CHAPTER- I

INTRODUCTION

1.1 THEORETICAL ORIENTATION OF THE PROBLEM

‘Oh Sport, You are Peace!’

Exclaimed, Pierre de Coubertin, the founder of Modern Olympic Games.

Plato in his work “The Republic” wrote, ‘No education is worth anything unless music and gymnastics form a part of it’.

Sports can be generally defined as activities involving physical exertion and skill which are governed by a set of rules or customs and participated in by individuals as a means of recreation or competition. The first sports most likely involved fishing or hunting for survival purposes or presentations of strength and agility to show physical superiority. Sport seems to involve basic human skills being developed and exercised for their own sake, in parallel with being exercised for their usefulness. The practice of sports teaches respect for rules, tolerance and solidarity, helps to develop the body and the spirit and gives joy, pride and feeling of well being. One of the most popular and oldest games of the Olympics is Gymnastics. It has
been a part of the games since ancient times. The sport traces its origins to Greece where athletes received physical training in a special arena, in addition to many other disciplines including the arts, philosophy and literature

Gymnastics has gained popularity all over the world. It has been defined differently in different periods by many persons. The word ‘Gymnastics’ has been derived from Greek word ‘Gymnos’ meaning naked art. In ancient Greece the word gymnastics was to denote the exercise done with naked body. All the exercises performed unclothed, whether it was running or throwing were known as ‘Gymnastics’. So there is no wonder if gymnastics is considered to be the basis for all kinds of sports or known as a ‘Mother of all sports’. Gymnastics changed its definition in 18th and 19th century. During this period the word ‘Gymnastics’ meant the exercises performed on apparatus and free hand exercises done to develop physical and mental strength. In those days, apparatus like benches, beam, jumping pits, ladders, ropes, weight lifting sets, dumbbells etc. were used to perform gymnastic exercises. Gradually the word ‘gymnastics’ went on condensing its definition and scope. The combination of physical skill, body mechanics and artistic expression is what we call gymnastics a sporting activity that gives great enjoyment
and satisfaction not only to the spectators but also to the
gymnast.

Gymnastics is one of the purest of all sporting activities,
proving the human body capable of movements and forms of the
greatest beauty. In her / his actions, the gymnast expresses
rhythms, shapes that are the basis of music, art and
architecture. When we watch a successful gymnast, it is as
though we are seeing the true function of the human frame.
Gymnastics is the closest sport of human perfection – the
ultimate in human performance. It is an exciting and beautiful
sport. It not only demands physical courage but grace and
mastery of the body as well.

Over the past 100 years gymnastics has made colossal
strides (Classes, 2006). It has emerged as one of the most
popular sports to watch both on television and live in the arena.
Perhaps more than any other sport it contains many of those
qualities which we most admire in human activity: strength,
grace, courage, skill and excitement. As a sport it is the supreme
test of ability. At the highest level of competition (Olympic Games
or the world championships) the difficulty of performance makes
all other sports look easy. In the training hall it is a sport which
like no other, offers an unlimited range of activities to learn.
Each simple skill is a building block which helps the gymnast to construct complex movements. Gymnastics exhibits the full range of the body’s physical potential and these qualities must be combined with strong mental preparation, expression and a sense of artistry. Of all the sports, none expresses the beauty of the human form as perfectly as gymnastics.

A perfect fusion of athletics and aesthetics, gymnasts ranks among the defining sports of the Olympic Games. Mixing strength and ability with style and grace, the high-flying acrobats have provided many of the most breath taking Olympic spectacles of the past quarter - century. Nadia Comaneci’s perfect 10 score at the 1976 Montreal Games, the first ever awarded, remains the high-water mark for most gymnastics fans. Gymnastics is highly skilled sport in which performance of the gymnast is evaluated on the basis of technique and difficulty of the skill. The exercises in gymnastics are so technically complex and often executed at such speed that the move is completed before its full impact has been registered on audience (Engel et al, 1980).

