Chapter III

METHODOLOGY

In this chapter the method adopted for the selection of subjects, rationale for the selection of subjects, selection of variables, justification of the variables selected, selection of tests, calibration of the instruments, reliability of tests, orientation of testers, orientation of subjects, design of the study, collection of data, training interventions, administration of tests and statistical techniques have been elucidated

Selection of Subjects

To accomplish the purpose of the study, twenty four (24) male handball players were selected from the Department of Physical Education and Sports Sciences, Annamalai University, Chidambaram, Tamilnadu. These subjects were classified into two groups namely handball specific aerobic training group (HSATG) and Control group (CG), each group constituted of 12 subjects. The selected handball players’ age were 22.12 ± 3.22 years; height 174.50 ± 7.83 cm and weight 65.62 ± 7.79 kg. The selected subjects gave their willingness to participate in this study. After getting the consent, the twenty four male handball players were medically examined and found they were free from disease and injuries. The present study
commenced in the month January 2013 with pre test data collection, which was followed by administration of training and finally ended in the month of March 2013 with post test data collection.

A written consent was obtained prior to initial data collection, which is given in Appendix A. This clearly explains the nature of the study, the training program for the training group and variables in which they will be tested. They were also informed that they were free to opt out of the study at any time if they felt any discomfort or any difficulty in continuing the training program. However, no dropouts were there in the present study.

Rationale for the Selection of Subjects

In perspective to the purpose of the study, the subjects were selected at convenience for both experimental and control groups, and each group consisted of twelve subjects. The subjects considered were the true representatives of the population as the selected subjects were the members of the Annamalai University Handball team that took part in the south zone inter university handball tournament. Above all, these subjects were adequate to draw meaningful conclusions and generalizations.
Selection of Variables

The investigator referred to various literatures and consulted with handball coaches to identify ideal variables. In addition to this by using the investigator’s personal knowledge and professional experience the following most appropriate dependent variables were selected for the present investigation and are presented in Table 1.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Variable</th>
<th>Unit of measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical fitness</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Speed</td>
<td>Seconds (sec)</td>
</tr>
<tr>
<td>2</td>
<td>Agility</td>
<td>Seconds (sec)</td>
</tr>
<tr>
<td>3</td>
<td>Explosive power</td>
<td>Centimetre (cm)</td>
</tr>
<tr>
<td>4</td>
<td>Arm explosive strength</td>
<td>Metres (m)</td>
</tr>
<tr>
<td><strong>Physiological</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Percent body fat</td>
<td>Percentage (%)</td>
</tr>
<tr>
<td>2</td>
<td>Lean body mass</td>
<td>Kilogram (kg)</td>
</tr>
<tr>
<td>3</td>
<td>Resting heart rate</td>
<td>No of beats per minute</td>
</tr>
<tr>
<td>4</td>
<td>Aerobic capacity</td>
<td>ml/kg/min</td>
</tr>
<tr>
<td>5</td>
<td>Maximal heart rate</td>
<td>No of beats per minute</td>
</tr>
<tr>
<td>6</td>
<td>Anaerobic endurance</td>
<td>Seconds (sec)</td>
</tr>
</tbody>
</table>

Independent variable

The independent variable selected in the present study was handball specific aerobic training which was administered three days per week for eight weeks. The HSATG underwent handball specific aerobic training and CG remained passive.
Justification of the Variables Selected

The game of handball is a combination of intermittent and high intensity exercise, which places great physical demands on the body. The success of a handball player depends on aerobic and anaerobic performance (Hoffman & Maresh 2000). However, handball requires tremendous endurance, speed, agility, repeated sprint ability and power (Ziv & Lidor 2009).

The importance of developing good conditioning programs based on the specific physiological demands of each sport is considered a key factor to success (Gillam 1985; Taylor 2003; 2004). The handball player needs to train multiple components of fitness. Thus, the athlete will concurrently perform various modes of training (e.g., strength, anaerobic, endurance). In the present study handball specific aerobic training was employed. This incorporates skills and movements specific to the sport, at intensities sufficient to promote aerobic adaptations, are being increasingly implemented in professional team sports environment (Lawson 2001). The perceived benefit of performing sports-specific exercise is that the training will transfer better into the athletes competitive environment and
that the greatest training benefits occur when the training
stimulus simulates the specific movement patterns and
physiological demands of the sport (McArdle, Katch & Katch
1996).

