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Athletics is one of the purest of all sports (Arora, 2005). Dating back to Ancient Greeks, athletics was the original event at the first Olympics in 776 BC where the only event held was stadium length foot race or stade (Arora, 2005). Athletics, also known as track and field events or track and field athletics, is a collection of sports events that involve running, throwing and jumping. Modern athletics events are usually organized on a 400 m running track, wherein most of the sports activities, such as field events, jumping and throwing take place. The name is derived from the Greek word ‘athlos’ meaning contest (Arora, 2005). The first race of record is noted to have taken place at first Olympic Festival in Ancient Rome in 776 B.C. During those times, the Olympics remained the main stage for all the track and field events and it only displayed such events every four years. The events began to evolve over the centuries as a number of new track competitions as well as the non-track and field events were incorporated. It was not until the eighteen hundreds that the history of track and field began to formally organize as grade schools and the universities began to incorporate daily exercise and running routines. Track and field history was so evidently rooted in
Ancient Greek and Roman times that it slowly began to develop into English culture. It was said that the first college competition was held between Oxford and Cambridge in 1864. Athletics was included in the first modern Olympic which was organized at Athens (Greece) in 1896 and has formed its backbone ever since. Women were first allowed to participate in track and field events in the Olympics in 1928. Men and women did not compete against each other and the tradition is followed till present day. Women generally run the same distances as men although hurdles and steeplechase barriers are lower and the weights of the shot, discus, javelin and hammer are lesser (Arora, 2005).

Athletics in India dates back to the Vedic era. Although it is indeed a mystery that when exactly athletics in India made its presence felt as a distinct sports form; however, it can be said that the well illustrated values of the Atharva Veda contoured the limn of Indian athletics. In the Vedic age or much later in the period of Ramayana and Mahabharata athletics were typically common forms of the sports, like chariot racing, archery, horsemanship, military tactics, wrestling, weight lifting, swimming and hunting. Although, no chronological records could be found about the contemporary form of athletics games started its journey in India, it is generally said that the present day athletics started to be played in India, just after the independence of India. Till then, the
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athletics has seen many transitive phases in India. At the initial period, the Indian people used to play the track and field games in the grass and cinder tracks. After that they started to play on synthetic surface for most of the major competitions. The synthetic tracks made the organizers jobs easier as there were no needs of manual marking of tracks and associated definitions for throws and jumps in those tracks. The introduction of technology in the game of athletics improved its status further as keeping the record of player’s timing became easier with the advent of modern technology.

In India all forms of athletic events are played like running, throwing and jumping. Running consists of different event like-Sprinting, long distance running, relay races and hurdles. In throwing the events are shot put, discus, hammer and javelin throw. And jumping events consist of long jump, triple jump and high jump. The athletics can be divided into four areas; track, field, road and combined events.

Track Events

Track events as the name implies are not any single event but group of various events. It can be said that all those events for which particular and proper track is prepared are included in the track events. Track events include sprints (100m, 200m and 400m), middle-distance running (800m and 1500m), long-distance running (5000m and 10000m),
hurdling (100m and 400m for women, 110m and 400m for men), relays (4 x 100m and 4 x 400m) and the 3000m steeplechase.

Field Events

Field events, the second part of athletic event is as valuable and important as the first one. Again it can be said that field events are not any particular event but are a group of events which are being played or performed on the field. For these events, no particular track is prepared but various preparations are done on the field itself. The events of throwing and jumping are included in these events.

Throwing Events

In this part of athletics different events come like shot put, hammer throw, javelin throw and discus throw.

Jumping Events

High jump, long jump, triple jump and pole vault come under the jumping events.

The high jump is a technical event. While most people feel that the bar clearance is only important aspect of high jumping, it is not. The run-up/approach is probably the most important aspect of this event (Dapena, 1995). Using the flop high jump technique (which is really the only technique used by the jumpers in these days); the jumper runs a curved approach towards the bar. The foot on the inside of the turn will be the
take-off foot and the athlete will actually cross the bar with his back facing the bar (Tan & Yeadon, 2005).

The roots of high jump in athletics go back as far as in the ancient era. At the present time athletics is one of the most popular scenarios in Olympic Games. At the times its emergence and professionalism in the games and sports every nation want to conquer the earth with their sporting performance. That’s why every country as well as the athletes are taking the help of biomechanics expert for enhancing the performance to compete their opponent. In this modern age every athlete is using the Fosbury-flop technique at international, national even in state level competitions too (Hussain, Khan & Mohammad, 2011). This technique was introduced for the first time in Mexico City Olympic 1968 Games. Before this technique various techniques were used by the jumpers.

Richard Douglas Fosbury (born March 6, 1947) an American athlete who found the variety of techniques used at the time- such as the technique in the evolution of high jumping was the ‘scissors’, in which the legs are lifted over the bar in alternation one after the other. The scissors was followed by the ‘eastern cut-off’ technique (sometimes called the Lewden Scissors in Europe). In this technique the athlete rotates the trunk into a horizontal position at peak of the jump. This lowers the trunk and therefore lifts the pelvis higher than in the simple
scissors technique, the result higher bar clearance. A disadvantage of the Eastern cut-off is that it needs tremendous flexibility. The eastern cut-off was succeeded by the ‘western roll’ technique. In this technique the jumper cleared the bar on his side, with the take-off leg tucked under the rest of the body. This technique probably did not improve much the effectiveness of the bar clearance in relation to the Eastern cut-off (Hay, 1993). However, it also did not need much flexibility. Thus, the contribution of the Western roll was to provide a reasonably effective bar clearance for a larger number of the high jumpers. The Western roll was followed by the ‘Straddle’ technique. In this technique the jumper cleared the bar face-down, with the body stretched along the bar. The Straddle allowed parts of the legs to be lower than the bar at the peak of the jump. This allowed the pelvis to rise to a greater height in relation to the position of the center of mass (COM) and therefore, improved the effectiveness of the bar clearance. Dick Fosbury revolutionized the high jump using a back-first technique, first started experimenting with this new technique at the age of 16 years, while attending high school now known as the Fosbury-flop.

