REVIEW OF LITERATURE
CHAPTER-II

REVIEW OF RELATED LITERATURE

The quest to enhance physical performance has led to very specific and multifaceted modes of training. Through constant search researchers have improved the methods and techniques used to enhance fitness levels and athletic powers.

The primary purpose of this investigation is to evaluate the level of different fitness components in relation to performance is to Indian hammer throwers. The importance of knowing more about the athletes and their athletic potential implies an organized, systematic and consistent evaluation. All evaluation procedure and means of testing should aim at objectively quantifying the athlete’s evolution, stagnation or eventual performance deterioration.

Every event boats of its own particular characteristics. These characteristics determine the structure of performance. Performance structure is the physical physiological mechanical and psychic structure of the motor action or actions done during the competition. Depending on the nature of sport qualitative and quantitative values of different selected parameters of this multidimensional process are recorded measured in order to get an idea of this process.
Sports performance depends on particular performance prerequisites and their harmonious relationship. These are personality, condition technique/coordination, tactics and constitutions condition i.e. physical fitness consists of strength speed, endurance and their complex forms is their main object of this study and analysis. Therefore the investigator in the beginning has presented the literature pertaining to physical fitness prerequisites needed for good performance in hammer throw followed by literature on training for the development of there prerequisites, their tests, test norms and studies related morphological characteristics of hammer throwers.

2.1 PHYSICAL FITNESS PREREQUISITES:

Gitts (1954) noticed that It is often possible for a man who is really too light for this event to do well at it by mastering speed, balance and technique to an extent that his more heavily built rivals might be unable to match.

Jabs (1965) advised that Speed and strength are perquisites. Sheer muscle power alone is not enough. A special kind of quick power is necessary. A good thrower must be able to apply this strength quickly and explosively. A long with strength goes weight and most world rank throwers weight at least 200-220 lean pounds.
Jabs (1965) remarked that Industriousness is another prerequisite. Many of today’s best throwers do not mean sure up to all the ideal characteristics, yet through long, hard work, they have achieved good results. Some day there will be a thrower tall but not too heavy, who will be extremely fast who will combine hard work to produce new record results.

Jabs (1965) suggested that Inconsistent and unreliable athletes is not desirable hammer prospective with possible exception.

Jabs (1965) stated that Good timing, coordination and rhythm are also prerequisites. Hammer turns are quick and one must act on reflexes. There is no time to think and respond to except during the preliminary swings.

Jabs (1965) advised that Height and long arms are highly derivable. Height and long arms help make for a longer effective hammer radius. Bear in mind that centrifugal force is a function of turning speed and the hammer radius. As a result a shorter thrower will have to turn part than his taller, longer armed competitor to throw the same distance.

Johnson (1969) rationalized that A throw the hammer thrower has strength requirements closely akin to those of the power lifter, it is very important that there are not permitted
completely to over side the concomitant development of mobility, speed, aerobic endurance.

**Ecker (1974)** stated that in hammer throwing, body mass and strength (particularly the legs, trunk and arms) are the most important contributors to increasing the speed of the hammer at release.

**Bush with weiskopf (1978)** noticed that an ideal hammer thrower is quick and very explosive. He has extremely strong legs and back. He has also supplied and well coordinated while strength is valuable.

**Sagar (1979)** remarked that too tall persons do not properly fit in this event because of the problem of the speed and coordination. An average hammer thrower in the international class may possess a weight about 100 kg and plus, but the height should be about 190 cm. The important characteristics of hammer thrower are the supplied hips and shoulders, length of arms and the measurement of the feet, which help in the proper training of the technique. Weight and strength in hammer throwing are particularly important to counteract the strong centrifugal pull of the hammer.

**Tancredo and Carter (1980)** pointed out that Speed style and, co-ordination, cowbird with a gymnastic-type application of power is the major qualities vital to this event.
**Pedomete (1981)** uttered that at present coaches are looking up youngsters who have good coordination optimum neuromuscular capacities and ability for great rotatory speed.

**Singh (1986)** stated that athletes and Coaches are becoming increasingly aware of the fact that as much as 90% of the versions for the success in sports due to mental mastery of the psychological pressure that one must deal with in competition.

**Bondartchuk (1987)** suggested that the criteria for selection are fairly tall athletes (160cm-170cm) and fast youngsters. By the later we have in mind young people who are capable of quickly rotating around the foot or the heel of the left (support) leg through push off and saving by the right leg.

### 2.2 TRAINING:

Once the physical fitness prerequisites are determined these serves as aim and objective of the training.

#### 2.2.1 SPEED:

**Gambetta (1981)** directed that when you develop training programe for your thrower, keep in mind that the timing, rhythm and graduation (build up) of the effort are important component of the throwing process. Each of these components is controlled by the athlete’s knowledge of the task at hand: from the
psychological understanding through the actual physical practice of the hammer throw.

Tschieve (1973) pointed out that special strength work in the high performance training of a thrower is directly combined with complex of the special training for each event, which emphasises speed.

According to Jarver (1977) speed is developed by rephrasing fast action in weight training, using under-weight hammers in throwing and including sprinting in the programme.

Sagar (1979) stated that the speed is built up in progression to achieve it to the maximum degree towards the third turn to transmit release velocity of 26 to 27 m/sec. to the hammer. Speed may be trained over short distances and reaction time is developed with different set of starting exercises and games.

- 20-30 M distance in sprints should be trained, especially in the competition period, through 50-60 and 80 m distances should also be trained other times with sub maximal speed.
- Tests with the stopwatch are useful means of training.
- Speed start may be given with or without gun from different positions as crouch, standing and flying action, to build up a stronger base.
- Repetition running is generally given during PP eg. 3X150 m or 2×250 m

- Special speed may be trained with slightly lighter weight hammer and full action of turning and release is performed with controlled but faster possible speed.

- Some times 6.25kg weight hammer should be trained with other Implements lighter than the hammer. A, physical component of speed is achieved via the following three avenues:

(a) **Running speed:** e.g. 6×30 m sprints or 6×40 m sprints. This type of training until should be included in the micro cycle target times taken from first foot contact following a standing start range from 3.7 sec. (top class) to 4.4 sec. (average) from 30m add, 1.1 sec. for 40 m timings

(b) **Elastic strength:** through bounding, hopping and jumping drills and short, very heavy hammer throwing, plus fast timed, weight training at 40-60 % loading.

(c) **Light hammer throwing** in which the accent is placed a speed. Hammers, which are either 0.5kg or 1.0kg lighter than the competition implement is most, appropriate to this purpose. The best time for this type of training is immediately preceding the major competition at which peak performance is planned.
Bondarchuk (1980) advised that throwing speed depends on the functional range of motion. When overly developed muscles interface with the range of motion, flexibility and speed also decreased.

2.1.2 ENDURANCE

Johnson (1969) pointed out that the nature of hammer throwing is such that during competition its aerobic endurance requirement is virtually nil. In training however the requirement is quit high in order to enable the thrower to sustain high quality work levels during long periods of training, either in lifting or in throwing. It is best developed by endurance training. Methods, involving run over 30 minutes duration. The loading can be progressed by increasing the working time of each section by 5 minutes per fortnight during the first six weeks of training.

Sagar (1979) remarked that a lot of turning is involved and technically the hammer has to be widely beaten with higher degree of torque, between lower & upper extremities both the above abilities play a vital role in the co-ordination of skill.

For general aspects, the following means are useful:
1. Hurdling, jumping exercises and medicine ball exercises to improve the strength & flexibility.
2. All types of games, particularly having rotatory movements, e.g. diving, skating, basketball and gymnastic exercises.
3. Streaking & flexibility exercises to improve the anatomical range of operation for the special aspect of these abilities, the technique of hammer turning and release may be trained under difficult set of conditions eg., rains, windy climate and different surfaces for the turning to acquire balance and smoothness.

Sagar (1979) advised that for general endurance continuous running or cross-country with slow intensity in the early preparation is often used as useful means. Interval training or fartlek forms the part of training in the middle preparation though cross-country may also be given sometimes for a change. Lot of turning exercises are also given to condition the rotational aspect of the hammer techniques.

For further increase of general endurance, through above mentioned may be used in varied forms with a comparative higher intensity, one has to turn more to the specific endurance related to the number of turns at a time or number of throws in a training unit. Training may be spread over longer sessions, i.e., numbers of hours are devoted more for all different specific means.

