletic activity of long duration, progressively and individually graded aiming at modeling the human physiology and functions to meet demanding tasks. (Marimuthu, 2004).

Each training means has its own specific effect on the performance capacity. This effect may be direct or indirect. Physical exercises have a direct effect on performance capacity (Singh, 1997).

The specificity principle holds that any training done to improve sport performance should duplicate as closely as possible the
demands of the sport in terms of the primary energy system involved and muscle groups used, along with the force, speed, range, frequency and duration of movement. This means that for whatever sport one is competing in (strength or endurance), the performance demands are the central focus of the training program.

**CROSS TRAINING**

While the specificity principle is one of the corner stone’s of athletic training, it has limitations that need to be addressed if peak performance is to be achieved. Generally, all sports require varying degrees of aerobic and anaerobic power along with strength and muscular endurance. Sports- specific training itself does not and cannot produce peak performance. This is possible only in conjunction with training variability, which embraces the concept of cross training.

In utilizing the sports specific training approach, the primary performance demand is the focus of training. As an example, in endurance sports where aerobic power is the key component, over distance training, or long, slow, distance training, is considered the specific training mode. On the surface, this approach may seem effective in developing aerobic power. In reality, it is ineffective in preparing the body for the total demands of peak endurance performance. Long, slow, distance training simply does not develop all the key components involved in maximizing aerobic performance,
such as anaerobic power, muscular strength, technical skill (performance efficiency), a sense of pace or the capacity to achieve maximal oxygen consumption. This is where cross training enters the training pictures. Cross training is a major step in the evolution of athletic training. Recently it has become a highly popular term most often associated with the training of triathletes.

**Theory of Cross Training**

Cross training is a holistic approach to peak performance training for both single sport and multi sport athletes. The simplest way to describe cross training is that it encompasses a complex training prescription in which two or more sports are combined into either a single workout or a long term cyclical program. It differs from sports-specific training in that it allows for the simultaneous training of multiple physiological variables (e.g. aerobic and anaerobic power, strength and muscular endurance). Cross training avoids both the boredom of single sport specificity and self-destructive tendency of over training *(O’Shea, 1990).*

**Popularity of Cross Training**

Cross training has been used in one form or another throughout the history of sport. In ancient Greece, strength training was used to enhance athletic performance in the predominant sports of the day: discus, javelin, sprinting, and wrestling - all sports requiring speed, strength and power.
Over the years, a number of Olympic professional, and amateur athletes have used cross training to improve their performances. Along with swimmers and Alpine and Nordic skiers, baseball players have used cross training to increase hitting power and speed. Because of the high physical demands encountered by triathletes training in three different sports, cross training is an integral part of their training regimens.

Today, athletes in a number of sports, from volleyball to wrestling, condition themselves with activities such as running and rope jumping. Athletes in almost all sports use weight or resistance training to improve their performance. Off-season cross training programs help athletes maintain aerobic endurance and strength (Moran and McGlynn, 1997).

As the popularity of multi-sport events such as triathlon, decathlon and biathlon have taken off, cross training has evolved into a sophisticated method of training, with impressive results that enable athletes to compete in grueling events. Research in cross training shows that humans can do much more exercise with greater workloads than ever imagined. Nobody would have thought of 50 years ago that humans could swim 2.4 miles, bike 112 miles, and then run 26.2 miles in succession (Iron man Triathlon distance) and not only live through the experience, but do so with smiles on their faces. Many Triathletes gain significant improvements in their major
sport through cross training with other sports when they have decreased their training in their primary sport.

Another development that has spurred the popularity of the cross training is the age of the Masters Athlete. While there have always been a few hearty individuals who have continued to train and compete beyond their 30s (some even competing into their 80s and 90s), the ranks of older athletes are now burgeoning (Moran and McGlynn, 1997).

Although older athletes can often handle a large volume of training, they need a longer period of time to recover from hard work outs or races. Therefore many of the world’s best Masters Runners have turned to cross training as a way to continue to train while recovering from tough competitions. Many of these athletes who previously had run seven days a week for years now run only four days each week and supplement this training with three days of cycling, swimming, or aqua jogging. This allows the leg muscles to be exercised while reducing the debilitating impact forces associated with running on an everyday basis. Many of these runners improve their performance while running less and cross training more.