The participation of women in sports has been controversial for many years. Earlier they were not allowed to participate in sports; even they were not allowed to watch the
ancient Olympic Games. The main hurdle in the participation of women in various sports had been cultural pressures and a fear of great muscular development causing lack of femininity. There is no activity in sports that women are actually unable to tackle, even including boxing and wrestling. There are no medical or physiological reasons that can or should prevent women from doing any sportive activity (Ferris, 1979). Weight-lifting for women was included in 1989 Asian Games for the first time. In fact studies show that females respond to exercises and to strenuous training in much the same way as do men (Roskamm, 1967; Kilbom, 1971; Edwards, 1974; Flint et al., 1974; Cunningham and Hill, 1975). For many years, the thought of women competing in Olympic Games was totally unacceptable. Pierre de Coubertin, the founder of the modern Olympic Games, fought against women's participation in Olympic Games. He claimed that women's sports may be against the 'laws of nature', and he tried to expel all women from the Olympic Games (Mayer, 1960). However, women participated in Olympic Games in 1900 held at Paris, where tennis and golf competitions were included. Female gymnasts participated in 1928 Olympic Games held at Amsterdam where the Dutch team won the gold medal. Gradually, more and more women took part in gymnastics. The USSR gymnasts took part in 1952 Olympic Games held at
Helsinki for the first time. The performances of the Soviet women gymnasts were outstanding and marked a big turning point in the history of women's gymnastics (Brian, 1980). During the 1970's, the world saw an explosion of interest in gymnastics. In the United States and in many western countries gymnastics became one of the fastest growing sports.

In the world of sport, women’s artistic gymnastics is an anomaly. Women artistic gymnastics consist of variety of skills on four apparatus i.e. vaulting table, uneven-parallel bars, balancing beam and floor exercises. Female artistic gymnasts are reported to be a special group in respect of biological development and performance characteristics when compared with female or male athletes representing some other sports events. Women Gymnastics is an unusual blend of sport and art, acrobatics and dance, stiffness and suppleness, flying and crawling, maturity and youth. To its credit, gymnastics has drawn enormous attention from the lay press and from scientists and physicians seeking to understand the sport (Ryan, 1995 and Malina et al, 2006).

The old records of the performance are being broken and new records are being established. Medals are won with a slight margin in performance. In competitive sports every factor has its
own bearing on the performance of the player. There are wide varieties of factors that determine athlete’s success: genetics, morphology, mental attitude, motor abilities, physiological abilities, desire, access to training and often money (Sherman et al, 1996; Gualdi and Zaccagni, 2001; Kaur et al, 2002; Kawashrma et al, 2003; Jain, 2004; Slater et al, 2005; Monika and Kalpana, 2005 and Nataraj and Kumar, 2006).

1.1.1 MORPHOLOGICAL PROFILES

Morphology is the scientific study of forms of living organisms. It is well known fact that sports performance is mainly determined by constitutional factors. Morphological profile of an individual is determined in terms of size and shape. Individuals who are gifted with specific physique required for a particular game generally excel. The components of physique such as size, body fat and lean body mass have been shown to effect physical performance capacity (Tanner, 1964; Eiben, 1972; Sodhi, 1976; Carter, 1982; Grewal, 1983; Huygens et al, 2002; Kaur et al, 2002; Jain, 2004; Gabbett and Geogieff, 2007 and Malousaris et al, 2008). The particular body size, shape and proportion may constitute important pre-requisites for successful participation in many sports. These traits should be considered in judging an individual’s potentialities for
participation in physical activities of different types. The basic structure must be present for the possibility of being an athlete to arise; lack of proper physique may make it almost impossible for an athlete to reach that degree of success (Tanner, 1964). No coach would attempt to make a champion out of any body; no amount of training will transform a thick set, round bellied individual into a track champion (Singh, 1978). Selecting the sport activity according to the physique is helpful in raising the standard of the sport. Tanner (1964) pointed out that the players who were the best in the world had definite body characteristics, for example the hurdlers have been found to have long legs and basketball players to be taller (Cureton, 1951; Hirata 1966 and Sodhi, 1976). Female Gymnasts have been reported to be lighter and shorter with low percent of body fat than other athletes (Faria and Faria, 1989; Filare and Lac, 2002; Kalpana and Bawa, 2004; Emma et al, 2005; Thomis et al, 2005; Vicente et al, 2007 and Theophanis et al, 2009). These advantageous physical characteristics of a gymnast facilitate the efficient functioning required for the necessary dynamic and powerful movements of short duration on the various apparatus.