Competition endurance should develop to such a level so that 6-12 numbers of throws may become consistent in training and competition so far the distance is concerned.
Prabhakar (1995) remarked that in order to build up endurance for this event, apart from running and swimming use the varied weight principle in workouts. This is done by keeping this distance thrown in each training unit move or fewer constants, but varying the weight and length of hammers.

2.1.3 AGILITY, MOBILITY AND FLEXIBILITY:

Johnson (1969) stated that high levels of mobility permit optimum expression of shell and effective range of movement. It is very important to remember that by its nature repeated weight training, particularly over limited ranges is important to the hammers throw.

These areas in which the hammer thrower has special mobility requirements are:

1. Rotation of the spine (a) at shoulder level (b) at hip level.
2. Forward rotation with depression at shoulder joint.
3. Hyperextension at sacro-lumber joint.
4. Extension at hip joint.
5. Dorsi flexion and lateral rotation (or eversion) at ankle joint.

Prabhakar (1995) expressing his views on flexibility stated that there is also the need to develop a strong but flexible vertebral column and hip joint to enable a wide range of movements and body torque. Trunk rotation should be done, along with weight exercise, a part of regular training workouts
for this event all through the year. Mobility of the hips could be further developed by some of the flexibility exercises for hurdles. It could be part of the warm-up at the start of the daily workouts. Agility is often neglected by hammer throwers. Agility is particularly important as far as the legs are concerned, some long and triple jumpers exercise must be done for this purpose.

2.1.4 Strength:

Gitts (1954) suggested that strength, however, remains an all-important factor; and it is vital that the athlete should achieve the maximum strength that his natural frame will allow.

Hildreth (1962) stated that hammer men must train regularly for strength with weights and resistance exercises, but this should not be allowed to supersede training for technique. The two should progress together so that the strength acquired is channelled into the correct technique.

Johnson (1969) uttered that the hammer thrower’s strength requirements approximate most closely to those of the weight lifter. Whether they are closer to those of the Olympic lifter or the power lifter is more difficult to quantity. Those muscles, which are employed to hold postural positions, work statically. They are best developed by exercises of a static nature (isometric) or by those involving very slow muscle activity, very heavy deed lifts come into this category, as do the other lifts of
power lifting. Correspondingly those muscles involved in turning and delivering must move more explosively. This quality can only be improved by dynamic lifting.

**Johnson (1969)** stated that a selection of activities suitable for the development of the hammer thrower's static strength is must.

**Johnson (1969)** commented out that absolute or maximum strength: most of the hammer thrower's lifting should be aimed at the improvement of his absolute strength. This can best be achieved by working at loading of between 85% and 100% of maximum for 2-3 set of 1-5 repetitions. This type of strength training is physically very demanding. Only one such unit should be attempted per week while other units should be undertaken at reduced loading.

### 2.1.5 EXERCISES:

Hammer throwers need to be particularly strong in their legs, buttocks, and back. Weight training exercises should be selected accordingly. Pulling exercises, for example, are more appropriate to the event. Bench press is contraindicated for hammer throwers since excessive pectorals development restricts the extreme forward rotation of the shoulders, and thereby the hammer's radius. Lifts to strengthen the back and abdomen are
very important to the hammer thrower. More appropriate the good morning.

According to **Felton (1970)** hammer builds up about 650 pounds of centrifugal force of release if it is to travel 240 feet. Your legs must add even more force, enough force to insure that your legs and hips will drive into the next turn with sufficient force to gain substantially on the hammer and permit you to complete the next turn woof ahead of the hammer. Use your legs as your primary source of turning and throwing power. Sweep the hammer through the widest possible radius while accelerating it strongly with your entire body, not just your arms.

**Lay (1971)** rationalising about training systems asks that why is more than one system needed?
We are all individuals and therefore all react to training in different ways: we have different strength levels, different strength potentials, a different motivational force, and different lengths of levers in the body and different speeds of muscular contraction.

In the words of **Lay peter (1971)** a high calibre lifter has learned by means of deep concentration auto-suggestion if you like boarding on self hypnosis, to release the normal inhibition
that limit physical strength. Top class athletes have mastered this same mental quality.

**Ariel Grideon (1972)** recited that Isometric: In 1953, Mullar released the results of their studies on static (isometric) exercise reported that a single two-thirds maximum isometric effort for six seconds once per day resulted in a five percent gain in strength per week.

**Mayhew (1972)** suggested two methods of isometrics, both of which use weights

(i) The athlete lift a heavily loaded barbell from a support structure, moves it several inches and hold it at the new position for a few seconds.

(ii) The athlete lifts a heavily loaded barbell from a support structure, moves it from two to six inches and presses it against a restraining structure.

**Lay (1972)** pointed out there are so many reasons for weight training e.g., bulking up for the thrower, gaining specific event strength/power, gaining general strength/power. Rehabilitation after an injury and losing body weight or mass are the common ones.

**Tschiene (1973)** rationalised that at present, all aspects of high performance training in the throwing events are in the process of scientific and practical differentiation. Strength
training is especially with in this aspect of differentiation since strength training occupies the main role in the conditioning of the thrower. The process has just begun (Especially regarding the importance of weight training to pave the way for special methods of improving the specific strength of the thrower in his top performance training.)

Tschiene (1973) experimentally proved that a move-extended repetition of movements, which are already mastered and executed with only small or medium muscle strains, leads to the stabilising of a slower movement of execution, which hinders the effectiveness of maximum exertion under competitive condition.

Tschiene (1973) noticed that it is evident that in a series there is no immediate change of throwing weights as in the other throwing events. There is a reason for this. Through the frequently changing centrifugal force, as well as through a corresponding necessary power employment for turning acceleration, there is a very difficult change-over of kinetic analysers, above all the vestibular approach. Because of this, technical faults can creep in, which mainly will affect (and often damage the equilibrium of the system). This extreme rotational throw is a peculiarity of hammer throwing.
According to **Tschiene (1973)** from examinations of exercises against changing the resistance of the throwing implements, it can be concluded that the steering mechanism for securing certain dynamic neuro-muscular reaction on the frequency of resistance very both in the speed and in the power of execution. A frequent change of resistance in a 3:1 ratio (3× with a lighter implement, 1× with a heavier or a normal one) and in 2:1 ratio caters to speed in the special movements. However, it affects the power of the movements somewhat negatively. Work with a implement in a ratio of 10:5 reduces speed but increases the power value of the movement. In executing throwing movements in which there is a increase in speed, maximal exertions are necessary.

**Fotschdan (1973)** suggested that if his sight is taken away by either blind folding him or having him close his eyes, he loses confidence in his actions and become pearful of his personal space (environment). But practising the sightless task and using confidence-building techniques will help him overcome this fear allowing a "replacement sense" or kinaesthetic awareness to guide him in unfamiliar surroundings.

Emphasis is on complete and total consideration and improved training.

**Ward (1974)** advised that after the first week, the weight should be increased 5 to 10 pounds for the upper body exercises and 10 to 20 pounds for the lower body exercises. With the increase in training weight, the repetition may drop. If so, work with the increased weight until the prescribed number can be performed. When this occurs, go two more workout periods, then increase the weight again. Improvement is not forthcoming unless there is overloading.

**Ward (1974)** suggested that during the conditioning period, many repetitions and moderate weights are the order of the day (3×10). During the training period, few reps and heavy weights should be executed (4×5).

**Ward (1974)** remarked that motivation of the athletes is important in strength training. First, you must convince the athlete that he will benefit from weight training secondly, provide experiences whereby he can see his progress. By nature, weight training is self-motivational. The athlete can see changes in his muscle mass and body proportions and experiences the increase in strength. This will throw gasoline on the fire. A good motivational and training technique is to attempt maximum lifts.
about every strength or eighth workout session in the training period.
Overall level of strength fitness acquired through associated strength, building activities (i.e. gymnastics, intense cycling and running).

**Black (1976)** suggested altogether 1500-2000 repetitions can be enough to improve your strength results by 5 percent during a period of 6 months.

**Bush & Weisbopf (1978)** noticed that quick footwork during the turns, the athlete tries to build up a high rate of speed and angular velocity in the hammer.

**Bush & Weisbope (1978)** recited that the best way to develop strength is to work against resistance. Isotonic resistance because of its dynamic characteristics is considered superior to the isometric types. The specific weight, repetition and sets should be determined by the athlete's level of development.

**Steben and Samball (1978)** observed that training for this event not only requires coping with the centrifugal nature of the event through stepwise procedures and drills for torque and counterforce orientation but it also necessitates strength of training of the legs and hips to accommodate this approach. The additional need to maintain a long hammer radius, while
accelerating rotationally demands strength sufficient to control
the implement through most of the event with pulling strength
needed for the release phase.