Exercisers often report reaching a plateau that seems to prohibit further improvement. A runner, for example, who does five miles a day eventually reaches a peak and then gradually begins to decline. Only by running faster, longer or more often, or by adding
new exercises, the runner continues to improve his or her fitness level. The new challenges and overloads afforded by cross training allow one to work more and differently. This can provide the motivation to overcome a stalled program (Edmund R., 1994).

A third major impetus for the increasing popularity of cross training has been the growing numbers of casual athletes. While the overall number of runners has decreased from the high-water mark of the late 1970s, the number of adults participating in fitness pursuits has increased. The area of greatest increase is in aerobic exercise, such as aerobic dance and step aerobics. Many previously sedentary individuals are going to athletic clubs and enjoying the benefits of being physically fit. (Moran and McGlynn, 1997).

Cross training describes the techniques of using multiple activities to achieve total body fitness. The emphasis is on comprehensive conditioning. For years many individuals have run, lifted weights, and swam for a total body work out. There will be a balance between cardiovascular conditioning, strength, coordination and flexibility. Participation in a variety of activities helps recruit new muscle fibers and develops new neuro-muscular pathways. Aerobic capacity and muscular strength and endurance can be increased as well as total body flexibility.
Benefits of Cross Training

Cross training offers tremendous improvements in one’s overall aerobic and anaerobic endurance, muscle strength and endurance, flexibility and agility, all of which will improve the performance of his primary sport. Following are some specific benefits of cross training.

Conditioning

One can achieve comprehensive cardio respiratory conditioning. Cross training is one of the most powerful techniques for achieving total body fitness and health benefits. The aerobic portion of a cross training program can improve the efficiency of the heart and lungs. It can also help control weight and improve the way the body handles cholesterol (Edmund R., 1994).

Aerobic Endurance

Cross training activities such as distance swimming, distance cycling, and aqua jogging (running or jogging in the water with a floatation vest) are very effective in increasing the ability of the cardiorespiratory system to supply oxygen to the working muscles. Nordic and Alpine skiers often use cycling and distance running during the off-season to maintain aerobic fitness. (Moran and McGlynn, 1997)
Anaerobic Endurance

For speed, sprinting and power sports, where energy is needed to power short bursts of maximal performance, anaerobic endurance (endurance that relies on energy for stamina without requiring the presence of oxygen) is vital. Sports such as middle-distance swimming, middle-distance running and wrestling are just a few examples of activities where the body depends on the energy stored in the muscles besides Rowing machines, Versa climber, and Plyometrics (Moran and McGlynn, 1997).

Muscular Strength

Muscular strength and power provide the basis for the majority of sport activities, especially those that rely on quick, explosive movements. A number of cross training activities that can overload the muscles by subjecting them to a greater-than-normal level of stress—such as stair climbing, weight training, and plyometrics—provide strength gains that athletes may not receive through training only in their primary sport (Moran and McGlynn, 1997).

Muscular Endurance

Muscular endurance requires repetitive muscle contraction against a resistance for extended periods of time. This kind of repetitive movement is common in such sports as rowing, gymnastics, long sprints, wrestling and swimming. As strength
increases, there tends to be a corresponding increase in endurance. Increased strength will also result in the ability to increase the number of skilled repetitions (Moran and McGlynn, 1997).

**Muscular Balance**

One can condition for total body muscular balance. The average fitness enthusiast is becoming more educated about the importance of muscle symmetry, the appropriate balance between strength and flexibility in opposing muscle groups. Overworking one group of muscles allows them to become too strong and their opposing muscle pairs working in concert allow for more effective and efficient movement and may decrease injuries. Cross training allows for greater muscle symmetry (Edmund R., 1994).

**Flexibility**

Almost all sports require good flexibility. Cross training activities, such as yoga, ballet, or gymnastics, that require a wide range of joint movement or a specific stretching program can reduce the possibility of aches, pains, and inflammation associated with joints stressed through rigorous activity (Moran and McGlynn, 1997).

