Chapter III

METHODOLOGY

This chapter describes the methodology and procedure adopted. It includes selection of subjects, selection of variables, criterion measures, reliability of data, instrument reliability, tester competency, reliability of subjects, collection of data, description of test items and statistical techniques employed for analyzing the data.

Selection of subjects

Thirty male volleyball players in the age group of 18 to 21 years who attended the Indian National Coaching Camp as a preparation for Under 19 Boys World Championship held in Tailand in the year 2003 and Under 21 Boys World Championship held in Iran in the same year were selected as subjects for this study. All players had completed 7 to 10 years of training under qualified coaches, developed high level of technical and conditional abilities. Only spikers and blockers were considered as subjects because only they perform spike in game situation. Research scholar sought permission from Volleyball Federation of India to conduct the study on probables of national team. Before administering the tests the scholar held series of meetings with the subjects, coaches of national coaching camp and explained to them the objective of the study.

Selection of variables

The research scholar made sincere efforts to review the related literature in the area of study and held series of discussions with experts to decide upon the variables to be taken up for the investigation. Sufficient numbers of studies have been done on vertical jump and countermovement jump to inquire about their contributing factors. But, so far no in depth studies have been found in the literature to discover the correlates of spike jump and block jump performance.
On the basis of variables analysed in the case of vertical jump and countermovement jump, reviewing the literature, feasibility of analysis as to which of the variables could be taken up for the investigation, keeping in view the availability of equipments and the legitimate time that could be devoted for tests, following anthropometric and physical performance variables were selected for this study.

**Dependent variables**

1. Spike jump
2. Block jump from static position
3. Block jump after stepping
4. Block jump after cross stepping

**Independent variables**

Anthropometric variables:

1. Weight
2. Height
3. Sitting height
4. Total arm length
5. Upper arm length
6. Forearm length
7. Total leg length
8. Thigh length
9. Lower leg length
10. Foot length

Strength variables:

1. Trunk flexion strength
2. Trunk extension strength
3. Right shoulder flexion peak torque 60 degrees/second
4. Right shoulder flexion peak torque 180 degrees/second
5. Right shoulder flexion power 60 degrees/second
6. Right shoulder flexion power 180 degrees/second
7. Left shoulder flexion peak torque 60 degrees/second
8. Left shoulder flexion peak torque 180 degrees/second
9. Left shoulder flexion power 60 degrees/second
10. Left shoulder flexion power 180 degrees/second
11. Right shoulder extension peak torque 60 degrees/second
12. Right shoulder extension peak torque 180 degrees/second
13. Right shoulder extension power 60 degrees/second
14. Right shoulder extension power 180 degrees/second
15. Left shoulder extension peak torque 60 degrees/second
16. Left shoulder extension peak torque 180 degrees/second
17. Left shoulder extension power 60 degrees/second
18. Left shoulder extension power 180 degrees/second
19. Right hip flexion peak torque 60 degrees/second
20. Right hip flexion peak torque 160 degrees/second
21. Right hip flexion power 60 degrees/second
22. Right hip flexion power 160 degrees/second
23. Left hip flexion peak torque 60 degrees/second
24. Left hip flexion peak torque 160 degrees/second
25. Left hip flexion power 60 degrees/second
26. Left hip flexion power 160 degrees/second
27. Right hip extension peak torque 60 degrees/second
28. Right hip extension peak torque 160 degrees/second
29. Right hip extension power 60 degrees/second
30. Right hip extension power 160 degrees/second
31. Left hip extension peak torque 60 degrees/second
32. Left hip extension peak torque 160 degrees/second
33. Left hip extension power 60 degrees/second
34. Left hip extension power 160 degrees/second
35. Right knee flexion peak torque 60 degrees/second
36. Right knee flexion peak torque 180 degrees/second
37. Right knee flexion power 60 degrees/second
38. Right knee flexion power 180 degrees/second
39. Left knee flexion peak torque 60 degrees/second
40. Left knee flexion peak torque 180 degrees/second
41. Left knee flexion power 60 degrees/second
42. Left knee flexion power 180 degrees/second
43. Right knee extension peak torque 180 degrees/second
44. Right knee extension peak torque 180 degrees/second
45. Right knee extension power 60 degrees/second
46. Right knee extension power 180 degrees/second
47. Left knee extension peak torque 60 degrees/second
48 Left knee extension peak torque 180 degrees/second
49. Left knee extension power 60 degrees/second
50. Left knee extension power 180 degrees/second
51. Right ankle dorsiflexion peak torque 60 degrees/second
52. Right ankle dorsiflexion peak torque 180 degrees/second
53. Right ankle dorsiflexion power 60 degrees/second
54. Right ankle dorsiflexion power 180 degrees/second
55. Left ankle dorsiflexion peak torque 60 degrees/second
56. Left ankle dorsiflexion peak torque 180 degrees/second
57. Left ankle dorsiflexion power 60 degrees/second
58. Left ankle dorsiflexion power 180 degrees/second
59. Right ankle plantar flexion peak torque 60 degrees/second
60. Right ankle plantar flexion peak torque 180 degrees/second
61. Right ankle plantar flexion power 60 degrees/second
62. Right ankle plantar flexion power 180 degrees/second
63. Left ankle plantar flexion peak torque 60 degrees/second
64. Left ankle plantar flexion peak torque 180 degrees/second
65. Left ankle plantar flexion power 60 degrees/second
66. Left ankle plantar flexion power 180 degrees/second
Flexibility variables:

1. Right shoulder flexibility
2. Left shoulder flexibility
3. Right hip flexibility
4. Left hip flexibility
5. Right ankle flexibility
6. Left ankle flexibility

Coordinative ability variables:

1. Reaction ability
2. Kinesthetic differentiation ability

Speed variable:

1. Speed

**Criterion Measures**

The criterion measures adopted in this study are as follows:

1. Spike jump measured in 0.5 of a centimeter for the vertical distance measured from the point of standing reach to the point where the subject is able to touch with his finger tips of his dominant hand on a scaled basketball board, by using three stride approach spike jump (Sharma, 1990).

2. Block jump from static position recorded in 0.5 of a centimeter for the vertical distance from the point of standing block reach to the point where the subject is able to touch his finger tips on a scaled basketball board, using block jump from static position (Sharma, 1990).

3. Block jump with side stepping measured in 0.5 of a centimeter for the vertical distance from the point of standing block reach to the point where the subject is able to touch his finger tips on a scaled basketball board, using block jump with side stepping (Sharma, 1990).

4. Block jump with cross stepping measured in 0.5 of a centimeter for the vertical distance from the point of standing block reach to the point where the
subject is able to touch his finger tips on a scaled basketball board, using block jump with cross stepping (Sharma, 1990).

5. Weight was measured to 1/10th of a kilogram, using an electronic weighing machine (Eston, 2001).

6. Height was measured in 1/10 th of a centimeter, using an anthropometer (Sodhi, 1991).

7. Sitting height was measured in 1/10 th of a centimeter from vertex of the head to the base of the sitting surface, using an anthropometer (Sodhi, 1991).

8. Total arm length recorded in 1/10 th of a centimeter, by measuring the straight distance from the landmark acromion to height of daetylion, using an anthropometer (Sodhi, 1991).

9. Upper arm length recorded in 1/10 th of a centimeter, by measuring the vertical distance from the landmark acromion to radiale using an anthropometer (Sodhi, 1991).

10. Forearm length measured in 1/10 th of a centimeter from the landmark radiale to stylion radiale, using an anthropometer (Sodhi, 1991).

11. Total leg length recorded in 1/10 th of a centimeter by measuring the vertical distance of height symphysion from sphyrion, using an anthropometer (Sodhi, 1991).

12. Thigh length measured in 1/10 th of a centimeter for a straight distance from landmark tibiae laterale to height trochanterion (Sodhi, 1991).

13. Lower leg length measured in 1/10 th of a centimeter for a distance from the landmark tibiae medale to sphyrion, using an anthropometer (Sodhi, 1991).

14. Foot length recorded in 1/10 th of a centimeter by measuring the distance between acropodion and pternion, using a sliding caliper (Sodhi, 1991).

15. Abdominal explosive strength measured using sit-up test and recorded in 1/100 of a second (Gain, 1980).


17. The force of plantar flexors and dorsiflexors of ankle joints, flexors and extensors of knee joints, hip joints and shoulder joints were measured using isokinetic testing device and recorded in Newton-meters (Chan, 1996).
Shoulder flexibility, hip flexibility and ankle flexibility were recorded in degrees for the range of motion using a universal goniometer (Clarkson, 1989).

Reaction ability recorded in centimeters using Ball Reaction Exercise Test (Hirtz, 1985).

Kinesthetic differentiation ability recorded in 1/10th of a centimeter, using Target Jump Test (Hirtz, 1985).

Speed measured by administering 20 meter dash test and time recorded in 1/100th of a second (Moir, 2004).

Reliability of Data

The reliability of data was ensured by establishing instrument reliability tester competency and subject reliability.