Richard Dick Fosbury’s backward twisting, revolutionary new high jump technique, used during the Olympic Games in Mexico City in USA indoor season of 1967/68, was first received in the Europe with
amazement and some suspicion. The reason for this was that the brief description of the movement of the ‘backward jump’, with the athlete ‘twisting in the air’. This attitude changed immediately when Dick Fosbury won the Olympic title and the ‘flop’ began its triumphant progress around the world. One indication of how drastically this technique affected the high jump is shown by the considerable enhancement in performance particularly for the women and the young athletes. The fact that there was not a single straddle jumper in the high jump final at the first World Athletics Championships in 1983, speaks for itself. It is, therefore, not quite the inconsistency it may first seem that Christian Schenk (GDR) on his way to Olympic victory in the decathlon in 1988 caused as much amazement as Dick Fosbury had twenty years earlier. Schenk cleared 2.27 cm using the technique which was unknown to most of the younger spectators the Straddle. This implies that, although the Straddle technique is now regarded as archaic, it has actually lost very little of its ‘performance capacity’ and its absolute replacement by the flop is not as logical as it may seem. A perfect high jump technique could be said to be one which facilitates the lifting of the jumper’s centre of gravity (C.G.) to a maximum possible height and, at the same time, permits the clearance of a bar set, ideally, at some distance above the height of the jumper’s centre of gravity (C.G.). While the first
requirement is primarily dependent on the development of the jumping power and only secondarily on the jumping technique, the second requirement appears to be exclusive result of the behavior of the body segments during the bar clearance. However, the flight trajectory of the centre of gravity (C.G.) and the rotational impulses about the three axes of the body are determined at the moment of take-off. It follows therefore, that technical descriptions which traditionally relate to the behavior of bar clearance should also include take-off action, which often varies from one athlete to another. In other words, flight behavior can only develop within the framework pre-determined by the take-off. The considerable variation in ground contact time of the Straddle take-off as compared to that of the flop alone indicates significant differences between the two techniques (Zhukov & Yufrikov, 1984, Muraki, Sakamoto, Asito & Shibukawa, 1982; Nigg, 1974).

During the recent years Fosbury-flop technique has taken the leading position by competitive high jumpers at the competitions throughout the world. This high jump technique can be divided in four phases: run-up, take-off, flight and landing (Hay, 1993). Run-up is comprised of the first part that is straight run-up, which turns into curve running of four to six steps before the take-off. The approach phase consists of a straight run-up followed by a curved section during the last
four to five steps before take-off. During this phase, the approach speed of the jumper builds up to between 6 and 8 m/s (Dapena, 1980a). Based on the past researches (Iiboshi, Ae, Yuuki, Takamatsu, Nasagawa & Tan, 1994; Bruggemann & Arampatzis, 1997), we can also compare cinematic parameters of more recent ones, where increase of horizontal speed of approach running (Isolehto, Virmavirta, Kyrolainen & Komi, 2007) is clearly visible. The purpose of such a run-up is to bring the jumper into the optimal position for take-off, which is in constancy with his speed-strength abilities (Hay, 1993). Take-off phase is defined as a period between the moment the take-off foot touches the ground at the bounce spot and the moment the foot leaves it (Arora, 2005). The take-off phase comprises the last foot ground contact during which the horizontal velocity decreases, the vertical velocity increases and the somersault momentum is generated (Dapena, 1980a,b). During the flight phase, the jumper rotates as the centre of mass (COM) rises in order to facilitate bar clearance. However, many of the characteristics of the flight phase are determined by the take-off phase and are dependent on the characteristics of the approach phase. In the early days of the Fosbury-flop, it was thought by some that the curved approach was nothing more than an idiosyncracy of Dick Fosbury (Fix, 1981). When running the curved approach, the body must lean into the curve to provide the necessary
centripetal force and so the take-off will start with the body leaning inwards. Since the body will rotate towards the bar during the take-off phase this initial orientation is advantageous, since it permits the necessary rotation during take-off without having excessive outwards lean towards the bar, as the flight phase begins (Dapena, 1980b; Ecker, 1976). Leaning inwards at the start of take-off and outwards at the end of take-off means that the body will be close to vertical throughout, so that the reaction force from the ground will be more effective in producing vertical velocity (Jacoby, 1987). A curved approach has also been thought to be beneficial in lowering the centre of mass (COM) before the take-off phase (Ae, Sakatani, Yokoi, Hashihara & Shibukawa, 1986; Heinz, 1974), as this allows the centre of mass (COM) to move through an increased vertical distance during the take-off (Dapena, 1993; Jacoby, 1986), resulting in a greater time during which to develop a large vertical impulse (Dapena, 1987; Jacoby, 1986; Wagner, 1985). To reach a horizontal orientation near the peak of the flight over the bar, the jumper needs to develop sufficient somersault angular momentum during the take-off (Dapena, 1995). This angular momentum is typically about an axis parallel to the bar (Dapena, 1980b). Several coaches have suggested that the curved approach is very useful in developing this somersaulting motion during the take-off phase (Fix, 1981; Jacoby, 1986; Paolillo,
1989) as well as during the penultimate contact phase (Heinz, 1974). Dapena (1980b) used 3-D cinematography to analyze the approach, take-off and flight phases of six Fosbury-flop jumpers and found that most of the somersault angular momentum was generated during the take-off phase. He thought that the data suggested that a curved approach might favour the production of somersault angular momentum during the take-off phase but did not speculate on mechanism. A number of researchers and coaches have described the curved section of the high jump approach as a ‘circular arc’ or even as ‘a quarter of a circle’ (Chu & Humphrey, 1981; Martin, 1982). Dapena, Ae and Iiboshi (1997) fitted an arc of a circle to four of the last five foot locations omitting the penultimate foot placement which typically lay outside this curve. Kerssenbrook (1974) analyzed Dick Fosbury’s approach and noted that the curvature increased as he approached the bar. While there is some agreement that the curved approach may aid the production of somersault rotation, the mechanism whereby this is achieved and the characterization of the approach curve are not well established. In spite of the different take-off actions of the ‘speed flop’ flight technique is equally effective as far as the economy of the bar clearance is concerned. The values measured for the difference between center of gravity (C.G.) and bar height for both the Straddle and the Flop vary between +8cm to 10cm (Kerssenbrock 1969, Nigg 1974;
Dapena 1980). Only Viitasalo (1982), in a sample of Fosbury-flop jumpers, measured ‘disadvantage’ values of up to 9cm between the highest point of the center of gravity (C.G.) and the height of the bar. It may, therefore, be stated that even today the Straddle is theoretically a genuine alternative to the power flop for some athletes. It is however, impossible to verify this hypothesis as the straddle is no longer taught.

