CHAPTER - III

METHODOLOGY

This methodology section depicts in details of the methods followed for selection of subject and variables, formulated research design, criterion measures adopted, reliability of data, instrument, tester reliability and subjects, administration of tests, collection of data and statistical procedure employed in the study.

3.1 SELECTION OF SUBJECTS

The primary purpose of this study was to predict the swimming performance based on selected anthropometric and somatotyping variables among state level swimmers. To achieve the purpose of the study, the investigator selected 100 state level male swimmers from different swimming pools of Tamil Nadu by random sampling. The age of the selected subjects ranged between 13 years to 17 years.

3.2 SELECTION OF VARIABLES

The researcher reviewed number of research articles, books, journals, coaching manuals and found that swimming performance of a swimmer may have relationship with anthropometric and somatotyping variables. Based on these observations, the investigator selected the following variables for this study.

3.2.1 Criterion variable

Swimming performance

3.2.2 Predictor variables

The following anthropometric and somatotyping variables were selected as predictors of the study.

3.2.3 Height & Weight

1. Height

2. Weight

3.2.4 Circumference variables

1. Upper arm circumference

2. Forearm circumference

3. Wrist circumference

4. Hand circumference

5. Chest circumference

6. Waist circumference

7. Gluteal circumference

8. Thigh circumference

9. Calf circumference

10. Ankle circumference

3.2.5 Length variables

1. Upper arm length

2. Lower arm length

3. Hand length

4. Hand span

5. Upper leg length

6. Lower leg length

3.2.6 Breadth variables

1. Biacromial

2. Transverse chest

3. Anterior – posterior chest depth

4. Elbow width

5. Knee width

6. Foot length

3.2.7 Skinfold variables

1. Biceps skinfold

2. Triceps skinfold

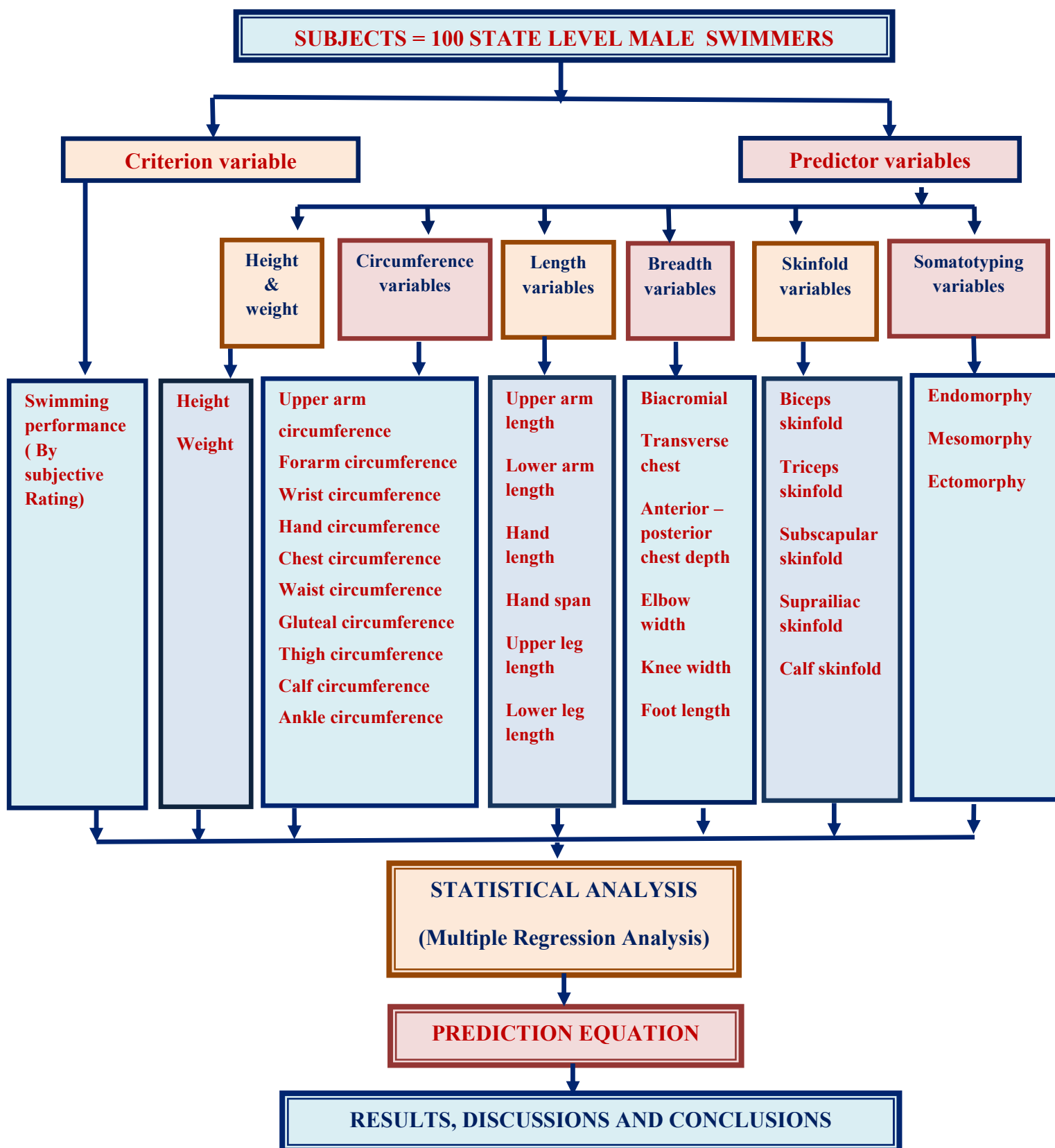3. Sub scapular skinfold

4. Suprailiac skinfold

5. Calf skinfold

3.2.8 Somatotyping variables

1. Endomorphy

2. Mesomorphy

3. Ectomorphy

3.3 RESEARCH DESIGN

The repeated measures research design was used with swimming performance as the criterion variable and the selected anthropometric and somatotyping variables as the predictor variables. The methodology adopted in this study was given below in figure 1 as flow chart.