Instrument Reliability

The anthropometer and goniometer used in this study were obtained from the Sports Anthropometry Department in Faculty of Sports Science, Netaji Subhas National Institute of Sports, Bangalore. The isokinetic dynamometer (Kin-Com) and stop watches at General Theory and Methods of Training Department in Faculty of Sports Science, Netaji Subhas National Institute of Sports, Bangalore were used for testing the strength and speed variables. Back extension strength of the subjects was measured by using Electronic Back Dynamometer at Exercise Physiology Department in Faculty of Sports Science, Netaji Subhas National Institute of Sports, Bangalore. All these equipments had been in use for research purpose. They were well calibrated and thus accepted as accurate enough for the purpose of this study.
Tester Competency

To ensure that the investigator was well versed in the techniques of measuring anthropometric variables, he had a number of training sessions under Dr. H. S. Sodhi, Senior Scientific Officer, Anthropometry Department, Netaji Subhas National Institute of Sports, Patiala, Punjab. Investigator also completed training to learn the techniques and procedures of testing under experts concerned to other variables. After attaining training under experts in the field, sample of ten subjects were tested by the experts and the research scholar himself and the findings were correlated which is presented in table 1.

TABLE-1

TESTER RELIABILITY COEFFICIENT OF TEST RE-TEST SCORES

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient of Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spike jump</td>
<td>.923</td>
</tr>
<tr>
<td>Block jump from static position</td>
<td>.947</td>
</tr>
<tr>
<td>Block jump with side stepping</td>
<td>.906</td>
</tr>
<tr>
<td>Block jump with cross stepping</td>
<td>.895</td>
</tr>
<tr>
<td>Weight</td>
<td>.916</td>
</tr>
<tr>
<td>Height</td>
<td>.961</td>
</tr>
<tr>
<td>Sitting height</td>
<td>.953</td>
</tr>
<tr>
<td>Total arm length</td>
<td>.903</td>
</tr>
<tr>
<td>Upper arm length</td>
<td>.928</td>
</tr>
<tr>
<td>Forearm length</td>
<td>.932</td>
</tr>
<tr>
<td>Total leg length</td>
<td>.880</td>
</tr>
<tr>
<td>Thigh length</td>
<td>.944</td>
</tr>
<tr>
<td>Lower leg length</td>
<td>.911</td>
</tr>
<tr>
<td>Foot length</td>
<td>.959</td>
</tr>
<tr>
<td>Trunk flexion strength</td>
<td>.884</td>
</tr>
<tr>
<td>Trunk extension strength</td>
<td>.862</td>
</tr>
</tbody>
</table>
Subject Reliability

Subject reliability was established by test-retest method where consistency of results were obtained by product moment correlation. Data collected from randomly selected sample of ten subjects by test-retest was correlated and coefficients of correlation obtained are presented in table 2.

### TABLE-2

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient of Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spike jump</td>
<td>.897</td>
</tr>
<tr>
<td>Block jump from static position</td>
<td>.916</td>
</tr>
<tr>
<td>Block jump with side stepping</td>
<td>.862</td>
</tr>
<tr>
<td>Block jump with cross stepping</td>
<td>.884</td>
</tr>
<tr>
<td>Weight</td>
<td>.922</td>
</tr>
</tbody>
</table>

N=10, Significant at 0.01 level, \( \text{tab } r(8) = 0.765 \)

From the table it is evident that very high correlations ranging from 0.961 to 0.862 were obtained for variables, thus establishing the competency of the tester to administer the tests.
Height .955
Sitting height .939
Total arm length .915
Upper arm length .913
Forearm length .922
Total leg length .870
Thigh length .903
Lower leg length .892
Foot length .938
Trunk flexion strength .867
Trunk extension strength .864
Right shoulder flexibility .874
Left shoulder flexibility .880
Right hip flexibility .822
Left hip flexibility .831
Right ankle flexibility .883
Left ankle flexibility .875
Reaction ability .912
Kinesthetic differentiation ability .877
Speed .904

N=10, Significant at 0.01 level, tab r (8) = 0.765

From the table 2 it is evident that very high correlations ranging from 0.955 to 0.822 were obtained for variables, thus establishing the subject reliability

Collection of Data

The necessary data was collected by administering various tests for the chosen variables. The speed, trunk flexion strength, kinesthetic differentiation ability, reaction ability and jump tests were administered in the Volleyball Indoor Training Hall of Netaji Subhas National Institute of Sports, Bangalore. Rest of the tests were administered in Physiology, Sports Anthropometry and General Theory and Methods of Training Department Laboratories in Faculty of Sports Science, Netaji Subhas National Institute of Sports, Bangalore.
Description of Test Items

Spike jump

Equipments:
1. A wall marked with a scale.
2. A basketball board marked with a scale.
3. Chalk powder.
4. A volleyball referee stand.

