CHAPTER III

METHODOLOGY

Research methodology involves a systematic procedure by which the researcher starts from the initial identification of the problem to its final conclusion. The role of methodology is to carry out the research work in a scientific and valid manner. The purpose of the study was to find out the effect of uphill, downhill and combined training on selected speed parameters and knee kinematics of college students. In this chapter, selection of subjects, selection of variables, experimental design, selection of tests, pilot study, reliability of data, instruments reliability, orientation to the subjects, training programme, test administration, collection of data and statistical procedure adapted to analyse the data are presented.

3.1. SELECTION OF SUBJECTS

To achieve the purpose of the study, 60 male students were selected from Mannar Thirumalai Nayakar College, Madurai. The age of the subjects ranged between 18-25 years. The selected subjects were divided into three experimental groups namely Uphill Training Group (UTG), Downhill Training Group (DTG) and the Combined (Combination of Uphill & Downhill) Training Group (CTG) and Control Group (CG) with fifteen subjects (n=15) in each. All subjects were informed about the nature of the study and their consent was obtained to co-operate till the end of the experiment. For the pilot study and final study experimental groups (namely UTG, DTG and CTG) were trained-up for eight weeks using selected uphill, downhill and combined (uphill and downhill) training were given independently. The subjects were free to withdraw their consent, in case they felt any discomfort during the period of their participation but there were no dropouts. A qualified physician examined the subjects medically and declared them fit for the study.

3.2. SELECTION OF VARIABLES

3.2.1. Dependent Variables

Sprinting speed, and especially acceleration, is an essential component of many different sports **(Delecluse, et al., 1995)**. Field sports, such as the various football codes (e.g. rugby league, rugby union, soccer, American football, Australian Rules), lacrosse, and field hockey, require the ability to generate speed quickly from a stationary or near stationary position (**Sayers, 2000**). Importantly, many of the sprints completed in field sports tend to be relatively short. For example, in sports such as rugby union (**Docherty, et al., 1988**), Australian football (**Dawson, et al., 2004**) and soccer (**Bangsbo, et al., 1991**), maximal sprints will often have a duration of two seconds (s) or less, which would equate to distances of approximately 10 meters (m). This places a great emphasis on the ability to accelerate (**Lockie, et al., 2003**), which is the capacity to generate as high a running velocity in as short a distance or time as possible. In order to maximize acceleration, a field sport athlete must ensure that their running technique allows them to attain a high sprint velocity very quickly. Indeed, the kinematics of the field sport athlete's running technique will greatly affect the resulting sprint performance.

As it was shown in earlier studies, performance in sprint races depend on several factors. According to **Kraaijenhof, (1990),** there are four factors affecting the 100 m run results: body build, neuro-muscular system, biochemical and physiological adaptation to short-term efforts and biomechanics. The biomechanical efficiency is one of the three components (the other two being metabolic system and neuro-Flogical efficiency) of speed distinguished by **Huntington (1993)**.

Performances in Sport keep improving year after year and records have now reached heights that seem very hard to beat. Among them the male athletics world record over 100 m, held by Usain Bolt in 9.58s is a model of technique that will certainly require a perfect optimization of the two components to the stride – amplitude and frequency to be beaten, or even approached again. A number of investigations have studied the criteria of efficiency in the run stride. In this context **Summers, (1997),** presented a model that indicated speed is greatly dependent upon stride amplitude, whilst stride frequency appears to be barely significant. This theoretical model is supported by the observations made by **Trouillon, (1974),** in subjects of regional level (12.9 s - 14 s, for 100 m), and **Gazeau, (1997),** who studied all the 100 m races at the 1988 Seoul Olympics. In the later study however results remained very global since the analysis was based on mean values obtained in the two consecutive 50 m run sequences.

When athlete breaks running performance down and look at the speed of an individual, it is the interaction of stride frequency and stride length. Stride length is determined by many factors, such as body height and leg length, but has been seen through research to be a factor that can be improved. When looking at sprinters, novices achieve maximal stride length at about 27 yards, whereas elite sprinters continue to increase stride length until about 49 yards. Stride frequency, or stride rate, the measurement of how often the leg cycles and strikes the ground to propel the individual can also be improved. Stride frequency is thought to be the more important factor as individuals reach maximal speeds and the more trainable factor.

