CHAPTER I

INTRODUCTION

1.1 Preamble

In today’s age of scientific knowledge humans have made rapid advancement in all walks of life and it is true in the area of games and sports. Also scientific knowledge in performance of sports disciplines has been revolutionized. The athletes, now a days, are using modernized and scientifically proven instruments for training. This helps athletes to perform better in their specific sports, with minimum expenditure of energy and time. Hence, sportsperson need to participate in year round conditioning programs to achieve the maximum efficiency, consistent improvement and balanced abilities. In fact, physical exercise is imperative to maintain physical fitness, physiological well-being and improving the immune system. To improve or sustain a preferred level of physical fitness, coaches need to administer proper training intensity during exercising so that the sportsman will be able to achieve desired level of physical fitness.

In case of sprinting performance a various types of training interventions are used. Generally, the exercises such as sprint drills, sprinting against resistance and plyometrics are preferred by coaches. Although, plyometric exercise has been used for several years, there’s very little evidence that this type of training improves sprint performance. Plyometrics exercise develops the power of muscles to provide force at high speeds (produce power) in energetic movements; these movements involve a stretch of the muscle forthwith followed by an explosive contraction of the muscle. This kind of shortening is known as the stretch-shorten cycle (Norman and Komi 1979). Plyometric exercises consist of vertical jumps, throughout that the participant jumps as high as potential “on the spot,” and bounds, all through that the participant leaps as high and as so much as potential, so
moving the body within the horizontal and vertical planes. It’s typically accepted that the additional specific training to a competitive movement, the bigger the transfer of the coaching impact to performance (Delecluse et al., 1995; Sale and Macdougall 1981). Athletes like sprinters, who need power for occupancy the horizontal plane, interact in bounding plyometric exercises (Wathen 1993).

In the present case, the investigator has been extremely enthusiastic to understand the changes caused by plyometric coaching followed by yoga practices in the specific physical fitness and sprint performance. Plyometrics refers to exercises that are designed to strengthen muscle, primarily through the utilization of jump training. Plyometric exercises represent a natural part of most sport movements because they involve jumping, hopping, and skipping (i.e., like high jumping, throwing, or kicking) (Anderst, Eksten and Koceja 1994; Bauer, Thayer and Baras 1990). The exercises involved in plyometrics are characterized by stretch-shortening cycle actions of particular group of muscles; that's, they begin with a speedy stretch of a muscle (eccentric phase) and are followed by a fast shortening of the same muscle (concentric phase) (Bobbert 1990; Bosco and Komi 1980; Bosco et al., 1982). Plyometric exercises enhances strength, muscle power, coordination, and athletic performance (Adams et al., 1992; Bediet et al., 1987; Brown, Mayhew and Boleach 1986; Holcomb et al., 1996). In fact, athletes with superior coaching and conditioning are stronger and better coordinated and less subject to injury.

Although numerous research studies on plyometric training and sprinting performance are carried out worldwide but there is little information available so far, evaluating the effect of plyometric training followed by traditional yoga training especially for the athletes of track events. Hence, in this study researcher intends to see the combined effect of plyometric exercises followed by yoga training on specific performance related physical fitness in sprinting and performance of sprinters.
1.2 Sports Training

Sports training is systematically planned preparation with the help of the exercise methods which realizes the main factors of influencing athlete's progress. The content of training includes all the basic types of preparation of the sportsman-physical, technical, tactical, psychological, and physiological. According to Singh sport training is a process of preparation of sportsman based on scientific and pedagogical principles for higher performance.

1.2.1 Implications for Sports Training

The first step in developing training programme to improve athletic performances is to identify the most important components for success in sport. The next step is to incorporate exercise in the programme that stress the physiologic mechanisms and tissues specifically involved, when these components are elicited. To accomplish this, the particular actions of the skeletal joints when performing in the sport should be known. With this information, the muscles producing these actions can be identified. Generally, the best way to train the muscles is by the same movements required in the sport. If this is not possible, then other movements involving the same muscles are employed in training. The specific method of training depends on the components that need developing: strength, power, speed and endurance. But the training principle that applies to all the components is the overload principle. For improvement that occurs from training, the muscles and physiologic systems must be continuously stressed to varying degrees on a length basis. The particular form or mode of overloading used, however, determines the specific component trained.

1.2.2 Sports Training Achievements

A sporting achievement demonstrates an athlete’s ability in the particular sport and evaluation of it by some acknowledged criteria. The
highest sporting achievements in a way stand by individual abilities in selected sport. A sporting achievement depends on the following factors and conditions.

1. Individual capacity of Athletes and the degree of their zeal to achieve.

2. The effectiveness of the system of training.

3. The scope of the sporting movement and the general social conditions of its development.

It is remarkable that the achievement at the present times swiftly increase with a corresponding increase in the volume of training. Even the most gifted athletes will not score well if they do not work persistently. Sporting achievement depends only on the effort of the athlete. Sport training as scientific and methodological foundations, improves its effect on the general level of sporting achievements. It is indicative that Olympic records of the first modern Olympic Games, which in those time seemed to be outstanding, today, they are within reach of thousands rank-and-file athletes. This is explained, in particular by the evolvement of new, scientifically substantiated training methods and means of execution of sports exercises.

In modern times, several methods of training are practiced by the coaches and the physical education personal. Weight training, interval training, interval sprint, slow continuous running, Fast continuous running, Fart-lek training, Circuit training are popularly known to athletes and coaches. Current literature adequately describes the performance of polymetric training in various sports activities.
1.3 Plyometrics – General Understanding

Coaches are continuously looking for ways to improve power and strength. They seek exercises that will improve power and strength. They seek exercises that will improve ability without consuming a great deal of time or increasing the risk of injury. Plyometrics is a method currently being used which has been rather extensively researched, usually with positive results.

Plyometrics is method of developing explosive power, an important component of most athletic performances. Coaches and athletes have sought methods and techniques for improving speed and strength combined is power and power is essential in performing most sorts of skills. Although Specific exercises designed to enhance quick, explosive movements have been taught for some time. Presently a system emerged which emphasizes “explosive reactive” power training. This system of athletic training is popularly known as plyometrics.

1.3.1 Meaning of Plyometrics

The term plyometrics was instituted by Fred Wilt in the wake of viewing Soviet competitors plan for their occasion in olympic style events. He felt this was a key to their prosperity. It is a poor term to portray what happens yet it has since been acknowledged and is presently overall created. The point when Wilt educated of the work being carried out by Michael Yessis on Soviet (Russia) preparing strategies, they immediately teamed up to help scatter data on plyometrics.

Since its presentation in the early 1980s, two manifestations of plyometrics have advanced. In the first form of plyometrics made by Yuri Verkhoshansky of the previous Soviet Union, it was characterized as the shock technique. In this, the player might drop down from a stature and
experience a “shock” after arriving. This thus might achieve a constrained, automatic flighty constriction which was then promptly exchanged to a concentric compression as the player bounced upward. The arriving and takeoff were executed in an amazingly brief time of time, in the extent of 0.1-0.2 seconds. The shock system is the best strategy utilized by competitors to enhance their velocity, briskness and power after improvement of a solid quality base.