Procedure:

The spike jump was calculated by subtracting the subject’s dominant hand reach in standing position from his spike jump reach. Hence the standing reach of the subject was measured first.

The subject was asked to stand with his dominant hand close to the wall marked with scale, his lateral side of the dominant hand side foot touching the wall to measure his standing reach. Then he was instructed to stretch his dominant hand vertically upward to touch the scale as high as possible, without raising the heels. The point the subject could touch was marked, red by the tester who was positioned on the referee stand keeping the eye level horizontal to the point of contact, facing the wall and recorded in 0.5 of a centimeter.

For assessment of spike jump, the subject was asked to stand at a comfortable diagonal distance away from the basketball board marked with scale to perform spike jump with three stride approach. Chalk powder was daubed on the tip of the fingers of his dominant hand. Then the subject performed a spike jump and touched the scale on the board with fingers as high as possible. The tester, who was positioned on the referee stand keeping the eye level horizontal to the point of contact, located the highest point with the mark of chalk powder made with the
middle finger of the subject on the scale and the reading was recorded. The standing reach was subtracted from the spike jump reach to calculate spike jump.

Scoring:

Three trials were given and the best out of three trials was recorded in 0.5 of a centimeter as the score of the subject.

**Block jump from static position**

**Equipments:**

1. A wall marked with a scale
2. A basketball board marked with a scale
3. Chalk powder
4. A volleyball referee stand.

**Procedure:**

The block jump from static position was measured by subtracting the standing block reach from reach of block jump from static position.

To measure the block reach in standing position, the subject was asked to stand facing the scale marked on the wall with his toes touching the wall. Then he was told to stretch his both hands upward and touch the scale on the wall as high as possible, without raising the heels. The position of the tester was as same as in the test to measure spike jump. The reach of the tip of the middle finger of the hand placed lower than the other was considered as the standing block reach of the subject and recorded in 0.5 of a centimeter.

Prior to the test to measure the block jump reach from static position, the subject was asked to apply chalk powder on his finger tips of both the hands. Then the subject took position keeping his hands close and in front of the chest, under the basketball board which is scaled in centimeters. The subject flexed his knees, then jumped upward from the spot without moving his feet, and touched the
board with both hands as high as possible. The position of the tester was same as in the event of spike jump test. The vertical distance from the floor to the chalk mark made by the middle finger of the hand touched lower than the other on the board was read from the scale and recorded as reach of block jump from static position.

Scoring:

In order to compute block jump from static position, the score of standing block reach was subtracted from the reach of block jump reach from static position. Three trials were given to the subject and the best jump was considered as the score.

Block jump after side stepping

Procedure:

Block jump after side stepping was measured by using the same equipments and procedure used to measure the block jump from static position, but the subject performed a side step prior to the block jump.

Scoring:

The score of block jump after side stepping was computed by subtracting the score of standing block reach from reach of block jump after side stepping. Three trials were given to the subject and the best jump was considered as the score and recorded in 0.5 of a centimeter.

Block jump after cross stepping

Procedure:

Block jump after cross stepping was measured by using the same equipments and procedure used to measure the block jump from static position, but the subject took a cross step prior to the block jump.
Scoring:

The score of block jump after side stepping was computed by subtracting the score of standing block reach from reach of block jump after cross stepping. Three trials were given to the subject and the best jump was considered as the score and recorded in 0.5 of a centimeter.

Weight

Equipment:

A standardized electronic weighing machine.

Procedure:

The subject, in minimal clothing was asked to stand barefoot at the centre of the platform of the weighing machine.

Scoring:

The weight of the subject was recorded from the display panel of the weighing machine in $\frac{1}{10}$th of a kilogram.

Height

Equipment:

A standardized anthropometer.

Procedure:

The barefooted subject was asked to stand straight, against an anthropometer, touching the anthropometer with head, back, buttock and both heels. The feet were placed parallel to each other and head was oriented in the Frankfurt plane, i.e. the lower border of the eye socket and upper border of the ear opening on a horizontal line. The shoulders were held comfortably and arms hung
at sides with palm touching the thighs. The subject was instructed to stretch upward and hold a full breath. Broca plane or ruler of the anthropometer was lowered slowly until it touched the vertex of the head in the mid sagittal plane firmly, but without exerting extreme pressure.