**Selection of Tests**

In the current exploration standardized tests and
procedures were used to assess the physical fitness and
physiological variables are presented in Table 2.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Variable</th>
<th>Methods/Tests/Equipments</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Physical fitness</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Speed</td>
<td>30 yard dash</td>
</tr>
<tr>
<td>2</td>
<td>Agility</td>
<td>T test</td>
</tr>
<tr>
<td>3</td>
<td>Explosive power</td>
<td>Vertical jump test</td>
</tr>
<tr>
<td>4</td>
<td>Arm explosive strength</td>
<td>Handball throw for distance</td>
</tr>
<tr>
<td>II</td>
<td>Physiological</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Percent body fat</td>
<td>Skin fold Caliper</td>
</tr>
<tr>
<td>2</td>
<td>Lean body mass</td>
<td>Weighing machine</td>
</tr>
<tr>
<td>3</td>
<td>Resting heart rate</td>
<td>Polar Heart rate monitor</td>
</tr>
<tr>
<td>4</td>
<td>Aerobic capacity</td>
<td>Yo-Yo Intermittent recovery test II</td>
</tr>
<tr>
<td>5</td>
<td>Maximal heart rate</td>
<td>Polar Heart rate monitor</td>
</tr>
<tr>
<td>6</td>
<td>Anaerobic endurance</td>
<td>300 yard run</td>
</tr>
</tbody>
</table>

**Calibration of the Instruments**

In this investigation standard equipments bought from
reputed companies were used. These instruments were
calibrated for its accuracy.
**Physical fitness components**

The physical fitness data were obtained from handball court which is available in the Department of Physical Education and Sports Sciences, Annamalai University, Chidambaram, Tamilnadu. To measure speed, agility, explosive power and arm explosive strength reliable equipments like measuring tape, stop watch, handball and cones were used for this study.

**Physiological variables**

In this investigation standard equipments and test were used to assess the selected physiological variables. The stadiometer, weighing machine, skinfold caliper, stopwatch, Yo-Yo intermittent recovery test II audio CD, polar heart rate monitor and measuring tape which were available at Exercise Physiology lab, Department of Physical Education and Sports Sciences, Annamalai University where used. These equipments were purchased from reputed firms, which ensure the reliability. Hence their calibrations were accepted as accurate enough to be use for present research.
Reliability of Tests

The testers’ 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, 8 male handball players were selected from the Department of Physical Education and Sports Sciences, Annamalai University, Chidambaram, Tamilnadu. All the criterion variables selected for the present investigation were tested twice for the same subjects under similar condition. The Pearson product moment correlation was computed separately for each variable and the coefficient of correlation thus computed is presented in Table 3.

Table 3

Reliability coefficients for test and retest on criterion variables

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Variables</th>
<th>Coefficient of correlation</th>
<th>Level of significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Physical Fitness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Speed</td>
<td>0.91</td>
<td>0.05</td>
</tr>
<tr>
<td>2</td>
<td>Agility</td>
<td>0.87</td>
<td>0.05</td>
</tr>
<tr>
<td>3</td>
<td>Power</td>
<td>0.87</td>
<td>0.05</td>
</tr>
<tr>
<td>4</td>
<td>Arm Strength</td>
<td>0.89</td>
<td>0.05</td>
</tr>
<tr>
<td>II</td>
<td>Physiological</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Percent body fat</td>
<td>0.82</td>
<td>0.05</td>
</tr>
<tr>
<td>2</td>
<td>Lean body mass</td>
<td>0.89</td>
<td>0.05</td>
</tr>
<tr>
<td>3</td>
<td>Resting heart rate</td>
<td>0.91</td>
<td>0.05</td>
</tr>
<tr>
<td>4</td>
<td>Aerobic capacity</td>
<td>0.78</td>
<td>0.05</td>
</tr>
<tr>
<td>5</td>
<td>Maximal heart rate</td>
<td>0.88</td>
<td>0.05</td>
</tr>
<tr>
<td>6</td>
<td>Anaerobic endurance</td>
<td>0.86</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Table value required for 6 df at 0.05 level of significance is 0.707
Table 3 reveals that all the criterion variables have a high inter class correlation coefficient. It implies that the internal consistency of all the criterion variables ranged between acceptable and reveals that the reliability of data is established.