1.3.2 Brief History of Plyometrics

Exercise physiology, and devices like agility dots, didn’t exist before the sixties. During the early seventies Russian sprinters dominated the international and Olympic field and track circuits. Jealous competitors whispered of a new secret training method that gave sprinters like Valery Borozov and Boris Zubov the speed bursts and the power to easily outdistance the pack. Investigator discovered that both these men had trained under a Russian coach named Yuri Verkhoshansky. Yuri was working with Moscow institute of aeronautic engineers as a physical education and track field coach. Only in two years he transformed twelve non athlete university students into highly skilled field jumpers. In addition, he became well-known for introducing barbell into training of sprinters and jumpers. Further, he introduced most admired and successful depth jump exercise. With this he became the main coach of the Moscow United Team in the sprint and jump events.

Verkhoshansky favored the term shock training rather than plyometrics, arguing that plyometric movements exist in all sports and differ from the formal discipline he devised. Today the term has morphed into several, including kinetic energy accumulation training, shock training, plyometrics, power metrics, drop jumps, and depth jumps each effectively utilizing agility dots. Chose any name you wish, but the theory and its practice have been the hottest and most discussed development in the fitness world for over two decades.
1.3.3 Physiology of Plyometrics

Many researchers have revised the physiological basis of plyometrics. Most of them are of the opinion myosin which makes the muscle fiber play an important role in muscle tension and activation of stretch reflex. Muscle elasticity is an important factor for stretch-shortening cycle products than a concentric muscles contraction. The tension developed by rapid stretching of muscles can be stored. For ex, consider a rubber band. Whenever you stretch it, there exists the potential for a rapid return. This mechanism is also present in muscles of human beings.

For the stretch shortening cycle, stretch reflex is another integral mechanism. A common example of the stretch reflex is the knee Jerk experienced when the quadriceps tendon is tapped with a rubber mallet. This tapping results in the stretching of the Quadriceps tendon.

Plyometrics utilizes the mitotic reflex in the development of power by allowing a retrenching of the muscles in the amortization phase. The muscle will resist over stretching and the kinetic energy developed in the amortization phase will be utilized to cause a powerful contraction to prevent over stretching of the affected muscle. Thus, the movement generated by the athlete is as the overload to eccentrically stretch the muscle before this immediate, concentric initiated. The faster the transition from eccentric contraction initiated.

The faster the transition from eccentric contraction to the concentric contraction is possible in Plyometrics. To the concentric contraction the greater will be tension in the concentric contraction. Conversely no lengthening of the muscle during the Concentric contraction phase occur or should a relaxation occur between the eccentric and concentric contractions, then most of these potential energy will be lost as heat energy.
Far lane say's physiological benefits of plyometric training research indicate that to bridge the gap between sheer strength (maximum or cross strength) is closely linked – with the following physiological factors:

- Speed of contraction
- Metabolic characteristics of the muscle
- Neuromuscular firing
- Transfer of kinetic energy

1.3.4 Principles of Plyometric Training

Plyometric training is a very intense, high nervous system demand activity that must take into account four factors:

- Training load,
- Basic strength,
- Skill
- Progression.

Training load:

The major consideration in plyometric training is the determination of appropriate plyometric training is the determination of appropriate training load. With the beginners, the variables of maturation and training experience compound the problem. If the intensity of plyometric exercise is low then training volume can be high.
Basic strength:

Basic strength is imperative but for youth elevated strength levels, such as ability to squat or leg press are not essential, particularly considering the relatively perform the balance and stabilization tests, then he or she must bring these qualities up to satisfactory standards. If a low paying back phase and slow switch from eccentric to concentric work is seen, then eccentric strength levels are no sufficient and the training should be low in volume and intensity.

Skill:

Proper exercise execution must be stressed at all levels. The elasticity of ankle, a knee and hip should be used to absorb shock and then use that force in subsequent movement. The athlete should react as if he found is hot, to highlight best speed off the ground. If the athlete makes loud slapping noises on landing, the technique is incorrect and the exercise should be stopped. An upright torso is needed to appropriately project the centre of mass and to evade strain on the low back. A proper arm action make a noteworthy contribution to balance and force production.

Progression:

Suitable beginning activities comprise jumping rope, hop scotch, sack recess and jumping or hopping, relays. Double leg take-offs at the beginning stages. The suggested progression in a teaching and training is , (1) landing (2) stabilization (3) jumping (4) in placing bouncing movements (5) short jumps (6) long jumps and 97) shock jumps.

Strong suggests a five stage progressive overloading of plyometric exercises. In stage I of plyometric training all jumps should be kept simple and are performed on flat ground. Responses are limited to 60 and a variety of jumps should be used. It consists of training for 4 weeks two days a week. For
stage II of plyometric progression, the total number of responses are increased to 8- and another day for a week is added for plyometric exercises. The increase in work load comes with inclusion of bounding jump of about 30 meters and depth jumps. The height of the depth jump boxes will be 16-24 inches. In stage III, the responses are increased to 100. The same sequence bounds are used but performed up hill or on stadium stairs. Single response jumps and depth jumps are included to a lesser extent while sequential bounding on the flat is increased to 100 meters.

Three training workouts per week is maintained for the four week period. Stage IV consists of a gradual progression to 120-150 responses per *plyometric session. This is the maximum number of responses that should be performed in a single training session. Depth jumps are increased to inch boxes with a slight inclusion. Stage V is designed to inure and maintain the power of the athletes at the highest level. Although the number of responses remains identical (120-150), the speed and distance increase in all exercises. Boxes are moved apart with increase in the number of jumps of jumps on the boxes to 50% of the whole plyometric workout. Hurdles are used as obstacles for bounding. The area set to a height of 36 inches and placed 3 feet apart for eight to ten hurdles.

1.3.5 Guidelines for Plyometrics

In dealing with plyometric exercise, just as with other forms of athletic training; certain guidelines should be followed. Warm-up/warm down/, high intensity/, maximize force/minimize time,/ rest properly and overload principles the advisable guidelines.

*Warm-up/Warm down*

Because plyometric exercises demand flexibility and agility all drills should be preceded by an adequate period of warm-up and followed by a
proper warm down. Jogging form running, stretching and simple calisthenics are strongly recommenced before and after every workout.

**High intensity**

Intensity is an important factor in plyometric training. Quickness of execution with maximal efforts is essential for optimal training effects. The rate of muscle stretch is more important than the magnitude of the stretch. A greater reflex response is achieved when the muscle is loaded rapidly. Because the exercises must be performed in tensely, it is important to take adequate rest between successive exercise sequences.

**Maximize force/Minimize time**

Both force and velocity of movement are important in plyometric training. In many cases the critical concern is the speed at which a particular action can be performed.