Scoring:

Measurement was recorded to 1/10\textsuperscript{th} of a centimeter.

Sitting height

Equipment:

A standardized anthropometer.

Procedure:

The subject was asked to sit stretched on a high stool, with the arms downwards and hands on the thighs. His lower legs hung downwards at an angle of 90 degrees with back of the knees touching the edge of the stool. The subject was asked to stretch up, sit straight, as tall as possible and to take a deep breath. The moving arm of the anthropometer was brought down on the top of the head, crushing the hair and make firm contact with the vertex.

Scoring:

The reading was recorded in 1/10\textsuperscript{th} of a centimeter.

Total arm length

Equipment:

A standardized anthropometer.
Procedure:

The subject was asked to stand erect with arms hanging down freely. The tip of the moving arm of the vertically held anthropometer was kept on the most superior and external border of the acromion process to measure the height acromion. The reading was recorded in \(1/10\)th of a centimeter. From the same position, the landmark dectylion, the most distally projecting point on the tip of the finger was located and the same procedure was used to measure the height of dectylion and was recorded in \(1/10\)th of a centimeter.

Scoring:

The value of height dectylion was subtracted from the value of height of acromion for recording the total arm length in \(1/10\)th of a centimeter.

**Upper arm length**

Equipment:

A standardized anthropometer.

Procedure:

The subject was asked to stand erect with arms hanging down freely. The tip of the moving arm of the vertically held anthropometer was kept on the most superior and external border of the acromion process to measure the height acromion. The reading was recorded in \(1/10\)th of centimeters. From the same position of the subject, the landmark radiale, the point at the proximal and lateral border of the head of the radius was located and measured its height in \(1/10\)th of centimeters.

Scoring:

The value of height radiale was subtracted from the value of the height of acromion for recording the upper arm length in \(1/10\)th of a centimeter.
**Forearm length**

**Equipment:**

A standardized anthropometer.

**Procedure:**

The subject was instructed to stand erect with arms hanging down freely. The tip of the moving arm of the vertically held anthropometer was kept on the point at the proximal and lateral border of the head of the radius called the radiale to measure the height radiale. The reading was recorded in $\frac{1}{10th}$ of centimeters. From the same position the landmark stylion, the most distal point on the styloid process of radius was located and its height was measured and recorded in $\frac{1}{10th}$ of a centimeter.

**Scoring:**

The value of height stylion was subtracted from the value of the height of radiale for recording the forearm length in $\frac{1}{10th}$ of a centimeter.

**Total leg length**

**Equipment:**

A standardized anthropometer.

**Procedure:**

The subject was made to stand erect, barefooted with feet little apart and body weight equally distributed. The tester placed his index and middle fingers below the naval point and gently palpated downward until the underlying bony surface called symphysis, the superior border of the symphysis pubis in cardinal sagittal plane. The tip of the moving arm of the vertically placed anthropometer was kept on the landmark symphysis to measure the height of symphysis. The
reading was recorded in $1/10^{th}$ of centimeter. From the same position of the subject, the land mark sphyrion, the most distal point on the medial malleolus of tibia was located and the same procedure was used to measure the height of sphyrion.

**Scoring:**

The value of height sphyrion was deducted from the value of the height of symphysion and the score was recorded in $1/10^{th}$ of a centimeter.

**Thigh length**

**Equipment:**

A standardized anthropometer.

**Procedure:**

The subject barefooted was made to stand erect. The land mark trochantrion was traced by pressing the trochanter area using index and middle finger, while the subject standing with weight on the other leg. The anthropometer was held vertically and the tip of the moving arm kept exactly on the superior point on the top of the greater trochanter of the femur and the reading was recorded in $1/10^{th}$ of a centimeter. The land mark tibiale laterale, the lateral border of the proximal end of tibia was traced by palpating the area of depression at the lateral side of the knee. After the identification of the land mark, the tip of the moving arm of the vertically placed anthropometer kept on the most superior point of the land mark and the reading of the height tibiale laterale was recorded in $1/10^{th}$ of a centimeter.

**Scoring:**

The value of height tibiale laterale was substracted from the value height trochantrion and recorded in $1/10^{th}$ of a centimeter.
Lower leg length

Equipment:

A standardized anthropometer.

Procedure:

The subject was asked to stand and the tester held the leg of the subject in his hand at level of knees, giving slight support in such a way that the foot was lifted above the ground. Then the leg was slightly flexed and the land mark tibiale mediale was located by palpating near the distal end of the patella. Then the subject was asked to stand erect and the tip of moving arm of the vertically held anthropometer was kept on the land mark. The height tibiale mediale was measured and recorded in 1/10th of a centimeter.

