Chapter III

METHODOLOGY

In this chapter the methodology adopted for the selection of subjects, classification of subjects, protocol, selection of variables, justification of the variables selected, selection of tests, calibration of instruments, reliability of tests, orientation of testers, orientation of subjects, administration of tests and statistical techniques have been elucidated.

Selection of Subjects

The study was proposed to compare RDT hockey academy male players of high and low achievers in terms of morphophysiological and biomotor variables. To accomplish the purpose of the study, twenty nine (29) male youth field hockey players were selected at random as subjects, who volunteered to participate in this study. These players were randomly classified into two groups namely high and low achievers. The high achievers group constitutes of 17 players and low achievers group constitutes of 12 players. These players were selected from RDT Hockey Academy, Anantapur, Andhra Pradesh, India. These players were selected during the academic year 2010 – 2011.

On average, the players had 4.9 ± 2.1 years of playing experience and represented different levels of competition and underwent regular morning training between 06:30 to 08:30 and evening practice between 16:30 to 18:30 regularly prior to the commencement of this study. Players remained passive for remaining hours. These subjects were accommodated in RDT Academy hostel, during the course of the study and similar diet was provided to all the subjects.

These subjects go to bed between 22:00 to 22:30 and wakes up from bed between 05:30 to 06:00 hours. Prior to the study, the investigator ensured that all the subjects had a good understanding of the requirements. When verbal consent was obtained, the researcher in consultation with the subjects sketched a time schedule to incorporate the sampling schedule and exercise testing. Written consent was obtained prior to initial data collection, which is given in appendix – A.

Classification of Subjects

The subjects were classified into high and low achievers for this study. High achievers subjects who represented highest level of competition and low achievers are immediately below high achievers level. This classification is done in accordance with the study carried out by Elferink-Gemser, *et al*., (2004).

Selection of Variables

The investigator inferred to various relevant literature, consulted with experienced experts in sports and biochemistry to identify ideal variables. In addition to this by using the investigator's personal knowledge and professional experience the following most ideal variables were selected in the present investigation.

Criterion Variables

The criterion variables selected in this study were morphophysiological and biomotor variables as follows:

Morphophysiological

1. Anthropometry
    a) Height
    b) Weight
2. Body Composition
    a) Percent body fat (%)
    b) Lean body mass
3. Somatotype
    a) Endomorphy
    b) Mesomorphy
    c) Ectomorphy

Biomotor Variables

1. Speed
2. Power
3. Agility
4. Flexibility
5. Strength
    a) Back strength
    b) Shoulder strength
    c) Abdominal strength
    d) Grip strength
6. Aerobic capacity

    VO_2 max predicted

Justification of the Variables Selected

Identification of specific characteristics of physique that may contribute to success in sports as well as the possible structural differences among athletes in various sports has been a subject of high interest for sport scientists and coaches. For instance, the importance of players' tall stature in some team sports (*e.g., volleyball, basketball, handball*) is accepted as it is well known that body height influences positively all body segment lengths and, in turn, athletic performance (Fleck, *et al*., 1985; Carter & Heath, 1990; Apostolidis, *et al*., 2004). Field hockey players are not identified by specific physical characteristics. The morphophysiological variables show some relationship to playing performance. In order achieve the purpose morphophysiological variables are selected which are not indicators of hockey skill potential (Reilly & Borrie, 1992). The physical profile of field hockey players varies between individuals.

Aerobic fitness is a very important component of fitness for hockey players. Hockey is played 70 minutes with just one 5-10 minute interval, during the game players had to perform continuously. This places a high demand on the aerobic system and good aerobic endurance is required to support repetitive bouts of high intensity exercise (Boyle, Mahoney & Wallace, 1994).

Anaerobic power and anaerobic endurance is high in elite hockey players (Reilly & Borrie, 1992). Although the majority of the game is spent in low-level activity such as walking and light jogging, repeated back-to-back sprints make speed and tolerance to lactic acid an important characteristic in players (Spencer, *et al*., 2004).