A rest period of 1 to 2 minutes between sets is usually sufficient for the neuromuscular systems stressed by plyometric exercises to recuperate. An adequate period of rest between plyometric training days also is important for proper recovery of muscles ligaments and tendons. Two to three days per week of plyometrics, especially jump drills and other leg movements, with heavy weight workouts of the lower body. Previously fatigued muscles, tendons and ligaments can become over stressed by the high resistive loads placed on them during the plyometric workouts. Utilize the overload principle, which specifies that increases strength results only from work performed at an intensity greater than that to which it is accustomed.
1.3.6 Rationale of Plyometrics in athletics

Before training schedule can be prescribed for jumpers, we must determine that exact requirements of the events necessary for successful performance. It is pointed out that a fast approach and a take-off of short duration were vital for high level performance in the horizontal jumps. A short take-off is also associated with better performance in the jump, provided the flop technique is used. Research suggests that an excessively long amortization phase (shock absorbing) is responsible for a larger loss of horizontal velocity in the long jump.

The importance of a short amortization phase is also indicated by research concerned with muscle mechanics of jumping. It has been well established that concentric muscle contraction is more powerful when muscle is previously stretch during the eccentric contraction. The research indicates that the enhanced muscular performance occurs only if deep knee bending is prove need and the amortization phase, as well as the time interval between the eccentric and concentric contractions is short. On the other hand, expressive flexion at the knee associated with slow stretching and a relatively long amortization does not result in a strengthened concentric contraction.

The method used in plyometric exercises will be different for the deferent jumping events, long jumpers will be more icon corned with horizontal jumps (double and single leg) off of a single box (with and without movement). Triple jumpers will be more concerned with multiple horizontal jumps off of two or more boxes (with or without movement) using predominantly a single leg take-off, high jumpers will be more concerned with vertical jumps (double and single leg) off of a single box (with and without movement). Sprinters, as long jumpers, will be concerned with horizontal jumps off of preparation is for the athlete to think of coming off the ground very quickly and explosively upon each landing. This is true whether the athlete is performing and hops, bounding, hurdle hops, box drills etc.
The 4th and last phase of 100 mts run occurs at the distance of 85 m to 100 m. This phase of the race is dependent upon an athlete’s ability to maintain his maximum speed achieved in phase three and minimize the slowing of the body. The 100 m race requires an immediate and rapid anaerobic energy supply. This energy is supplied almost arc illusively by high energy phosphates ATP and creatine phosphates (cp). This 100 m race does not utilize oxygen as an energy source-the race is dependent upon ATP-CP immediate energy system which is nearly depleted in only 6 to 8 seconds. At this time the athletes speed decreases due to lactic build up in the muscles. Even though lactic acid is improved, the tolerance can be maintained at the top speed for a longer period of time. Training of Plyometric exercises can enhance the lactic acid tolerance and therefore performance of running and jumping may be improved.

1.4 Brief Introduction to Yoga

The Asanas

In Patanjali’s Yoga-darsan an asana is defined as Sthirasukhamasanam (any posture that can be maintained with comfort is an ‘asana’. Prayatnasathilyanantsamapattibhyam (lack of effort and contemplation as if it is never going to end characterize it). Apart from contraction and relaxation, there is third state of muscle which is known as the ‘Catch’ state. It is the ligament like contracted state of muscle which has been well studied biologically in the bivalve mollusks. It is characterized by maintenance of high tension without consumption of energy. A catch state could be very useful for a yogi which in to stay in a single posture for prolonged period for other advanced practices.

Patanjali mentions asanas only as a pre-requisite to other advanced practices of Pranayama, Pratyahara, Dharana, Dhyana and Samadhi. Later, by other sages more stress must have been laid on different asanas for improvement of bodily health. Scriptures says there are as many as asanas as
there are species of animals. Eighty four lakhs of them have been mentioned by Lord Siva.

For this reason, it can be stated that any posture that one can imagine is an asana. They might have been named and re-named and the older names forgotten down the centuries. For this reason, there is some difference in the naming of some asanas according to different authors. There is no scope to device new asanas. For a common man, performing a few asanas should suffice. There is enough freedom for everyone to choose a few asanas which one finds particularly useful and possible to perform. In fact, the asanas one selects for oneself should include one for each of the different group of muscles e.g. flexor of arm or extensors of thighs etc.

From medical point of view, yogasanas can be divided into two categories: one requiring a sustained muscle contraction. The examples are Trikonasana, Matsyasana, Salabhasana and Dhanurasana. Due to the fact that they require sustained muscle contraction, they are anaerobic exercises. When one starts the practice of yoga, maintaining such a posture in one asana beyond about 30 seconds is difficult. So much so that when one sees the difficulty in staying in an asana for long, one wonders about the definition of asana given above. But with regular practice of a few weeks to months one is able to perform an asana for much longer; for 90 seconds or more and one would be comfortable while performing that particular asana. Such an asana is said to have been perfected ‘achieved’ i.e. one has achieved perfection in that asana. By regular practice of asanas, the muscles build their oxygen stores in the form of myoglobin and the capacity for oxygen debt increases. Such trained muscled do not put an immediate demand on the blood circulation, (thereby sparing the heart) with each trivial activity of the day to day life.

The second type of asanas does not require any sustained muscular effort. Such asanas are good for chanting of ‘Aum’, pursuing meditation
(dhyana) and Samadhi. This category includes Padmasana, Siddhasana and Bhadrasana, in short, all sitting postures.

Asanas have musculoskeletal and visceral beneficial effects, in addition to being preparatory to further practices of pranayama and dhyana. Some of the effects are quite obvious; one can see that in a particular asana the stress is borne by a certain group of bones, ligaments and muscles. This stress strengthens these bones, muscles and ligaments.

**Physiological basis of Asanas**

Isotonic exercises lead to muscle hypertrophy. There is increase in the size of muscle fibres and the bulk of muscles increases. There is increase in oxidative metabolism and training increases the number of mitochondria.

However, most yoga asanas are static postures, some of which require muscle contractions which are of isometric nature.

The effects of continued training in isometric exercise probably have not been studied so far. There is no great increase in the bulk of muscles, but, as one can observe in a trained Yogi, the capacity for sustained isometric contraction increases.

**Blood circulation through skeletal muscle at rest and in aerobic exercise**

Flow of blood in the resting muscle is low. When a muscle contracts, it compresses the blood vessels contained in it. If it contracts maximally or even 70% of the maximum, the blood flow is completely stopped. Between contractions the blood flow is greatly increased to about 30 folds. Blood flow in resting muscles doubles after sympathectomy (cutting away of sympathetic nerves). During exercise (repeated contraction and relaxation) local factors such as a fall in PO2 rise in PCO2 accumulation of K+ and other metabolites
such as lactic acid cause vasodilatation in the muscle. Fluid transudation into the extracellular space is increased and this is taken away by the lymphatics. The lymph flow thus greatly increases. The oxygen consumption of an exercising muscle can increase up to 100 folds. This is supplied by an increase in the blood flow is seen only during relaxation of the muscle. During its contraction, all the contained blood vessels are, in fact, squeezed and there is hardly any flow of blood through them. The blood flow is seen to increase several folds when the muscle during relaxation when the muscle is repeatedly contracted and relaxed. On the other hand, in yogasanas, the muscles are contracted in a sustained way. The blood vessels remain continuously squeezed for the whole duration the muscle contraction is maintained. For such sustained contraction the muscle has to draw upon its stored energy in the form of ATP and creatine phosphate and derive more energy using its stored oxygen in myoglobin-yes, the body has stores of oxygen in the form of oxyhaemoglobin in the blood and myoglobin in the muscles. The brain has no stores of oxygen and it is for the brain that continuous supply of oxygen by breathing is a must.