**Wolfeira (1978)** directed that the athlete engaged in weight
training is often compelled to approach a weight session
aggressively utilising maximum explosion with each lift. Wolfe
explains that the fast, explosive move is not always that which is
most beneficial.

**Garhammer (1979)** stated that the basic consideration for
strength and power development: The development with the
competition implement takes place at a higher level of power in
the strong physical sense. This high power level can only be
developed with the help of specific exercises and specific
implements (including heavy implements). The preceding
strength-training period with heavyweights develops the
indispensable basic potential of working abilities.

**Garhammer (1979)** noticed that the body copes with the
strain of exercise in a very specific adaptation pattern, coaches
and athlete can maximise training benefits by creating workout
periodization schedules, based on the body's adaptive abilities.

**Shea (1979)** rationalised the effects of super quality
strength training on the neuromuscular system as a result of
isotonic, full-range, multiple-joint strength training, three occurs in the neuromuscular system:

1. An increase in the neuro-fibres diameters.

2. An increase in the length of the motor neurone, providing a greater synaptic area for the effective release of neurotransmitter.

3. An increase in the size of the neuromuscular junction in proportion to muscle fibre type.

4. An increase in the motor endplate area (synaptic control area of the muscle fibre) which expands in proportion to the increase in axon length in the hypertrophied muscle.

5. An increase in the number of functional synapse which allows the athlete to utilise a greater percent of the motor units in a group of synergistic muscles at any one time; by performing a dynamic strength movements over and over for a prolonged periods of time correct patterns of "nerve-reflexes" are developed in which the synapse blocks weak signals while allowing the strong ones to pass, channalise, the signal in the proper direction.

Spatial summation: (multiple fibre summation) means by which signals of increasing strength are transmitted in the nervous system by utilisation of progressively grater numbers of fibres.
Stimulus becomes more intense as the number of nerve fibres stimulated increases.

These changes dearly indicate that the neuromuscular expression of strength is greatly enhanced through a lorry range training program constructed around and emphasising the power clean, power snatch and full squat.

One should realise that speed of contraction has specific training effect on the neuromuscular system. Training at slow speeds has a definite advantage over high speed lifting for the development of maximal strength.

**Sagar (1979)** advised that maximum strength dominates to meet the demands of strong counter pull of centrifugal force during the execution of the technique in this event. The percentage for the general working of strength for hammer is:

- Maximum strength: 65% to 60%
- Explosive strength: 35% to 40%

The intensity of weight in different exercises like snatch, dean and squats has gone quit higher side in the modern strength training of a hammer thrower. Certain set of isometric exercises is also given which may suitably be combined with isometric strength for an effective development.

Writing about depth jumping **Johnson (1980)** stated that Tschiene (1973) says "the method of depth jumping is interesting
to the thrower too... they lend themselves to the development of specific leg activity. The stress height of the accelerated muscle work is for greater than it is in any other method and the strength maximum will be reached faster.

Poliquin (1988) remarked that to change the nature and form of the exercise is another way to gain strength faster while eliminating boredom. The order of recruitment of motor units is fixer for a muscle for a certain movement even if the rate of force development and the speed of contraction change. However, in the case of change in position or in the case of a multi-functional muscle accomplishing different movements.

Poliquin (1988) pointed out that eccentric training allows one to reach the highest level of muscular tension possible, which in return greatly favours the development of hypertrapplug and strength.

Poliquin (1988) studied that it has been shown many times over that different combinations of concentric and eccentric training increase strength faster than if concentric training is used alone.

Poliquin (1988) observed that one reaches his strength potential faster if methods favouring the development of muscle mass are used first to be followed afterwards by methods afterwards by methods favouring motor unit activation
enhancement (increased recruiting and firing rate of motor units, i.e. nervous system training). One must force adaptation of muscle through volume (accumulation phase) to increase the cross sectional. Once the cross-sectional is built one must improve its innervation’s through intensity (intensification phase). This form of training variety allows the elimination of physiological and psychological causes of progress stagnation caused by an overemphasised specification. In this manner strength and muscle mass can be built at higher and faster.

Poliquin (1988) pointed out that in order to force the neuro-muscular system to adapt to the training load; it is of the utmost importance to plan variations in both volume and intensity of the load.

Young (1989) advised that strength and power training must be maintained throughout the competition phase of the year, although the volume of resistance training can be kept low for maintenance purposes. I attempt to use two sessions per week for this purpose.

Young (1989) remarked that it is concluded that power development can be achieved using heavy loads as well, if not better than using a method incorporating light loads that relies an speed of bar movement providing contractions are performed as fast or explosively as possible.
**Freeman & Arne (1990)** rationalised that the hammer thrower must have overall strength, but these muscle groups should have special consideration in the power training:

**Legs**

* The extensors of the hip (the gluteus and others)
* The extensors of the knee (the femoris group)
* The planter flexors (gastrocnemius and soleus)

**Lower Body**

* The twisters of the trunk (obligius abdominis externis and internis)
* The muscle controlling the shoulder and arms (trapezius, rhomboids, deltoids, latissimus).
* The extensors of the trunk (erector spinae, quadratus, lumborum).
* The finger flexors.

**Bondarduck et. al. (1991)** suggested that the consideration of the strength-resistance-ration is most important in the learning process since best efforts can only be achieved if none of the muscles involved in the movement reach their maximum contraction potential. Earlier it was stated that the new generation of hammer throwers shows great speed and a high level of speed strength. These factors together with the
development of the velocity - rhythm structure are the focus of Petrov.

**Bondarchuk (1991)** observed that every motor skill has its own typical muscular contraction pattern, involving both dynamic strength and static strength. It is more effective to employ isometric contractions for the development of dynamic strength on the other hand is achieved by the use of overcoming and yielding contractions. Interestingly, there is no correlation between one's static and dynamic strength, particularly when rapid movements are executed. In this situation the amount of strength decreases as the speed increases.

**Judge (1992)** advised that the development of top performances requires:

* The development of the main reserves in the competition exercise through analysis of the technique and the training load of the previous years.

* Contusions for the training load for the new preparation period, planning of competitions and test performances.

* Control of the training, comparison between "actual value and set value"

**Caprara (1994)** pointed out that the smaller muscles of the leg such as the hamstring gluteus minimus and the groin
complex all play vital roles in maintaining pasture and producing rotational force.

Parbhakar (1995) remarked that unlike the short putter the hammer thrower uses his legs & lower back more than his upper body and arms. You could every say that the shoulder & arms play a comparative passive role.

2.1.6 SPECIFIC AND SPECIAL STRENGTH

Johnson Carl (1969) advised that that training which relates strength and speed to competition provides the final piece in the strength jigsaw. In the weight room this can be achieved by reducing loading to between 40% and 60% of maximum and by selecting lifts which are capable of being done explosively, e.g. jump squat or snatch and then placing most emphasis an speed.

The elastic strength component of leg strength can be improved via-hopping bounding and jumping activities of the training effects is greatest in those involving fever than three elements i.e. triple jump, three spring jump and standing long jump. Twisting depth jumps additionally develop the elastic component of the rotational abdominal musculature for hammer throwers the jump should be performed double footed. Optimum heights are between 75cms an 110cms it may take several weeks to attain these heights.
The throwing of heavy hammers, particularly shot heavy hammers can be used to impious the special & Elastic element of the throw itself. These hammers come in 8kg, 9kg, 10kg and 12kg sizes used on wines giving a 121.5cm overall length, the two larger sizes train the static strength of the back & shoulders. By removing the wires & substituting shorter ones of not more than 50cms it is possible to retain the elastic strength training effect. It is also possible to assess performance in 161b hammer. In the gymnasium 5kg medicine balls can be thrown from various standing, kneading and sitting positions to expand the range of activities which bring about improvements to the special and elastic strength components of the throw.

**Sagar (1979)** suggested the following exercises for Isometric Special Strength:

i) Iso-Chord Exercises: These are more of imitational exercises. Certain important position of turn may be fixed for a moment. Big mirror in front may be kept to get the prefect kinetic image of a position.

ii) Metal rope is fixed and the ground and release position is fixed or held for 20 repetitions with regulated recovery in between each time.
iii) Fixing the knees at varying angles for increasing by strength mint for turn and release movement against the fixed isometric bars.

iv) One can hold the bars in different forms of heave. Alternate grips may be specially used to improve the strength of specific muscles.