For better mechanical understanding of Fosbury-flop high jump technique we can describe the whole technique in different parts:

**The Approach (Run-up)**

The flop approach in the High Jump consists of 8 to 12 steps, not taking into account the rather varied preliminary phase (Krejor & Popov 1986). The last three to five steps are run in the form of a curve with a radius of approximately 8 to 12 meters. It is a general principle that the higher the approach velocity (may be up to 8.73 m/s Zhukov & Yufrikov 1984) the greater the radius. The first 8-12 steps of the approach are run on a tangent which then progressively leads to the so called ‘impulse curve’. As it is possible to control the direction of the run only during the support phases, the impulse curve itself, naturally, is affected only during the support phases (Muller 1986). Dapena and Chung (1988) presented that the fast approach run can help to exert a larger vertical force to the ground. In the flight phases, the jumper’s centre of gravity (C.G.) moves
in a straight line on the chord of his approach curve. The term chord is chosen deliberately since the higher the approach velocity, the greater the inward lean of the jumper. It is supposed that, at the highest point of the flight parabola, the center of gravity (C.G.) is at the same height as the bar. An even more economic form of bar clearance (e.g. with the C.G. 5 cm below the bar height) makes a clearance of 2.45m possible without changing the data used in the model. The inward lean of the body during the curved section ‘automatically’ results in a lowering of the center of gravity (C.G.) in the direction of the centre of the curve. The degree of inward lean is dependent on the approach velocity and can be greater than 30°. The corresponding percentage lowering of the center of gravity (C.G.) is approximately 13%, in the case of a 30° lean, to 18% in the case of a 35° lean, if one converts the absolute values of 12 to 15 cm published by Beulke (1974). The maximum degree of lowering is reached during the penultimate stride. As jumpers strive to take-off with their C.G.’s as high as possible, they are forced to straighten up from their lean toward the centre of the curve. This straightening movement starts during the penultimate contact and continues during the last stride until the take-off position has been reached. The resulting ‘straightening momentum’ (Beulke, 1973; Beulke, 1974) has two important advantages which explains the reason for the curved approach of the Fosbury-flop. Firstly,
the straightening momentum continues after the take-off according to the law of conservation of momentum. Consequently, a rotational momentum about the transverse axis is available. This is absolutely necessary for an economic bar clearance without the need to dispel the energy from the take-off impulse.

Secondly, the straightening momentum runs more or less parallel to the aimed at direction of the acceleration, thus leading to a path of the preliminary acceleration directed diagonally upwards. This is essential in order to bring about the change of direction of the center of mass (COM) as smoothly and fluently as possible. Straddle jumpers have no comparable assistance. They have to perform the take-off preparation as well as the take-off itself, including the production of rotational momentum, by themselves as it were, which makes high demands on movement technique. In doing so, a reduction of the vertical proportion of the take-off velocity is inevitable.

In the Fosbury-flop approach there is a noticeable change of the ratio between the flight and the support time. Floppers tend to start the first (straight line) part of the approach with a springy, high knee action and then they switch to an increasing emphasis on the stride frequency as they get closer to the bar. In doing so, there is a reduction of the flight time relative to the support time, mainly during the last stride.
However, this trend particularly as far as the rhythm and the organization of the last three strides concerned is not universal. Some athletes shorten the last stride length of their approach in comparison with the preliminary stride, whereas others lengthen it.

**Take-off Preparation: Last approach stride**

The forceful horizontal drive of the support leg and the very fast pull-through of the other leg leads to a pronounced split which is characteristic of the last stride. In this phase, the trunk leans backwards and the arms are well behind the trunk at the reversal point of the drawback the movement in preparation for the double arm swing. The path of the center of gravity (C.G.) during this last stride is flat. The extended take-off leg does not just wait passively for the ground contact but performs a downward movement in an active and pre-stretched way. The fact that the flight time of this stride is only half as long as the flight times of the preceding phases of the approach is therefore understandable. By the time the foot of the extended, or only slightly bent, the take-off leg has been planted, the ‘backward lean before take-off’ has been acquired. The characteristic of this phase is a take-off foot position well in advance of the center of gravity (C.G.) and a backward lean of approximately 10° to 15°. There is only a slight change of the hip angle at the side of the take-off leg, in order to ensure the elastic lever function of this leg (as
related to trunk). At this moment, the arms are still held at the back and downward but they are already moving forward and upwards, as is typical of the double-arm swing. Immediately after this, the free leg performs a dynamic forward and the upward movement which is contrary to the action of the jumping leg (Tidow, 1989).

**Take-off Phase**

The take-off takes place close to the upright at the side of the free leg and around one meter away from the bar. The jumping foot is planted at an angle of approximately 30° to the plane at uprights. The speed flopper has approximately 120 to 170 milliseconds of time available for the take-off. Consequently, the pre-tensed, almost extended, take-off leg may only amortize ‘passively,’ i.e. bend only slightly in the knee joint in order to initiate the change of direction of the center of gravity (C.G.) and also to create an optimal working angle for the jumping muscles. Here, the jumper must ‘switch over’ as fast as possible from an eccentric to a concentric contraction, while his muscle tension is of the explosive reactive ballistic type.

At first, the active use of the arms and the free leg increases the pressure on the take-off leg even further. Only the subsequent locking of these parts of the body with the explosive final extension makes it possible to reduce some of load. Thus, the locking indirectly contributes
to a more effective vertical force. The double arm swing is, without question, more effective than the counter arm swing, demonstrated by the original flopper Fosbury himself, or than the single arm action (which many the floppers prefer). Firstly, the double arm swing is “neutral with regard to rotation,” i.e. it does not be against the necessary rotation about the longitudinal axis as is the case with counter arm swing (Muller, 1986; Beulke, 1973). Secondly, the height of the center of gravity (C.G.) at take-off can be significantly increased by locking the lifting movement of both arms above the shoulder height. Finally, a dynamic double arm swing is more effective with regard to transfer of momentum than the two other possibilities. These arguments also hold true for a straight free leg, as in the Straddle.

However, in contrast to the arm action, the straight leg swing never caught on. The main reason for this is that the relatively great moment of inertia makes a diagonal and fast upward swing of a straight leg (which will be called ‘diagonal upward pull’ in the following) more difficult.

It is, however, worth mentioning that 20 years of flop jumping have led to a change from the original flop. While Fosbury himself demonstrated a bent free leg action resembling that used in the long jump take-off, today almost all speed floppers show an opened free leg during the take-off. The greater than 90° angle at the knee joint can be called a
compromise which is effective only to a limited extent. The reason for this is that this angle is normally preceded by a leg swing with the lower leg brought to the buttocks. As already mentioned, this is presumably less effective. In any case, the short ground contact time and the comparatively long distance the free leg must cover, in the speed flop do not allow a ‘properly’ kicked and extended movement of this leg. On the other hand, a bent free leg does favor an increased angular velocity of this. As far as the take-off height of the CG is concerned, once again the straight free leg swing has the advantage (Strishak, 1982).