**The Oxygen Debt Mechanism**

When one stays in an asana requiring sustained muscle effort, the respiration does not increase greatly. The respiration is seen to increase after the asana is relaxed. This is particularly true about asanas which require contraction of larger muscles like paraspinal muscles (e.g. Bhujangasana, Salabhasana, Matsyasana) or the quadriceps and the Glutei (e.g. Utkatasana, Tikonasana and Mahavirasana). After relaxing these asana, one needs to take deep breaths three or four times. The muscles use their stored oxygen during the contraction and they need to replenish their stock when the asana is relaxed. Sometimes they take back so much of oxygen that at this time a brief hypoxia is produced.
Three mechanisms operate which can sustain muscle activity even in absence of increase in blood supply.

1. The phosphorylcreatine is used to synthesize ATP.

2. Some ATP synthesis is accomplished by anaerobic oxidation of glucose to pyruvic acid which gets converted into lactate.

3. Some oxygen stored in myoglobin is utilized.

It is known that in a short run of say 100 meters that takes about 12 seconds, about 85% energy is derived anaerobically. In the same way, our day to day activity involves running up to about 20-40 steps which should be completed without any demand on the heart to supply more blood. This is possible if there is a huge store of oxygen in the muscles themselves. Yoga asanas possibly bring about precisely these changes. However, presently all we know is that continued practice of yoga asanas increases the capacity to sustain the asanas for longer duration of about say, beyond 90 seconds. Most likely this increased capacity of muscles results from increased concentration of myoglobin, creatine and ATP.

**Muscle Relaxation is an Active Process:**

In a new born infant, fists are tightly closed. Closed fists do not seem to serve any purpose in the human newborn, but if one observes a newborn monkey, the purpose of closed fists is immediately obvious. The mother monkey opens the fists of the newborn, gives skin fold of her own belly in its hold in each of the four limbs. Thus the newborn monkey hands securely and tightly to the belly of the mother. So tight is the grip that even if the mother monkey jumps from one branch of a tree to another, the newborn monkey does not fall down. The newborn has as yet no control established on its muscles, i.e. it cannot contract voluntary muscles of its body, a fact that
everyone know, but in the case of the fist muscles, it is the reverse it cannot open the fist if it wishes so.

There have been some studies regarding the forearm muscles of the newborn monkey, but our knowledge regarding their structure, function and blood flow kinetics is far from complete. However, if we can say that in the newborn the corticospinal and other descending tracts are not well formed. That is the reason why the newborn does not have control on its limbs, at the same time it should become clear that it is the same absence of developed descending tracts that leads to its inability to relax the forearm muscles. A similar state of closed fists results from certain lesions of the CNS in adults, especially the frontal lobes, and then it is known as the ‘grasp reflex’. Such inability to open the fists is also characteristic of myotonia, which is an inherited disorder of the muscle cell involving the relaxation process.

In adult human beings there are certain muscles that remain in a constant state of contraction. Erector spinae muscle are accustomed to stay in contraction for prolonged times during sitting and standing. The internal urethral and anal sphincters remain in persistent state of contraction. In these sphincters, their constriction is automatic while relaxation is voluntary. Other sphincters such as the pyloric sphincter and the sphincter of Oddi have their own special opening and closing stimuli. The smooth muscles of blood vessels have been a subject of detailed study because of their importance in maintenance of vascular tone and the blood pressure. All types of muscles have their own ion channels and pumps, like the calcium channels and calcium pumps. Calcium channel blockers used as antihypertensive medicines relax vascular smooth muscles.

**The Catch-State of Muscles**

Studies done in mollusks have revealed that the bivalve mollusk closes itself on perception of any danger. The muscles involved are the adductor
muscles, also known as the Anterior Byssal Retractor Muscles. These muscles are able to maintain a high tension for prolonged periods without consuming energy. Application of acetylcholine to these muscles produces a quick response with simultaneous activation of the catch mechanism, which does not reverse even if the acetylcholine is removed. Such ‘catch’ state is usually not seen in mammalian muscles. The human newborn comes with closed fists, which is a state somewhat like myotonia. This occurs despite a poor innervations of the muscles and in all likelihood does not involve a continuous neural stimulation. The molluscan adductor muscles are rich in another protein called ‘twitchin’ and it is speculated that its involvement is important for the catch state.

It is a distant hypothesis whether with continued practice of sustained muscle contraction one is able to achieve a ‘Catch State’. Twitching is not normally found in human muscles. However, the genes responsible for the production of twitchin are present in the human genome. Therefore, there is reason to believe that a catch like state is achievable in human beings.

It is common observation that in the beginning of practice of yogasanas every aspirant becomes a little breathless after having maintained an asana for even a few seconds. This happens as the muscles that have used up their oxygen and ATP stores replenish them when the asana is released. With continued practice over months to years this requirement lessens to such an extent that any compensatory increase in ventilation is hardly noticeable. This finding needs to be confirmed by scientific measurements of oxygen consumption in fresher particularly in comparison to old practitioners.

Relaxation of muscle is an active process requiring active, energy dependent pumping out of calcium ions from the vicinity of the actinmyosin complex into the sarcoplasmic reticulum, in skeletal, cardiac and smooth muscles. In the heart a disturbance of the relaxation mechanism is called ‘diastolic dysfunction’.
A catch like state is achievable also by inhibition of the sarcoplasmic reticular Ca++ pump which is responsible for relaxation of a muscle. It is now known that the sarcoplasmic Ca++ pump can be inhibited by several chemicals. These include ‘peptide C28 W’ and an indigenous peptide Glucagon’. With the present state of knowledge it is not possible to rule out the presence of some peptidergic fibers supplying the skeletal muscles or some such peptide being secreted as a co transmitter by cholinergic fibres in some special circumstances.

**The Value of Muscle Relaxation**

To some extent and especially in some individuals, complete relaxation of the skeletal muscles does not occur even when not in action and even during sleep. This may cause muscle pain. Similar failure of relaxation in vascular smooth muscle may be a cause of hypertension in some patients.