Figure 1

Flow chart

SUBJECTS = 100 STATE LEVEL MALE SWIMMERS

Criterion variable

Predictor variables

| Height & weight | Circumference variables | Length variables | Breadth variables | Skinfold variables | Somatotyping variables |

Swimming performance (By subjective Rating)

Height

Weight

Upper arm circumference
Forarm circumference
Wrist circumference
Hand circumference
Chest circumference
Waist circumference
Gluteal circumference
Thigh circumference
Calf circumference
Ankle circumference

Upper arm length

Lower arm length

Hand length

Hand span

Upper leg length

Lower leg length

Biacromial

Transverse chest

Anterior – posterior chest depth

Elbow width

Knee width

Foot length

Biceps skinfold

Triceps skinfold

Subscapular skinfold

Suprailiac skinfold

Calf skinfold

Endomorphy

Mesomorphy

Ectomorphy

STATISTICAL ANALYSIS

(Multiple Regression Analysis)

PREDICTION EQUATION

RESULTS, DISCUSSIONS AND CONCLUSIONS

3.4 CRITERION MEASURES

By reviewing the literature and in discussion with professional experts, the following measures were applied to collect data on selected criterion and predictor variables. The following criterion measures and test are presented in table - I

Table I
CRITERION MEASURES
ANTHROPOMETRIC AND SOMATOTYPING VARIABLES AND THEIR MEASUREMENT SPECIFICATIONS WITH REQUIRED EQUIPMENTS AND UNIT OF MEASUREMENTS

I	Height and Weight	Equipments	Unit of measurement
1	Height **(Kansal Devinder,2008)**	Stadiometer	Centimeters
2	Weight **(Kansal Devinder,2008)**	Weighing machine	Kilograms

II	Circumference variables	Equipments	Unit of measurement
1.	Upper arm circumference **(Kansal Devinder,2008)**	Anthropomet-ry flexible measuring tape (non - extendable)	Centimeters
2.	Forearm circumference **(Kansal Devinder,2008)**		
3.	Wrist circumference **(Marfell-Jones Micheal and other, 2006)**		
4	Hand circumference **(Yobu A., 2010)**		
5	Chest circumference **(Marfell-Jones Micheal and other, 2006)**		
6	Waist circumference **(Marfell-Jones Micheal and other, 2006)**		
7	Gluteal circumference **(Marfell-Jones Micheal and other, 2006)**		
8	Thigh circumference **(Kansal Devinder,2008)**		
9	Calf circumference **(Kansal Devinder,2008)**		
10	Ankle circumference **(Marfell-Jones Micheal and other, 2006)**		