The human body comes in a huge array of different shapes and sizes, but specific body types tend to favour specific sports. By analyzing the build, height and mass, one can discover the
most suitable fitness activities for his body and perhaps a hidden athletic talent. Knowing your body type and adapting a routine that matches your dominant genetic predisposition also can mean the difference between fun and frustration. Tendency to accumulate fat can be a severe disadvantage for a long distance runner, but not for a swimmer who must maintain body heat and buoyancy. So instead of bemoaning your build and exercising in ways that don’t suit you, celebrate your body type. Everybody has its advantages; knowing your morphological tendency is the first step toward identifying your hidden athletic aptitude.

1.1.2 SOMATOTYPING

Somatotyping is one of method of describing morphology. It is a convenient description of overall physique in terms of body shape and composition, independent of body size. It is expressed in three numbers rating that describer the body as a whole. The rating represents the evaluation of three components: endomorphy, mesomorphy and ectomorph of the physique. It is the scale that describes the degree of an individual’s fatness or leanness and an endomorph is the individual at the far end of the scale. Mesomorphy refers to the muscular-skeletal development per unit of height and ectomorphy refers to the
relative linearity of the physique, and some one at the far end of this scale will appear tall and slender (Carter, 1980). It describes a particular category of body, determined on the basis of certain physical characteristics (Bailey et al, 1982).

The technique of somatotyping as a means of assessing body shape and composition, independent of size, has been applied to the description of groups of outstanding international athletes. Somatotype studies were conducted on Olympic athletes by Tanner at the 1960 Rome Olympics, de Garay et al, at the 1968 Mexico Olympics and Carter et al, at the 1972 Munich Olympics and at 1976 Montreal Olympics. The relationship between somatotype, body composition and motor manifestation has been studied since past three decades till date (Bale, 1981; Beunuen et al, 1981; Sodhi and Sidhu, 1984; Debnath and Bawa, 2000; Kawasharma et al, 2003; Elizabeth and Francisco, 2006; Malousaris et al, 2008 and Irurtia, 2009). Each game and sport requires a particular type of physique and body composition. Any fit person can become a gymnast. It does not matter what shape or size you are, but to get to the top in the sport it is of great help to have a proportionate physique (Tanner, 1964).
Over the years the sport of gymnastics has changed drastically, in the mid 1970's Nadia Comaneci was slender and graceful, catering to the sport when rhythm, dance and grace were the criteria. Mary Lou Retton had a stockier, more powerful and strong body to accomplish the powerful dynamic skills that were required to win the 1984 U.S. championship. The present sport of gymnastics has taken the past (Nadia Comaneci and Mary Lou Retton) to create gymnast with a combination of power and grace such as Shannon Miller and Kim Zemeskial who possess petite, slender yet powerful bodies - a small body packed with power to produce the required highly technical twisting moves, and a slender look for the grace and rhythm that gymnastics now demands (Calabrese, 1985; Bale, 1994 and Claessens et al, 1999). The elite female gymnasts have a balanced meso-ectomorphic physique with a slim body low in fat, small hips with relatively short trunks and quite broad shoulders (Beunen et al, 1981; Caladrone et al, 1986; Monika and Kalpana, 2005 and Theophanis et al, 2009).