In yoga, In Savasana we make deliberate effort to relax all skeletal muscles of the body one by one. The wave of relaxation ultimately trickles down to the smooth muscles of the arterioles. Thus the vascular bed dilates and the blood pressure gets reduced. The technique of muscle relaxation used in Savasana can also be used while going to sleep. The blood pressure lowering effect of Savasana has been well demonstrated by K.K. Datey and others.

During an asana, the muscles which are in sustained contraction develop hypoxia. This may have a threefold benefit. It has been shown that the stem cells isolated from skeletal muscles grown in hypoxic environment (6% oxygen) develop into myocytes while those grown in 20% oxygen develop into adipocytes. Thus obesity will not occur in a person in whom muscle hypoxia occurs on a day to day basis.

For any movement occurring in the body, say for example we take the case of flexion and extension at the knee, all the fibres of the extensor muscle
do not contract at the same time. Since the fibres take origin from different locations called the ‘head’ or origin of a muscle some from one point of a bone, some from another and still others from a different bone, it can be understood that different fibres are in advantageous position at different degrees of flexion or extension. The muscle fibres that contract when the joint is near full extension are not the same which contract when it is near full flexion. In order to give anaerobic exercise to each and every group of muscle fibres, different asanas have to be selected where different degrees of flexion of a joint are maintained.

**Bone Physiology**

Bones have outer part called the compact bone and the inner part called the trabecular bone. Compact bone has low surface to volume ratio, and there are very few cells: the osteocytes. They receive nutrients via the Haversian canals which contain blood vessels. Around each Haversian canal collagen is arranged in concentric layers forming cylinders called the Haversian system.

Because of the high calcium and phosphorus content the bone provides the rigidity required for locomotion and protection of vital organs.

Old bone is constantly being resorbed and new bone formed. In this way it is also able to respond to the stresses and strains that are put on it. The bone trabeculi get aligned in the direction of stress.

To put stress on different bones of the body is the aim of exercise. When one performs different yoga asanas, one is putting stress on different bones. For example, in tadasana, when we stand on our toes with our heels elevated, we are putting stress on the small bones of the toes— the metatarsals. In trikonasana the stress is on the neck of femur. In this way, different asanas contribute to maintaining the strength of different bones. How much time of stress is just enough to maintain the normal bone strength,
remains to be studied. However, much depends upon the available time and most of us will be able to devote about one hour for yoga asanas in which each asana can be performed for about 1-2 minutes.

One may wonder what quantum of growth stimulus is delivered to the bones in such a short time, but we must understand that any quantum is better than having no stimulus at all.

Osteoporosis is an important problem in which there is loss of bone mass density. It is related to age, physical inactivity and withdrawal of hormonal support, such as after menopause. Osteoporosis weakens the bones and leads to fractures. A fracture of neck femur needs to be treated with surgical replacement.

**General Principles while Performing Yoga Asanas**

1. The practice of asanas should be performed very regularly every day at the specified time. Those who wish to achieve health and proficiency quickly may go ahead performing asanas twice in a day.

2. Cooling down by Aunkara chanting should be performed before starting the asana session everyday. In fact, in yoga there is no place for warming up. One should go slow while performing an asana. Jerks should be avoided. Every asana should be performed only once. Repeating it makes it an aerobic exercise.

3. In asanas that involve bending, stretching, twisting etc., one should try to attain the maximum possible bending, stretching and twisting, then maintain this position effortfully for the longest duration one can, and come back slowly.

4. One should try to increase very gradually the extent of bending, stretching and twisting, and the duration of stay in an asana day by day
and week by week. If going this way increases the total time required to
perform the asanas beyond available, it is a good idea to perform half
the asanas on alternate days, rather than reducing the time for
individual asanas.

5. If at any time there is pain while performing an asana, that asana
should be avoided for a few days as long as the pain persists.

6. While bending forwards, one should exhale and while bending
backwards one should inhale.

7. After performing a forward bending asanas, one should counterbalance
immediately by a backward bending asanas. For example, Matsyasna
should be followed by Halasana.

8. Right bending or twisting asanas should be followed by left bending or
twisting for an equal time.

9. Wherever possible, convergence of eyes should be performed while in
the asana. Apart from some asanas which require visual fixation for
balancing like the Vrikshasana, Garudasana and Natarajasana,
convergence can be practiced with almost all asanas.

Factors influencing physical performance

At the most general level physical performance is a function of all the
physical and mental characteristics of the individual. Some of these are
determined at the moment of conception by the genetic material derived from
the father and mother. The most obvious is the individual’s gender. Some
characteristics may be acquired later through the processes of growth,
maturity and learning, while others result from the interaction of the
individual’s basic genetic make up with his environment. All this may seem
rather far removed from the scoring of goals in a football match or the winning
of an athletic event, but in fact such achievements are subject to just these
constraints. Sporting achievement is a complex mixture of genetic make up and environmental influences including training and in attempting to reach any meaningful conclusions about physical performance it is useful to try to separate these two factors. There have been several studies of genetic effects in athletes and it is becoming clear that they have a most important influence. In the case of a few characteristics most obviously gender the effect is entirely genetic. But in many others there is interaction with environmental factors such as training. Training can fine tune the characteristic, but the limits of achievement are genetically predetermined.

Certain environmental influences occurring after conception have permanent effects and, together with genetic factors, these represent invariable constraints on the athlete’s performance. Characteristics that are relevant to physical performance and over which the individual has little or no control include gender, age, somatotype, height, and the distribution of motor units types. Many of the effects of the first two factors are obvious, but a few of the lesser known points are refereed to elsewhere.

At a less general level it is possible to demonstrate that physical performance is influenced by specific physiological characteristics, many of which can be measured or otherwise described. These include such variables as strength, joint mobility and the capacity for various types of physical work. These are frequently classified as components of physical fitness. This, too, is a useful way of analyzing physical performance because it highlights variables which can generally be modified or improved through training. As more is known about the biological effects of exercise it has become clear that the changes are all due to definite anatomical, physiological and biochemical adaption. It seems convenient to group these variable aspects of physical performance under one heading since they are all factors over which the individual has some control.
Physique

Physique has an important influence on athletic performance but is only to a very limited extent under the individual’s control. A large number of studies have shown that successful sportsmen tend to have particular types of physique and that this is related to athletic success.

Size

Apart from the obvious observation that height is an advantage to rugby forwards, basketball players and throwers, there are also more subtle effects of differences in body size. These occur because the human is three dimensional. If the height of a three dimensional object is doubled its surface area increases four times and its mass is multiplied eight fold. Thus, when individuals of different size are considered, the body surface area and the cross sectional area of muscle (and therefore strength) tend to vary in proportion to the square of height. Variables such as weight and blood volume increase in line with height cubed. Thus changes in size tend to produce differences in the relationships between such variables as strength, weight, power output, acceleration and work capacity. This means that individuals of various sizes are better equipped for different types of activity.