Contrary to the view of Reid (1982), it must be recognized that the diagonal upward pull mentioned above is demonstrated by Fosbury and by almost all other jumpers. The one-sided pull at the pelvis which is caused by this diagonal swing brings about a rotation about the longitudinal axis, which overlaps the already mentioned rotation about the medial axis. Therefore, in the flop, a backwards clearance of the bar has no need for rotation around the transverse axis. The take-off process is presented in three phases overlapping one another. It is particularly important that the longitudinal axis of the jumper’s body is vertically aligned at the moment of breaking contact with the ground- i.e. during the final take-off position. Here, the upright nearer to the take-off spot can be used as an ideal object of reference. The often repeated demand that, at
the moment of breaking contact with the ground the shoulder next to the bar should be at the same height as the shoulder at the inner side of the curve (Tancic, 1985), is rarely fulfilled. Fosbury shows a lift of the shoulder at the inner side of the curve. From the point of view of anticipation, this seems to be sensible in relation to the following flight towards the bar. Presumably the take-off force, which is different in each case, is responsible for this varying behavior. If the take-off force is just not great enough, the jumper intuitively ensures that it is directed slightly to the side of his CG by positioning his shoulder axis diagonally to the bar. This leads to a pronounced rotation about the medial axis. Thus, the exactly-vertical alignment of the jumper with a horizontally lifted shoulder girdle is an optimal requirement for very high jumps.

**Flight Phase or Bar Clearance**

As already mentioned, all subsequent movements of the jumper are determined by the actions made at take-off, i.e. the trajectory of the centre of gravity (C.G.) and the rotational movements are already fixed. However, by an optimal positioning of body segments and simultaneous shifting of partial masses at both sides of the bar it is, at least theoretically, possible to have the center of gravity (C.G.) ‘sail through’ below the level of the bar. The optimal configuration for this is a ‘forward bend of the trunk.’ as was postulated by Hay in the technique bearing his
name (Hay, 1973). The bar clearance position in the dive straddle fulfills the demand for a horseshoe like posture. Because of the normally considerably reduced dorsal flexibility of the lumbar spine, it is rather difficult to achieve an optimal body shape with the flop. Fosbury himself, for example, performed his jump with only a minimal hyperextension in the hip area and uninterrupted visual contact with the bar. However, even here, technical development has led to some conspicuous changes. For example, during the flight phase the lowering of the counter-arm (i.e. the arm on the opposite side of the free leg) and the resulting positioning of the arm at the side of the body is now used by very few jumpers. Although this also leads to the lowering of partial mass, so that the ‘rest of the body’ is correspondingly lifted, a reaching over the bar with the arm at the external side of the curve and its immediate lowering behind the bar as well as a trunk following this ‘guiding movement’ with a significantly overextended shoulder and lumbar section (hyperlordosis) leads to a more effective clearance. The double arm swing demonstrated here is ‘opened up’ with the arm at the side of the free leg ‘leading’ and reaching over the bar. The lowering of the free leg together with an active overextension in the area of the cervical spine allows the jumper to achieve a ‘bridge formation’ with a pronounced arc.
As the hip joint at the side of the free leg is locked or ‘held’ during the take-off as well as during the first part of the flight phase, it is essential that the free leg is lowered in order to accomplish the required overextension of this joint. Whether this is done actively or whether it is a natural reaction to the lift of the pelvis is immaterial. It remains decisive that the hip joint at the side of the free leg must be brought from a flexed position to a retro-versed position within the bar clearance phase.

However, in the case of low jumping heights and correspondingly short flight phases, an active lowering of the free leg, starting immediately after the take-off, is essential. A positive side effect of this is the reduction of the moment of inertia around the longitudinal axis during the flight phase, but, even here, it is more important that the lowering of somebody segments causes the lifting of the rest of the body. This brings the pelvis into a more favorable position.

A possible optimal alternative to this method of performing the flight phase for smaller high jumpers is discussed by (Killing, 1989). This can be interpreted as a kind of the preparatory movement introducing and facilitating the immediately following overextension. Correspondingly, within this variant, the hip area performs successive movements of extension, flexion, overextension and flexion.
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L-position Phase or Preparation for Landing

If one is to characterize the ‘flight behavior’ described and discussed so far in the chronological order, the sequence will be the rise of the whole body and opening of the arms during bar clearance and ‘overextension’ in the hip and the cervical spine area. As the rotation impulses about the medial and the longitudinal axes, which overlap one another, are relatively weak, there is comparatively little energy available for a rotation about transverse axis, which would facilitate the clearance. So the ‘release’ of hyper-extension, or closing up action must be coordinated and timed exactly in order not to dislodge the bar with the legs.

A take-off angle of 45°-55° or 55°-63° (Strishak, 1982; Viitasalo, 1982; Nigg, 1974) does not, especially in the case of speed floppers, automatically provide a steep, ‘narrow’ flight parabola, but rather an originally ‘flop typical’ relatively straight path of the centre of gravity (C.G.). This can be verified by the flight distances, which are up to four meters in the speed flop. In the same way many flop jumpers show a comparatively long gliding phase along the bar. An unexpected lowering of the buttocks immediately behind the bar is much rarer. In any case, the ‘opening’ and the ‘overextension’ must be followed by a ‘closing’ movement. Whether this movement is introduced by an active hip
bending, followed immediately afterwards by an extension of both knee joints, whether both the movements take place simultaneously or whether they are carried out in the reversed order cannot be clearly determined. In the practice, many athletes show a smooth movement process initiated by a bending of the hips and with the phases overlapping one another. Presumably, the variant preferred in each case is also influenced by the type of extension movement. It is furthermore dependent on whether, the jumper glides over the bar or lowers his buttocks abruptly behind the bar. For the latter technique of bar clearance in the flight phase relatively more rotational energy about the transverse axis is needed, but a less pronounced arch of the back compensates for this.

If the knees are bent very much in the hyperextension phase, their extension must take place simultaneously with the bending of hips; otherwise the lower legs would dislodge the bar. In the case of a pronounced ‘arch’ and a relatively long gliding movement a comparatively long holding of the hip extension is sensible because this arched position is very similar to the form of flight parabola. In this way the buttocks are kept away from the bar and the flexion of the hips and extension of the knees can overlap one-another relatively ‘smoothly’ after the pelvis has crossed the bar.
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The flexion of the hips leads naturally to a lowering of this segment of the body mass so that, by way of reaction another body segment rest of the body is lifted. In this way the ‘reactively’ lifted legs can be taken out of danger zone by opening the knee angle. Having flexed the hips and extended the knee joints, the jumper assumes an ‘L’ position as he descends for the landing.