The perfect female gymnast is small and slim with a high strength to weight ratio and an even musculature. She has a narrow body to permit speedy rotation and superb balance. Over about 25 years, the shape of the elite female gymnasts has changed towards a more slender, ectomorphic build. It is
demonstrated in previous publications (Claessens et al, 1991 and Claessens et al, 1999), that average age, height and weight of elite female gymnasts in Olympic and World Championships have declined from the 1964 Olympic Games in Tokyo until the 24th World Championship, held in Rotterdam, in 1987. Because of both public and medical concerns at that time, the Federation International de Gymnastique (FIG) has introduced a rule that from 1997 a gymnast has to be minimum 16 years of age to compete in a world championship or Olympics Games. The rule was instituted with the intention of reducing the highly gymnastic training and competition pressures, both physical and emotional. However, based on the height and weight data from the World Championships in Lausanne in 1977, and the Olympic Games in Sydney in 2000 (Borms and Caine, 2003), it is demonstrated that mean height and weight still declining as compared to the World Championship in 1987, notwithstanding mean chronological age increased from 16.5 years (World Championship, Rotterdam, 1987) to about 18 years (Olympic Games, Sydney, 2000). Average height, weight of the female gymnasts participating at the Olympic Games in Sydney, 2000 was 152 cm and 43 kg as compared to World Championship in Rotterdam, 1987 (154 cm and 44 kg). There is an average decline in height and weight despite of average increase in age of about
1.5 years (Claessens et al, 2006). Compared to reference girls of same chronological age outstanding female gymnasts are remarkably small in body size. The morphological configuration of the elite female gymnast is clearly illustrated in their ecto-mesomorphic somatotype on average 1.8 – 3.7 – 3.1 (Claessens et al, 1992). Elite female gymnasts have an estimated body fat percentage of 7.1 ± 2.6% and a fat-free mass of 42.8 ± 5.1 kg. Based on the preceding, the nowadays elite female gymnast can be described by the following physical qualities: a relative small stature, a light body weight, narrow hips with relatively broad shoulders, an ecto-mesomorphic body shape, and a high body density corresponding to a relative low percentage body fat and late mature.

Sporting activities make great demands on the human physique and competitors strive to develop and strengthen those physical attributes which are most needed in their chosen sport. The selection of right body to suit a particular sport can make the difference between success and failure.

1.1.3 CARDIOVASCULAR FITNESS

Cardiovascular endurance is the most important aspect of fitness. It is the ability of the heart to provide oxygen to muscles during activity for a prolonged period of time. It is basically how
strong your heart is. The heart is the most important muscle in the human body. Another reason that cardiovascular endurance is important is because the heart controls the oxygen flow to all the muscles - meaning cardiovascular health has a direct impact on the performance, both endurance and strength wise. Without cardiovascular endurance one can not improve the rest of the fitness. Top athletes also have more efficient hearts; one thing characteristic of all elite athletes is there pumping capacity, or stroke volume. It is what gets oxygen out of the muscles. The heart rate changes during recovery is objective way of evaluating fitness status, indicated that heart rate is an important physiological variable to evaluate fitness status (Brouha, 1960 and Barnard et al, 1973).

Gymnastics is an anaerobic sport. Anaerobic means ‘without-oxygen’. Gymnasts tend to have middling levels of aerobic (with oxygen) capacity. Gymnastics performances usually last less than 90sec, but the level of intensity of the activities is too high as for long-term performance such as seen in endurance sport long duration events like the marathon. A gymnast need more endurance in the lungs and heart in order to last through the exhausting gymnastics routines. It is an “acyclic” sport which means that the same movements are not repeated over and over. One of the major benefits of gymnastics
activities is that it subjects the gymnast’s body to a wide variety of stimuli. The generally assumed superiority of aerobic training has been shown to be illusory for many areas of fitness, particularly with regard to weight loss.

However, conflicting scientific evidence were found to exist in respect of cardiovascular fitness and respiratory fitness of gymnasts. Based on the available research results, it is questioned, whether gymnastics is an activity which requires cardiovascular endurance. But the type of interval training being done by advanced gymnasts has forced the sports scientists and experts to accept the need of cardio-respiratory fitness with gymnasts at all levels. Highly trained gymnasts were found not to possess high respiratory fitness and circulatory fitness (Bosco, 1973). But according to Black and Johnson (1975), Champion gymnasts were found to possess lower heart rate and blood pressure, which is considered to be the outcome of cardiovascular fitness invoked by interval training.

The gymnasts were found to possess vital capacity and $\text{MVO}_2$ to a lower level (Monpetit, 1976). Currently, exercise heart rates exceed 190 beat x min (-1) as compared to 135 to 151 beat x min (-1) in the seventies (Jemni et al, 2001). It is conjectured
that a high level of aerobic fitness is a prerequisite even for superior performance in anaerobic sports (Aziz et al, 2000).