Components of Physical Fitness

Flexibility

Flexibility is concerned with the movement that occurs at joints. The majority of writers use the term to indicate the range of movements that is possible, and this is the meaning adopted. Most of the machines require a rigid framework upon which to operate. In the human body this is provided by the skeleton which acts like a series of girders against which the muscles contract and develop force. Many manmade machines are expected to produce only a single kind of movement and so require few movable joints. The human body is capable of an enormous repertoire of different movements
and has only a few immovable joints but a large number that are capable of different kinds of motion. Some e.g. the knee and elbow joints are designed to move mainly in one plane. These act in a similar manner to the hinge on a door. Others are capable of movement in several directions. Typical examples are the joints found at the hip and shoulder.

Where two bones come in contact they are covered by a layer of hyaline cartilage, a tough, smooth material which reduces friction. The joint space is enclosed by the joint capsule, a tissue which secretes synovial fluid. This is a thick, slippery liquid containing the complex carbohydrate, hyaluronic acid, which keeps the joints lubricated. The joint capsule is surrounded by ligaments, these are strong fibrous tissues which prevent the joint being pulled apart, they influence the range of movement. The knee joint has strong ligaments at the side and back but none at the front. This reflected in the type of motion possible. The shoulder joint has much looser ligaments which allow a wider range of movement including rotation. Over the ligaments there is a layer of muscle or tendon. Tendons join muscle to bone and may be short, or long enough to traverse several joints, or those that connect the forearm muscles to the finger bones.

Joint motion is limited by a number of factors. Disease and injury can cause changes which include damage to the cartilage, deposits of solids in the joint space, inflammation of the capsule, or a deficiency of synovial fluid. These conditions frequently make any degree of movement painful and difficult. In the healthy individual the range of movement is usually limited by bone structure, the properties of the ligaments, the length of muscles or tendons, or the intervention of soft tissue. Extension of the knee is limited by the length of ligaments at the rear, while flexion is topped by the contact of soft tissue in the calf and thigh. In contrast, hip flexion is usually limited by the length of the hamstring muscles.
The length and suppleness of ligaments and muscles is not fixed. Where these factors limit joint motion, flexibility can be increased through training. Typical examples are movements at the shoulder, hip, ankle and spine. Two types of changes occur. Short term changes which follow limbering up exercises or a warm up, are quickly reversed. Several weeks of stretching maneuvers will produce longer lasting changes. These are largely independent of the warm up phenomenon and a period of limbering up will produce a further improvement.

**Stability and Flexibility**

Joint must be sufficiently flexible to allow the athlete necessary movement, but not so loose that rigidity is lost or limb put in a position where it is susceptible to injury. Too much flexibility or flexibility in the wrong place, can be disadvantage.

Excessive mobility is most commonly a problem at the shoulder and knee. It occurs because the relevant ligaments are too long and results in susceptibility to injury. This is most likely to occur in contact sports such as soccer or rugby. Instability of the shoulder predisposes the individual to dislocation, weak knee ligaments are likely to lead to knee sprain or damage to the semi lunar cartilage. Both these injuries can very disabling. Excessive mobility of the knee or shoulder is a reason for excluding an individual from a heavy contact sport. These conditions can usually be improved by building up the musculature around the joint through weight training. In cases where the movement is excessive, an orthopedic surgeon should be consulted. Studies by Leighton (1957) have shown that many groups of athletes have lower shoulder mobility than some untrained individuals. This is presumable due to a development of the muscles round the shoulder girdle.

Where joint motion is limited primarily by muscle length the situation is different. Too much flexibility is unlikely to lead to instability but too little will result in muscle strain. Sprinters are often disabled by hamstring injury which
could be prevented by better hip mobility. In order to minimize the possibility of strains, all athletes should aim for a reasonable level of trunk, hip and ankle flexibility. There may then be other requirements specific to particular events.

It is difficult to make generalizations about flexibility because of differences in joint structure and the demands of various sports. Untrained individuals tend to be deficient in most aspects of joint mobility and a general, all round programme is needed at the commencement of training. Excessive flexibility is unlikely to be a problem at this stage and shoulder exercise are desirable. Although excessive mobility can be a problem in sportsmen, tightness of the shoulder muscles is more common in the untrained and this can lead to muscle strain. Trunk and hip mobility are also important and should be stressed in a general fitness programme. It has been reported that flexibility exercises are sometimes effective treatment for lower back pain, neuromuscular tension and muscular pain.

Athletes should begin training with a general flexibility programme, paying particular attention to joints where mobility is limited by muscle length. These include the hip, ankle and shoulder and all aspects of spinal motion. There will then be requirements specific to individual sports. A rugby player will need stability at the knee and shoulder, in javelin thrower shoulder mobility is of greater importance. The coach will need to analyze individual activities to arrive at the combination of rigidity and mobility appropriate to each.

Definitions

The term flexibility has been used to indicate the range of motion at a joint. Static flexibility is the range of motion when the joint is moved very slowly. During a rapid movement the range may be slightly different and we would designate this dynamic flexibility. Some people used the term to describe the resistance of a joint to motion but the term resistance for this variable. The resistance to motion varies with the joint angle, generally being
lower near the middle of the range, and with the speed of movement. It has been measured in animals under laboratory conditions. But not in humans in sporting situations. In a particular motion resistance will be influenced by the action of antagonist muscles, tissue inertia and viscosity, as well as the frictional properties of the joints involved.

Strength

Strength is the maximum force that can be developed during muscular contraction. Force is measured in the same units as weight often in lb or kg. Sometimes lb-wt is used instead of lb and kg-wt or kp instead of kg. The latter terms are more correct, but for measurements made on the earth’s surface there are no practical differences between the two types of unit.

Muscle

There are three types of muscle in the body, each with slightly different properties. Cardiac muscle occurs in the heart and is especially suited to short, regular contractions. The gut and blood vessels contain smooth muscle which can operate with the minimum of intervention from the nervous system. The third type is that which moves the bones of the skeleton and is known as skeletal or striated muscle, from its appearance under a microscope. Skeletal muscle is the only type under voluntary control, being operated mainly by the conscious part of the brain.

The gross structure of skeletal muscle can be observed in the lean portion of a joint of meat. It consists of reddish fibres separated by connective tissue which is non contractile. At each end this tissue forms the tendons which join the muscle to bone and transmit the force of contraction.

Connective tissue also isolates the fibre from its neighbors so that each is capable of contracting independently. Muscle also contain several different
kinds of nerve, and blood vessels which supply oxygen and nutrients and remove waste products.

The nerves that initiate muscular contraction are known as motor neurons. Most control several muscle fibres which contract simultaneously when the nerve is stimulated. The muscles fibres controlled by a single nerve are known as a motor unit. Where very precise movement is necessary, such as in the muscles which control the direction of eyes, each motor unit consists of only a few muscle fibres. In the muscles of the legs and back, motor units may consist of more than 100 fibres. The individual fibres making up a motor unit are widely scattered throughout a particular muscle. Any given portion of a muscle may contain fibres from 20 to 50 different motor units.