**Orientation of Testers**

The investigator alone could not organize the administration of tests, research scholars from Department of Physical Education and Sports Sciences, Annamalai University, were employed 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 involved in overall supervision of the subjects and the testers. All the testers performed their duty to the utmost satisfaction.

**Orientation of the Subjects**

Prior to exploration, the investigator informed the rationale of the study and brief introduction about handball specific aerobic training and highlighted its impact on the selected physical fitness and physiological variables. The method of executing each test was demonstrated and explained to the subjects by the researcher. Subjects were
motivated to exhibit their maximum performance in the selected tests. All the subjects cooperated to their best during the course of experimentation.

**Design of the study**

For the present study pre test – post test randomized group design (Thomas, Nelson & Silverman 2005) was applied and which consists of a control group (CG) and an experimental group (HSATG).

**Figure 2**

*Study design with pre test and post test with test procedure and intervention phase*

Day 1: **Morning** - Height, weight, body composition, speed, explosive power, agility, arm explosive strength and anaerobic endurance

**Evening** – Resting heart rate, aerobic capacity and peak heart rate
These groups were used to find out the effect of handball specific aerobic training on selected physical fitness and physiological variables. Equal numbers (twelve) of subjects were assigned randomly to both the groups. HSATG was exposed to training with a set of handball specific game drills selected for specific purpose. The HSATG underwent training for a period of eight weeks. The training sessions were conducted three days a week (i.e. Monday, Wednesday, and Friday). Measurement of physical fitness and physiological variables was taken for both experimental and control groups as depicted in Figure 2.

**Collection of Data**

All the subjects were tested on physical fitness and physiological variables prior to training, after four weeks of training and after eight weeks of training. The testing session consisted of warm-up and test interspersed with rest. All the tests were explained and demonstrated. Before testing, the subjects were given practice trials to become familiar with the testing procedures. All the tests were counterbalanced pre and post testing to ensure that testing effects were minimized. Subjects performed each test as per the testing procedure and the scores of best trials were taken for this study. In the
morning on the day of testing, measurements like height, weight, body composition, speed, explosive power, agility, arm explosive strength and anaerobic endurance were assessed. However, in the evening resting heart rate, aerobic capacity and maximum heart rate was evaluated.

**Training Protocol**

*Handball specific aerobic training*

Handball specific aerobic training was performed three days per week for eight weeks. The subjects performed four repetitions of high intensity game for the duration of 4 minutes each at an intensity of 90 to 95% of HRmax (Figure 3).

**Figure 3**

*Handball specific aerobic training diagram*
After 4 minutes of handball specific aerobic training was followed by 4 minutes of handball passing drills as active recovery at an intensity of 60 to 65% of HRmax (Figure 4). The players were strapped with polar heart rate monitor and exercise heart rate were fixed and if they perform below or above the fixed range it would produce a beep sound, to alert the players, so as to modify the pace of the game played or drill practiced.

**Figure 4**

Handball passing drill diagram

Running direction of the players

Passing direction
**Rules**

The coaches encourage the players to perform activity of high intensity. In this training 4 players played against 4 players at high intensity in a standard handball court of 40 by 20 metres. In order to play at high intensity, the rule of the game was simplified and also to avoid interruption in the game and increase the exercise load.

**The rule modifications were:**

- Dribbling and defence contacts were not allowed
- Walking, ball hitting below the knee of court player and illegal dribbles were not penalised,
- Goal keeper throw was granted immediately after a goal,
- Goal was not validated unless all the four players be present in the opponents court at the time of goal,
- Ball was replaced immediately when it went out of the playing area,
- Throw in was administered immediately without delay,
- Penalty throw, substitutions, warning and disqualifications were not granted,
- Goalkeepers were instructed to remain inside goalkeeper area during the entire duration.
Administration of Tests

Physical fitness variables

30 metres sprint

Purpose

The purpose of the test was to determine the player's maximum sprint speed and the ability to accelerate from a stationary position.