Stride frequency involves many more components of running from impulse production, speed of force generation, support phase, flight phase and recovery phase. Traditionally, research has focused on either uphill training or downhill training individually to improve running performance. Uphill training focuses on speed-strength and improvement of stride length. Downhill training focuses on improving stride frequency. Regardless of uphill or downhill training, it is recommended not to use a slope that affects speed by more than 10% either direction. A slope of 3 to 7 degrees can normally help achieve ample downhill assisted speed (**httpwww.tri4fitness.netuploadsLooking_for_a_Change_in_Running_Performance.pdf**).

Yada, et al., (2011), stated that the running velocity, stride length, release distance and flight distance of the elite sprinters were significantly greater than those of the student printers. The elite sprinters did not fully extend the knee and ankle joints of the support leg at the toe-off while the student sprinters tended to show the converse motion. **Yada, et al., (2011),** suggested that student sprinters should use hip joint extension rather than flexion-extension of the knee and ankle joints, and should keep the shank leaning forward during the support phase.

Some of the traditional step kinematic measures used to describe running technique include: step length, which is the distance between alternating contacts of the left and right feet; step frequency, which is the rate at which steps can be reproduced; contact time, which is the duration of the contact between the support leg and the ground; and flight time, which is the period when the athlete is airborne during the sprint step. It is generally thought that to improve sprint performance, there must be an increase in one or both of the factors that affect velocity – step length or step frequency (**Donati, 1996 and Vittori, 1996**).

Lower extremity kinematics and kinetics during level running have been well-documented (**Chapman and Caldwell, 1983**; **Milliron and Cavanagh, 1990 and Winter, 1983**). Recent training regimens intended to improve sprinting performance have included incline treadmill running at speeds above 4.5 m/s 21 with grades over 30% (**Delecluse, et al., 1995**). These training protocols are designed to enhance muscular loading of the hip, knee, and ankle extensors during stance and the hip flexors and extensors during recovery (**Delecluse, et al., 1995**). It has been suggested that these muscle groups are primarily responsible for generating forward propulsion during running and sprinting (**Jacobs, et al., 1992; Jacobs, et al., 1993 and Mann, et al, 1986**). Studies on explosive lower extremity extension movements such as sprinting suggest that coordination of the mono- and bi-articular muscles crossing these joints is important for optimal performance (**Jacobs, et al., 1992; Jacobs, et al., 1993; Jacobs, et al., 1996 and Prilutsky and Zatsiorsky, 1994**). An integrated biomechanical analysis during high-speed incline sprinting would provide insight into the nature of muscular loading and coordination during these conditions, and would enhance the understanding of the effectiveness of such training programs. Hence, the following dependent variables were selected for this study.

I. Speed Parameters

1. Speed
2. Elastic power
3. Stride length
4. Stride frequency

II. Knee Kinematics

5. The angle of knee flexion at foot strike

   - at 30 and 80 meters of 100 meters race, and

6. The angle of knee extension at foot strike

   - at 30 and 80 meters of 100 meters race.

3.2.2. Independent Variables

Runners today increasingly understand the importance of combining strength work with regular running. It strengthens tendons and ligaments, reduces the risk of injury and improves overall running form. The problem is that most runners tend to do the majority of their strength specific work in the gym, through squats, leg extensions or arm and shoulder presses. While these exercises do increase strength and muscular power, they do it in isolation of one's running, focusing on individual joints and small sets of muscles. Hill sessions, in contrast, force the muscles in one's hips, legs, ankles and feet to contract in a coordinated fashion while supporting one's full body weight, just as they have to during normal running. In addition, on uphill sections one's muscles contract more powerfully than usual because they are forced to overcome gravity to move one up the hill. The result is more power, which in turn leads to longer, faster running strides. (http://www.runnersworld.co.uk/general/ **everything-you-need-to-know-about-hill-training/159.html?print=true**).

Hill work is an extremely effective way to gain more power, increase running economy and improve speed. The repetitive nature of hill workouts forces the muscular system to develop in response to the stress being placed on it, while the nervous system increases firing patterns to fast-twitch muscle fibers. Completing hill workouts also increases speed and endurance because of the resistance inherent to running up hill and the associated increase in heart rate. Hills should be thought of as a form of speed work and included intentionally; they help introduce the body to faster work with less impact at a slower pace. Injury prone runners who struggle with adding faster work will find hills provide the same stimulus with less risk. It might seem a bit counterintuitive, but, if done properly, running up a hill at a slower pace with lighter foot strikes is actually a much safer approach than jumping on the track and hammering out speed work. Hills are also a great way to athletes your heart rate up for an extended period of time, thus increasing overall aerobic development (**Culpepper, 2012**).