If the take-off spot has been correct and if rotation about the longitudinal axis is sufficient, the longitudinal axis of the body is at the right angle to the plane of the uprights during the landing, which takes place near the upright farthest away from the take-off. The upper part of the back and the arms, which are spread at both sides of the body, hits the mat first.

In the previous mentioned paragraphs the researcher has discussed all the important phases of the Fosbury-flop high jump technique which are essential to understand the biomechanical analysis of Fosbury-flop technique.

For many years the term Kinesiology (the science of movement) was used to describe that body of knowledge concerned with the structure and function of muskulo-skeletal system of the human body. Later the study of the mechanical principles applicable to the human movements became widely accepted as an integral part of Kinesiology. Later still the
term was used rather accurately to encompass all the sciences that might usefully contribute to the study of the human movement. At this point it became clear that Kinesiology had quite lost its usefulness to describe specifically that part of the science of movement concerned with either the muskulo-skeletal system or the mechanical principles applicable to the human movements. Several new terms were suggested as substitutes and anthropomechanics, biodynamics, anthropokinetics, biokinetics, kinenthropology and homokinetics all had their proponent. Ultimately there emerged one term that gains the much wider acceptance than any other that was biomechanics. Human biomechanics focuses on the mechanics of the human system rather than the physiological or biochemical function of human beings. However, physiological functioning and biochemical tissue properties are many times important considerations within the discipline of the biomechanics. Human biomechanics researches address a broad range of topics related to the human mechanics. Studies include examining the mechanical function of muscles, cartilage, nerves, skin, connective tissue, bones, joints, and internal organs.

During the 20th century, biomechanics developed from a relatively obscure area of the study to a widely recognized professional discipline. As we enter the 21st century, biomechanics is a professional area of study.
Biomechanics is a discipline which deals with the understanding, predicting and explaining phenomena within a content domain. In biomechanics, movements are studied in order to understand the underlying mechanisms involved in the movements or in the acquisition and regulation of skill. The uniqueness of biomechanics as an area of study evolves not from a unique body of knowledge, but from the questions that are asked relatively to understand human movements (Bates, 1991). Techniques and methods from other scientific disciplines, such as physics and engineering, are used to examine the human movements. In this way, biomechanics involves mechanical measurements used in the conjunction with biological interpretations (Higgins, 1985). Thus, biomechanics is a key area of study within a realm of exercise science. Biomechanics is a sport science that applies the laws of mechanics and physics to human performance, in order to gain a greater understanding of performance in the athletic events through modeling, simulation and measurement. It is also necessary to have a good understanding of the application of physics to sport, as physical principles such as motion, momentum, resistance and friction play a part in the most sporting events. The primary role of biomechanics is to understand the mechanical cause-effect relationships that determine the
motions of living organisms.

Biomechanical research of sports technique aspects of the human body as well as the sports equipments as a mechanical system of the moving. In the modern computerized systems, the computer software programs are used to evaluate the collected human movements/motions data and process it. With these software programs, it is now possible to make sophisticated calculation and comparison between the subjects, the cases and the models related with the movement. Movement researchers collaborated with various fields like physics, mechanical engineering etc. can effectively or minutely determine the abnormal movement patterns, measure deviations from a desired pattern, and assess a variety of biomechanical errors made by an athlete.

A great demand of attention to the advancement of equipments is due to various changes of techniques at highest level. The biomechanical analysis of the technique (Fosbury-flop) is the answer to change the demands of higher performance. At the international level of competitions, a very small variation in the technique may result in the win or the lose. Every nation is backing their sports person with the biomechanical researches to accomplish the need. There have been fewer researches in the field of athletic, especially in Fosbury-flop technique of high jumpers.
India has not even set to its initial in the biomechanical researches in this field. In India no such types of researches have been undertaken till date in sports biomechanics. In the computer era, the motion analyses software and programming made the biomechanical research specially in kinematics possible to read the athletes motion and hence, I have taken the step to carry out the research work on this dimension (Fosbury-flop high jump technique).

**BIOMECHANICS**

Biomechanics of human movements broadly defined, as the science involving the internal and external force acting on the human body and description of the motion, including the pattern and speed of movement of the body segments (Chow & Carlton, 1998). Biomechanics is an applied form of mechanics and consequently the methods used to investigate the mechanical principles. However, biomechanics have not developed in the wake of mechanics but as a bordering science in the other scientific discipline such as anatomy, physiology and technique of different sports.

The basis for the field of biomechanics is that the laws of mechanics apply to living organisms just as well as they do to the inanimate objects. In the human performance, biomechanics contributes
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to the description, explanation and prediction of the mechanical aspects of human exercise, sports and the play.

**KINEMATICS**

Kinematics is a branch of classical mechanics which describes the motion of the objects without consideration of the causes leading to the motion. The other branch is dynamics, which studies the relationship between the motion of the objects and its causative factors. Kinematics is not to be confused with kinetics and to dynamics as used in modern day physics; this term is no longer in active use.

Kinematics is a branch of biomechanics concerned with the study of movement with reference to the amount of time taken to carry out the activity. Kinematics, the branch of biomechanics concerned with describing the motion of bodies, thus kinematics deal with such things as how far a body moves, how fast it moves and how consistently it moves. It is not concerned at all with the cause of motion of the body. In other words we can say that the kinematics is that branch of biomechanics, which is concerned with description of the movements of segments of the body without regard to the forces and cause due to the movement occurred.
BIOMECHANICAL ANALYSIS

A biomechanical analysis evaluates the motion of a living organism and the effect of forces on it. The biomechanical approach to the movement analysis can be qualitative, with movement observed and described, meaning that some aspect of the movement measured. The use of the term biomechanics in this text incorporates the qualitative components with a more specific quantitative approach. In such an approach, the motion characteristics of a human or an object are described using such parameters as speed and direction, how the motion is created through application of the forces both inside and outside the body, and the optimal body positions and actions for efficient and effective motion.

The biomechanical analysis of different events can help to understand the critical point of technical performance thus helping coaches and athletes in their preparation. One area of major attention over the past few years is that of biomechanical analysis. Human motion analysis is frequently used today for both clinical and research application. The art and the science of motion analysis has expanded beyond the basic descriptions of ambulatory patterns to include the front line clinical roles in rehabilitation, surgery, orthotics, prosthetics, ergonomics and athletics.
Biomechanical analyses can be divided into four areas:

(1) Noncinematographic analysis

(2) Basic cinematographic analysis

(3) Intermediate cinematographic analysis

(4) Biomechanics research.