**Warm-up and Cool-down Exercises**

Warm-up and cool-down exercises help maximize the potential of each training period by preparing one’s body for vigorous activity. They also enhance one’s ability to recover from a long, hard
workout by slowing the heart rate gradually and helping to prevent muscle injury and soreness (Moran and McGlynn, 1997).

**Injury Prevention**

Strength improvements yield greater protection against injuries, particularly overuse injuries. Cross training works in muscle groups other than those needed in the primary sport or uses the primary sport’s muscle groups in different patterns, allowing more areas to share the training stress and reducing stresses on muscles, tendons, ligaments and bones (Moran and McGlynn, 1997).

**Reduced Injuries**

Many people find that some diversity in their exercise routine helps avoid injury. By spreading out the exercise stress on more muscles and joints, they are able to do more exercise with fewer overloads in the vulnerable areas. For example, an individual who develops foot problems from too many miles of running may be able to switch to a few days on a stair stepper and to cycling. Cross training reduces the total impact forces and spreads the stress of the work to a variety of muscle groups and anatomical structures (Edmund R., 1994).

**Injury Rehabilitation**

Cross training activities allow one to continue to train and prevent detraining when he cannot participate in his main sport due to an injury. Cross training can even help to rehabilitate an injury.
When specific limbs or joints have to be immobilized, strength and flexibility cross training exercises can focus on other body parts - especially contra-lateral limbs - to help maintain muscle strength and range of motion. Movement (using flexibility and strength-training exercises) early after an injury is vital. Strength training through a full range of movement is required because improved levels of strength must be reached for each stage of rehabilitation and the eventual return to activity (Moran and McGlynn, 1997).

**Training Extension**

Cross training allows one to perform additional work within his primary sport with less risk of overtraining or injury. Suppose a distance runner who usually runs 35 to 40 miles a week effectively without injury, attempts to increase his mileage to 45 miles a week, he probably repeatedly becomes susceptible to overuse injury. In this situation, a cross training program can help in several ways.

- Strength training can strengthen the problem, injury-prone areas, allowing them to better withstand additional training stress.

- Activities such as cycling or swimming can provide an additional endurance training stimulus with minimal or no additional stress to these problem areas.
Warming up and cooling down with an activity such as bicycling can be a non-stressful way to improve training preparation and recovery (Moran and McGlynn, 1997).

**Spice of Life**

Cross training can benefit both the fitness enthusiast and the competitive athlete. By learning new sports and physical activity skills, recreational exercisers will find new exercise opportunities. Increasing their repertoire of physical activities will help them find several that they really enjoy, thereby ensuring that exercise is recreational and not just routine.

As it relates to athletes, it cannot overlook the primary need for specificity of training. But when cross training can be incorporated into an athlete’s training, it may well improve overall fitness, help avoid injury, keep the athlete motivated throughout the season and reduce the chances of over training (Edmund R., 1994).

**Variety**

Variety of exercises makes exercising more exciting and challenging. Studies of exercise adherence indicate that many people drop out of exercise programs because they become burned out or bored. Cross training, with a variety of challenges, can stimulate motivational levels as well as muscles (Edmund R., 1994).
**Mental Break**

Cross training with other sports or activities provides a mental vacation without detraining or a loss of the fitness level. This can be very effective for breaking through the doldrums or plateaus in training. Variety can add spice to one’s fitness program and increase his motivation *(Moran and McGlynn, 1997).*

**Weight Loss**

Individuals who need to lose weight must design a program that promotes mobilization and burning of fat. This is usually accomplished when one exercises for longer periods of time (over 30 minutes) and at an intensity of 60 to 75% of maximum heart rate. Overweight individuals can extend their work outs safely and enhance weight loss by combining activities. For example, an exerciser can ride a bicycle for 20 to 30 minutes and then walk for an additional 20 to 30 minutes *(Edmund R., 1994).*

**COMPLEX TRAINING**

In the never ending search for that extra competitive edge, enterprising coaches, athletes and trainers have experimented with combinations of plyometric and explosive drills alongside more traditional weight training exercises with the view to further enhancing maximum power development. Such combined work outs are invariably given the title of complex (or contrast) training. As in the case of plyometric training, complex training appears to have its
origins in Eastern Europe. Chu (1996) was of the opinion that “Complex training was developed by the Europeans to blend the results of heavy weight training with what they call shock training and what is called plyometrics by Indians.”