According to **White (2015),** hills provide resistance, therefore increasing the intensity of training, which results in increased strength. Increased strength can improve speed on the track, road and cross-country and also decreases the possibility of injuries. Uphill running can be used to increase form by concentrating on a relaxed style. On the other hand, downhill running can teach relaxation and improve leg speed and stride. Technique is the most important part to running hills successfully. When approaching the hill the runner should consider it as an opportunity to relax, change pace, and use different muscles. The head should be upward, looking forward, which keeps the body perpendicular to the ground for best traction.

Facciono, (1992 and 1994) and Bissas, et al., (2002) stated that more specifically, research has shown that assisted methods such as towing, high-speed treadmill sprinting, and downhill sprinting produce a running velocity greater than what can be achieved under unassisted conditions,4 potentially as a result of increasing stride length or frequency. According to **Mero et al., (1992), Ozolin, (1971) and Paradisis, et al., (1995)**, Downhill sprinting is also an efficient and cost-effective method for increasing an athlete's maximum velocity. Nonetheless, the optimal slope for over speed training has not been determined.

Running downhill is completely different to running uphill. The skill, technique, and attitude are opposite. Downhill running also needs practice to condition one's body to the intense pounding and faster speed of running. Downhill strides are a great way of increasing speed. The secret is to let gravity do all the work by tilting forward and letting the hill carry one down. . To efficiently use this momentum, the runner should lengthen his or her stride, trying to keep the hips over the feet. (**White, 2015**),

Four training studies have evaluated aspects of downhill sprinting, using slopes of 3° or 3.25°. **Bissas, et al., (2002)** examined the effect of a combination of uphill and downhill sprinting at slopes of 3° with subjects demonstrating improved running velocity compared with controls, (**Bissas, et al., 2002; Paradisis, et al., 1995 and Paradisis and Cooke, 2006**) possibly because of increased stride rate, which also improved with training. **Paradisis, et al., (1995) and Paradisis and Cooke, (2006)** in their investigation, however, failed to demonstrate improvement in sprint time for a group that trained at 3.25° of slope compared with subjects who performed flatland running. **Suellentrop's (1981)**, study also using a hill slope of 3°, sought to examine acute variables associated with downhill sprinting.11 In that study, subjects were filmed and timed during a 40-m sprint on flatland, as well as 3° uphill and downhill slopes. Results indicate that downhill running produced approximately 5.4% faster sprint velocity than flatland running, lending support to the idea that downhill running has a positive acute effect. According to the study, this improvement was accrued as a result of greater stride length. Anecdotal observations of **Facciono, (1994) and Facciono, (1992)**, and some evidence suggest that downhill sprinting has positive acute (**Kunz and Kaufmann, 1981**) and chronic (**Bissas, et al., 2002 and Paradisis and Cooke, 2006**) effects on sprinting time, velocity, and stride, despite the fact that there is no information regarding the optimal slope for such training.

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Based on the above facts of different training procedures, the researcher selected the following independent variables.

1. Uphill training
2. Downhill training, and
3. Combined (uphill and downhill) training

3.3. EXPERIMENTAL DESIGN

The experimental design used for this study was similar to a random group design involving sixty participants, who were divided at random into three groups of fifteen each. This study consisted of three experimental groups: Group I – uphill training group (UTG), Group II – downhill training group and Group III - combined (uphill and downhill) training (CTG) and a control group (CG). All the participants were tested prior to and after the experimentation on selected dependent variables.

3.4. SELECTION OF TESTS

The following standardized tests were used to collect the relevant data on selected dependent variables and they are presented in Table I.

TABLE I
SELECTION OF TESTS

<table>
<tr><th colspan="3">Variables</th><th>Test Procedure</th><th>Measurements</th></tr>
<tr><td rowspan="4">Speed</td><td colspan="2">Speed</td><td>100 meters run</td><td>In Seconds</td></tr>
<tr><td colspan="2">Stride Length</td><td>Foot prints</td><td>In Meters</td></tr>
<tr><td colspan="2">Stride Frequency</td><td>60 meters run</td><td>In Numbers</td></tr>
<tr><td colspan="2">Elastic Power</td><td>Bunny Hops</td><td>In Meters</td></tr>
<tr><td rowspan="4">Knee Kinematics</td><td rowspan="2">Angle of knee flexion at</td><td>30 meters</td><td rowspan="2">Video Analyze</td><td rowspan="2">In Degrees</td></tr>
<tr><td>80 meters</td></tr>
<tr><td rowspan="2">Angle of knee extension at</td><td>30 meters</td><td rowspan="2">Video Analyze</td><td rowspan="2">In Degrees</td></tr>
<tr><td>80 meters</td></tr>
</table>

3.5. PILOT STUDY

A pilot study was conducted to assess the initial strength and capacity of all the participants in order to fix the training load. For this, 15 college men students were selected at random and divided into three groups of five each, in which group I underwent uphill training, group II underwent downhill training and group III performed combined (uphill and downhill) training under the supervision of the scholar. However, the individual differences were considered, while constructing the training programmes, the basic principles of sports training namely progression, over load and specificity were followed.