III	Length variables	Equipments	Unit of measurement
1.	Upper arm length **(Marfell-Jones Micheal and other, 2006)**	Large sliding caliper	Centimeters
2.	Lower arm length **(Marfell-Jones Micheal and other, 2006)**	Segmometer	Centimeters
3.	Hand length **(Marfell-Jones Micheal and other, 2006)**		
4	Hand span **(Clarke and Clarke, 1989)**		
5	upper leg length **(Marfell-Jones Micheal and other, 2006)**	Segmometer	Centimeters
6	lower leg length **(Marfell-Jones Micheal and other, 2006)**		

IV	Breadth variables	Equipments	Unit of measurement
1	Biacromial **(Kansal Devinder,2008)**	Large sliding caliper	Centimeters
2	Transverse chest **(Marfell-Jones Micheal and other, 2006)**		
3	Anterior-posterior chest depth **(Marfell-Jones Micheal and other, 2006)**		
4	Elbow width **(Kansal Devinder,2008)**	Small sliding caliper	Centimeters
5	Knee width **(Kansal Devinder,2008)**	Large sliding caliper	Centimeters
6	Foot length **(Marfell-Jones Micheal and other, 2006)**		

V	Skin fold variables (mm)	Equipments	Unit of measurement
1	Biceps skinfold **(Kansal Devinder,2008)**	Harpenden skin fold caliper	Millimeters
2	Triceps skinfold **(Kansal Devinder,2008)**		
3	Subscapular skinfold **(Kansal Devinder,2008)**		
4	Suprailiac skinfold **(Kansal Devinder,2008)**		
5	Calf skinfold **(Kansal Devinder,2008)**		

VI	Somatotyping	Equipments
1	Endomorphy **(Kansal Devinder,2008)**	Using Heath Carter (1967) Method of Somoto typing.
2	Mesomorphy **(Kansal Devinder,2008)**	
3	Ectomorphy **(Kansal Devinder,2008)**	

3.5 PILOT STUDY

The researcher conducted a pilot study with ten swimmers who were not subjects of this research study to determine the methods of testing, evaluate the competency of the researcher testing, recording the measurements, calculation of scores and field equipments used in the present investigation.

3.6 RELIABILITY OF DATA

To meet the scientific research requirements, the investigator established the reliability of the data through reliability of instruments, tester and subjects.

3.7 RELIABILITY OF THE INSTRUMENTS

Stadiometer, weighing machine, anthropometry flexible measuring tape (non - extendable), small sliding caliper, large sliding caliper, segmometer and harpenden skinfold caliper were used in this study. All anthropometric instruments used in the

research were from standard companies and their calibrations were accepted as reliable at par with international standards for anthropometric equipments. The measurements were collected twice and correlated for reliability.

The investigator used intra class correlation coefficient obtained by test and retest method is presented in table II.

Table – II

THE RELIABILITY COEFFICIENT OF THE SUBJECTS IN ANTHROPOMETRIC, SOMATOTYPING AND SWIMMING PERFORMANCE BY TEST AND RETEST METHOD

S. No	Test items	Coefficient of Correlation
1	Height	0.92*
2	Weight	0.96*
3	Upper arm circumference	0.90*
4	Fore arm circumference	0.95*
5	Wrist circumference	0.93*
6	Hand circumference	0.91*
7	Chest circumference	0.97*
8	Waist circumference	0.94*
9	Gluteal circumference	0.93*
10	Thigh circumference	0.98*
11	Calf circumference	0.95*
12	Ankle circumference	0.90*
13	Upper arm length	0.93*
14	Lower arm length	0.95*
15	Hand length	0.96*
16	Hand span	0.98*
17	Upper leg length	0.99*
18	Lower leg length	0.91*
19	Biacromial	0.95*
20	Transverse chest	0.98*
21	Anterior – posterior	0.92*
22	Elbow width	0.97*
23	Knee width	0.95*
24	Foot length	0.92*
25	Biceps skinfold	0.95*
26	Triceps skinfold	0.97*
27	Subscapular skinfold	0.96*
28	Supra – iliac skinfold	0.93*
29	Calf skinfold	0.90*
30	Endomorphy	0.93*
31	Mesomorphy	0.97*
32	Ectomorphy	0.92*

Table value r =(0.05) (2,7) = 0.735   * significant at 0.01 level

3.8 RELIABILITY OF THE TESTER

The tester's competency was established together within reliability of test. To determine the reliability of the test, the performance of ten swimmers were recorded twice under similar conditions by the researcher. This was done by the test and retest method on regular days. The repeated measurement of swimmers were conducted on the selected predictor variables to determine reliability in an univariate situation.