Complex Training is a technique used by many strength and conditioning coaches to enhance both the strength and power of their athletes. Complex training is basically a superset where the athlete performs a high-intensity strength exercise and follows it with a plyometric exercise with similar biomechanical demands (i.e. the same muscle groups and/or joint angles) of the strength exercise (Patrick, 2009).

Complex training as a series of several exercises performed in succession with the goal of the entire complex the improvement of one physical characteristic (Verkhoshansky, 1973). The complexes, according to him, were for inclusion in the special preparatory period of training and designed to increase the ability to produce power quickly or “explosiveness” and speed of movement of the legs.

Complex training is the simultaneous combination of having resistance training and plyometrics. It can be another valuable method for short-term and speed improvements in athletes in isolation or in conjunction with other power development methods (Daniel, et al., 2007).
However, a somewhat more detailed definition is provided by Cronon, McNair and Marshall (2002) who state “Complex training consists of alternating between resistance training and plyometric exercises biomechanically similar in movement within the same exercise session. The maximized excitation by increased recruitment and forming speed and the minimized inhibition by Golhi tendon organs facilitates greater force production”.

**Theory of Complex Training**

According to Chu (2000), “Complex training programs should be created to fit the specific needs of each athlete” and he emphasizes the necessity of the needs analysis. Furthermore, the resistance training exercises are going to be combined with plyometric drills or exercises, the athlete must be technically competent and experienced in both types of training.

Complex training has been recommended as a method of incorporating plyometrics with strength training. Some research findings suggest that plyometric performance is enhanced when performed three - four minutes after the strength training set. Following are the key points of the complex training in the light of various aforesaid definitions.

- Complex training combines high-load weight training and plyometric exercises and drills in the same workout.
• It may provide performance and training benefits greater than those seen with more traditional approaches.

• This training technique is advanced and suitable for highly trained and very strong individuals.

• As with plyometric training, an individual’s suitability for this type of advanced training must be determined following a needs analysis.

• Guidelines for avoiding injury in both plyometric training and heavy resistance training must be followed.

Complex training develops power in every sport-specific manner. It is simply a much better approach to preparing the body for the demands of a specific sport. In fact, the power increases achieved through complex training are up to three times more effective than conventional training program (Chu, 1996).

The four basic parts to complex training are weight (or resistance) training, plyometrics, sports specific training and spring work. Complex work outs match pairs of exercises. First, resistance exercise is performed to stimulate muscle fibers. Then, there is a plyometric move using the muscle fibers and the nervous system to work together to trick slow twitch fibers into reacting like fast twitch fibers.
In ‘complex training’, the body starts at a no stress level and hits a low point as it fatigues from the resistance exercise. Then, the recovery starts. Since the body does not know what to expect next, it taps its energy, stores to overcompensate for the next demand. Training within this window of “super compensation” allows athletes to make great gains. Plyometric moves are the perfect complement to this resistance works because they emphasize short burst of power (Chu, 1996).

‘Complex Training’ is a road map that can help one develop an important edge. In complex work outs, strength moves are combined with speed work to help gain power and produce the greatest results in the least amount of time. Plyometrics follows the theory that the body has an arousal mechanism that enables an athlete to take advantage of the body’s capacity for physical output. Europeans exercise textbooks showed athletes performing various hopping, skipping, jumping and throwing exercises designed to stimulate this arousal mechanism.