Strength is also central to a hockey training program. Although players aren't required to hold off physical challenges (*when compared to other multi-sprint sports*), power is required for acceleration, speed and quick changes in direction. Upper body strength allows players to shoot more powerfully and pass over a greater range of distances.

The unique demands of the sport mean that strength endurance is just as crucial as explosive power. Careful planning is required to ensure that both muscular power and muscular endurance can be effectively developed alongside each other without leading to over-training and fatigue. Hockey conditioning also plays a crucial role in development of physical and physiological variables. Considering these facts criterion variables are selected.

Selection of Tests

In the current exploration ultimate and consistent tests were used to assess the selected morphophysiological and biomotor variables as presented in table -1.

Table - 1

Tests used for criterion variables

S.No	Variables	Methods / tests /equipment
I	Morphophysiological variables	
1.	Anthropometry	
	Height (m)	Stadiometer
	Weight (kg)	Weighing machine
2.	Body Composition	
	a. Percent body fat (%)	Skinfold Caliper
	b. Lean body mass	Skinfold Caliper
3.	Somatotype	
	a. Endomorphy	Heath carter method
	b. Mesomorphy	Heath carter method
	c. Ectomorphy	Heath carter method
II	Biomotor variables	
4.	Speed (sec)	30 m dash
5.	Power (cm)	Standing broad jump
6.	Agility (sec)	6x10 agility test
7.	Flexibility (cm)	Sit and Reach Test
8.	Strength	
	a. Back Strength (kg)	Back and leg dynamometer
	b. Shoulder Strength (number)	Pushups
	c. Abdominal Strength (number)	Sit ups
	d. Grip Strength (kg)	Grip dynamometer
9.	Endurance	
	a. VO_2 max predicted (ml/kg/min)	1mile run and walk test

Calibration of Instruments

In this investigation standard equipments were used to assess the selected morphophysiological and biomotor variables:

Morphophysiological variables

The stadiometer, weighing machine, Harpenden skinfold caliper, sliding calliper for the breadths and a flexible steel or fibre glass tape for the girths which are available at RDT Hockey Academy, Anantapur, Andhra Pradesh, India were used to quantify morphophysiological variables. The equipments were purchased from reputed firms, which ensure reliability.

Biomotor variables

The stop watch, leg and back dynamometer, grip dynamometer, sit and reach box and standing broad jump mat are available at RDT Hockey Academy, Anantapur, Andhra Pradesh, India were used to quantify biomotor variables. The equipments were purchased from reputed firms, which ensure reliability. Hence their calibrations were accepted as accurate enough to use for present research.

Reliability of Tests

The tester's competency for test administration was evolved with the reliability of tests. To establish the reliability of tests, test and retest method was followed. For this purpose, 10 male hockey players were selected at random by from the RDT Hockey Academy, Anantapur, Andhra Pradesh, India. All the criterion variables selected in the present investigation were tested twice for same subjects under similar condition. As suggested by Johnson and Nelson (1982) univariate correlation (*intra class correlation*) was computed separately for each criterion variables. The obtained reliability coefficient is given in table - 2.

Table - 2

Reliability coefficients for tests and retest on criterion variables

Sl. No	Variables	Coefficient of Correlation	Level of significance
1	**Anthropometry**		
	Height	0.6556	0.05
	Weight	0.7625	0.05
2	**Body Composition**		
	Percent body fat	0.7429	0.05
	Lean body mass	0.6584	0.05
3	**Somatotype**		
	Endomorph	0.7315	0.05
	Mesomorph	0.7499	0.05
	Ectomorph	0.9507	0.05
4	**Biomotor**		
	Speed	0.6429	0.05
	Power	0.8781	0.05
	Agility	0.6930	0.05
	Flexibility	0.7003	0.05
	Back strength	0.6913	0.05
	Shoulder strength	0.7520	0.05
	Abdominal strength	0.6586	0.05
	Left hand grip strength	0.6835	0.05
	Right hand grip strength	0.6810	0.05
	Aerobic capacity	0.6350	0.05

Table value required for 8 df at 0.05 level of significance is 0.632

The entire criterion variables were significant at 0.01 level and this reveals that all the test items are reliable. Hence, these tests were used in this study.