3.9 SUBJECT RELIABILITY

The co-efficient of Correlation in Table II also indicated the subject's reliability because the same swimmers were tested under similar conditions by the same tester. No motivational procedures were used during the testing.

3.10 ORIENTATION OF THE SUBJECTS

To get the full co-operation from the subjects, the researcher explained the swimmers (subjects) about the purpose, tests to be administrated and its procedures. Required practices tests were conducted to help the swimmers to understand the testing procedure.

3.11 ADMINISTRATION OF TESTS

The following tests were administered to measure the selected anthropometric variables, somatotyping variables and swimming performance.

3.12 CRITERIA FOR SUBJECTIVE RATING

To determine the swimming performance of the swimmers of the selected subjects were assessed by three experts subjectively. Three qualified coaches who served as experts rated each criteria in the swimmers. The criterion score such as nine criteria/variables each and every one is different types of the score for a total of 100

marks (Table III). The average of the marks of the three experts were taken as the criterion/variables scores.

3.12.1 Criteria for subjective rating of swimming performance

The following criterion/variables were selected such as free style, backstroke, breaststroke, butterfly stroke, Performance in the specialized event, adapting scientific principles, awareness of rules, general fitness and specific fitness. Free style, backstroke, breaststroke and butterfly stroke were awarded with 10 marks for each one. Performance in the specialized event was awarded 20 marks. Adapting scientific principles, awareness of rules, general fitness and specific fitness were awarded with 10 marks for each one for a grand total of 100 marks (Table III).

3.12.2 Subjective rating procedure

To determine the subject's swimming performance in actual swimming situation, the subjects were tested before the training session organized by the investigator.

To assess the swimming performance, three senior swimming coaches were nominated. The experts assessed the swimmer's swimming performance by awarding the marks for the nine criteria/variables as mentioned in the Table – III.

Table - III
CRITERIA FOR SUBJECTIVE RATING OF SWIMMING PERFORMANCE

Sl. No	Criteria / variables	Marks
1	Free style	10
2	Backstroke	10
3	Breaststroke	10
4	Butterfly stroke	10
5	Performance in the specialized event	20
6	Adapting scientific principles	10
7	Awareness of rules	10
8	General fitness	10
9	Specific fitness	10
	Total	100

3.13 COLLECTION OF DATA

The method of data collection from the state level swimmers on selected anthropometric and somatotyping variables were explained below.

3.13.1. Height

Purpose

To measure the height of the swimmers.

Equipment used

Stadiometer

Description

"The swimmer (subject) was asked to stand erect, barefooted on a plane horizontal surface against a wall, with his heels, back of the shoulders and head touching the wall. He was requested to stretch the body upwards as much as possible without his heels leaving the ground. The head and face was checked for its being in Frankfort plane. To get it easily, the swimmers was asked to see towards an object in front of him approximately at a height of his eyes, then the researcher adjusts the trachea and infra-orbital points in a horizontal line. The stadiometer was kept in front of the swimmers and the crossbar was adjusted so that its lower edge touches the highest point of the swimmers's head (point vertex)" **(Kansal Devinder,2008).**

Score

Height was recorded to the nearest 0.1 centimeters.

3.13.2. Weight

Purpose

To assess the weight of the swimmers(subjects).

Equipment used

Portable weighing machine.

Description

'The investigator checked that the scale was reading zero. The swimmer (subject) was asked to stand on the centre of the scales without support and with the weight distributed evenly on both feet' **(Marfell - Jones Michael and others, 2006).**

Score

Weight was recorded to the nearest 0.1 kilograms.

3.13.3. Upper arm circumference

Purpose

To measure the upper arm circumference of the swimmers.

Equipment used

Anthropometry flexible measuring steel tape. (Non - extensible).