Then the most distal point on the medial malleolus called spyrion was located and same procedure used in measuring tibiale mediale was applied to measure height spyrion and recorded in 1/10th of a centimeter.

Scoring:

The lower leg length was found out by subtracting the value height spyrion from height tibiale mediale and recorded in 1/10th of a centimeter.

Foot length

Equipment:

A standardized sliding caliper.

Procedure:

In order to measure the foot length the subject was asked to stand barefooted with complete sole of the foot touching the floor. The straight distance
between acropodion and pternion of the left foot was measured with sliding Caliper.

Scoring:

The Foot length was recorded in 1/10th of a centimeter.

**Sit-up test**

**Equipments:**
1. A standard floor mat.
2. A stop watch.
3. A 10 kilogram weight plate.

**Procedure:**

Subject assumed supine position on the floor mat with knees bent. He held a 10 kilogram weight plate with both hands at the back of the neck. An assistant was assigned to hold his legs at the knee. On the command 'start' the subject performed sit-ups as fast as possible simultaneously the stop watch was started. On completion of seventh sit-up the tester stopped the stop watch.

**Scoring:**

The time taken to complete seven sit-ups was recorded in 1/100 of a second. Two trials were taken and the best performance was considered as the score of the subject.

**Back strength test**

**Equipment:**

*Electronic Back Dynamometer*

**Procedure:**
The subject was asked to stand on the dynamometer base, with feet parallel and about six inches apart. He was asked to keep his head erect, back straight, and fingers extending down the thighs. The tester adjusted the length of the chain connecting the bar in a manner that the bar was held at level of the finger tips of the subject. The subject bent slightly forward, with knees straight and grasped the bar near either end. A mixed grips i.e.; one hand supinated and other pronated were used. The subject was asked to lift the bar keeping his back straight, with a maximal effort.

Scoring:

The score was recorded in kilograms from the display of the dynamometer. Three trials were given and the best out of three trials was recorded as the score of the subject.

Shoulder flexion and extension strength tests

This test was administered to measure peak torque and power in flexion and extension of right and left shoulders of the subject.

Equipments:

Isokinetic dynamometer

Procedure:

The subject was seated on the seat of the dynamometer with back straight, the hip and trunk were positioned at an angle of 110 degrees and a velcro pelvic strap was fastened at the waist, across the trunk. The dominant shoulder was tested first. To test the shoulder the dynamometer shaft was aligned with frontal axis passing through the glenohumeral joint. The subject held the handle of the dynamometer with his hand.
The strength of concentric contraction during flexion and extension of shoulder was measured in two speeds i.e. 60 degrees/seconds and 180 degrees/seconds. The test protocol consisted of a warm up session which contains three sub maximal and three maximal repetitions with same isokintic test velocity, and three real test repetitions. As the dynamometer started, the subject performed flexion and extension at the joint as per the protocol pre set in the dynamometer.

Scoring:

After the completion of warm up and three maximal concentric contraction printout of the performance was obtained and peak torque and power at 60 degrees/second and 180 degrees/second speeds in flexion and extension were recorded in Newton-meters (Nm) as the scores of the subject.

Same procedure was followed to test the peak torque and power in flexion and extension of non-dominant shoulder of the subject.

**Hip flexion and extension strength tests**

This test was administered to measure peak torque and power in flexion and extension of right and left hip joints of the subject.

**Equipment:**

Isokinetic dynamometer

**Procedure:**

The subject was asked to take a supine position keeping the dominant side close to the dynamometer. The seat was adjusted in such away that the dominant side was not supported in order to perform the flexion and extension of the hip without obstruction. A velcro pelvic strap was fastened at the waist to stabilise the subject. The axis dynamometer shaft was aligned with frontal axis.
passing through the hip joint. The force pad was kept at the back side of the thigh just above the knee joint, strapped around the thigh firmly.

The strength of concentric contraction during flexion and extension of hip was measured in two speeds i.e. 60 degrees/seconds and 160 degrees/seconds. The test protocol consisted of a warm up session which contains three sub maximal and three maximal repetitions with same isokinetic test velocity, and three real test repetitions. The subject performed flexion and extension at the joint as per the protocol already set in the dynamometer.

Scoring:

After the completion of warm up and three maximal concentric contractions the printout of the performance was obtained and peak torque and power at 60 degrees/second and 160 degrees/second speeds in flexion and extension were recorded in Newton-meters (Nm) as the scores of the subject.