If a gymnast obtains cardiovascular endurance in total condition, she needs only to concentrate on technique during performance of an exercise instead of struggling through to reach the dismount (Fukushima, 1981). To meet the criteria for elite level performance, physiological demands on gymnasts are continuously increased. There is a need of cardiovascular and cardio respiratory fitness with gymnast at all level (Moffat, 1984; Walia, 1985 and Jemni, 2009).

1.1.4 MOTOR ABILITIES

Motor ability refers to the capacity of an individual that forms a foundation for performing a number of skills. The different components of motor abilities are also important factors which influence the performance of a player. In advanced countries the evaluation of physical fitness is becoming increasingly important not only to assist in the selection of the sportsmen but also for planning, control and evaluation of the training. It is well known that there is mutual, interactive relationship between human abilities development and success in particular activities.
The various components of motor abilities such as, strength, flexibility, speed, coordination, agility etc. play vital role in physical activities. Depending upon the specific type of activity in sports events, the requirements for endurance, speed/power and strength are also specific (Ikai, 1970). If all other aspects are equal, the player with better motor abilities will excel in performance. Edwards Vannie (1977), former USA women’s Olympic coach has pointed out that a prime reason for the improved performance of United States women gymnasts in the 1968 Olympic Games was their improved physical fitness. They were stronger, more flexible, more enduring and had greater agility.

Artistic gymnastics is a unique sport in terms of the physical demands (strength, speed endurance, flexibility etc.) placed on the body during training and competition. Gymnasts perform complex skills that require astonishing fitness and exceptional daring. These characteristics of gymnastics have been understood and embraced for decades within the sport. However, outside the sport physicians and scientists have been skeptical. Gymnastics is a sport that requires ever-increasing and specialized motor abilities (Bernik et al, 1983 and Haywood et al, 1986). The multi-composition and complexity of the large number of exercises in combination with the diversity of
apparatuses demand long, intensive and prolonged specialized training, on a daily basis, from the beginning of the gymnast’s career, which starts at an extremely young age. Indeed, relative international sources repeatedly stress the importance of motor capabilities, body composition and aptitudes in order to achieve high performance (Mironov and Schinkar, 1985; Bajin, 1987 and Frederick et al, 2007). To obtain the optimum results in the execution of the complicated movements which are typical in gymnastics, a right balance between muscular strength, resistance, speed and shifting body mass is required (Smith, 1989).

Studies tackling the motor system found the factors of flexibility, repetitive arm and shoulder girdle strength, explosive and repetitive trunk and leg strength to contribute favourably to successful performance of the gymnastics motor structures (Tkalcic, 1986; Faria and Faria, 1989 and Sadura, 1989).

1.1.5 STRENGTH:

Strength is the ability of the body or its segments to apply force. Muscular strength may be defined as amount of tension (kg or pound) a muscle or a group of muscle can exert. There is a very high relation of muscular strength to general health, physical fitness or capacity for activity. Without strength, there
can be no physical activity. Moreover, when muscular strength is low, all other life functions are handicapped (Cureton and Larson, 1941). High level of strength is essential for good performance in almost all sports. Its relative significance varies depending on the nature of the particular activity on all apparatus.

Gymnastics is not an easy sport and it will not be mastered quickly. In all sports there is a challenge. It may be an object which has to be moved, an object which is a target, or an object which has to be surmounted. In gymnastics the challenge is one’s own body weight. The battle is against time and gravity. A gymnast has to perform exercises against gravity and he needs more relative strength to execute complicated movements on different apparatus (Spence et al, 1980; Faria and Faria, 1989; Singh and Debnath, 1989; Muller et al, 2000). A gymnast has to lift his body against gravity by applying force through the arms. According to Johnson (1979), strength is the primary contributor and therefore fundamental to excellence in gymnastics.

Gymnasts of both sexes require both high power and high capacity energy systems and strength is one of the major redeeming characteristics of gymnastics. They demonstrate their strength by being able to move their bodies through a myriad of
positions. Their strength is high when expressed relative to their body weight. Gymnasts tend to develop their upper body strength more than many other sports. Female gymnasts have a light bodyweight but are very strong. Their strength enables them to move, support and control their body through a range of positions. Gymnasts and other athletes who must move their body weight as the primary resistance need to train for strength relative to body mass rather than absolute strength (Poliquin, 1991 and Sands et al, 1991). More than 60% of the movements performed by men and 30% of gymnastic movements performed by women gymnasts are of momentary supporting nature (Fukushima 1981). These types of movements require a definite amount of strength. In tumbling phase of floor exercises and entire take-off stage of vaulting table, one needs muscular strength for an appropriate take off. A good balance and variety of strength exercises must be worked towards each day in order to become a successful gymnast.