A muscle fibre either contracts maximally or not at all. It is not possible to vary the force of individual contractions of a single fibre but this can be done in a whole muscle in one of two ways: by varying the number of motor units involved in the movement, or by changing the rate at which contraction occurs. These mechanisms are known, respectively, as spatial and temporal summation.

Although the contraction of skeletal muscle is generally initiated by the conscious part of the brain there is also a degree of automatic control. This often overlooked but it has an important influence upon coordination and the development of strength. The athlete makes the decision to lift a weight or kick a ball with the conscious part of his brain, but the details of motor unit involvement are determined at lower levels of the brain and in the spinal cord. The upper brain acts like a managing director making a policy decision. The detailed execution of this is left to many other individuals who have specialized knowledge of the working of different departments. The overall success of the policy will depend upon the performance of all these individuals. A similar situation occurs with muscular contraction. The nervous system must learn to utilize the available equipment most effectively if
maximum strength is to be developed. This process appears to take place in the initial stages of strength training. Several studies have shown that neurological changes take place and that at the start of training strength increases without a corresponding change in muscle size. This is presumably due to better utilization of the existing tissue by the nervous system.

These subconscious mechanisms are influenced by information from several sources, including the muscles themselves. Nerve endings in muscle detect compression, lack of oxygen, excessive tension and other conditions likely to lead to damage. Endings in tendons are sensitive to stretch an indication of excessive muscle tension. These outputs are fed into the spinal cord and brain, along with information from other sources, and may limit or inhibit muscular contraction. The output from tendons has a direct inhibiting effect upon the motor neurons of the muscles that are causing the tension. This normally prevents the muscle contracting with its maximum force. In exceptional circumstances, such as an extreme emergency, these constraints may be removed. There have been a number of reports of mothers managing to lift huge weights in order to save a trapped child. In laboratory studies exposure to hypnosis, drugs and rifle shots have been shown to produce supra normal peaks of strength.

In sporting situations acts of strength are seldom the work of single muscles. Usually, several muscles cooperate in the direct development of force, and many others are involved indirectly in stabilizing the body. The nervous system has a considerable role in the development of strength and this can be optimized through training and practice.

**Types of Muscular Contraction**

The term contraction is applied to a muscle whenever it is stimulated and consumes energy in developing a force. Rather confusingly, the muscle does not necessarily become shorter in the process. The type of contraction where shortening does occur is known as concentric contraction. Sometimes
a muscle contracts but is unable to overcome a greater opposing force and the muscle gets longer. This type of contraction is termed eccentric. It is frequently used to resist the force of gravity as when an individual steps off a chair or lowers a fragile television set onto a table. Occasionally a muscle contracts against the resistance of an immovable object or meets an exactly equal opposing force. In this situation no movement occurs and the contraction is said to be isometric because the muscle does not change its length.

Isometric contraction would appear a somewhat pointless phenomenon but it is actually of great importance as the only means of providing rigidity to the body. The skeleton is a freely movable framework which is stabilized by the contraction of opposing muscles on opposite sides of joints. A heavy weight can be lifted with the arms only if the spine and leg joints are stabilized by isometric contraction. In an isometric contraction no force is wasted in overcoming inertia or tissue resistance, so that a greater force can be developed than in an isotonic contraction.

An isotonic contraction occurs if a muscle contracts while maintaining constant tension. It takes place if an isolated muscle is used to lift a weight. Isotonic contractions are rate when a muscle is in position in the body even if a constant weight is raised. This is because the changing length of lever arms varies the resistance applied to the muscle. Although the weight of the barbell does not change during the course of a lift, the changing length of lever arms means that the force applied to the muscle does vary. The exercise is not truly isotonic, and the muscle is not developing maximum tension throughout its whole range of movement.

**Endurance**

In everyday language the term endurance is used to describe the durability of an object or an individual's ability to tolerate circumstances that are less than pleasant. In sport it is usually used in the context of the ability to
sustain some form of physical activity. This implies that the athlete operates like many mechanical engines which are able to develop maximum power until they finally break down or run out of fuel. In the case of the human machine the situation is less straightforward. The power that can be developed depends upon the duration of the activity. This becomes apparent when the relationship between race length and running speed is examined. There is no particular achievement in being able to run continuously for four minutes, but it is very much harder to do so at a pace which results in a mile being covered. Superficially this may appear to be a matter of speed rather than endurance, but in fact endurance is very much involved. A minute mile requires a speed of 6.7 meters per second. It is relatively easy to maintain this pace over 100 meters – the distance would be covered in about 15 seconds, 50 per cent slower than the current record. A successful miler must maintain this speed for almost 4 minutes which requires the development of half a horsepower over this period. While it is easy to work at this rate for a few seconds, very few individuals can develop such power over a period of several minutes. Endurance thus amounts to more than the ability to continue physical activity; it involves continuing to work at a rate that is high in relation to the duration.

**Energy sources**

Maximum power output varies with duration because different energy sources are involved. Some provide power at a high rate but are quickly exhausted; others last for much longer but are capable of supporting only a low work rate. There are similarities with a space vehicle that is powered by a multistage rocket. The size of each energy source is inversely related to the maximum rate of power output. High energy phosphate compounds provide energy at the greatest rate but the total amount available is so small that exhaustion occurs in a few seconds. At the other end of the scale the body can have vast stores of fat but the rate of utilization of this fuel is so low that it is normally used as an energy source only during light or moderate activity. Endurance is primarily about the ability to generate energy at an appropriately
high rate. The biological mechanism by which this occurs is considered as follows:

**Energy for muscular contraction**

All the energy used by the human is obtained from foodstuffs, carbohydrates being the most important type. Glucose is one of the simplest carbohydrates. It is compound of carbon, hydrogen and oxygen that has a great deal of energy locked into the chemical bonds holding the atoms together. This energy was obtained from the sun during the process of photosynthesis. When glucose is combined with oxygen it is converted back into carbon dioxide and water and the energy in the chemical bonds is released, sometimes as heat, occasionally in a form that can be used to produce muscular contraction. The energy available is known as the free energy. In the case of glucose this amounts to approximately 400 kcal per 100 g, about the amount used during one hour of moderately heavy physical activity. If glucose is burnt it is converted into carbon dioxide and water and all the energy is released as heat. It cannot be converted into muscular work and in order to provide energy in a useful form the body allows the reaction to proceed in a series of steps. A small amount of energy is released during each step and is transferred to other chemicals that are used during the contraction of muscle. The most important of these is adenosine triphosphate (ATP). The step-wise process occurs due to the intervention of other chemicals known as enzymes. These play a vital role in the regulation of all aspects of body chemistry and several aspects of physical fitness.

The rate of a particular chemical reaction is often influenced by the concentration of the principle enzyme involved. This has implications for physical activity because a higher concentration of a key enzyme may allow energy to be produced at a faster rate. In many cases it has been shown that athletes have a higher concentrations of these enzymes than non-athletes. For example, Costill et al., (1976a) found that successful runners had about three times the concentration of succinate dehydrogenase in their leg muscles
as untrained subjects. This enzyme is involved in the citric acid cycle and an increase in concentration would be expected to benefit performance in middle and long distance running. It has also been shown that an increase in enzyme concentrations is one of the effects of training. For example, Thorstensson et al., (1975) demonstrated a 36 per cent increase in creatin phosphokinase an enzyme involved in the release of energy from creatin phosphate after sprint training.