Same procedure was followed to test the peak torque and power in flexion and extension of non-dominant hip of the subject.

**Knee flexion and extension strength tests**

This test was administered to measure peak torque and power in flexion and extension of right and left knees of the subject.

**Equipments:**

Isokinetic dynamometer

**Procedure:**

The subject was seated on the seat of the dynamometer keeping his dominant knee close to the dynamometer with back slightly reclined and the thighs well supported by the seat. A velcro pelvic strap was fastened at the waist, across the trunk. Distal femoral strapping was also done to ensure minimal femoral
motion. The arms were folded and kept across the chest. The axis of the dynamometer was aligned with frontal axis passing through mechanical axis of the knee joint around which flexion and extension took place. The resistance pad was placed at the level immediately superior to the medial malleolus and strapped around the lower part of the shank, not arresting the dorsi flexion at ankle joint. To immobilize uninvolved leg was kept behind the stopper.

The strength of concentric contraction during flexion and extension of knee was measured in two speeds i.e. 60 degrees/seconds and 180 degrees/seconds. A warm up session contained three sub maximal and three maximal repetitions with same isokintic test velocity, and three real test repetitions were set in the computer of the dynamometer. On signal the subject performed flexion and extension at the knee joint as per the protocol pre set in the dynamometer.

Scoring:

After the completion of warm up and three maximal concentric contractions, the printout of the performance was obtained. Peak torque and power at 60 degrees/second and 180 degrees/second speeds in flexion and extension were recorded in Newton-meters (Nm) as the scores of the subject.

Same procedure was followed to test the peak torque and power in flexion and extension of non-dominant knee of the subject.

Ankle dorsiflexion and plantar flexion force tests

This test was administered to measure peak torque and power in dorsiflexion and plantar flexion of right and left shoulders of the subject.

Equipments:

Isokinetic dynamometer
Procedure:

The subject was seated in a long sitting position with back support, keeping his dominant side toward the dynamometer. The subject was asked to flex his dominant hip by flexing the knee at 90 degrees. The limb was stabilized with a supporting pad which was strapped firmly at the distal part of the thigh. The foot was positioned on the resistance pad and was strapped with Velcro strap at knee.

The strength of concentric contraction during plantar flexion and dorsiflexion of ankle was measured in two speeds, i.e., 60 degrees/seconds and 180 degrees/seconds. The test protocol consisted of a warm-up session which contained three sub-maximal and three maximal repetitions with the same isokinetic test velocity, and three real test repetitions. As the dynamometer was to start, the subject performed flexion and extension at the joint as per the protocol already set in the dynamometer.

Scoring:

After the completion of warm-up and three maximal concentric contractions, printout of the performance was obtained. Peak torque and power at 60 degrees/second and 180 degrees/second speeds in dorsiflexion and plantar flexion were recorded in Newton-meters (Nm) as the scores of the subject.

Same procedure was followed to test the peak torque and power in dorsiflexion and plantar flexion of the non-dominant ankle of the subject.

**Shoulder flexibility test**

**Equipment:**

Universal goniometer

**Procedure:**

The subject was asked to sit on a table, keeping his right thigh close to
the edge of the table so that subject can move his arm freely with the palms facing medially. The axis of the goniometer was placed at the lateral aspect of the center of the humeral head approximately 2.5 cm inferior to the lateral aspect of the acromion process. The stationary arm of the goniometer placed on the lateral midline of the trunk and the movable arm parallel to the longitudinal axis of the humerus, pointing towards the lateral epicondyle of the humerus. The subject was directed to move his arm in anterior direction to the limit of motion in flexion. The moveable arm of the goniometer was also moved along the arm of the subject. Care was taken to avoid tricky movements like trunk extension and shoulder abduction. At the end of the movement the degree, the movable arm reached was recorded from the protractor. Then the subject was asked to move his arm posterior to the limit of motion in extension keeping the moveable arm of the goniometer along with. The reading in the protractor was recorded at the limit of the motion.

Scoring:

The degrees the arm moved in sagittal plane was calculated from obtained scores and recorded in degrees as right shoulder flexibility score of the subject. The same procedure was followed to measure the left shoulder flexibility of the subject.

**Hip flexibility test**

Equipment:

Universal goniometer

Procedure:

The right hip flexibility of the subject was measured with the subject in supine position on a long table. The hip and knee on the test side kept in the neutral position. The left hip may be flexed or extended. The trunk was stabilized through body positioning. The axis of the goniometer was placed over the greater trochanter of the femur. The stationary arm positioned on the midaxillary line of the trunk and
the movable arm parallel to the longitudinal axis of the femur, pointing towards the lateral epicondyle. The subject was directed to flex his hip to the limit while flexing the knee. The subject was instructed to keep the pelvis on the surface of the table and not to flex the lumbar spine. The moveable arm of the goniometer traveled with the thigh to the end of the range of motion.