1.1.6 FLEXIBILITY:

Flexibility is another component which needs to be considered equally important. It may be defined as the degree to which an individual is able to move the joints of the body through their complete range of motion. Physical activities and
sports involve vigorous movements, the joints and muscles need a tremendous amount of flexibility to facilitate efficient and desired movements. Diving, hurdling, modern dance require great flexibility in certain body region in order to demonstrate good form, however, a gymnast requires sufficient flexibility in all parts of the body to perform movements accurately. There are many exercises such as split sitting, leaps, walkovers, etc. which depends purely on flexibility. Fukushima (1980) described the flexibility as an important aspect in gymnastics and further stated that flexibility must be accompanied by muscular strength around such joints as the shoulders, hips, wrists and ankles. The ability to hyper extends and flex of shoulders and hips is an essential requirement for learning many gymnastics skills. Suppleness in all joints i.e. legs, particularly in the hips and shoulder region is essential to achieve the maximum possible range of movement.

Gymnastics emphasizes flexibility due to the need for gymnasts to adopt certain specific positions in order to perform skills. Clearly, because the rules of assessment in gymnastics performance, call for deductions when a gymnast can not achieve a specific position. A high degree of total body flexibility is desirable and unusual amount of flexibility in certain body movements is necessary for maintenance of correct form in
gymnastics (Jenson and Fisher, 1979). Both genders display a large degree of mobility and flexibility in their joints (Haywood et al, 1986).

Flexibility also allows doing different skills and their progressions with greater ease, giving as faster results through training. For example to advance from the advanced tuck planche position to the full planche position, one usually goes through the "straddle planche". That involves holding the full planche position with spread legs, to increase leverage and making the hold easier. With more flexibility, one can more easily and further spread her legs, resulting in a faster progression. Someone, without much flexibility in the legs and hips will have a harder time strengthening the straddle planache due to the reduced control over the amount of leverage she has. Strength through the whole range of flexibility is often important in gymnastics. Even if a gymnast is able to kick the leg to a 180 degree split to the back does not mean he is strong enough at that degree of flexibility to hold the leg at 180 degree separation in a scale. The judges will take special notice of gymnasts who have 180 degree plus split leaps and jumps, even though 180 degrees (or less in compulsories) is all that is usually required.
Flexibility is commonly accepted as an important component in reducing the potential for injury and for improving performance during physical activity and sport (Baley, 1977; Hare, 1979 and Fukushima, 1981). A relationship between poor flexibility and injury has been established in various musculo tendinous units that included the Achilles tendon (Leach et al, 1981), Hamstring Tendons (Garrett et al, 1984 and Worrell, 1994).

Some misconception is there that increase flexibility affects the strength of the muscle. Research has shown that an increase in strength does not cause a decrease in flexibility. Strength does not lead to muscle boundness but contrarily it results in the improvement of flexibility (Fox, 1979). When the execution of strength exercises are done with restricted amplitude of movements, it may result in residual muscle contraction or adopted shortening, thus leading to decrease in flexibility.

Martin (1979) also recommended a favourable mixture of strength and flexibility exercises. He states that on one hand the strength training exercises have active effect on the flexibility of joints i.e. vertebral column, hip and shoulders, on the other hand too much stretching again reduce the strength of the muscles. Wilson et al (1992) reported that there is improved
rebound bench press performance after flexibility training, which may be due to reduction in the stiffness of the upper extremities. Kinser( 2008) concluded that stretching exercises greatly increase flexibility while not altering the explosive strength.

It has been proved that substantial increase in strength does not have any adverse effect on flexibility. Proper relationship between strength and flexibility are deciding factors for achieving success in all gymnastic events. The benefits of improved flexibility are the increased mechanical efficiency in movements, grace in movement and decrease the chance of various muscular injuries.