3.6. RELIABILITY OF THE DATA

Three months before the commencement of the pilot study, the reliability of the data was established by using 15 participants at random. To ensure reliability, test and re-test method was executed. In between the test and retest one-day rest was given to all the participants. The researcher using the same equipments under identical conditions tested for all the selected variables twice on the same participants. The raw data are presented in appendices III, IV, V, VI, VII, VIII, IX and X. The intra class co-efficient of correlation was used to find out the reliability of the data and the results are given in table II.

TABLE II
INTRA CLASS CO-EFFICIENT OF CORRELATION ON SELECTED VARIABLES

S.No.	Variables	'R' value
1	Speed	0.82*
2	Elastic power	0.83*
3	Stride length	0.81*
4	Stride frequency	0.82*
5	The angle of knee flexion at foot strike at 30 meters of 100 meters race	0.80*
6	The angle of knee flexion at foot strike at 80 meters of 100 meters race	0.81*

*Significant at 0.01 level.
(Table value required for significance at 0.01 level of confidence is 0.514)

Since the obtained 'R' values are much higher than the required value, the data are accepted as reliable in terms of instrument, tester and the participants.

3.7. INSTRUMENTS RELIABILITY

Instruments like stopwatches, measuring tape and video analyzing (trail version) software, an available in the laboratory of Department of Physical Education, Mannar Thirumalai Nayakar College, Madurai were all reliable and manufactured by standard companies. Instrument reliability was also established by test-retest method.

3.8. ORIENTATION TO THE PARTICIPANTS

The investigator explained the purpose of the training programme and also the involvement of the participants. Before the commencement of the training programme, the uphill training methods were taught to group I (UTG), downhill training methods were taught to group II (DTG) and the combined training programme were taught to group III (CTG). Three one-hour sessions were spent on alternate days (Mondays, Wednesdays and Fridays) to practice the specified training exercises. Two one-hour sessions were spent on alternate days (Tuesdays and Thursdays) to practice exercise and drill related to specific training. This helped them to perform the uphill, downhill and combined training exercises perfectly.

3.9. TRAINING PROGRAMME

The participants underwent their respective training programme under strict supervision. The group I (UTG) underwent uphill training, group II (DTG) underwent downhill training and group III underwent combined training and group IV (CG) did not participate any training programme during the training period, and they treated as control group. The duration of training period was restricted to eight weeks and the number of sessions per was confined to three. Each Individual's training load and intensity were fixed according to the training principles. Prior to every training session, subjects underwent 10 minutes of warm-up exercise, which included jogging, stretching, striding, jump and toe touch. All the participants involved in training programme were questioned about their stature throughout the training period. None of them reported any injuries. However, muscle soreness was reported in the early weeks, but it subsided later. Training location's longitude and latitude are 78.077E and 9.90N respectively. Based on the response of the participants in the pilot study, the training schedules were constructed and presented in Appendices I and II.

3.10. TEST ADMINISTRATION

3.10.1. 100 Meters Run

Objective

To assess the speed performance of the subjects.

Equipment

Measuring tape, starting clapper and stopwatch

Procedure

Two lines (start and finish) were drawn 100 meters. Subjects were advised to use standing start method. The subject stood behind the starting line with the command 'ready' and on 'clap' they ran through the 100 meters distance. The elapsed time from the starting signal up to the runner crossing the finish line was measured with a stopwatch.

Scoring

Each subject was given only one trial 100 meters race time was recorded as test score.

3.10.2. Bunny Hops Test

Purpose

To measure the subject's elastic power

Equipment

Measuring tape.

Procedure

The procedure prescribed by (**Seagrave, 1996**) was employed to measure elastic power. The subject took position on the take off line. When the subjects completed the five stride bounding (Bunny Hops), the performance was measured from the nearest break to the takeoff line. Three trials were given.

Scoring

The best of the three trials was recorded in meters.