Regardless, the theory underpinning complex training is one of training the neuromuscular system specifically for maximum power output and rate of force development and of maximizing the involvement of the fastest muscle fibers. According to Ebben and Watts (1998), “High load weight training increases motor neuron excitability and reflex potentiation, which may create optimum
training conditions for subsequent plyometric exercise. The idea behind complex training is to take advantage of post activation potentiation, a phenomenon, which occurs when muscle force is enhanced as a result of its contractile history. Performing a squat with heavy load would lead to an enhancement in muscle force, which theoretically should increase the force output of the jump squat (Patrick, 2009). Also, the fatigue associated with high load weight training may force more motor units to be recruited during the plyometric phase, possibly enhancing the training state.”

The complex training program can be used in the general, specific and competition phases of training. To get the best from these training workouts, the athlete need to be physically fresh and motivated. Type II B fibers are not magically recruited by just doing the workout, it is to be focused on the exercises and perform them as explosively as possible. Hard aerobic or anaerobic session started did not perform any static stretching exercises as this will relax the muscles and reduce force production potential. It is the quality of execution of each exercise that is important not the quantity.

Complex training is included within the schedules of many elite athletes, sportsmen and women. In the United Kingdom, rugby teams in particular seem to be particularly keen on this method of training for enhancing explosive power. Similarly, complex training is popular among American football teams and with many athletes
engaged in jumping and/or multiple sprint sports, such as volleyball, basketball and tennis.

Nowadays, sports activities are classified into several areas such as performance sports, physical education, rehabilitation sports, fitness and leisure–sports and adventure sports. Performance sports aim at high sports performance and for that, the physical and psychic capacities of a sportsmen are developed through various training means and methods. Most physical movements incorporate the elements of force, quickness, duration, complexity and a range of motion to a certain extent. Further, individual motor aspects and physiological components such as strength, speed, endurance and coordination are distinguished in such a way that training is no more an amateur job. The athlete can be perfected through the physiological components, commonly known as bio-motor abilities, strength and power are the most critical for many sports. All team sports and speed power dominant sports rely on solid strength and power development. Understanding the mechanics and physics of strength training and incorporating those principles into the training program will give the athletes a competitive edge. (Sethu, 2004).

Sports performance is indeed an aspect of complex human performance, which has several dimensions. Hence several disciplines of sports science are required to work in a coordinated manner to explore the nature of sports performance and the process of
improving them. These disciplines of sports science such as sports medicine, sports physiology, sports training, sports bio-mechanics and sports psychology have their own specified areas of study and focus on specific aspects of sports performance and sports training. *(Singh, 1991).*

Most sports require power, muscular endurance or both. The level of maximum strength effects both power and muscular endurance. Power cannot reach high standards without a high level of maximum strength because power is the product of speed and maximum strength.

Strength and power are the most critical for many sports. All team sports and speed-power dominant sports rely on solid strength and power development. Understanding the mechanics and physics of strength training and incorporating those principles into our training program will give our athletes a competitive edge. *(Bompa, 1999).*

**STRENGTH**

Strength is a conditional ability which depends largely on the energy liberation processes in the muscles. Strength is also perhaps the most important motor ability in sports as it is a direct product of muscle contractions. All movements in sports are caused by muscle contractions and, therefore, strength is a part and parcel if all motor abilities, technical skills and tactical actions. Strength and strength training, therefore, assume high importance for achieving
good posture and for prevention of injuries is usually overlooked which in the long run can prove harmful.

Strength is the ability to overcome resistance or to act against resistance. Strength should not be considered a product of only muscular contractions. It is, in fact, a product of voluntary muscle contractions caused by the neuro-muscular system. In sports movements, strength always appears in some combination with the duration and speed of movement i.e. in combination with the duration and speed abilities. In each sports movement strength appears in a different form.

Factors Determining Strength

Strength is a highly trainable motor ability. The important factors which determine strength are given below.