Scoring:

The degrees the movable arm moved away from the starting position to the limit of motion in flexion were recorded in degrees as the right hip flexibility score of the subject.

The same procedure was followed to measure the left hip flexibility of the subject.

**Ankle flexibility test**

This test was administered to measure the range of motion of the right and left ankle in dorsiflexion and plantar flexion through sagittal plane.

**Equipment:**

*Universal goniometer*

**Procedure:**

The subject had to take a supine position, right knee flexed to approximately 20 to 30 degrees and a roll was placed under the knee joint. The foot was in the neutral position i.e. perpendicular to the lower leg. The axis of the goniometer was placed approximately 1.5 cm inferior to the lateral malleolus of right leg. The stationary arm of the goniometer placed parallel to the longitudinal axis of the fibula and the movable arm parallel to the longitudinal axis of the fifth metatarsal. The subject was directed to perform dorsiflexion to the limit of motion. The moveable arm of the goniometer was also moved along the foot of the subject.
The degree of the movable arm reached at the maximum dorsiflexed position was recorded. Then the subject was asked to move his foot downward to the limit of motion in plantar flexion keeping the moveable arm of the goniometer along the foot. The reading from the protractor was taken at the end of the motion.

Scoring:

The total degrees the foot moved from the limit of dorsiflexion to the limit of plantar flexion calculated from the obtained readings and recorded as the right ankle flexibility score of the subject and recorded in degrees. Same procedure was adapted to measure the left ankle flexibility.

**Ball reaction exercise test**

This test was administered to find out the reaction ability of the subjects.

Equipment:

1. Two wooden planks of four meters length each.
2. One inflated volleyball.
3. A supporting stand.
4. Pencil, papers, and pad.

Procedure:

Two wooden planks of four meters each were kept inclined by a supporting stand having a height of one meter and twenty centimeters so that it could enable a volleyball to roll freely from a height of one hundred and twenty centimeters. The lower ends of the wooden planks were kept at a distance of one meter and fifty centimeters away from the starting line. Outer side of one of the planks was graduated in centimeters. A volleyball was held by the tester at the top of the planks. The subject was asked to stand behind the starting line, facing opposite to the planks. On clapping the subject would take a turn, would run
towards the planks and would stop the ball with both hands which was dropped on
the signal. Each subject was given a practice trial before the actual commencement
of the test

Instructions:

1. The ball should be stopped with both hands.
2. The ball should not be pushed upwards while stopping.

Scoring:

The score was the distance measured from top of the planks to the point
where the subject stopped the ball. Only two trials were given and the best one was
recorded as the score of the subject. The score was measured in centimeters

Target jump test

This test was administered to measure kinesthetic differentiation ability
of the subjects.

Equipments:

1. Jumping box (90c.m height).
2. Gymnastic mat.
4. Chalk.

Procedure:

A 90 cm high, jumping box was kept close to the edge of the
gymnastics mat. A line was marked with the chalk, on the mat at a distance of 1
meter from the edge of the base of the jumping box. Subject was asked to stand on
the box and instructed to jump over the line from the box; in such a manner that the
heels of the feet should exactly touched the line at the time of landing. The
distance between the point of contact of heel on the mat and the target line was
measured with the help of measuring tape. After a demonstration and instructions two trials were given to each subject.

Scoring:

The average value of scores of two trials was considered as the final score of the subject, recorded in $1/10^{th}$ of a second.

Speed test

Equipments:

Stop watch

Procedure:

Two parallel lines i.e., starting line and finishing line having 20 meters distance in between were marked on the field. After a thorough warm up, the subject was asked to take any type of starting position behind the starting line. The tester took position in line with the finishing line. The subject sprinted from the starting line to finishing line. The stop watch started at the moment the subject performed the initial movement and stopped when he crossed the finishing line.

Scoring:

Three trails were given and the best of the three trials was recorded in seconds as the score of the subject.
**Statistical Technique**

In order to measure the magnitude of linear relationship between anthropometric measurements and motor performance variables to spike jump and block jump in volleyball a coefficient known as Product moment correlation was employed. Multiple correlations were used to know the correlation between groups of independent variables and each dependent variable (Prakash 2000). FoxPro Software developed by a firm authorized and well recognized in the field of physical education was utilised in the statistical procedure.