Long term endurance

Some sports involve a prolonged period of physical activity- long distance running, canoeing, skiing and cycling are examples. In such activities endurance can be influenced by one or more of a large number of different factors. The more important include: the supply of nutrients, cardiovascular function, the ability to regulate body temperature, water and electrolyte loss, tissue breakdown and injury, resistance to fatigue.

Fuel supply: during prolonged physical activity the stores of muscle glycogen become exhausted and energy is obtained from other fuels supplied via the bloodstream. These include glucose obtained from glycogen that is stored in the liver, fats, and chemicals derived from the breakdown of protein. The release of these substances is controlled by a complex series of hormones that match the supply of fuel to the demands of the muscles. The system is not yet fully understood but it appears that training leads to changes in the hormonal balance during exercise. Diet has an important influence on the availability of fuels.

Cardiovascular Function: During prolonged exercise there is a gradual decline in the subject's stroke volume and a corresponding increase in heart rate. It is not known for certain whether this is due to fatigue of the heart muscle, or to other causes. Maher et al., (1978) suggest that it is probably due to changes occurring in the circulation which lead to a pooling of blood and a decrease in the venous return to the heart.
**Temperature regulation:** Physical activity leads to a massive generation of heat. When working hard an athlete produces about as much heat as a one bar electric fire. If steps were not taken to secure the removal of this heat a fatal rise in body temperature would rapidly occur. One of the constraints upon long term endurance is the ability to maintain body temperature at a normal level.

### 1.5 Statement of the Problem

The fundamental aim of plyometrics is to decrease the ground contact time that an athlete expends when running or jumping. This time reduces as the sprinter gets stronger, and practices the skills of their game. Further, vertical jump performance and leg muscle strength are key factors for successful sprinting performance (Canavan and Vescovi, 2004; Potteiger et al., 1999; Bobbert, 1990). Additionally it is important for carrying out daily routines and everyday jobs (kraemer et al., 2001). In fact, the capacity of muscles to accumulate and return elastic energy efficiently is significant in activities that involve the stretch-shorten cycle (Komi, 2000). A stretch shortening cycle means eccentric contraction of muscle followed by concentric contraction. This contraction and relaxation of muscles provide muscular force (Auro and Komi, 1986; Cavagna, Dusman and Margaria, 1968; Asmussen, and Bonde-peterson, 1974).

Given the general importance in athletic performance, and in assessment of human muscle power capabilities, as well as general popularity of plyometric training among coaches and athletes, it would be of both scientific and practical relevance to determine a precise estimate of the effect of plyometric training followed by yoga training on sprinting ability. Hence, researcher has undertaken this study entitled **"Effects of yoga and plyometric training on physical fitness and performance of sprinters"**.
1.6 Problem and its Relevance

Plyometric exercises are used by athletes in all types of sports to increase strength and explosiveness (Chu, 1998). Plyometrics exercise comprise of a quick stretching of a muscle (eccentric action) immediately followed by a concentric or shortening action of the same muscle and connective tissue (Baechle and Earle, 2000). Athlete’s explosive leg power and muscular strength plays a major role in success in many sports. Additionally, Yessia and Haltfield (1986) reported that in track and field events the athlete has to use strength or power as speedily and forcefully as possible. Nevertheless, previous research reports suggest that plyometric training can improve muscular power (SaezSaez de Villarreal et al., 2008; McClenton et al., 2008; Gehri et al., 1998). Further, previous studies (Blattner and Noble, 1979; Brown, Mayhew, and Boleach, 1986; Ford, et al., 1983) indicate that plyometric exercises increase jumping ability and improve the ability of muscles to return elastic energy.

Further, breathing pattern can impact on performance in athletes; therefore, athletes need to develop correct breathing practices and this can be achieved through yogic breathing (Pranayama). Further, it has been perceived that deep breathing decreases performance anxiety and improves concentration. The correct breathing techniques are presented in yogic texts and can benefit athletes in improving their skills.

Despite the benefits of yoga practices little or no scientific literature is available in case of sprinting performance. Hence, the researcher has planned this study to see the effect of conventional plyometric training followed by yoga practices among sprinters.
1.7 Objectives of the Study

- To examine the selected fitness parameters and sprinting performance of athletes.
- To prepare separate training schedules of “plyometric exercises”, “yoga practices” and “yoga plus plyometrics” considering the enhancement in the selected fitness variables and sprinting performance.
- To conduct a controlled experiment for evaluating the efficacy of the newly designed training programmes on the selected variables so as to exhibit top sprinting performance in athletics.

1.8 Hypotheses

On the basis of literature available, so far, it is hypothesized that:

\( H_1 \): The selected plyometric training would be beneficial to improve the physical fitness and sprinting performance.

\( H_2 \): The selected yoga training would be beneficial to improve the physical fitness and sprinting performance.

\( H_0 \): The stimulus of selected plyometric plus yoga training programme may not be effective in improving specific physical fitness and sprinting ability of the athletes.

1.9 Significance of the Study

- The study may bring an excellent result showing improvement in selected components of physical fitness suitable for sprinters as well as improvement in sprinting performance of the sample athletes.
• The newly designed training schedule of plyometric and yoga training, as a result of this study, may be beneficial for the Indian athletes participating in national and international competitions.

1.10 Delimitation of the Study

The present investigation was delimited to the school level male elite athletes aged 14 to 18 years.

• Eight major variables considering physical fitness, and four sprinting events as mentioned in the methods were delimited for measurements.

1.11 Scope and Limitations of the Study

The study has very wide scope towards helping research scholars, sport scientists, and scientists of physical education to conduct similar studies. However, this study could not include athletes of other long distance runners or the athletes of field events like jumping and throwing events. Although psychological aspects of sprinters are to be an important part, the present study could not include the same.

1.12 Operational Definitions of the Terms

Sprinting

Sprinting is included in track and field events. Sprints are nothing but short distance running events.

Yoga

Yoga is a system that benefits the body, mind and spirit by teaching self-control. It is a series of postures and exercise through breathing, relaxation and mediation.
Yoga is an efficient method of toning muscles and vital organs is the ideal method of ensuring good health and Fitness. It brings a state of homeostasis, which leads towards a well-balanced personality. The major techniques of Hathayoga are Asanas (Body postures) Pranayama (Breath Control), Bandha (Physiological Locks), Kriyas (Cleansing Process) and Mudra (Gestures).

The ultimate goal of yoga is self-realization so that each individual can attain his or her complete physical, emotional, mental and spiritual potential.

**Plyometrics**

Plyometric training is known to be an powerful form of exercise that needs maximal efforts to create the physiological change associated with elite athletic performance.