Orientation of Testers

Since, the investigator alone could not organize the administration of tests, coaches from the RDT Hockey Academy, Anantapur, Andhra Pradesh, India, were recruited to serve as testing personals. The purpose of the study, testing procedures and method of scoring were briefly explained and demonstrated to the

testers. The investigator had overall supervision on the subjects and the testers. All the testers performed their duty to the utmost gratification.

Orientation of Subjects

Prior to exploration, the investigator informed the rationale of the study and concise preface of morphophysiological and biomotor variables comparison between high and low achievers hockey players from RDT Hockey Academy, Anantapur, Andhra Pradesh, India. The way of doing each test was demonstrated and explained to subjects by the researcher. Subjects were motivated to exhibit their maximum performance in selected test. All the subjects cooperated to their best during the course of experimentation.

Collection of Data

Each subject reported to the lab for testing morphophysiological and biomotor variables during the middle of the training year. First, the measurements with regard to height, weight, morphological, flexibility, power and maximum oxygen consumption (VO_2max) were obtained. Then, after three days of recovery these subjects were tested for biomotor variables like speed, strength and agility.

Administration of Tests

Body Composition

Objective

Measuring body fat percentage is an easy method of discovering correct body weight and composition. Beneath the skin is a layer of subcutaneous fat, and the percentage of total body fat can be measured by taking the 'skinfold' at

selected points on the body with a pair of calipers. This test only requires four measurements.

Equipment required

Skinfold Caliper and measuring tape

Procedure

Estimation of body fat by skinfold thickness measurement. Measurement can use from 3 to 9 different standard anatomical sites around the body. The right side is usually only measured (for consistency). The tester pinches the skin at the appropriate site to raise a double layer of skin and the underlying adipose tissue, but not the muscle. The calipers are then applied 1 cm below and at right angles to the pinch, and a reading in millimetres (mm) taken two seconds later. The mean of two measurements should be taken. If the two measurements differ greatly, a third should then be done, then the median value taken.

The sites

There are many common sites at which the skinfold pinch can be taken. The four sites proposed by Durnin and Womersley (1974) is applied in this research. The sites recommended by Durnin and Womersley (1974) are Triceps, Biceps, Subscapular and Suprailliac (waist).

Formula to Calculate

Body density and percentage body fat is calculated using the equations of Durnin and Womersley (1974), for each side of the body, using the following equations:

$$\text{Density } (g/cm^3) = c - m \, (\log \Sigma S)$$

Where:

D = Density

c and m = standard age and sex-specific coefficients

SS = Sum of all four skinfold measurements (mm)

Once density is calculated, the Siri (1961) equation is used to estimate Percentage body fat:

$$\text{Fat (\%)} = [(4.95 / D) - 4.5] \times 100$$

Where:

D = Density

4.95 and 4.5 are the constants calculated by Siri (1961) using the assumptions on the density of FM and FFM.

Lean Body mass (Wilmore & Costill, 1994) was measured using the following equation:

$$LeanBodyMass = \frac{(100 - bodyfatpercentage)}{100} \times weight$$

Somatotype

The descriptions are essentially the same as in Carter and Heath (1990). The following techniques ideally should be used for subsequent calculation of the Heath-Carter anthropometric somato-type. Where the choice is possible, measures should be taken both on left and right sides and the largest measure should be reported. In large-scale surveys, measuring on the right side is preferable. The anthropometric equipment needed includes a weighing scale, a stadiometer

(*a height scale attached on a wall*) and a Broca plane, or an anthropometer for measuring the height, a skin fold caliper, a small sliding caliper for the breadths and a flexible steel or fibre glass tape for the girths.