1) Noncinematographic analysis:

Noncinematographic analysis is the most common analytical technique used in the sports by coaches, athletes and others. No film or videotape is used in capturing the performance and the component parts of the execution of the motor skill. It requires a disciplined approach to observing and then analyzing skills, but does not require complicated mathematical calculations. It does need a full understanding of biomechanical principles. Obviously, a qualitative analysis is subject to some error in the interpretation.

2) Basic cinematographic analysis:

Basic cinematographic analysis involves the use of film or videotape for improving the performance of an athlete. It also does not involve any mathematical calculations. One advantage of non-cinematographic analysis is that we can see the movements in a very slow motion (frame by frame). The analysis allows for seeing what really occurred versus what we may think took place. It is helpful in reducing
the amount of guess work and, thus error in the correcting motor skills since it is a qualitative analysis.

3) Intermediate cinematographic analysis:

Intermediate cinematographic analysis requires some mathematical calculations to enhance the analysis. In this type of analysis the use of film is necessary to capture the motor skill and subsequent analysis. It is a quantitative analysis, where the velocity and force along with other data are calculated, thus allowing for a significant reduction in guess work in analysis of the component parts of a given skill. As a result, the analysis increases the chances of teaching the skill accurately.

4) Biomechanics research:

Biomechanics research involves highly sophisticated biomechanical equipments, such as high speed cameras, motion analysis software, force plates, EMG for muscle involvement, transducers, computers and much more. The equipments allow for very accurate determination of factors that influence the human performance. It is the method for publishing in the scientific journals and usually a doctorate in biomechanics is needed. As we might imagine, it takes a lot of time to reduce the data before treated with the statistical procedures.

A biomechanical analysis conducted from either of two perspectives. The first, kinematics and second kinetics. Kinematics is
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concerned with the motion characteristics and examines motion from a spatial and temporal perspective without the reference to the forces causing the motion. A kinematic analysis involves the description of movements to determine how fast an object is moving, how high it goes and how far it travels. Thus, position, velocity and acceleration are the components of interest in a kinematic analysis. By examining an angular or linear movement kinematically, one can identify segments of a movement that require improvement, obtain ideas and the technique enhancements from elite performers, or break a skill down into identifiable parts. By each of these, further understanding of the human movements. Pushing on an object may or may not move the object, depending upon the direction and the strength of the push. A push or pull between two objects that may or may not result in motion is termed a force.

QUALITATIVE ANALYSIS

The qualitative analysis system includes the development of a theoretical model as a basis for identifying faults judging their relative importance. In the qualitative analysis, the performance is evaluated subjectively based on direct and visual observation and this method is widely used, as it is less expensive. To conduct qualitative analysis,
requires some prior knowledge of the sports or the activity concerned, in particular if the motor skills to be analyze.

A qualitative analysis includes the visual and photographic observations, which usually result in a description or a judgment of the strong and the weak points of a given performance. Visual analysis has the obvious advantage of not requiring expensive equipments but suffers from limited accuracy and the most effectively practiced by an expert coach with an experienced eye. Without instant replay, the teacher must depend upon the senses to be able to quickly see what it took place. With luxury of film or videotape and the time to view repeatedly a single performance, the chances for correctly diagnosing an error enhanced.

The filming process itself is very critical and most ordinary game films are not of much use in analyzing of an individual because of the probability of the poor camera angle, background and light. The time and the expense needed to photograph individual performers and then to study the film for perhaps several hours is usually justified.

QUANTITATIVE ANALYSIS

In the quantitative analysis technique, the evaluation is objectively based on the measurements taken from recording (e.g. film, videotape, force-time curves) of the movements. At any level of the quantitative analysis, there is a need for interaction between the coach and the
biomechanist, if maximum performance is to be achieved. Quantitative evaluation of the movement requires that a permanent record be collected for a number of trials so that each can be viewed and analyzed. Recording of permanent data on movement may take a number of different forms, for example cinematography, accelerometry, dynamometry or electrogoniometry and electromyography (EMG). While some of these techniques may not be available for general use, a more informed reading of the scientific biomechanics literature can only occur if it understands how objective data are derived.

In quantitative analysis system, the performance is first recorded and then it is evaluated objectively. This method is used only for research purposes and it is quite expensive. It involves the measurement and recoding of hard data about the movement, gait analysis (walking, running Parkinson Ian gait), sequential analysis in kicking, throwing and jumping, postural characteristics in relation to performance and it goes well beyond qualitative analysis because of its emphasis to identify the mechanical principals that affect motion and the movement patterns, and employ the physical principles of the human body facilitate improvements in the performance.

Image analysis techniques, including both movie photography and videography, provide the opportunity to capture the complex movements
sequences on the film or videotape so that a detailed analysis can be performed. However, an understanding of sampling frequency relative to photography or videography is needed prior to discussing the different image analysis techniques, as both are sampling processes that record information at discrete points in time during a continuous motion. The sampling rate needed for an accurate representation of the movements must be at least twice the value of the highest frequency component contained in the movements, although many researchers believe sampling rates of 5 to 10 times the maximum frequency component are necessary. Excessive sampling either increases the cost when using high-speed photography or limits the choice of cameras when using the high-speed videography. Under-sampling will cause vital movement characteristics to be missed or distortions to arise. At the subjective level of analysis, film or video techniques may be use to record movements and allow general comments to be made on the observed characteristics. At an objective level it is not sufficient to just record and observe movements, as detailed measurements must be completed and inferences drawn with reference to the movements. Specific equipment and procedures must be use if accurate objective data are to be collected using the image analysis techniques.
Movie Photography

In high speed cinematography a motor-driven camera capable of providing frame rates up to approximately 500 Hz (c.s
\(^{-1}\)) and exposure times up to approximately 1/10000 s. is needed to accommodate movement and the sport skills of differing speeds. In a golf drive for example, the ability to clearly record the impact of the ball and the club head would require an exposure time of approximately 1/3600 s and a frame rate of 400 Hz. The 400 Hz frame rate ensures that the moment of impact captured on film, while the exposure time guarantees that no blurring of the image occurs. For an analysis of jogging, an exposure time of 1/800 s would provide a clear image of the leg, while a frame rate of 100 Hz is sufficient to sample leg movement at the required frequency.

The collection of data from film for analytical purposes (digitizing) is the most time-consuming and tedious aspect of the cinematographic research. A stop-action projector is needed to control film movement so that an operator can move an (X-Y) coordinate system until a pointer, pen, light or cross-hairs lie over the desired anatomical landmark to be digitized.