Muscle Cross Section

The muscle cross section indicates the size of the muscle. It is an accepted fact that bigger and larger muscles can generate more force. The force which can be generated by one square centimeter of muscle ranges from about 6 – 10 kp. (Hartmann and Tunneman 1986). Strength can be increased by increasing the muscle cross section (hypertrophy) through appropriate means and methods of strength training.
Muscle Fibre Spectrum

The muscles consist of muscle fibers which are basically of two types: fast twitch fibers (white fibers) and slow twitch fibers (red fibers). The fast twitch fibers can contract faster and can produce more force. On the contrary, slow twitch fibers take more time to contract but these can keep contracting for a longer duration. The muscles which have a high percentage of fast twitch muscle fibers, therefore, can produce more strength. The size of such muscle can also be considerably increased through strength training. The proportion of these two types of muscle fibers is largely genetically determined and cannot be changed through training or by some other means. The muscle fibre spectrum, however, has a wide range of variation from muscle to muscle and from individual to individual. The persons who have muscles with favourable muscle fibre spectrum, therefore, have better strength ability and trainability for strength.

Coordination

The level of strength is markedly affected by co-ordination. The role of co-ordination in strength performance can be discussed from the three levels of co-ordination involved in tackling or overcoming a resistance.
(i) **Skill**

The process of overcoming or acting against resistance involves some type of movement involving muscles of more than one body part. The best results are achieved if this movement is done skillfully. The skill can be acquired through motor learning and as a result the strength performance can be improved.

(ii) **Inter muscular co-ordination:**

The inter muscular co-ordination refers to the proper temporal and dynamic co-ordination between different muscles and muscle groups (muscle energy) which are contracting to overcome or tackle a resistance. Good co-ordination at this level makes it possible to achieve the summation of individual forces generated by different muscles thus resulting in a higher resultant force.

(iii) **Intra- muscular co-ordination**

The intra muscular co-ordination refers to the co-ordination among different motor units within a muscle. A muscle can contract with greater force if all the contracting motor units (whether slow twitch or fast twitch motor units) contract in a manner which enables greater force production.

The improvement in co-ordination is the second most effective means of improving strength. The added advantage here is less increase in muscle size for achieving higher strength performance. Hence in sports where strength improvement without
any appreciable increase in body weight is desirable the strength improvement should aim at the improvement of co-ordination. Inter and intra muscular co-ordinations are beyond conscious control of humans but can be significantly improved by using appropriate methods of strength training.

**Energy Supply**

The ultimate source for muscle contraction is the rate and amount of energy supply through chemical reactions taking place in the muscles. The energy for muscle contraction is primarily obtained through the break down of phosphogens (ATP and CP). The amount of phosphogen stores is, therefore, important for strength performance or tackling resistances with high speed. However, the speed and energy can be improved through training.

**Body Weight**

It is generally known that heavier persons are stronger than lighter persons. This is particularly true in case of trained sportsmen. The positive relationship between body weight and strength can be partly explained by the larger muscle mass of bigger and heavier persons. Perhaps greater mass of bones, connective tissues and, possibly also, fat tissues is essential to support large muscles, All this results in more body weight.
**Psychic Factors**

Certain psychic factors like motivation, arousal, emotions of anger, aggression, etc., have a marked affect on strength performance. It has been proved that psychic factors limit the individual’s capacity to fully utilize his strength capacity or potential. A fully aroused state of mind with the determination to apply maximum force results in a very strong nerve impulse leading to activation of larger number of motor units. The trained sportsmen are able to push their psychological limits to a significant extent.

Strength is also influenced to a lesser or greater extent by the following factors:

- Physique and constitution
- The length of the muscle at the time of construction.
- Strength and stability of the musculo-skeletal system.
- Bio-mechanical factors like leverage and angle of pull.

**SPEED**

One of the major requirements in many sports is speed. In sports such as sprinting, soccer, cycling, hockey, fencing, games and many other team sports, speed is a major factor determining the overall outcome. For endurance athlete’s speed can mean the ability to win in a spring finish or break away from an opponent in a tactical situation. Training speed, like strength, is crucial for athletes of all
ages and abilities. Children should be encouraged from young age to continuously strive to be quicker. Developing an elite athlete must continuously strive to find new ways to develop speed, and older master athletes must continuously train speed since it is more easily lost through the aging process.