Isometric exercise may preferably be done at the end of the session, especially so during the preparation period or otherwise the session of the still may be done after about to hours of recovery after such sessions.

Leg Peter (1972) noticed that there are highly specific exercises designed to build massive power directly into the movement of delivery in the shot, discuss javelin and hammer. The apparatus required for simulating deliveries must be one of the following: a simple pulley system and iso-exerciser or one of the new revolutionary isokinetic exerciser. Using an overweight implement does not give the same effect. Adopt as accurately as you can the final throwing position of your event and ensure that the apparatus is set up in such a way that it resists motion in the correct angle of delivery.

Tschiene (1973) writing on effect of lighter & heavier implements stated that it has been proved experimentally (elect myographic research by Butento 1957, Datow 1962) throwing
with lighter or heavier implements. The number of working muscle bindings, their activity as well as the force and the speed of their contractions are different from those in throws with standard implements. With increasing amounts of training, throws with a single implement of heavier weight develop a special type of neuron muscular excitation. It is faster, at least for that particular weight and also aids in perfecting of a smoothly-coordinate movement for this type of excitation and for the perfecting of movement there are only optimal, not maximal relations.

According to Tschiene (1973) special strength exercises for the throwing events are of a twin character. They perfect power by utilizing an almost identical motion structure at that of the actual event and in this way they achieve stabilization of deseterity in technique.

Steben and Sambell (1978) suggested that throwing hammer of various weights on a step-down basis (heavy to sub competition weight) is a valuable specific power weight training method. This practice is particularly valuable on a concentrated basis during the later season. The heavier implements develop torso and shoulder musculature while slightly lighter hammer work develops turning speed.
According to **Shea (1979)** the all-round specific strength training is very important as a connecting link between general and specific strength training.

**Jarver (1977)** has given the following points on specific strength:

- Strength is developed by weight training exercise and throwing over-weight hammers.
- Specificity should dominate the weight exercises but a high level all-round strength must be achieved first.
- The demands for strength training are extremely high in the hammer throw because of the enormous resistance created by the centrifugal force in the throw.
- Specific strength exercises should include rotational exercises for lateral flexors and rotator muscles of the trunk.
- Exercises for all back muscles should also be emphasized.
- Leg power is in addition to weight exercises developed by using standing long jumps triple jumps and bouncing exercises employed by triple jumpers.
- For specify, varied resistance throwing using heavy than normal and lighter than normal implements employed.

The distribution of heavy, normal and lighter hammer should be adjusted according to individual strength a speed.
Sagar (1979) also suggested special strength pertaining to swings and Turns:

1) Heavier weight of Hammer: It is use to such an extent that it can support the coordinated movements during turns. Always begin with the normal weight before shifting to heavier weights. Sometimes 4 turns can also be tried. 30 minutes or training is sufficient in the circle to control the three turns in an effective manner. Length of the wire could be 1.25m., i) Two swing one-turn, ii) Two swings two turns than three turns.

2) Shorter wire makes the turning difficult as the double support phase is shortened. So a reverse adaptation has to be made in this case.

3) Another special strength exercise is done by performing footwork of the turns with the barbell placed on the shoulders. Two people must be on the side to stop the barbell after the completion of the turn. Resistance is given to fix for a few seconds and again the turn is continued till the next stoppage. Thus, partial isometric resistance is given under normal pressure. It may be done 5×4 sets. i.e. 20 items altogether at a time.

4) Turns can be performed using single arm hold for hammer.
5) Turns with normal hammer may be performed with additional resistance on body in the shape of weight jacket and anklets.

He suggested special strength pertaining to total action of swings turns and release:

1. Heavier hammer up to a weight of 10kg may be used for, i)
   Two P. Swings three turns and release. One can combine the heavier hammer with the normal during the PP in the following manner: April=8kg, May=9kg, June=10kg, July=10kg, August=9kg, September=8kg.

2. There are certain exercises where turns and release are more dominant without much impact of swings as stated below.
   
   a) Turning with 7.257kg Shot and Release:- Due to shortened radius in this case, move strength is demanded to increase the velocity towards release.

   b) Another exercise of similar nature is with heavier medicine bill.

   c) Turning and release may be performed with 10kg. Special shape hammer with one meter length of solid handle just like a sledgehammer.

3. Other exercises with different implements may be done from time to time.
a) Full action of swings turns and release with the kettle bells.

b) Use the pulley to perform release imitation to strengthen the specific muscle involved in hammer release.

c) Using the weights or barbells in a heave action to strengthen the release part.

4. There are a few other set of exercises in which special strength is involved more skillfully.

a) Turn & release with the dumbbells and weight plates may be applied as variations.

b) Turning in front of the mirror with heavy sand bag placed on the shoulders.

c) Turning and release of heavier steel rods.

Sagar (1979) has given the following suggestions on means of special strength:

Special Strength pertaining to preliminary swings: -

1. Swings with Kettle bells and sand bags where the weight is heavier than the normal weights of hammer e.g. 10kg.

2. Heavy weight hammer up to 15kg with a longer wire provides a greater radius of motion in counteraction of hip during preliminary swings. Once a week, in preparation period may be done in the following pattern: - April=10kg,
May-June = 12.5 kg, July-August = 15 kg, September = 10 kg. Sometimes hammer with short-wire may also be taken up.

3. Preliminary swings with double-hammer can be had if heavy weight hammer is not available. It provides a means of variation.

Caprara (1994) has given the following examples of exercises, which will specifically strengthen the muscle group:

1. Single Leg Step up.
2. Walking Side Lunge.
3. Squat Rotation.
4. Front Squat (Below Parallel).
5. Snatch Squat.
6. Parallel to Bottom Squats.
7. Straight Leg Deadlifts.

2.1.7 GENERAL WEIGHT TRAINING FOR HAMMER THROWERS.

According to Bosen (1972) some of the more important barbell exercises for hammer throw are as follows:

I. Heavy dead lift with bent knees, vigorously straightening the knees and trunk, arms relaxed, using a reverse grip.
II. Two hand press with trunk twisting.
III. Bent forward rowing with a bar bell.
IV. Trunk twisting with bar bell on shoulder.
Davis (1973) suggested the following things should be kept in mind developing training programme:

1) The program should be carried out three days per week.
2) The basic exercises involving the larger muscle groups are the best for overall development of strength.
3) Cardio-vascular training is needed to a certain extent along with heavy weight training and skill practice.
4) The best days to practice the skill in yours event are during the days you train with the weights.
5) The weight training program should be modified at least once every six weeks.
6) The weight program should not be done in the morning or in the evening.
7) During the heavy training day, throwing should be done before the weight training.
8) For the best results in ultimate power and strength for explosive type movements the repetition should be low.
9) For best results, complete concentration on the life is necessary.

Steben & Sambell (1978) advised generally, strength workouts may be undertaken two or three times a week with muscle groups that require it particularly the legs, power-
training concepts should be reserved for the arms and shoulders.

**A. Hip, knee and ankle exercises**

**B. Exercises for torque & rotational requirements of the hip**

**C. Torso or trunk exercises**

**D. Total exercises**

**E. Shoulder, arm and wrist exercises**

### 2.1.8 SUITABLE EXERCISES FOR STRENGTH

Tancred & Carter (1980) remarked that the squat may possible be regarded the most vital strength training exercise for hammer throwing, when one considers that the complete technique (apart from delivery) is performed in a semi squatting position.

**Bent-over rowing:** although the arms remain straight throw out the hammer throwing technique, there is a great deal of need for
strength in the middle and upper back, which this exercise superbly provides.

**Dead lift:** the object of this exercise is to lift the weight by straightening into an upright position while maintain straight arms.

**Hyperextensions:** this exercise is ideal for strengthening the back and is preferable to the dead lift. The stronger athlete may clasp a weight against the back of his head. This exercise may be varied by turning the trunk alternatively to left and right as the upper body is being raised.

**Example of supplementary exercises:**

According to Bosen *(1972)* some of the more important barbell exercises for hammer throw are as follows:

I. Heavy dead lift with bent knees, vigorously straightening the knees and trunk, arms relaxed, using a reverse grip.

II. Two hand press with trunk twisting.

III. Bent forward rowing with a bar bell

IV. Trunk twisting with bar bell on shoulder.

**2.1.8 ADDITIONAL WEIGHT THROW:**

An additional weight throws exercise in which a 16 or 25.5kg (35 to 56lb) weight is swung to and pro several times and released with a checking motion over the release shoulder.
According to Johnson (1969) hammers suitable for 12,13 and 14-year-old beginners can easily be made from 6lb. and 7lb. shots drilled and with a spindle fitted, or from tennis balls fill.