The co-ordinates of this point are then stored on a computer. In order for the anatomical landmark to be located, it must be clearly marked on the subject being filmed, so that an accurate identification of
the segments end point or joint centre is possible. These co-ordinate data are then smoothed prior to being mathematically manipulated in the calculation of kinematic and kinetic data.

Information additional to the co-ordinates of the selected landmarks is required. A large sweep-hand clock may be included in photographic field to establish the actual frame rate of the camera. Alternatively, internal camera lights which flash at a set rate may be used to mark the film and allow film speed calculation. A spatial scale, such as a large meter rule must also be filmed in the plane of action to convert film scale measures to real values.

This type of scientific analysis may be done on any of several levels and ranging from research that has immediate applicability to sports, scientist in the lab are aided by interesting and very technical measuring and the recording devices: including high speed cameras, motion analyzers, force platform and computers.

**Two Dimensional Analysis**

This type of analysis commonly uses one camera and fewer markers on the subject than in more complex 3-D analysis. Although it has limitations, it was the first method used by sport researchers and biomechanists, and is still used today by many research labs that utilize motion analysis, and is easily adapted for student research.
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Video Analysis

Once film or video is recorded it must be analyzed. This usually entails digitizing points off of a film or video using a special machine, or even using tracing paper overlaid on a monitor. Video can be captured by a computer and relevant points digitized directly using image analysis programs such as NIH Image and Measurement in Motion. In the motion analysis activity included here, Quick Time movies are used to digitize points that make up an angle between the leg, ankle and foot. This angle lets one analyze the effect shoes have on pronation and supination.

Videography is the most common objective data collection techniques used in biomechanics because they provide a permanent and visual record of performance. There are the non-imaging measurement procedures that provide valuable biomechanical data for the objective analysis of movement. It may be preferable at times to measure some of the kinematics aspects of a movement directly, rather than derive the measurements from film or videotape.

Digitize

Images, whether film or video, need to be processed into a format that the computer can use. Video capture cards are used to capture video and convert/transform it into a digitized form, ready for analysis. The
sport researcher also uses this term in reference to capturing the coordinates of markers placed on the body for motion analysis. The procedure for motion analysis with Measurement in Motion entails “digitizing” markers on an athlete's leg to create an angle that can be used for analysis.

**High Speed Video**

Today many researchers are turning to video that can shoot at a rate of 30 to 10,000 images per second. Some of the cameras used for high-speed video that can also be fit to “automatically” digitize markers. The time from filming, or data collection, to data analysis has been cut from weeks to days with such innovations.

**Calibration Angle**

This angle is a measure of hyper flexion and hyperextension whiles the subject perform the Fosbury-flop high jump technique. The most common condition is for the subject to exhibit a slight positive angle.

**Cinematographic System**

In the “early days” of sport, research and motion analysis scientists used cameras that could shoot 16 mm film at rates greater than 200 frames per second. This allows researchers to capture data from events that occur very fast. The down side to using film is that it is expensive,
both to purchase and develop and takes more time and special equipment to analyze.

**DEFINITION OF TERMS**

The following terms were defined to provide consistency in terminology:

**Biomechanics:** Biomechanics is the science that examines the internal and external forces acting on a human body and the effects produced by these forces.

**Kinematics:** Kinematics is the geometry of motion without any reference of force, i.e. time, distance, displacement, velocity, and acceleration.

**Linear Kinematics:** It deals with the kinematics of translation, or linear motion. When a body moves, all part of it travels exactly the same distance, in the same direction in the same time.

**Linear Distance:** Distance is commonly used to describe the extent of a body's motion, when a body moves from one location to another, simply the distance does a body travel the total path in a certain interval of time.

**Linear Velocity:** The combination of the instantaneous speed and the direction of linear movement at the time is a vector quantity known as the linear velocity.

\[
\text{Linear Velocity} = \frac{\text{Displacement}}{\text{Time taken}}
\]

**Angular Kinematics:** Rotational or angular kinematics is the description of the rotation of an object. It deals with the kinematics of rotation or
angular motion. In angular kinematics every particle of the body moves in a circle and the centers of all these circles lay at the axis of rotation.

**Angular Distance:** The length of angular path covered by a rotating body when it moves from one position to another is called angular distance.

**Angular Velocity:** The rate of change the position of an object in angular path in respect to time is known as angular velocity.

Angular Velocity = Angular distance / Time taken

**Calibration:** Refers to the process of determining the relationship between the output (response) of a measuring instrument and the value of the input quantity or attribute used as a measurement standard.

**Cinematography:** Motion picture photography.

**Cinematography:** Motion picture photography.

**Dimension:** A term denoting the spatial extent of a measurable quantity.

**Two-dimensional:** Occurring within a single plane; requiring a minimum of two coordinates to describe, for example x- and y- coordinates.

**Digitizing:** The process of specifying or measuring the x- and y-image coordinates of points on a video frame; more strictly called coordinate digitizing.

**Inverse Dynamics:** An analytical approach calculating forces and moments based on the accelerations of the object, usually computed from
measured displacements and angular orientations from videography or another image-based motion analysis system.

**Statics:** The branch of mechanics in which the system being studied undergoes no acceleration.

**Videography:** The process of capturing images on a videotape or directly to a computer; also used to include the later analysis of these images.

**Axes:** The imaginary lines of a reference system along which position is measured.

**Axis of Rotation:** An imaginary line about which a body or segment rotates.

**Countermovement:** A movement made in the direction opposite to that of the desired direction of motion - as in a countermovement jump.

**Reference System:** A system of coordinates used to locate a point in space.

**Projectile:** An object (or person) - that has been flung into the air.

**Projection Angle (release angle, take-off angle):** The angle at which a projectile is released.

**Projection Height (release height, take-off height):** The difference between the height at which a projectile is released and the height at which it lands.
**Projection Velocity (release velocity, take-off velocity):** The velocity at which a projectile is released, may be broken into horizontal and vertical components. The magnitude of the projection velocity, with no indication of its direction, is the projection (release, take-off) speed.

**Range:** The horizontal distance a projectile travels.

**Sequential Movement:** A movement that involves the sequential action of a chain of body segments, often leading to a high-speed motion of external objects through the production of a summed velocity at the end of the chain of segments.

**Trajectory:** The flight path of a projectile determined by the horizontal and vertical acceleration of the projectile and its projection speed, angle and height.

**Skill:** General pattern of movement that has been adapted to the limitation of a particular activity.

**Approach Run Phase:** The approach run begins on the first frame and ends at the frame of heel strike on the second last stride.