a) Weight

The subject, in minimal clothing, stands in the centre of the scale platform. Body mass should be recorded to the nearest one-tenth of a kilogram, if possible. A correction is made for clothing so that nude weight is used in subsequent calculations. Avoid measuring body mass shortly after a meal.

b) Height

The subject is standing straight, against an upright wall with a stadiometer or against an anthropometer, touching the wall or the anthropometer with back, buttocks and both heels. The head is oriented in the Frankfort Plane (*i.e. the lower border of the eye socket and the upper border of the ear opening should be on a horizontal line*). The subject is instructed to stretch upward and take and hold a full breath. The measurer should lower the Broca plane or the ruler until it touches the vertex firmly, but without exerting extreme pressure.

c) Skinfolds

Raise a fold of skin and subcutaneous tissue at the marked site firmly between thumb and forefinger of the left hand, and pull the fold gently away from the underlying muscle. Hold the caliper in the right hand and apply the edge of the plates on the caliper branches 1 cm below the fingers, and allow them to exert their full pressure before reading the thickness of the fold after about two seconds. The Harpenden caliper is used for collection of data.

i) Triceps skinfold

The subject stands relaxed, with the arm hanging loosely. Raise the triceps skinfold at the midline on the back of the arm at a level halfway between the acromion and the olecranon processes.

ii) Subscapular skinfold

The subject stands relaxed. Raise the subscapular skinfold adjacent to the inferior angle of the scapula in a direction which is obliquely downwards and outwards at 45 degrees.

iii) Supraspinale skinfold

The subject stands relaxed. Raise the fold 5–7 cm above the anterior superior iliac spine on a line to the anterior axillary border and in a direction downwards and inwards at 45 degrees.

iv) Medial calf skinfold

The subject is seated, with the legs slightly spread. The leg that is not being measured can be bent backwards to facilitate the measurement. Alternatively, the foot may be placed on a box with the knee flexed. Raise a vertical skinfold on the medial side (*aspect*) of the leg at the level of the maximum girth of the calf

d) Breadths

i) Biepicondylar humerus breadth

The subject holds the shoulder and elbow flexed to 90 degrees. Measure the width between the medial and lateral epicondyles of the humerus. In this position, the medial epicondyle is always somewhat lower than the lateral. Apply the caliper at an angle approximately bisecting the angle of the elbow. Place firm

pressure on the cross branches of the caliper in order to compress the subcutaneous tissue.

ii) Biepicondylar femur breadth

The subject is seated, or standing upright with one foot on a pedestal, with knee bent at a right angle. Measure the greatest distance between the lateral and medial epicondyles of the femur. Place firm pressure on the cross-branches in order to compress the subcutaneous tissue.

e) Girths

i) Upper arm girth, flexed and tensed

The subject holds the upper arm horizontally and flexes the elbow 45 degrees, clenches the hand and maximally contracts the elbow flexors and extensors. Take the measurement at the greatest girth of the arm. The tape should not be too loose, but should not indent the soft tissue either.

ii) Standing calf girth

The subject stands with feet slightly apart. Place the tape horizontally around the calf and measure the maximum circumference. The tape should not be too loose, but should not indent the soft tissue either.

Flexibility tests

Sit and Reach Test

Objective

The objective of this test is to monitor the athlete's lower back and hamstring flexibility.

Equipment required

Sit and reach box (*or alternatively a ruler can be used, and a step or box*)

Procedure

This test involves sitting on the floor with legs stretched out straight ahead. Shoes should be removed. The soles of the feet are placed flat against the box. Both knees should be locked and pressed flat to the floor - the tester may assist by holding them down. With the palms facing downwards, and the hands on top of each other or side by side, the subject reaches forward along the measuring line as far as possible. Ensure that the hands remain at the same level, not one reaching further forward than the other. After some practice reaches, the subject reaches out and holds that position for at one-two seconds while the distance is recorded. Make sure there are no jerky movements.