Equipment

Electronic stopwatch, marking cones and measuring tape.

Procedure

The test involved running a single maximum sprint over 30 metres, with the time recorded. A thorough warm up was given, including a few practice starts and accelerations. The start was from a stationary standing 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 two seconds prior to starting, and no rocking movements were allowed. The tester provided 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.
Scoring

Two trials were allowed, and the best time was recorded to 1/100th of a second. The timing started from the first movement and ended at finishing point.

T – Test

Purpose

The T-Test is a test of agility for players, and includes forward, lateral, and backward running.

Equipments

Measuring tape, marking cones and stopwatch.

Procedure

Four cones were set out (5 yards = 4.57 m, 10 yards = 9.14 m). The subject stood at cone A to start. On the command of the timer, the stop watch was started, the subject sprinted to cone B and touched the base of the cone with their right hand. They then turned left and shuffled sideways to cone C, and touched its base, this time with their left hand. Then they shuffled sideways to the right to cone D and touched the base with the right hand. Then they shuffled back to cone B touching with the left hand, and ran
backwards to cone A. The stopwatch was stopped as they passed cone A.

Scoring

The trial was not counted when the subject cross one foot in front of the other while shuffling, failed to touch the base of the cones, or failed to face forward throughout the test. The best time of three successful trials to the nearest 0.1 seconds, was recorded as the individual’s score.

Vertical jump test

Purpose

To measure the explosive power (vertical) of the subjects.

Equipments

Vertical jump board, chalk powder, a metre ruler.

Procedure

The players stood side wards near a wall and reach up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertips was marked and recorded. The subject then jumped vertically as high as possible swinging both arms and using the legs to assist in projecting the body upwards and attempt to touch the wall at the highest point of the jump.
Scoring

The difference in distance between the reach height and the jump height was the score. The best of the three attempts was recorded.

Handball throw for distance

Purpose

This test measures arm explosive strength.

Equipment

Handball and measuring tape

Procedures

The subjects were directed to stand with a handball in their dominant hand (right). They were permitted to take three steps and execute over hand throw.

Scoring

The distance from the restraining line to where the handball ball landed was recorded. The measurement is recorded to the nearest centimetre (10 cm). The best result of the three throws was recorded.
**Physiological variables**

**Height**

*Purpose*

To measure the stature of the subjects.

*Equipment*

A stadiometer.

*Procedure*

To measure the subjects standing height, the subjects were asked to stand erect on the platform of the stadiometer without shoes, by keeping the heels together, back and head touching the scale and the face looking straight.

*Scoring*

Height was recorded to the nearest centimetre.

**Weight**

*Purpose*

To measure the body weight of the subjects.

*Equipment*

Weighing machine

*Procedure*

The subjects were wearing the minimum of clothing. The weighing machine used to measure body weight was placed in an area, which was smooth and even surface and with
sufficient light, so that, the investigator is capable of properly recording the observation.

*Scoring*

The zero point of the weighing machine was checked often during the measurements. The weight of the subjects was recorded to the nearest kilogram.

**Percent body fat**

*Purpose*

Measuring percentage of body fat by taking the 'skinfold' thickness at selected points on the body with a skinfold calipers.

*Equipments*

Skinfold caliper and measuring tape

*Procedure*

The skinfold measurements were taken from three to nine anatomical sites, that too only on the right side of the body. In this study, four sites (abdominal, triceps, thigh and suprailliac) as proposed by Jackson and Pollock (1985) was considered. The tester pinched the skin at the appropriate site to raise a double layer of skin and the underlying adipose tissue, but not the muscle. The calliper was 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 was taken. Whenever the two measurements differed greatly, a third was done, and then the median value was taken.

**Abdominal:**

A mark was made 5 cm adjacent to the umbilicus (belly button), to the right side. Then a vertical pinch was made at the marked site, and the caliper placed just below the pinch.

**Triceps:**

A mark was made at the mid-upper arm, midline of the posterior aspect of the arm over the triceps muscle, measured with the elbow bent at 90°, used for identifying the biceps and triceps SFT. During the measurement, the arm was hang down freely by the side, palms inwards towards the thighs.