Tschiene (1973) uttered that a remark about the weight of the heavy hammer in my option, it is not advantageous for the process of technical perfection when, at a performance level under 70.00m, several throws are made with the 10kg hammer. Then a deterioration of the technique occurs. The thrower drags the implement with his left shoulder and arm into the turn because he must set himself against the very strong hammer pull. Because of this, the very important leg and hip movements are neglected. This is main fault in hammer throwing. On the other hand, throws with 12.5kg hammer 1.00m length, 2 and sometime 3 terms are permissible.

Bush (1978) suggested following training drills:

1. **The dumbbell:** Throwing dumbbell is an excellent exercise for beginning athletes. They scam to learn the hammer technique earlier than working with hammer itself since the dumbbell is shorter, they have better control over it. Some effective exercises include throwing the dumbbell over the head, backward over the left shoulder and swinging it with one arm.
2. **Throwing the Shot:** Hammer throwers get good practice throwing a shot, preferably women’s shot, with both hands. With his back to the direction of the throw, the athlete swings his straight arms first to the right, than wide to the left. Arching his back, he throws the shot behind him.

3. **Swinging the sledgehammer:** - The thrower can throw a sledgehammer with a long wooden handle. He can swing it a few times in front of him, shifting his body weight from the right leg to the left one. The implement can be thrown in the same manner as the shot or the ball.

4. **Thirty-five Pound weight throw:** - The weight throw can be valuable to a hammer thrower. In the addition to developing strength & technique, this drill can be providing important indoor competition for the athlete.

5. **Six-Pound Bag hammer:** - A bag hammer has proven to be a fine training aid in teaching footwork, the turns, and release. A heavy canvas bag filled with cut-up auto fire section or old magazines can be tied on the end of a four feet nylon or orlon cord, with a plastic tube on the handle.

**Pedomonte (1986)** writing about the weight of the implement stated that American hammer coaches are debating if the use of the 35lb weight can be of help or of damage for their athletes. In the soviet Union that implement is largely used but
considered as a specific strengthening exercise and also as a technical means for learning the final phase of the throw. It is interesting to note that according to the individual characteristics, Soviet coaches use very heavy weights: 35-55-80lb. For example Yuriy Seydich during 1982, did some 4000 throw with 35lbs weight, from November to February.

According to **Pedemonate (1986)** while performing the swinging drills use light hammers of 4-5kg (8-11lb), standard implements, heavy hammers of 8-12.5kg (18-25lb), barbell discs of 10kg (22lb) and auxiliary hammers (a medicine ball in a bag with a cord and a handle).

According to **Khun (1994)** the use of different weight and different length wire hammers can be most effectively based on the hammer coefficient. The coefficient of the competition hammer that weighs 7.25kg with a 1.20m long wire is 8.7 (i.e., $7.25\text{kg} \times 1.20\text{m} = 8.7$)

To develop strength in the hammer throw the athlete should use hammers with a coefficient greater than 8.7, i.e.

- 10kg weight $\times 0.90\text{m} = 9.0$
- 8kg weight $\times 1.10\text{m} = 8.8$
- 9kg weight $\times 1.00\text{m} = 9.0$
To develop speed the athlete should use hammers with coefficients less than 8.7 i.e; 

- 5kg weight × 1.00m length=5.0
- 6.25kg weight × 1.00m length=6.25
- 7.25kg weight × 1.00m length=7.25
- 8kg weight × 1.00m length=8.0

To develop speed strength the athlete should use hammers heavier than 7.25kg with a wire shorter than 1.00 and a coefficient less than 8.7 i.e.: 

- 8kg weight × .90m length=7.2
- 9kg weight × .90m length=8.1
- 10kg weight × .60m length=6.0

The length of the wire and the weight of the implement vary according to the aims and goals of a particular training period. The main aim in winter is the development of strength followed by the development of speed strength in the pre-competition period and finally the improvement of speed in the competition period. Most common in the competition period is the employment of 6.25kg hammers with normal length wires of 7.25kg hammers with a wire length of 0.95m or 0.90m.
2.3 TESTS AND TEST NORMS:

Tschiene peter (1973) remarked that weight training and load amounts per exercise stated that one of the characteristics of today’s strength training among top-class thrower is the great weight of single exercises. Obviously a higher level of intensity has been reached, for example here are some figures from hammer throwing in which weight training most necessary.

Walter Schmi  Karl Hans Riehm  Anatoly Bondarchuk  
(71) (250’8”)  (wg)72(242’6”)  (su)72(75.88m)(248’11)  
Power clean=180kg  Clean (split)=165kg  clean=180kg  
Squat=280kg  Squat=220kg  Squat=250kg  
Snatch=137kg  Snatch=130kg  Snatch=130kg  
Dead lift=330kg  Dead lift=260kg  Dead lift=350kg  
Bench press  Bench press=125kg

Sagar (1979) suggested the following points:

(1) Important exercise which forms the tests for general strength may be power clean, snatch, special form of dead lifts and ½ squats.

(2) Tests are conducted pertaining to vertical and horizontal jumps. It forms an interesting competitive feature amonist a group of hammer throwers.

(3) Timings for 20-30m distance may be tested. Improvement may be noted from time to time.
(4) Distance for a kettle-bell may be noted from swings release and then with turns and throw.

(5) Heavy hammer tests may be conducted to check up specific strength in the following forms:

(i) Two swings one turn and throw.
(ii) Two swings two turns and throw.
(iii) Two swings three turns and throw.

The “acceleration increase” in specific strength may be noted for the purpose of analysis and future reference.

According to McGill Kevin (1984) the performance depends principally on capable technique & the physical capacity of the athlete. For a level of capable, satisfactory technique one can elaborate the models of physical characteristics corresponding to the different performances. We propose therefore the relative tables below for different throwers. In using these tests one can define the profile of an athlete by comparing him to the corresponding model of performance. One can also put in evidence the strong points and the weak points by comparing to the physical model; the use of these tests permits an evaluation of the training effects and eventually allows reorienting the coaching. The passing of these tests often brings a motivation net negligible in the course of the year.
Bondartchuk (1987) suggested that in hammer throwing the most promising athletes are those who are able to rotate quickly with a hammer of varying weight. The test for rapid rotation on the left (support) leg is considered to be the most informative and reliable.

According to Gverin (1987) we pay less attention to speed running over 30m from allow start, standing long jump or the standing two-leg jump upwards. This is because there is no direct relationship between the ability to move in a straight and in a rotating direction.

Davis (1993) writing on endurance (Fitness for weight) test stated that contrary to popular through weight training as not good as other methods to develop physical fitness. He suggests that thrower should run a minimum of five rules per week at an 8.00min. pace or better to meet minimum physical fitness standards.

Test: > Cooper suggest any type of athlete, regardless of size and weight should be able to cover 7/4 mile in 12 minutes and to be just in good shape be able to do 3/2 miles in 12 minute.

2.4 STUDIES RELATED MORPHOLOGICAL CHARACTERISTICS OF HAMMER THROWERS.

Several investigations have studied the relationship of morphological, anatomical and structural characteristics with
physiological and functional phenomena. Most of them have come to the conclusion that a certain correlation exists between the build of body and the motor capacity (Kohlrausch, 1929; Cureton, 1941; Hebbelinck). The correlation between various body measurements and the motor performance have been studied extensively (Kohlrausch, 1929; Arnold, 1931; DiGiovanna, 1943; Miller 1952; 1958; Wolanski and Pyzuk, 1972).

Amar (1920) pointed out that people of small stature were relatively strong as compared with the tall ones, and quicker because the weight decreases in proportion to the cube of the size, whereas the force decreases in proportion to the square of the size, being approximately proportional to the cross-section of the muscle. Short heavy-set people are remarkably strong and make good weight lifters, craters and heavy laborers. The “grasshopper” types with relatively long legs (particularly forelegs) make good jumpers, runners, valuators, hurdlers and agility athletes.”

The components of Kinanthropometry such as size, shape, physique and body composition have been shown to affect the ability and capacity of physical performance. Studies have shown positive and significant relationships between physique and body composition with physical performance.
The first adequate data on the body size of Olympic athletes in different sports were reported by Kohlraush (1929), who measured athletes took part in 1928 Olympic games. Although statistical treatment was limited that time but still the data indicated that there were differences in body dimensions between events. Earlier to this Sargent for the first time in 1887 pointed out that athlete did run two types. He found that the sprint runners were typically light and relatively long bones with full chested bodies.