Scoring

Record the best score in cm or inches beyond the base of your foot, or you did not reach your toes, measure how far before the feet you were (*a negative measurement score*).

Strength tests

Back and Leg Strength

Objective

The objective of this test is to measures back strength of athletes.

Equipment required

Strength dynamometer, usually composed of a cable tensiometer

Procedure

Make sure the dial is reset to zero before you start. Stand upright on the base of the dynamometer with your feet shoulder width apart. Let your arms hang straight down to hold the center of the bar with both hands, and with the palms facing toward the body. Adjust the chain so that the knees are bent at approximately 110 degrees. In this position your back should be bent slightly forward at the hips, your head should be held upright, and you should look straight ahead. Then without bending your back, pull as hard as possible on the chain and try to straighten your legs, keeping your arms straight. Pull against the weight steadily (*no jerky movements*), keeping the feet flat on the base of the dynamometer. Maximum performance will result when your legs are almost straight at the end of the lift. If not, adjust the chain length and starting position.

Scoring

Record the final resistance on the back and leg dynamometer in terms of kilogram (kg).

Handgrip Strength Test

Objective

The objective of this test is to measure the maximum isometric strength of the hand and forearm muscles. Handgrip strength is important for any sport in which the hands are used for catching, throwing or lifting.

Equipment required

Handgrip dynamometer

Procedure

The subject holds the dynamometer in the hand to be tested, with the arm at right angles and the elbow by the side of the body. The handle of the dynamometer is adjusted if required - the base should rest on first metacarpal (*heel of palm*), while the handle should rest on middle of four fingers. When ready the subject squeezes the dynamometer with maximum isometric effort, which is maintained for about 5 seconds. No other body movement is allowed. The subject should be strongly encouraged to give a maximum effort.

Scoring

The best result from three trials for each hand is recorded, with at least 15 seconds recovery between each effort. Record the final resistance on the hand grip dynamometer in terms of kilogram (kg).

Push up test

Purpose

Push-ups are used to assess the strength and endurance of the upper body muscle groups.

Equipment required

Floor mat or flat ground, stopwatch

Procedure

The aim of this test is to perform as many push-ups in you can in one minute. The starting position is with your arms straight, elbows locked, body straight, hands placed slightly wider than shoulder-width apart with fingers pointing forward and both feet on the floor. From the starting position, on the

command ‘go,’ start the push-up by bending your elbows and lowering your body until the shoulders drop below the level of the elbows, then return to the starting position. Pausing to rest is permitted only in the up (*starting*) position.

Scoring

The maximum number of correctly performed pushups is recorded.

Comments

For the push up to be counted, the body must remain rigid in a generally straight line, and move as a unit while performing each rep, and the technique as described must be adhered to. If you rest on the ground or raise either hand or foot from the ground, the test will be terminated.

Sit Up

Objective

Abdominal muscle strength and endurance is important for core stability and back support. This sit up test measures the strength and endurance of the abdominals and hip-flexor muscles.

Equipments required

Non-slippery flat surface, exercise mat, stopwatch, and partner to hold the feet on ground.

Procedure

This test requires the athlete to perform as many sit-ups as possible in 60 seconds or 1 minute. Initially athletes were provided with 10 minutes of warm up. Then the athlete lies on the mat with the knees bent, feet flat on the floor and their hands on their ears where they must stay throughout the test. The assistant holds

the athlete's feet on the ground when the assistant gives the command "GO" and starts the stopwatch, athletes perform sits up by touching the knees with their elbows, then returns back to the floor and continues to perform as many sit-ups as possible in 60 seconds or 1 minute. The assistant keeps the athlete informed of the time remaining and counts and records the number of correct sit-ups completed in given time and uses this recorded value to assess the athlete's performance

Scoring

The completion of one complete sit up (*up and back*) counts as one. The sit up must be performed correctly for it to be counted.