**Thigh:**

The mid-point of the anterior surface of the thigh, midway between patella and inguinal fold was marked. After making anterior thigh landmarks, a vertical pinch was taken. This measurement was taken with the subject in sitting position and the knee bent at right angles.
Suprailliac:

It was marked a centimetre above the anterior superior iliac spine in the mid-axillary line. The measurement was done horizontally when the subject breathed gently.

Formula to Calculate

Percentage of body fat was calculated using the following equation of Jackson and Pollock (1985):

\[
\text{Percent body fat} = \left\{ (0.29288 \times \text{sum of skinfolds}) - (0.0005 \times \text{square of the sum of skinfolds}) + (0.15845 \times \text{age}) - 5.76377 \right\}
\]

**Fat Weight** = Body mass (kg) × (Percent body fat/100)

**Lean body mass** = Body mass – Fat weight

Resting heart rate

Purpose

To record the resting heart rate of the subjects.

Equipments

Polar heart rate monitor consisting of a transmitter and a wrist watch.

Procedure

The subjects were asked to lie down for 10 minutes comfortably without crossing their legs and keep the body still and relaxed during measurement. The electrical signal transmitted through the heart muscle by the heart was
detected at the skin by the transducers and those electromagnetic signals containing heart rate data were sent by the transmitter to the watch wore at the wrist by the subjects for the display of heart rate.

Scoring

The number of heart beat per minute was recorded as shown in the Polar watch.

Yo-Yo intermittent recovery test II

Purpose:

To assess the aerobic capacity of the subjects.

Equipment:

The Yo-Yo intermittent Endurance Test CD and CD player, 20m marked distance on a flat surface and cones.

Procedure:

A 20 m distance was measured out and marked on the floor and 2.5 metres section and marked with cones (A, B and C). The subject ran between these two lines with a beep from a CD player. The subject placed one foot on or beyond the 20 m marker at the end of each shuttle. The subject then had a 5 second active recovery by jogging to cone A and back to cone B. Once again he continued running between the cones B to C
and C to B as signalled by the CD. The assistant kept a record of each completed lap. When the subject could not complete a successful out and back shuttle in the allotted time then the test was stopped. The assistant recorded the total distance covered.

Scoring:

Using the distance covered Bangsbo et al. (2008) prescribed a formula to estimate aerobic capacity.

\[ \text{Aerobic capacity} = \text{Distance in metres} \times 0.0136 + 45.3 \]

Polar heart rate monitor

Purpose

To measure the maximal heart rate in response to exercise of the subjects.

Equipment

Polar heart rate monitor consisting of a transmitter and a wrist watch.

Procedure

The subjects wore Polar heart rate monitor and performed Yo-Yo intermittent endurance test. The electrical signal transmitted through the heart muscle by the heart was detected at the skin by the transducers and those electromagnetic signals containing heart rate data were sent
by the transmitter to the watch wore at the wrist by the subjects for the display of heart rate.

**Scoring**

The number of heart beat per minute at the moment the exercise testing was terminated, was recorded as displayed in the Polar watch.

**300 Yard run**

**Purpose**

To determine the anaerobic endurance capacity of the subjects.

**Equipment**

Stop watch and two parallel lines of 25 yards distance.

**Procedure**

The subjects stood behind the starting line facing the other line. On an auditory signal, the subjects sprinted towards the line marked 25 yards away, making foot contact with it, then immediately sprinted back to the starting line. Six such round trips were made as fast as possible without stopping (6 × 50 yards). After completion of the first trial 5 minutes rest was provided during which they may walk or stretch but remain alert for the starting time on the second trial. The time elicited for second trial was noted.
Scoring

The average of two trials was recorded to the nearest 1.0 second.

Statistical Technique

The data collected from the HSATG and CG on selected physical fitness and physiological variables were statistically analysed to examine the changes. A two-way repeated measure ANOVA with last factor repeated was applied to examine the difference between groups and testing conditions. When the interaction was significant simple effect was applied and Scheffé S post hoc test was applied to examine the paired mean difference between different testing conditions. All the statistical tests were calculated using the statistical package for the social science (SPSS) for windows (Version 16). The level of statistical significance was set at $p < 0.05$. 