1.1.7 Speed:

Besides this, speed is an equally important component which plays a vital role in sports activity. Speed is defined as rapidity with which a movement or successive movements of the same kind may be performed (Clark, 1967). It is the capacity of an individual as a whole or any organ to move with the greatest velocity. Speed is desired in almost all sports activities, but in some sports its significance is more. In basketball, fast hand and firm movements are essential to good ball handling. In tennis, badminton and handball, speed is equally important. Often only a small increase in movement speed or running speed can
improve an athlete's performance. In gymnastics, many difficult exercises are performed on vaulting table. It requires good sprinting ability. Faster and smooth approach run plays a decisive role in the execution of different vaults. Speed drills are important for gymnastic events that require a run-up – most notably the vault, where energy for the take-off is transferred from the approach sprint.

Research to date has demonstrated the importance of running speed and an accurate take-off on vaulting performance (Krug et al, 1998 and Bradshaw, 2004). In addition, numerous studies have indicated that high running and take-off velocities are a prerequisite for the performance of difficult vaults (Sharma, 1992 and Takie, 2000). Takei (1988, 1990) has done considerable analysis of vaulting for both men and women with extensive models of vault performance. In spite of training emphasis on maximizing run-up speed, gymnasts probably do not require an absolute maximum running speed. More importantly, the gymnast should strive to attain the highest speed that the athlete can control. In recognizing the importance of this aspect of vaulting for the successful completion of a vault, coaches frequently advise their gymnasts to “run harder” (Bradshaw, 2004). Vaulting speeds (up to approximately 7 and 8m/sec for women and men, respectively) may be directly related
to the difficulty of vault performed (Takie, 1990). Vaulting speeds may be inversely related to the complexity of the gymnast’s pre-vaulting table movement, i.e., running speeds for Yurchenko’s are less than speeds for front handspring type of vaults. In addition, speed reduces in vaults where the gymnast’s rotation reverses in after flight—such as in the Hecht vault.

A high degree of conditional abilities facilitate the learning, practicing and mastering the technical skills in gymnastics. A gymnast needs total physical control and a whole range of attributes – strength, power, speed, suppleness, spring, agility – and these must be combined with the ability to perform with elegance, amplitude and extension. The player with the right combination of proper physique, physiological and motor abilities will obtain higher level of skill performance. Khan (1990) pointed out that the failure of Indian players in 1990 Asian Games was because the physique and fitness of most of the participants were not up to the required standards and further stated that if a person has no basic talent he can not achieve anything even with the help of top class coaches.

There is a need to put greater effort to raising the standard of gymnastics through scientific research and proper planning. Gymnastic is a technical sport and motor abilities have a strong
tie-up with performance in gymnastics. It looks essential; firstly, to enlist the needed abilities which favourably influence the performance. In view of this the investigator aims to find out through this study whether morphological, physiological and motor abilities variables have any relationship with competitive performance in gymnastics. Hence the present study has been taken.

1.2 STATEMENT OF THE PROBLEM:

The present study was designed to find out the relationship of morphological, physiological and motor abilities with performance of female gymnasts.

So the problem is stated as:

“RELATIONSHIP OF MORPHOLOGICAL, PHYSIOLOGICAL AND MOTOR ABILITIES WITH PERFORMANCE OF FEMALE GYMNASTS.”

1.3 HYPOTHESES:

The study has been conducted with the following hypotheses:

1. It was hypothesised that there would be significant relationship between morphological characteristics and performance of female gymnasts.
2. It was hypothesized that there would be significant relationship of motor abilities with performance of female gymnasts.

3. It was further hypothesized that there would be significant relationship of cardiovascular fitness with performance of female gymnasts.

4. It was also hypothesized that there would be significant correlation among the three variables i.e. morphological, cardiovascular fitness and motor abilities.

5. There would be significant differences in morphological characteristics, cardiovascular fitness and motor abilities between high performance and low performance gymnasts.

1.4 OBJECTIVES:

Present study has been conducted with the following objectives:

1. To find out the correlation of morphological variables with competitive performance of female gymnasts.

2. To observe the correlation of cardiovascular fitness with performance of female gymnasts.
3. To examine the correlation of motor abilities (strength, flexibility and speed) with performance of female gymnasts.