**Take-off Preparation Phase:** The frame of the contact of the both leg on the ground at the last stride.

**Take-off Phase:** The frame of separation of the support toe from the ground.

**Flight Phase:** The frame when jumper reaches above the bar on his back.
**L-position Phase:** This is the frame just before the landing in which the athlete’s body makes a shape like ‘L’.

**Landing Phase:** The frame at a time when body touch to the mat.

**Longitudinal Axis:** Imaginary line that goes throughout the length of a body or segment.

**Plane of Motion:** A two-dimensional plane running through an object. Motion occurs in the plane or parallel to it. Motion in the plane is often called planar.

**Sagital:** It refers to the plane that divides a body or segment into the right and left portions.

**Frontal:** It refers to the plane that divides a body or segment into the front and back portions.

**Horizontal:** It refers to the plane that divides a body or segment into the up and down portions.

**Elbow Angle:** The anatomical line of radius and line draw between shoulder joint to elbow joint.

**Shoulder Angle:** The anatomical line of humerus and line draw between hip joint to shoulder joint.

**Hip Angle:** The anatomical lines of femur and drawing line between the shoulder joint to the hip joint.

**Knee Angle:** The anatomical lines of femur and tibia.
Ankle Angle: The anatomical lines between the tibia and foot at ankle joint.

STATEMENT OF THE PROBLEM

The present study was focus on the selected kinematical parameters i.e. segmental angles, linear velocity of different segments and angular velocity of different segments at different phases i.e. approach-run, take-off preparation, take-off, flight, L-position and landing; it may also help to find the relationship of these parameters with the performance (jumped height) of Flop technique. Therefore, the present empirical investigation has been entitled as “Biomechanical analysis of Fosbury-flop technique of elite Indian high jumpers”.

HYPOTHESIS

On the basis of previous research studies and literature reviewed, experts opinion and scholar’s own understanding of problem, it was hypothesized that- the joints angles, linear and angular velocity of different joints at different phases (approach run phase, take-off preparation phase, take-off phase, flight phase, L-position phase and landing phase) and stride length will influence significantly in the high jump performance.
DELIMITATIONS

- The study was delimitated to the Intervarsity/National level high jumpers.
- In this study only male high jumpers were taken.
- In this study only qualified jumpers were analyzed.
- In this study only those jumper were taken who used Forsbury-flop Technique.
- The study was based on 2D (Two Dimensional) biomechanical analysis only.

LIMITATIONS

- The changes in climatic condition as wind velocity, temperature, atmospheric pressure and relative humidity during the testing period could not be controlled and their possible influence on the result of this study was recognized as a limitation.
- The changes of the psychological, social as well as physiological condition of the high jumpers during the period of data collection could not be controlled and their possible influence on the result of this study was recognized as a limitation.
- Certain factors like daily routine, life style and food habits, which would have an effect on the performance of the Fosbury-flop technique, could not be controlled.
• The proper care has been taken to use the available appropriate equipment. The instrument errors may also be a limitation for the study of biomechanical analysis of Fosbury-flop technique, but consistent calibration has been attempted.

• The various tool and equipment available in motion analysis software used could not be enhanced and not in our controlled.

• The accuracy of various equipment or software used and then ability to digitize the kinematic data was considered as a limitation of this study.

• The film speed of 60 frames per second was not fast enough to identify the exact timing, velocity and angles of the body.

• Movement of the subjects were not always perpendicular to the axis of the camera lens due to the multiplanner movement of same body parts.

**OBJECTIVES OF THE STUDY**

In order to realize the goal of the present study the following objectives have been stated:

• Upper body and lower body segments were analyzed during the approach run phase.

• Upper body and lower body segment were analyzed during the take-off preparation (last stride) phase.
• Upper body and lower body segment were analyzed at the time of take-off taken by the athlete while performing Fosbury-flop high jump technique.

• Different joints linear velocities were analyzed during performing the Fosbury-flop high jump technique.

• Different joints angular velocities were analyzed during performing the Fosbury-flop high jump technique.

• Upper body and lower body segmental joints were analyzed at the time of flight (bar clearance) successfully of the high jumpers.

• Body joints angles were analyzed at the time of L position phase during performing the Fosbury-flop high jump technique.

• Body joints angles were analyzed at the time of landing phase during performing the Fosbury-flop high jump technique.

• Last stride length was analyzed.

• New/ appropriate mechanical aspect of Fosbury-flop high jump technique were determined for enhancing the performance of the high jumpers.

• New/ appropriate mechanical aspect of Fosbury-flop high jump technique will provide the scientific approach of the learning aspect of Fosbury-flop high jump technique.
SIGNIFICANCE OF THE STUDY

The present study of the biomechanical analysis of Fosbury-flop high jump technique would contribute to the society in the following ways:

- The biomechanical analysis of the Fosbury-flop technique of Indian high jumpers would provide a strategic functional guide for the coaches, physical education teachers as well as the athletes to achieve efficiency during high jump.

- The study will provide the mechanical basis required for measurement of appropriate length of the run-up and take-off for achieving optimum jump.

- The study will provide a base to the athletes who participate in high jumping event.

- The study will provide the mechanical basis required for measurement of appropriate jumping angle and body arch to achieve the maximum height during Fosbury-flop high jump technique.

- The study will provide the mechanical basis required for measurement of appropriate curve and other related biomechanical factors required for achieving the optimum successful jump.
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- The study will provide a reliable functional biomechanical manual or guide for athletes, coaches and physical education teachers to assess the performance of any athlete and/or draw up a particular training programme for an athlete.

- The study will generalize the biomechanical aspect of Fosbury-flop technique of Indian high jumpers.

- The players, coaches and the experts of Fosbury-flop technique of high jump will be greatly benefited with the feedback provided of the existing method performing the Fosbury-flop technique.

- The analysis of Fosbury-flop technique of high jump can be used as guideline to enable coaches and others who are experts of this field.

- This research project will be an answer to the player’s capacity of their movement specificity and their contributions to clear the bar successfully.

- The mechanical analysis of various movements executed by a high jumper involved in the process of taking run-up, last approach stride, take-off will be explored the shortcoming in the movement specific responsible for minimizing the chance of failure in the flight (bar clearance).
• The findings will explore new variations for successfully bar clearance.

• The findings of the study will explore a number of effective variations in the take-off preparation.

• The findings of the study will evolve new measures for improving the performance of Indian high jumpers.

• The findings of the study will go a long way in capitalizing the chance of medal winning of our Indian high jumpers at International competitions.

• The findings of the study will benefit the budding high jumpers who could be best groomed from very beginning of their learning process to develop a flawless motor habit by using the principles derived from the present analytical study.