Krakower (1935) reported data on 16 high jumpers and found that the type of individual that succeeded in high jump had long legs, a short body and broad feet.

Cureton (1941) stated that in general people with long legs and long arms and relatively short trunks were physically work types in long sustained heavy work but might show great speed and endurance at high levels of athletic activity.

Cureton (1951) studied 22 track and field champion athletes of the United States and reported typical track men to the slight in skeletal framework with longer forelegs relative to thighs, and longer legs relative to the length of the trunk, but were exceedingly well-muscled. The jumpers, hurdlers and vaulters were relatively slim in skeletal build and were typically taller with longer legs and shorter trunks. The shoulder
width/bi-iliac hip width index was shown to the important for differentiating javelin throwers and gymnasts from other types of athletes. The typically throwers (including shot putters) were those with greater arm span/height and great upper arms length/forearm length. The jumpers, hurdlers and vaulters are relatively great leg length/trunk length and relatively large foreleg length/thigh length. Cureton stated." The success of athletic champions is not full explained by inherent anthropological body-type, there are great differences in performance. Developing the proper skill takes man years of patient training of the muscular system”.

Telka et. al. (1951) studied the top-ranking track and field athletes and reported the throwers to be the tallest than other athletes. The positive correlation between the relative upper limb length, relative shoulder breadth, relative chest circumference (with stature) and performance was found in sprinters.

However, the same workers (Pere et. al., 1954) again reported the top-ranking track and field athletes and related various body measurements to performance. Throwers were tallest in this materiel and they seemed also to benefit most from their heights. The correlation between the relative upper limb length (with stature) and performance was significant in throwers and long distance runners. The correlation between the
relative shoulder breadth (with stature) and performance was negative and highly significant in the case of the throwers. The correlation between the relative chest circumference (with stature) and performance was negative and highly significant in the case of sprinters and positive and significant in the case of throwers.

Correnti and Zauli (1964) and Tanner (1964) studied the track and field athletes and swimmers of Olympic Games, which were held at Rome in 1960 and were compared with the 1928 data of Kohlraush. The same general differences among events were observed and a considerable increase in size was also noted.

Tanner (1964) examined physique and body composition of Olympic athlete at Rome during 1962 and inferred that the athletes were both born and made. Further he stated the basic structure must be present for the possibility of being an athlete to arise.

The outstanding study to date on track and field competition is Tanner’s (1964) in which 137 competitors in Olympic and British Empire and commonwealth games were studied. This sample represented a little over a third of all those at Rome who had achieved the Olympic Standard. He found that only half of the somatotypes in the general population were
present in the Olympic sample, which ranged from endomesomorphs through ectomesomorphs to mesoectomorphs. There was marked difference in somatotype distribution between competitors in different events. The discus, javelin and hammer throwers and shot putter mostly ranging between 2-5-3 and 2-3-5 among the runners; there was a clear difference between sprinters and others.

In **Tanner’s (1964)** data, the high jumpers were tall men. They had the longest legs relative to the trunk of all the athletes (with the possible exception of hammer throwers). The pole-vaulters had distinctly broader shoulders in relation to trunk length than track athletes, but still their shoulders were not as broad as those of the throwers.

The throwers of discus, shot, javelin and hammer differed greatly in physique from the other athletes. As a group, they were taller and heavier, with long arms in relation to their legs. They had broader shoulders and broader hips, even for their trunk size and were somewhat fatter than the track athletes. Their proportions of legs to the trunk were similar to those of middle distance runners. The large arm bone was not seen in javelin and hammer throwers or in the sample of weight lifters.

**Hirata (1966)** studied the size and age of competitors of Olympic games held in Tokyo at 1964. Results showed
considerable differences in age, height and weight of participants in different events. He also presented a comprehensive data on the difference among countries in regard to body size of their people and suggested that countries with people whose general physique was limited to the characteristics of champions in certain events should concentrate on those events only.

**Carter (1970)** reviewed 33 British Empire games and 34 USSR outstanding Wrestlers. He found them to be high in Mesomorphy and low in Endomorphy and Ectomorphy components. He observed that USSR wrestlers showed 167.1 cm as their mean height while British wrestlers were 173 cm in their mean height. He further stated that there were 21% ectomorphic among British wrestlers while none was ectomorphic in Russian sample.

The study done by **Forbes et al. (1970)** on measurement of K40 and skinfolds of 293 boys aged 8.5 to 18 years and 179 girls aged 7.5 to 18 years has shown that at these ages males may have higher proportion of their body fat situated subcutaneously than do females.

Studies of body composition in certain sports indicated that the athletes who were very lean but heavy because of a well-developed musculature were superior in performance in
performance in certain competitive sports activities, such as Football, weight-lifting and throws (Bullen, 1971).

Malina et. al. (1971) reported data for the college-age female distance runners and concluded that they were shorter and lighter and exhibited shorter sitting height, narrow bony diameters, smaller skin folds and a lower percent fat than controls.

Malhotra et. al. (1972) studied the functional capacity and body composition of the throwers, jumpers, sprinters and the middle and long distance runners. The trackmen and jumpers were found to have a higher lean body mass with less fat content than the throwers who were tall and heavy built. The middle and long distance runner had highest and the throwers, the lowest maximum oxygen intake capacity values in term of body weight and lean body mass. Similarly, the trackmen had lowest maximum heart rate than the other groups of athletes. The jumper and thrower had stronger muscle power; however, the latter were strong in arm and shoulder muscle strength too.

Muthiah and Venketswarlu (1973) studied the Indian track and field athletes and noticed the thrower to be heavier, taller and older than other athletes. The jumpers and the hurdlers were taller and heavier than sprinters, but were shorter and lighter than thrower.
**Tcheng et. al. (1973)** made a comparative study among state finalists and average school wrestlers. The anthropometric study revealed that state finalists’ wrestlers were older, had wider diameters, small circumference and lower skinfold values than the average wrestler.

**De Garay et. al. (1974)** studied for the first time comprehensive anthropometric data on Olympic level Wrestlers. A total of 1265 subjects from various disciplines including 90 wrestlers were observed. The studied variables are differed significantly with changes in weight categories.

**De Gray et. al. (1974)** examined 1265 Olympic athletes at Mexico Olympics in 1968, from the total number of 6084 competitors and studied the apparent relationship between sports specially and physical structure of the individual. This study clearly supports, the hypothesis: (a) there is a strong relationship between structure of athlete and the specific task in which he excel and (b) Clear physical prototypes exists for optional performance at the Olympic level games. **De-Gray et al (1974)** were perhaps the first to report comprehensive anthropometrical data to Olympic women players.

**Sidhu and Wadhan (1974)** worked on throwers who were found to be heavy and tall with relatively large limb circumferences and bicondylar diameters. They had better-
developed lean tissue in the limbs associated with greater amount of fatty tissue.

**Sidhu et. al. (1975)** took the upper arm roentgenograms and some anthropometric measurements of 22 throwers and compared them with 45 normal non-athletes. The throwers were found to be significantly taller and heavier with bulkier builds of large circumferential measurements and skeletal measurements. Their lean body mass was greater than that of control sample. Roentgenogram metric assessment displayed that the constant throwing exercise had resulted in grater development of the upper arm muscles (1954; *Tanner 1964; Hirata 1966; Muthiah 1973*). In throwing events, greater weight is useful, because when the object is thrown forwards and upwards, an equal and opposite reactive force is exerted on the athlete, pushing him backwards and down. The effect of this is less if the athlete is heavier; more, if he is lighter (*Tanner, 1964*). The height in them will be of further advantage by making the flight of the implement longer before it touches the ground. While throwing the Hammer, the speed of the hammer at the moment of releases is of prime importance in determining how far it will go, and for a given angular velocity (dependant on how fast the thrower does his turn) the speed is proportional to the length of the ‘leaver’ throwing the hammer, i.e.the distance of the hammer
head from the axis of thrower; hence the desirability of long and muscular arms.

Hirata (1966, 1979) reported data in respect of the participants of Rome, Yokyo, Munich and Montreal Olympic players with respect to different game and events. Among athletes the short and middle distance runners and jumpers were, as a whole, younger, but the long distance runners and throwers were older.

Eiben (1980) studied the Hungarian female national players and reported them to be tall (174.8 cm) and heavy (64.28 kg) with proportionally long lower extremities wide trunks and muscular upper arms.