Description

"The swimmer (subject) was asked to stand at ease with equal weight on both the feet and with hands hanging freely. The upper arm circumference was usually measured on the left naked upper arm locating the point acromiale and radiale and then the mid point of these two points was marked with a skin marking pencil by a horizontal line" **(Kansal Devinder,2008)**.

Score

Upper – arm circumference was recorded to the nearest 0.1 centimeters.

3.13.4. Forearm circumference

Purpose

To measure the fore arm circumference of the swimmers.

Equipment used

Anthropometry flexible measuring steel tape. (non - extensible).

Description

"The flexible measuring steel tape was wrapped around the fore arm just below the elbow point and the maximal measurement was recorded by moving the flexible measuring steel tape slightly up and down keeping the circle of tape in horizontal direction and touching all around"**(Kansal Devinder, 2008).**

Score

Fore arm circumference was recorded to the nearest 0.1 centimeters.

3.13.5. Wrist circumference

Purpose

To measure the wrist circumference of the swimmers.

Equipment used

Anthropometry flexible measuring steel tape. (non - extensible)**.**

Description

"The swimmers assumed relaxed standing positions. The swimmer's right arm was slightly flexed at the elbow, the forearm supinated and the hand relaxed". Wrist circumference was measured perpendicular to the long axis of the forearm distal to the styloid process" **(Marfell - Jones Michael and others, 2006).**

Score

Wrist circumference was recorded to the nearest 0.1 centimeters.

3.13.6. Hand circumference

Purpose

To measure the hand circumference of the swimmers.

Equipment used

Anthropometry flexible measuring steel tape. (Non - extensible).

Description

'The swimmer was asked to wrap the measuring tape around the hand at the fullest part, where the fingers meet the palm. This usually stretches around from the outer side of the palm (just below the pinkie finger) to the inner crook of the hand (between the index finger and thumb). Not measured outside of the thumb – just the palm' **(Franchesca V Havas, 2006).**

Score

Hand circumference was recorded to the nearest 0.1 centimeters.

3.13.7. Chest circumference

Purpose

To measure the chest circumference of the swimmers.

Equipment used

Anthropometry flexible measuring steel tape. (non - extensible).

Description

"The researcher stands to the right of the swimmers who abducts the arms to the horizontal position allowing the tape to be passed around the thorax. The stub of the flexible measuring steel tape and the housing are then both held in the right hand while the researcher uses the left hand to adjust the level of the tape at the back to the adjudged level of the marked mesosternale. The researcher resumes control of the stub with the left hand and using the cross - hand technique positions the tape in front at the level of the marked mesosternale. The swimmers was instructed to lower their arms to the relaxed position with the arms slightly abducted. The flexible measuring steel tape was then

readjusted as necessary to ensure it has not slipped and does not excessively indent the skin. The swimmers should breathe normally and the measurement was taken at the end of a normal expiration" **(Marfell - Jones Michael and others, 2006).**

Score

Chest circumference was recorded to the nearest 0.1 centimeters.

3.13.8. Waist circumference

Purpose

To measure the waist circumference of the swimmers.

Equipment used

Anthropometry flexible measuring steel tape. (non - extensible).

Description

"The researcher stands in front of the swimmers who abducts the arms slightly allowing the flexible measuring steel tape to be passed around the abdomen. The stub of the flexible measuring steel tape and the housing are then both held in the right hand while the researcher uses the left hand to adjust the level of the flexible measuring steel tape at the back to the adjudged level of the narrowest point. The researcher resumes control of the stub with the left hand and using the cross-hand technique positions the tape in front at the target level. The swimmers should breathe normally and the measurement was taken at the end of a normal expiration (end tidal). If there was no obvious narrowing the measurement was taken at the mid-point between the lower costal (10th rib) border and iliac crest" **(Marfell - Jones Michael and others, 2006).**

Score

Waist circumference was recorded to the nearest 0.1 centimeters.

3.13.9. Gluteal circumference

Purpose

To measure the gluteal circumference of the swimmers.

Equipment used

Anthropometry flexible measuring steel tape. (non - extensible).

Description

"The researcher passes the flexible measuring steel tape around the hips form the side. The stub of the flexible measuring steel tape and the housing are then both held in the right hand while the researcher uses the left hands to adjust the level of the flexible measuring steel tape at the back to the adjudged level of the greatest posterior protuberance of the buttocks. The researcher resumes control of the stub with the left hand, and using the cross-hand technique, positions the flexible measuring steel tape at the side, checking that it was held in horizontal plane at the target level, before taking the measurement" **(Marfell - Jones Michael and others, 2006).**

Score

Gluteal circumference was recorded to the nearest 0.1 centimeters.