3.10.3. 100 Meters Run

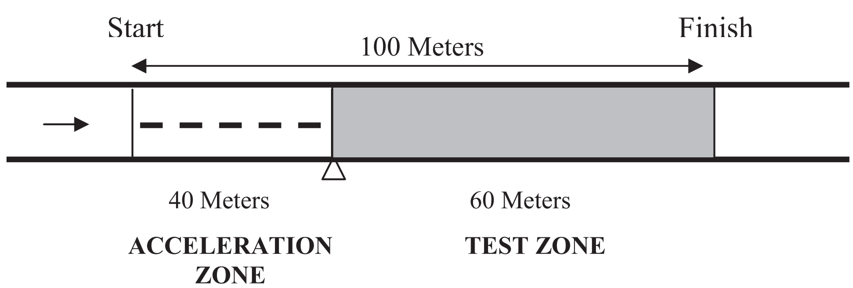
Purpose

The purpose of this test was to measure the stride length of the subjects.

Facilities and Equipment

Test course on the track, sawdust, scorecards, and a standard measuring tape was used.

TEST COURSE



Procedure

The subjects were allowed to run fast about 100 meters to measure speed, the measurement of the length of stride was taken in the test course, which consists of an acceleration zone of 40 meters and the test zone of 60 meters (between 40th to 100th meters). The participant used the acceleration zone to gain maximum speed through the 60 meters test course. A light coating of sawdust was spread over the test zone that highlighted the footprints. Stride length was the distance from the tip of the rear toe to the tip of the front toe was recorded to the nearest meters. To avoid the bilateral discrepancies two successive strides were measured to the nearest meter (**Seagrave, 1996**).

Scoring

The average of two successive strides of the participant was recorded in meters as the individual score.

3.10.4. 100 meters run

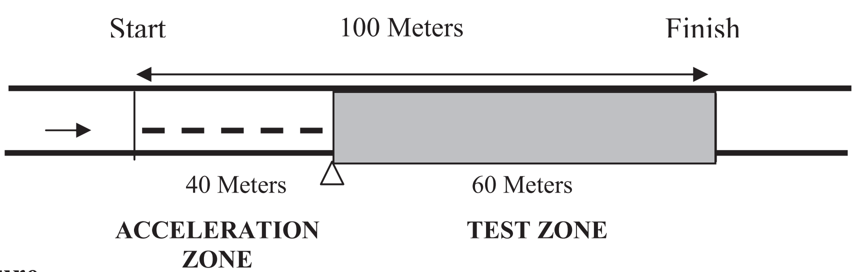
Purpose

The purpose of this test was to measure the stride frequency of the subjects.

Facilities and Equipment

Test course on the track, sawdust, standard measuring tape, scorecards, and electronic stopwatch was used.

TEST COURSE



Procedure

The participants were allowed to run fast about 100 meters to measure speed, the measurement of the stride frequency was taken in the test zone of 60 meters (between 40^{th} to 100^{th} meters). The time elapsed for five right/left foot contacts of the participant after the initial supporting phase in the test zone. Thus, recording the time taken for ten strides (**Seagrave, 1996**).

Scoring

Dividing the number of strides (10) taken by the time recorded given the number of strides ran in one-second.

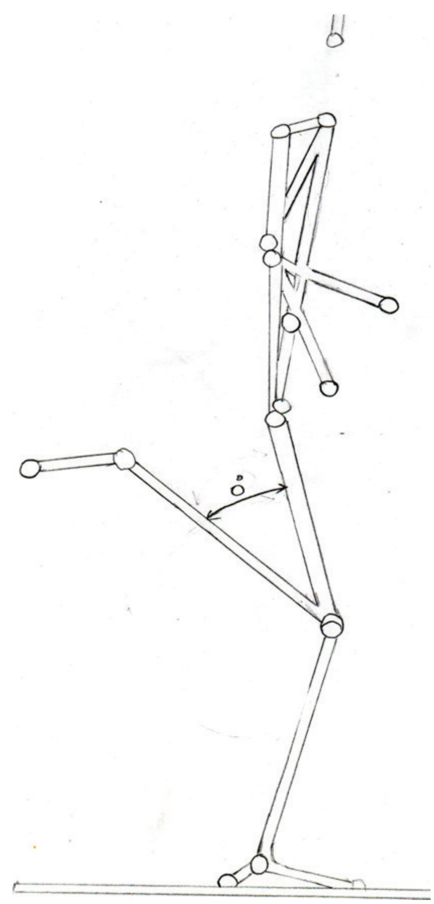
3.10.5. Angle of Knee Flexion at Foot Strike

Purpose

The purpose of this test was to measure angle of knee flexion at foot strike of the subjects at 30 meters and 80 meters of 100 meters race.