It is often assumed that those blessed with great speed or strength (power) is born with a higher percentage of fast-twitch fibers, and that no amount of speed work (or neuronal stimulation) will turn a cart-horse into a race horse. Few individuals are inherently destined for any particular type of sports activity, and how these sportspersons are developed mostly on two factors:

- The way our sporting experiences are shaped at a relatively early age.
- How the training of the muscle fibers are done throughout one’s sporting careers.

Moreover, every athlete can improve starting, stopping and cutting speed, acceleration, and overall playing speed. Although it is true that genetics is important, keeping in mind that heredity only deals the cards; environment and training plays the hand. Regardless of genetic makeup, any athlete can get faster with proper training.
While most people involved in sports training accept that the speed is a quality someone either born with or not, it does not mean that it is not trainable. A person is born with an ultimate speed potential, and only by planned training can this potential be fully realized, although the performer must be encouraged to adopt the likely approach to achieve the ultimate potential. At any stage in a player's career he or she must always function with the belief that they can produce faster movements. Indeed, this is a basic philosophy of all involved in sport – the ultimate performance is always “Just around the corner” (Paish, 1991)

Speed is largely determined by the muscles rate of force development or power. It is difficult to develop the highest level of speed without developing peak power. And also speed training helps to improve speed off the mark and acceleration. Moving limbs at maximum velocity requires motor neurons to be stimulated and fixed in co-ordinations and at just the right time.

Speed is a skill that must be taught. All young athletes have mechanical, postural and technical issues that must be fixed in order to unlock their speed potential. Pure speed training has broken it down into step-by-step process. Speed is the quickness of movement of a limb, whether this is the legs of a runner or the arm of the shot putter. Speed is an integral part of every sport and can be expressed as any one of, or combination of, the following: maximum
speed, elastic strength (power) and speed endurance (Baechle, et al., 1994).

**POWER**

Power has been defined as the optimal combination of speed and strength to produce movement (Chu, 1996). More specifically, power represents the ability of the athlete to produce high levels of work through a given distance. The more power an athlete possesses the greatest the level of work performed (Wilson, 1992). Power is a combination of strength and speed: Power = Strength (Force Application) X Speed (Velocity). Therefore, an analysis of the components of strength and speed should help to define the fundamental mechanisms controlling the expression of power.

According to Bompa, (1990) some coaches and trainers, especially in track and field and certain team sports, believe that maximal power training should performed from day one of training through the major championship. They theorize that if power is the dominant ability, it has to be trained throughout the year except during the transition phase (off-season). They use exercises such as bounding and implements such as medicine balls and the weights. Certainly athletic fitness does improve through the year. The key element however is the athlete’s rate of improvement throughout the year, especially from year to year, not just whether the athletic fitness improves. Strength training has been shown to lead to far better
results than maximal power training, especially when periodization of strength is used; power is a function of maximum strength. To improve power, one must improve maximum strength. Under these conditions, power improvement is faster and reaches higher levels.

**STATEMENT OF THE PROBLEM**

The present study was designed to find out the Effect of Cross Training and Complex Training on Strength and Speed Parameters of College students.

The study was conducted to investigate particularly if there were any significant differences in strength and speed parameters among subjects trained under cross training and complex training respectively. As such, the study was focused on the following questions:

**RESEARCH QUESTIONS**

1. Would the cross training and complex training program improve the selected dependent variables while the presence of covariate (control)?

2. Would the cross training and complex training program differ each other and also with control group while improving the selected dependent variables?
ASSUMPTIONS

Validity of this study will rely on the following assumptions:

1. With the exception of the research treatment, subjects neither increased nor decreased their daily activity from levels previous to the study.

2. Subjects neither increased nor decreased their daily caloric intake from levels previous to the study.

3. Subjects will perform the cross training and complex training protocol correctly.

4. Subjects will perform the assigned two different training sessions separately for three days per week.

5. Subjects will not perform any vigorous exercise during the course of study.

6. Subjects will be tested accurately by standardized test items.

7. Subjects complied with the best of their ability to the training and testing directions.

HYPOTHESES

It has been scientifically accepted that any systematic training over a continuous period of time would lead to produce changes on athletic qualities. Based on the study conducted and
reviewing the related literature available in the area, the investigator formulated the following hypotheses:

1. There would be significant improvement on selected strength and speed related parameters due to the effect of cross training and complex training when compared to control group.