4. To evaluate the correlation of morphological variables with motor abilities.

5. To find out the correlation of morphological variables with cardiovascular fitness.

6. To study the correlation of cardiovascular fitness with motor abilities.

7. To establish differences in morphological variables between high performance and low performance gymnasts.

8. To study the differences in cardiovascular fitness between high performance and low performance gymnasts.

9. To discover the differences in motor abilities between high performance and low performance gymnasts.

1.5 DELIMITATIONS:

1. The study was delimited to Indian female gymnasts only.

2. The female gymnasts under investigation consist of those gymnasts who took part in All India Inter University Gymnastics Championship (2008-2009).
3. The age group of female gymnasts was in the range of 18-24 years.

4. The study was delimited to body type and body composition (morphological parameters).

5. The study was further confined to cardiovascular fitness to measure physiological characteristics.

6. The study was delimited to selected motor abilities (four strength tests, three flexibility tests and one speed test).

### 1.6 LIMITATIONS:

1. Due to the competition pressure, the gymnasts may not have given their best performance in their selected tests and hence this may be treated as a limitation of the study.

2. Sometimes, the biased judgment by few judges during the competition was considered as the limitation of the study.

### 1.7 DEFINITIONS AND EXPLANATION OF THE TERMS

**MORPHOLOGY:**

Morphology is the scientific study of forms of living organisms.
The branch of biology, that deals with the form and structure of organism without considering of function (Oxford Dictionary).

**PHYSIOLOGY:**

It is a branch of biology that deals with the functions and activities of life or of living matter (as organs, tissues, or cells) and of the physical and chemical phenomena involved.

**CARDIOVASCULAR FITNESS:**

It is the ability of the heart, blood vessels, blood and respiratory system to supply oxygen and fuel to the working muscles at a steady rate for a considerable length of time.

**BODY COMPOSITION:**

Body composition refers to the athlete’s body fat and lean body mass.

**MOTOR ABILITIES:**

The general motor ability is the ability of the individual in the elements which underline motor performance such as muscular strength, muscular power, muscular endurance, coordination, agility and balance etc (Larson, 1951).
PERFORMANCE:

Performance is actual accomplishment as distinguished from potential ability, capacity of aptitude (Good, 1959).

GYMNASTICS:

Gymnastics is a sport in which individuals perform optional and prescribed fetes which demonstrates strength, balance and body control. Gymnastics encompasses calisthenics and tumbling as well as work on apparatus (Webster’s Sport dictionary, 1976).

“Gymnastics is a sport involving the performance of sequence of movements requiring physical strength, flexibility and kin aesthetic awareness”.

STRENGTH:

It is the ability to overcome resistance or to act against resistance. The amount of tension a muscle or group of muscles can exert in a single maximum contraction. It is in fact, a product of voluntary muscle contraction caused by the neuron muscular system.
**FLEXIBILITY:**

Flexibility is defined as the range of possible movements about a joint or a sequence of joints (Barrow and Rosemary, 1939).

**SPEED:**

Speed is the capacity of moving a limb or part of the body lever system or the whole body with the greatest possible velocity (Dick, 1980).

**SOMATOTYPE:**

It is one of method of describing morphology. It is a convenient description of overall physique in terms of body shape and composition, independent of body size.

**HIGH PERFORMANCE GYMNASTS (GROUP A):**

The best 24 gymnasts in the All India Inter University Gymnastics Championship were put under Group A.

**LOW PERFORMANCE GYMNASTS (GROUP B):**

The other gymnasts who got more than 20% marks in All India Inter University Gymnastics Championship were put under Group B.
1.8 SIGNIFICANCE OF THE STUDY:

Though few studies have been conducted on Indian female gymnasts, but not a single study has been conducted on the All India Inter University level female gymnasts. This study has been chosen to fill this gap. The results of the study may lead to the understanding of the part played by morphological characteristics, cardiovascular fitness and motor abilities to achieve high performance. The study will help in improving the fitness level for better performance in gymnastics. The study will help the coaches in formulating training programmed for gymnasts according to their requirements and selection at initial stage. Gymnasts will come to know their weaknesses regarding physiological and motor abilities.