A group of top ranking hokey players has been studied by Sidhu & Sodhi (1979) to see the effect of training on subcutaneous tissue. The players were divided into three groups on the basis of estimated work load depending upon their field positions- group I being under maximum work load which is followed by group II and group III in a gradually descending order. Group I showed a substantial thinning of skin and subcutaneous tissue with training whereas group II also indicated this phenomena but of lesser magnitude. But contrarily group III had shown thickening at most of sites. The sliming is relatively more in the limbs than that in the trunk.
Roche et. al. (1981) in one of their longitudinal study on white subjects of the Fels, found BMI to be the best indicator of percentage body fat in men and girls; subscapular skinfold as the best indicator in boys; and triceps skinfold, in children and women.

Malina et. al. (1982) analysed six skinfold measurements among the athletes of Montreal Olympic Games to identify principal components of fatness and anatomical distribution of fat, i.e. fat patterning and found that fatness is more influenced by sports and inference training than is the anatomical distribution or patterning of fat on the extremities relative to the trunk.

Carter (1984) reported that evolution of physical characteristics of contemporary Olympians is influenced to a large extent by sociologically factors, cultural determinate such as dietary habits, the role of men and women and the pursuit of physical activity within culture will determine the status of Olympic athletes.

The skinfolds pattern of athletes has been studied extensively on a large data of top-level athletes (Sodhi, 1986). The skinfolds studied were biceps, triceps, subscapular, suprailliac, thigh and calf. The fat folds were found to be of greater thickness at the trunk region and thinner at limbs. In
different categories of sports men the minimum value of fat was noticed at biceps and the maximum at subscapular or suprailiac (mid axillary line) sites. It seems that in the field condition, the assessment of only subscapular and suprailiac skinfold may provide sufficient help in order to understand the degree of muscular fitness in case of sports men especially those of high performance (Sodhi, 1991).

The Investigation made by Housh et. al. (1988) to determine the yearly changes in the body composition as well as absolute and relative isokinetic forearm flexion and extension strength of high school wrestlers. The findings of this study indicated that the improved wrestling performance and the increased weight classification, which normally occurs during high school, are, in part, a function of yearly changes in body composition and muscular strength.

Pectracca & Biasioli (1990) reported that the bioelectrical impedance could correctly evaluate the body composition both in normal subjects and those of uremia. Thus, due to its reliability and simplicity, it could be largely used and not only in normal subjects but also in all the pathologies concerning body water and malnutrition.

Density and percentage of fat in the body were investigated by Petrasck et. al. (1990) in 403 females and 356 males of
Czech population. Fat values were found to increase with age, growing in females and males between the ages of 17 to 49 years from 27.1 to 35.4 and from 16.3% to 26% respectively.

**Sodhi et. al. (1991)** Suggested that the discus and hammer throwers and shot putters as well as the middle and heavy class wrestlers must reduce fat weight for better efficiency, in this connection it is also suggested that wrestlers be provided psychological counseling to avoid taking excessive amounts of animal ghee.

Body composition of North Italian athletes was studied by **Gualdi et. al. (1992)** in relation to sex, age, sports and level performance. About thickness and anatomical distribution of subcutaneous fat females showed skinfolds thicker than males. Significant differences were observed in skinfold thickness means of different sports groups. Sub scapular and forearm skinfolds were the best discriminant variables for male and females respectively. With aging body density decreased whereas fat percentage and fat free mass increased.

**Duquet et. al. (1993)** studied six children’s somatotype from their sixth to their seventeenth birthday. He plotted the changes of each components of somatotype with time and also compares the somatochart profile of children with each other. The endomorphy, Mesomorphy and Ectomorphy
component changes with increase in age from sixth year to 17 years. The endomorphy of three, mesomorphy of two and ectomorphy of four children increases from sixth to seventeenth years.

The investigation has been done by *Rajni (1994)* on twenty three top ranking Indian weightlifters belonging to three broad categories such as light class (N=8), medium class (N=10) and heavy class (N=5). Results reveal that the majority of weightlifters are overweight by 0.5 to 4.5 kg and the Indian weightlifters are found to be younger in age and heavier because of excessive fat than those Olympic level weightlifters.

*Sodhi and Rajni (1994)* investigated the physical structure of elite Indian boxers by dividing them into three broad weight categories viz light, medium and heavy. The boxers showed a gradient of increasing body measurements with the advancement of weight categories. And Indian boxers were found to possess significantly more body fat with less development mesomorphic component. But ectomorphy does not much differ from Olympic counterparts.

*Khanna et. al. (1994)* found that the Cuban boxers are taller and dit gives them advantage over the opponent during competition. The optimum requirement of developing the mesomorphic components beyond that it may not play
significant role in improving the performance. Body fat should not exceed 10%, 12%, and 15% in lower, middle and heavy weight categories respectively. The aerobic and anaerobic development of the boxers should be optimum. The most important aspect that is, recovery should be faster and the boxers should have better cardio-respiratory adaptation with technical superiority can determine the success in the competition.

Balla & Walia (1996) studied 154 infants (86 males and 68 females) born to normal healthy Punjabi parents residing in the Chandigarh and outskirts comprised the sample for the longitudinal study. The two measure of muscle mass, mid upper arm muscle circumference and corrected upper arm diameter were estimated at monthly interval from 1 month to 12 month of age. Monthly distance and velocity means for two measures of muscle mass along with their SD(s) are presented growth velocities for the two indicators of muscle mass in general depicted rapid declaration during about first half of infancy rather than the latter one where trends becomes more consistent. Male infants in general possessed higher means for muscle mass than the females. Sex differences for distance data were found to be significant from 4 to 6 months; however, gender
differences remained statistically no significant for monthly growth velocities throughout the age-range considered.

**Dkhar et. al. (1997)** studied 260 Khasi men 9143 football players; 117 ‘control’ subjects of Meghalaya, northeast reveals a general dominance of mesomorphy in both the groups with ectomorphy.

**Trippo & Klipstein-Grobusch (1998)** investigated a comprehensive analysis a body build, body composition and nutritional status. The study sample consists of 498 men and women aged from 35 to 65 years. Subjects underwent a detailed anthropometric examination in compassing thirty-one body measurements, eleven skinfolds thickness measurements, and bioelectrical impedance analysis for determination of body composition. The body composition was clearly associated with age and body build. Comparison of estimates of body fat showed considerably deviating results for skin fold thickness measurements and bioelectrical impedance analysis depending on the equations used. It was concluded that for assessment of nutritional status, body composition should be investigated taking into account body build in addition to age and sex.

**Murakani (1999)** studied the changes in body shape among Japanese women aged in their 20’s by measuring the subcutaneous fat over whole body and its circumference at
certain points. The longitudinal research clarified that the subcutaneous fat thickness tends to increase with age significantly lower parts of the trunk.

Moreno et. al. (2001) examined adolescent children of Zaragoza (Spain) were becoming centrally obese to a greater extent than predicted by their relative body weights. Two cross sectional studies were conducted in 1980 and 1985 among selected subjects and four skinfolds thicknesses (biceps, Triceps, subscapular, suprailiac) were measured and some indices of fat patterning were calculated: triceps/subscapular skinfolds (T/SS), Biceps + triceps/ subscapular + Suprailiac skinfolds (B+T/ SS+SI). As a result, a trend to a central pattern of adipose tissue distribution, especially in males and that too at the young ages (6-11 yr in males and 6-7 yr in females) was found.

Tetsuya et. al. (2001) in competitive sports, the body composition of athletes has a significant influence on the athlete's performance. In this study we analyzed the body composition of women Judo athletes. In the lighter weight categories, body fat % and LBM were lower than in the heavier weight categories, and this tendency was more marked in the higher-level athletes. The fat volume % increment was most marked in the trunk and tended to be higher in the heavier weight categories. However, the fat volume % in the legs and
head decreased at and over 78kg weight categories. The fat volume% in the arms did not change in any of the weight categories. There was no significant correlation between right or left hand grips in regard to body fat composition.

The investigation of body composition was done by Ibnaziaten et al. (2002) Monitoring of several anthropometric parameters in young handball players of various ages indicated that the physical activities was beneficial to health, promoting a decrease in fat mass and an increase in muscle mass. The findings also revealed that from the ages 10 to 14, percentage of fat mass decreases, and a changes in the distribution of subcutaneous fat is observed.