3.13.10. Thigh circumference

Purpose

To measure the thigh circumference of the swimmers.

Equipment used

Anthropometry flexible measuring steel tape. (non - extensible).

Description

"The swimmer wearing only underwear was asked to stand at ease with equal weight on both the feet. The middle of the thigh was marked by a horizontal line

dividing the distance between the trochanterion and the lateral and lower most point on the lateral condyle of femur, in equal two parts. The flexible measuring steel tape was wrapped around the thigh at the level of horizontal ling and the circumference was measured by keeping the flexible measuring steel tape in a horizontal direction and touching gently thigh surface all around"**(Kansal Devinder, 2008).**

Score

Thigh circumference was recorded to the nearest 0.1 centimeters.

3.13.11. Calf circumference

Purpose

To measure the calf circumference of the swimmers.

Equipment used

Anthropometry flexible measuring steel tape. (non - extensible).

Description

"The swimmer usually stands in a straight position. This straight position would make it easier for the measure to align the eyes with the tape. The researcher passes the tape around the calf and then slides the tape to the correct plane. The stub of the tape and the housing are both held in the right hand while the researcher uses the left hand to adjust the level of the tape to the marked level. The researcher resumes control of the stub with the left hand and using the cross of the stub with the left hand and using the cross – hand technique positions the tape so that it was held in a plane perpendicular to the axis of the leg. The tape was then readjusted as necessary to ensure it has not slipped and does not indent the skin" **(Marfell - Jones Michael and others, 2006).**

Score

Calf circumference was recorded to the nearest 0.1 centimeters.

3.13.12. Ankle circumference

Purpose

To measure the ankle circumference of the swimmers.

Equipment used

Anthropometry flexible measuring steel tape. (non - extensible).

Description

"The swimmer stands in straight position. The straight position would make it easier for the measure to align the eyes with the flexible measuring steel tape. The researcher passes the flexible measuring steel tape around the ankle and manipulates it up and down this region to ensure that the minimum girth was obtained. The stub of the flexible measuring steel tape and the housing are both held in the right hand while the anthropometrics uses the left hand to adjust the level of the flexible measuring steel tape to the marked level. The researcher resumes control of the stub with the left hand and using the cross-hand technique positions the flexible measuring steel tape so that it was held in a plane perpendicular to the axis of the leg. The flexible measuring steel tape was then readjusted as necessary to ensure it has not slipped and does not excessively indent the skin" **(Marfell - Jones Michael and others, 2006)**

Score

Ankle circumference was recorded to the nearest 0.1 centimeters.

3.13.13. Upper arm length

Purpose

To measure the upper arm length of the swimmers.

Equipment used

Segmometer

Description

"Segmometer was held on the Acromiale while the other branch is placed on the Radiale. If the branches of the segmometer are too short to allow clearance of the Deltoids, a large sliding caliper should be used. The segmometer or caliper measurement scale should be parallel to the long axis of the arm" **(Marfell - Jones Michael and others, 2006).**

Score

Upper arm length was recorded to the nearest 0.1 centimeters.

3.13.14. Lower arm length

Purpose

To measure the lower arm length of the swimmers.

Equipment used

Segmometer

Description

"Lower arm length was distance between the previously marked Radiale and Stylion landmarks. Segmometer was held against the Radiale and the other branch was placed on the stylion landmark" **(Marfell - Jones Michael and others, 2006).**

Score

Lower arm length was recorded to the nearest 0.1 centimeters.

3.13.15. Hand length

Purpose

To measure the Hand length of the swimmers.

Equipment used

Segmometer

Description

"Segmometer was placed on the marked Midstylion line while the other branch was positioned on the Dactylion" **(Marfell - Jones Michael and others, 2006).**

Score

Hand length was recorded to the nearest 0.1 centimeters.

3.13.16. Hand span

purpose

To measure hand span of the swimmers.

Equipment used

Anthropometry flexible measuring steel tape. (non - extensible).

Description

"The swimmers was asked to wide open his right hand and the hand span was measured from the tip of the thump to the tip of the little finger in a straight line" **(Clark and Clark,1989)**

Score

Hand span was recorded to the nearest 0.1 centimeters.