Comments

Make sure that the subject does not "bounce" off the floor - only correctly performed curl ups should be counted. The partner may assist by counting aloud the number of repetitions.

Standing broad jump

Objective

The objective of this test is to measure the explosive power of the legs or athletes elastic leg strength.

Equipment required

Tape measure to measure distance jumped, non-slip floor for takeoff, and soft landing area preferred. Commercial Long Jump Landing Mats are also available. The take off line should be clearly marked.

Procedure

The athlete stands behind a line marked on the ground with feet slightly apart. A two foot take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backwards. Three attempts are allowed.

Scoring

The measurement is taken from take-off line to the nearest point of contact on the landing (*back of the heels*). Record the longest distance jumped, the best of three attempts.

Speed

Objective

The objective of this test is to determine acceleration and speed.

Equipment required

Measuring tape, stopwatch, cone markers, flat and clear surface of at least 50 metres.

Procedure

The test involves running a single maximum sprint over 30 metres, with the time recorded. A systematic warm up should be given, including some practice starts and accelerations. Start from a stationary position, with one foot in front of the other. The front foot must be on or behind the starting line. This starting position should be held for 2 seconds prior to starting, and no rocking movements are allowed. The tester should provide hints for maximizing speed

(*such as keeping low, driving hard with the arms and legs*) and encouraged to continue running hard through the finish line.

Results

Two trials are allowed, and the best time is recorded to one-hundredth of a second. The timing starts from the first movement (*if using a stopwatch*) and finishes when the chest crosses the finish line.

Agility

Objective

This is a test of speed, body control and the ability to change direction (agility).

Equipment required

Marker cones, measurement tape, stopwatch, flat non-slip surface, 10 metres of distance is marked by two parallel lines of 5 metres each.

Procedure

The subject stands behind the starting line. On getting starting signal "GO" he runs faster, goes nearest to the other line and touches it with the one hand, turns and comes back to starting line, touches it with hand, turns and repeats it for a total of 5 times and 6th time runs over the line as fast as possible.

Scoring

The time taken by the performer to complete the course of 6 x10 metres to the nearest 1/10th of a second is recorded as score of the test. Only one chance is given.

Aerobic capacity (VO_2max from a one mile jog)

Objective

To monitor the development of the athlete's VO_2max.

Equipments required

To undertake this test 400 metre track, stopwatch, weighing Scales, heart rate monitor and an assistant

Procedure

Initially the assistant weighs and records the athlete's weight. Then the athletes were provided with warm up for 10 minutes. When the athlete is ready the assistant gives the command "GO" and starts the stop watch and the athlete commences the test. The athlete has to jog for one mile at an easy, steady pace, making sure that they take longer than eight minutes (*males*), or more than nine minutes (*females*). The assistant stops the stopwatch when the athlete completes one mile, records the time and immediately records the athlete's heart rate (bpm).

Assessment

The George *et al*. (1993) algorithms to calculate VO_2max are:

- Male Athletes VO_2max = 108.844 - 0.1636W - 1.438T - 0.1928H

Where,

W = Weight in kg,

T = Time for the one mile run and

H = Heart Rate at the end of the run

Statistical Analysis

SPSS statistic software package (*SPSS Company, America, version 11.0*) was used in statistical analysis for the morphophysiological and biomotor performance measurements. Descriptive report was given to all measured and derived variables. ANOVA was used for comparisons of mean values between the high and low achievers field hockey players. This ANOVA was performed between unequal groups, since high achievers consist of 17 subjects and low achieves consist of 12 subjects. Intra class correlation was applied to know the correlation coefficient. The α value of 0.05 was set for statistical significance.

In order to realize the criterion variables that contribute to the classification of players as high achievers and low achievers, discriminant analysis was appraised, and thereby unstandardized canonical discriminant function coefficients is used to derive the regression equation that classifies players to the categories namely: high achievers and low achievers based on their basal characteristics. Further, multiple correlation was computed to know the collective influence of determinants on level of achievement and then multiple regression equation was derived.