2. There would be significant difference on the selected strength and speed related parameters among the experimental groups such as cross training and complex training groups with control groups.

**DELIMITATIONS**

The study was delimited in the following factors.

1. To achieve the purpose of the study, forty five male students studying Bachelors of Engineering in RVS College of Engineering and Technology, Coimbatore, Tamil Nadu, India, during the academic year 2008-2009 were selected as subjects.

2. The age of the subjects ranged from 18 to 21 years.

3. All the subjects were inmates of the college hostel and studying in the same college. Hence, the nutritional status and day-to-day activities of all the subjects were same throughout the experimental period.

4. The subjects were assigned at random into three groups of fifteen each (n=15). Group I underwent cross training, group II
underwent complex training, group III acted as control group who did not participate in any training during the training period other than their daily schedule in the curriculum.

6. The dependent variables such as arm strength, explosive strength, strength endurance, acceleration, speed and speed endurance were selected for this study.

7. The selected criterion variables for the study were assessed by the following standardized test items. Arm Strength was assessed by pull ups test, Explosive Strength was assessed by vertical jump test, Strength Endurance was assessed by bend knee sit ups test, Acceleration was assessed by 30 meters Run Test, Speed was assessed by 50 meters run test, and Speed Endurance was assessed by 150 meters run test respectively.

8. The data were collected on selected criterion variables at prior to and immediately after the experimental period as pre and post tests respectively.

LIMITATIONS

The following limitations were considered while interpreting the results of the study.

1. The previous experience of the subjects in the field of sports and games, which might be influencing on the training and data collection were not considered.
2. Psychological factors, food habits, rest period and lifestyle etc., could not be controlled.

3. The weather conditions such as atmospheric temperature, humidity and meteorological factors during testing and training periods were also not considered.

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

5. Since the manual operation was made using stopwatch during 50 meter run and 150 meter run, the time was recorded in one tenth of a second.

**DEFINITIONS OF OPERATIONAL TERMS**

**Training**

Training is a pedagogical process, based on scientific principles, aiming at preparing sportsmen for higher performance in sports competitions *(Singh, 1991).*

**Cross Training**

Cross training is using another sport activity or training technique to help improve performance in the prime sport or activity *(Moran and McGlynn, 1997)*
Complex Training

Complex training is a combination of high intensity resistance training followed by plyometrics (Baechle and Earle, 2000).

Acceleration

Accelerations involve varying pace suddenly and dramatically to make a more past or away from competitors within a race (Benyo and Henderson, 2002).

Speed

The capacity of moving a limb or part of the body’s lower system or the whole body with the greatest possible velocity is called speed (Rogers, 1980).

Speed Endurance

Speed Endurance is measured by timing a maximum effort sprint from a standing or crouch start over 150 meters. The average velocity is calculated by dividing distance by time. (Seagrave, 1996).

Arm Strength

Arm strength is the maximum force that can be generated with the arms. (Baugarder, 1991).

Explosive Strength

The ability of the neuromuscular system to overcome resistance with a high speed of contraction. (Singh, 1991).
Strength Endurance

The ability of a muscle or group of muscles to overcome resistance or to act against resistance for longer duration under conditions of fatigue or tiredness. (Singh, 1991).

SIGNIFICANCE OF THE STUDY

1. The ultimate goal of research in physical education is to help coaches and physical educators to train their athletes and players based on new concepts to improve their performance.

2. The findings of the study would reveal the extent to which the speed and power training improves the speed parameters.

3. Interval running is one of the very important training regimens to improve reaction time, coordination, power and speed, which are basic for athletic performance.

4. The results of the study may be useful to the professional colleagues of physical education and sports to prepare training schedules for specific event.

5. This study would reveal the extent to which the varied intensity and repetitions of interval running would influence beneficially the various factors that has an impact on performance, so that adequate attention can be given to these variables.

6. The findings of this study would add to the quantum of knowledge in the area of sports training.