3.13.17. Upper leg length

Purpose

To measure the upper leg length of the swimmers.

Equipment used

Segmometer

Description

"Segmometer was placed on the marked Trochanterion and the other branch was placed on the marked Tibiale laterale site". **(Marfell - Jones Michael and others, 2006).**

Score

Upper leg length was recorded to the nearest 0.1 centimeters.

3.13.18. Lower leg length

Purpose

To measure the lower leg length of the swimmers.

Equipment used

Segmometer

Description

"Segmometer was placed on the marked Tibiale mediale site and the other branch was positioned on the marked Sphyrion site" **(Marfell - Jones Michael and others, 2006).**

Score

Upper leg length was recorded to the nearest 0.1 centimeters.

3.13.19. Biacromial

Purpose

To measure the Biacromial of the swimmers.

Equipment used

Large sliding caliper

Description

"This distance was measured with the branches of the large sliding caliper placed on the most lateral surfaces of the acromion processes (below the marked Acromiale

landmark). The swimmers stands with the arms hanging at the sides, and the measures, standing behind the subject, should bring the caliper branch es   into   the   acromion processes at an angle of about 30 degree pointing upwards. Pressure should be applied to compress the overlying tissues, but should not move the shoulders" **(Marfell - Jones Michael and others, 2006).**

Score

Biacromial was recorded to the nearest 0.1 centimeters.

3.13.20. Transverse chest

Purpose

To measure the transverse chest of the swimmers.

Equipment used

Large sliding caliper

Description

"The downward angle of the caliper would prevent the caliper from slipping between the ribs. The measurer stands in front of the swimmers. Care must be taken to avoid inclusion of the Pectoralis Major or Latissimus Dorsi muscles. Gentle pressure is exerted to compress soft tissue, but should not be sufficient to compress the ribs. The measurement was taken at the end of a tidal expiration" **(Marfell - Jones Michael and others, 2006).**

Score

Transverse chest was recorded to the nearest 0.1 centimeters.

3.13.21 Anterior – posterior chest depth

Purpose

To measure the anterior – posterior chest depth of the swimmers.

Equipment used

Large sliding caliper

Description

"Hold the rounded tips of the caliper branches between the thumb and digits 2-3 so that the tips are placed on the landmarks with very light pressure. The measurer applies the caliper over the right shoulder of the swimmers who was instructed to breathe normally. The rear branch of the caliper should be positioned on the spinous process of the vertebra at the horizontal level of the Mesosternale. Measurement was taken at end-tidal expiration" **(Marfell - Jones Michael and others, 2006).**

Score

Anterior – posterior chest depth was recorded to the nearest 0.1 centimeters.

3.13.22. Elbow width

Purpose

To measure the elbow width of the swimmers.

Equipment used

Sliding caliper

Description

"The swimmer was asked to bend her left arm at an angle of 90 degree that was the forearm and upper arm make a right angle while upper arm is in the horizontal direction and forearm in the vertical direction. The researcher, standing opposite the swimmers, (that is face to face) applies the two arms of the caliper to the outer most points on the lower end of the humerus exerting sufficient pressure to minimize the soft tissues effect. The caliper makes an angle of 45 degree to the axis of upper arm and forearm" **(kansal devinder,2008).**

Score

Elbow width was recorded to the nearest 0.1 centimeters.

3.13.23. Knee width

Purpose

To measure the knee width of the swimmers.

Equipment used

Sliding caliper

Description

"The swimmer was asked to sit down on a horizontal surface with her lower leg hanging and having no clothing on the knees. The arms of the sliding caliper (in case of children) or the crossbars of the anthropometric compass are applied on the outermost points of the condyles of femur with full pressure so as to compress the soft tissue" **(Kansal Devinder,2008).**

Score

Knee width was recorded to the nearest 0.1 centimeters.

3.13.24. Foot length

Purpose

To measure the foot length of the swimmers.

Equipment used

Large sliding caliper

Description

"To facilitate accurate measurement, the caliper scale should be aligned parallel to the long axis of the foot. (The long axis of the foot runs through the second digit). Minimal pressure was applied to the large sliding caliper. During the measurement the subject stands on the box" **(Marfell - Jones Michael and others, 2006).**

Score

Foot length was recorded to the nearest 0.1 centimeters.