Equipment

Two video cameras (CANON) and video analysis software (trail version)



Cunningham, et al., (2013

Procedure

The subjects' 100 meters trial timing was considered as the speed performance. Sprinters motion were Videotaped at 30 frames per second and it was fixed at a distance of 8m from the outer edge of the 8th lane. Two cameras were fixed at the 30 meters and 80 meters of 100 meters races. The video was carefully observed with the help of Quintic Sports Biomechanics Video Analysis Software (trial version) on angle of knee flexion at foot strike at 30 meters and 80 meters.

Scoring

After repeated observation the angle of the above mentioned parameters was found-out and recorded in degrees.

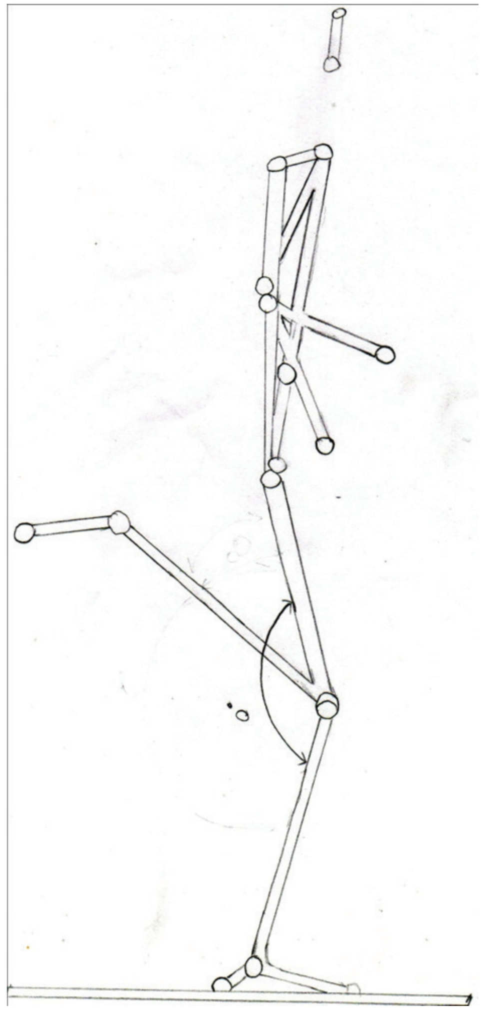
3.10.6. Angle of Knee Extension at Foot Strike

Purpose

The purpose of this test was to measure angle of knee extension at foot strike of the subjects at 30 meters and 80 meters of 100 meters race.

Equipment

Two video cameras (CANON) and video analysis software (trail version)



Cunningham, et al., (2013

Procedure

The subjects’ 100 meters trial timing was considered as the speed performance. Sprinters motion were Videotaped at 30 frames per second and it was fixed at a distance of 8m from the outer edge of the 8th lane. Two cameras were fixed at the 30 meters and 80 meters of 100 meters races. The video was carefully observed with the help of Quintic Sports Biomechanics Video Analysis Software (trial version) on angle of knee extension at foot strike at 30 meters and 80 meters.

Scoring

After repeated observation the angle of the above mentioned parameters was found-out and recorded in degrees.

3.11. COLLECTION OF DATA

The data on selected dependent variables for pre and post tests were collected three days before and after the training programme respectively. Speed, stride length and stride frequency performance was tested on the first day. On the second day, elastic power was tested.

3.12. STATISTICAL TECHNIQUE

The data was collected from the four groups before and after the experimental period. The collected data were analysed by using analysis of variance for 4 x 2 factorial experiment [group (UTG, DTG, CTG and CG) x test (pre and post)] with repeated measures on the last factor was used on selected speed parameters such as speed, elastic power, stride length and stride frequency and the analysis of variance for 4 x 2 x 2 factorial experiment [group (UTG, DTG, CTG and CG) x angle of knee position (at 30 meters and 80 meters) x test (pre and post)] with repeated measures on the last factor was used on knee kinematics such as angle of knee flexion and extension at foot strike. Whenever the 'F' ratio for interaction was found to be significant, simple effect test was used as a post-hoc test to determine which of the group was significant and whenever the 'F' ratio for interaction was found to be significant in the simple effect test, Scheffe’s test was used as a post-hoc test to determine which of the paired means were significant. In all the cases 0.05 level was fixed as significant level to test the hypothesis.