Eisenmann and Malina (2002) stated that age- and sex-associated variation in subcutaneous adipose tissue of adolescents engaged in regular endurance training is similar to trends observed in the general population of youths, although sum of six skinfolds (biceps, triceps, subscapular, suprailliac, abdomen, calf) is less. An increase in SUM6, rather than the ratio of the sum of three trunk skinfolds to the sum of three extremity skinfolds (TER), is significantly associated with an increase in low density lipoprotein cholesterol (LDL-C), triglycerides (TG) and TC: HDL in adolescent males, and a decline in high density lipoprotein cholesterol (HDL-C) and an
increase in TG in females. This study demonstrates the differential effects of gender on the pubertal development of SAT and blood lipoproteins in young distance runners and highlights the need to explore the interactions among sexual maturation, fatness, fat distribution, exercise training, and blood lipoproteins during adolescence.

The study has been conducted by Singh et. al. (2003) on 121 junior boxer ranging in age from 16 to 18 yrs. Body proportions were calculated according to formula of Ross and Wilson. The result indicated that height increases from lower weight categories to higher weight categories. The heavy and super heavy weight players possess positive z-values due to more body weight than those of phantom. The higher weight categories possess more z-values of upper arm, forearm and thigh circumference than those of phantom.

The anthropometric evaluation of Indian boxers who participated in eight different weight categories in Busan Asian games had been carried out by Singh et. al. (2003) A Comparison also had been made so as to evaluate possible structural discrepancies of the Indian boxers. The study thrown light exclusively on the on the limitations to the boxers performances due to morphological characteristics like absolute and proportional body size, body composition and somatotype.
Warner (2004) investigated that despite widespread use of skinfolds to estimate body fatness, few prediction models have been validated on females athletes to develop a skinfold model that predict fat free mass in female collegiate athletes. In these athletes fat free mass can be predicted accurately from body mass and abdominal and thigh skinfold. In conclusion, it was found that a body composition model using body weight and two skinfolds showed excellent validity for predicting fat free mass in collegiate level female athletes.

Kang et. al. (2005) investigated the national female hockey players (senior, N =19 and junior, N=40). Fifteen anthropometric measurements were taken, on each subject, using standard technique of Wiener and Lourie (1969), to demonstrate subcutaneous fat patterns, somatotype, and compared within and also with the other countries of the world. From this study it was found that height, weight and mesomorphic component of international players showed significant dominance over Indian national players and also showed significant difference of ‘t’-test values. The senior players are heavier in weight, less in height, having high % body fat, low LBM and having lesser musculo-skeletal development when compared to international players.
Kapoor et. al. (2005) showed that the high altitude adult females to be leaner and to store more fat on the trunk region as compared to females from plains, thereby pointing towards the fact that not only the quantity of fat but also the way it is distributed over the body’s surface differs among females inhabiting two contrasting environmental situations.. The present study however points towards the limitation of BMI as an index of obesity and the of BMI with the skinfold thickness would provide a better insight into the body composition of an individual. Although a clear age related redistribution of fat in favour of trunk has been found among the highlanders who have yet not reached thei mid age their pattern may provide some adaptive advantage to the delicate organs situated in the upper trunk region against the climatic status of high altitude.

Eight skinfolds were measured on males (n=130) and females (n=56) of top class runners by Arrese et. al. (2005) It was to determine skinfold value between both sexes in order to identify the association of sex and event with fatness and distribution of subcutaneous fat. The study concluded that the lower skinfold value, found in all groups of runners, may be due to their high performance. This analysis also showed that a slight excess of fat is not beneficial in order to obtain a high performance.
Investigation conducted by Kang et. al. (2005) showed the changes in fat patterns during adolescence (10-17 yrs.) among schedule cast males of Naraingarh (Haryana). Various anthropometric indices have also been calculated to assess the fat patterning in these adolescents subjects. Percent body fat was calculated by using skinfolds measurements as well as BMI. It was seen that body fat% calculated by skinfold measurements is a better measure of adiposity than that by BMI.

Legaz and Eston (2005) studied thirty top class runners to determine if the changes in specific skinfold sites induced by intense athletic conditioning over a three year period were associated with changes in running performances in high level athletes. On the basis of the findings it may conclude that the anthropometric assessment of top class athletes should include an evaluation of all skinfolds. The lower limb skinfold may be particularly useful predictor of running performance.

The additional adiposity has a negative effect on performance in homogeneous groups of elite runners. The purpose of this study was to determine weather the sum of skinfolds thickness and a specific single skinfold site were related to competitive running performance in homogeneous groups of male and female elite athletes. Biceps, triceps, subscapular, pectoral, iliac creast, abdominal, front thigh and
medial calf were taken among 184 top class runners (130 males and 54 females). The result of the study indicated that skinfold thickness in lower limb were positively associated with running time over several distances and may be a useful predictor of athletic performance.

**Roy et. al. (2006)** studied the body composition of one hundred and twenty two sportspersons, including sixty-two females, belonging to five disciplines of weight categories sports in Imphal, Manipur. This study highlighted that the male and female sportspersons are yet to develop optimal body composition, specific for their particular discipline, for success both in the national and international sports arena.

**Willy, et. al. (2006)** the purpose of this study was to assess relative total body fat and skinfold patterning in Filipino national karate and pencak silat athletes. Participants were members of the Philippine men's and women's national teams in karate (12 males, 5 females) and pencak silat (17 males and 5 females). In addition to age, the following anthropometric measurements were taken: height, body mass, triceps, subscapular, supraspinale, umbilical, anterior thigh and medial calf skinfolds. Relative total body fat was expressed as sum of six skinfolds. Sum of skinfolds and each individual skinfold were also expressed relative to Phantom height. The men had a lower
proportional triceps skinfolds (-1.72 ± 0.71 versus - 0.35 ± 0.75, p < 0.001). Collapsed over gender, the karate athletes (-2.18 ± 0.66) had a lower proportional anterior thigh skinfold than their pencak silat colleagues (-1.71 ± 0.74, p = 0.001). Differences in competition requirements between sports may account for some of the disparity in anthropometric measurements.

**Debnath and Debnath (2006)** conducted the study to differentiate the body composition and somatotype characteristics of elite sports women, in individual sports disciplines. Fat percentage, lean body mass and somatotype of each athlete were obtained by applying appropriate methods. So from the findings of the study it has been concluded that there are significant differences in fat percentage, lean body mass, somatotype characters among Indian elite female gymnasts track sprinter, long distance runner, swimmer sprinters and long distance swimmers. Indian elite female gymnasts and track sprinters have been found as balanced mesomorphic; the long distance runners as mesomorph-ectomorph; the swimming sprinters as balanced mesomorph; and the long distance swimmers have been found to possess central somatotype.

**Freednman et. al. (2007)** examined the additional information provided by skinfold thicknesses on body fatness, beyond that conveyed by BMI-for-age, among healthy 5- to 18-
years old (n = 1196). Although the body mass index (BMI, kg m \(-2\)) is widely used as a measure of adiposity, it is a measure of excess weight, rather than excess body fat. It has been suggested that skinfold thicknesses be measured among overweight children to confirm the presence of excess adiposity. Skinfold thicknesses, when used in addition to BMI-for-age, can substantially improve the estimation of body fatness, the improvement among overweight children is small.

The study of Franchini et. al. (2007) had as objectives (1) to compare the morphological and functional characteristics of the male judo players of the Brazilian Team. According to these results the main conclusions are: (1) the physical variables measured do not discriminate performance when analysis is directed to the best athletes; (2) a higher percent body fat is negatively correlated with performance in activities with body mass locomotion (Cooper test and the SJFT); (3) judo players with higher aerobic power performed better in high-intensity intermittent exercise; (4) judo players with bigger circumferences present bigger absolute maximal strength.

Malousaris et. al. (2008) studied the morphological characteristics of competitive female Volleyball players. Volleyball athletes of this study were mainly balanced endomorphs. Significant differences were found among athletes
of different playing positions, which are interpreted, by their varying role and physical demands during a volleyball game.

Investigation made by Hagmar et. al. (2008) to characterize various parameters related to weight control in Olympic competitors. It shows optimization of body weight and composition is a key priority for elite athletes striving for a competitive advantage. The weight control practices employed by Olympic athletes participating disciplines that emphasize leanness appear to be sub optimal. Counseling concerning weight control could be used as a tool to prevent illness and enhance performance.

Nevill et. al. (2008) stated cast serious doubts on the validity of BMI to represent adiposity accurately and its ability to differentiate between populations. These findings suggest a more valid (less biased) assessment of fatness will be obtained using surface anthropometry such as skinfolds taken by experienced practitioners following established procedures.