3.13.25. Biceps skinfold

Purpose

To measure the biceps skinfold of the swimmers.

Equipment used

Harpenden skinfold caliper.

Description

"The swimmer (subject) with a naked arm was asked to stand at ease with hanging arms. Usually, the mid point of the upper-arm marked previously for measuring upper-arm circumference helps to provide a landmark for measuring biceps and triceps skinfolds. These skinfolds are also to be taken at exactly the same level where the upper-arm circumference was measured. The skin and subcutaneous fat fold was picked at about 1cm above the marked level on the anterior side of biceps muscle. The jaws of the caliper are applied on the fold so that the marked horizontal line is approximately at a level of the mid point of the jaws and that the jaws hold a double layer of skin plus subcutaneous fat. The lighter arm of the caliper was slowly released so as to put full pressure of the jaws on the vertical skinfold. The reading was noted from the dial of the caliper about two seconds after leaving the small arm of the caliper when the reading was quite stable" **(Kansal devinder,2008)**

Score

Biceps skinfold was recorded to the nearest 0.1 millimeters.

3.13.26. Triceps skinfold

Purpose

To measure the triceps skinfold of the swimmers.

Equipment used

Harpenden skinfold caliper.

Description

"This method was the same as explained in case of biceps skinfold (as given above) except that the fold in this case was picked up on the posterior side of upper arm over the triceps muscle". **(Kansal Devinder,2008)**

Score

Triceps skinfold was recorded to the nearest 0.1 millimeters.

3.13.27. Subscapular skinfold

Purpose

To measure the subscapular skinfold of the swimmers.

Equipment used

Harpenden skin fold caliper.

Description

"This skinfold was picked diagonally below the inferior angle of the scapula almost parallel to the medial border or scapula in such a way that the skinfold forms an angle of roughly 45 degree to the horizontal, with its lower end pointing outwards. The jaws of caliper are applied about half a centimeters below the fold picking tip of the thumb. The measurement, as usual, was recorded after two seconds of releasing full pressure on the fold" **(Kansal devinder,2008).**

Score

Sub scapular skinfold was recorded to the nearest 0.1 millimeters.

3.13.28. Suprailiac skinfold

Purpose

To measure the suprailiac skinfold of the swimmers.

Equipment used

Harpenden skinfold caliper.

Description

"A skinfold was lifted about 1 centimeters above and 2 cm medial to the anterior superior iliac spine on the left side. The jaws of the skinfold caliper are applied parallel to the natural direction of the picked up skinfold which was usually horizontal or slightly oblique pointing upwards latterly and downwards medially. The reading was recording correct up to 0.2 mm as in all other skinfold measurements" **(Kansal Devinder,2008).**

Score

Suprailiac skinfold was recorded to the nearest 0.1 millimeters.

3.13.29. Calf skinfold

Purpose

To measure calf skinfold of the swimmers.

Equipment used

Harpenden skin fold caliper.

Description

"The swimmers was asked to sit on the corner of a table top in such a way that his/her one leg is in front of the longer side of table and the other leg is in front of the breadth side of the table. The researcher sits on her feet in between the two legs of the swimmers and picks up the skinfold on the medial side of the left leg of the subject and applies the jaws of the caliper exactly in line with the marked level where the calf

circumference was measured. As usually, the reading correct up to 0.2 mm is recorded about two seconds after releasing the full pressure on the jaws of the skinfold caliper" **(Kansal Devinder,2008).**

Score

Calf skinfold was recorded to the nearest 0.1 millimeters.

3.13.30. Endomorphy

Purpose

To measure the endomorphy of the swimmers.

Equipment used

Heath-carter method

Description

"The three skinfolds such as triceps, subscapular and suprailiac are added up and multiplied by the factor 170.18/swimmers height and then the nearest value form the Heath-carter rating form was encircled. The first component rating vertically below the encircled value provides the endomorphy component of the physique of the swimmers measured" **(Kansal Devinder,2008).**

Score

Endomorphy was recorded to the rating box. (see table IV)

3.13.31. Mesomorphy

Purpose

To measure the mesomorphy of the swimmers.

Equipment used

Heath-carter method

Description

"For finding mesomorphy component, the swimmer's height was encircled on the height scale row of Health-carter second component as encircled. Then the humerus bicondylar and femur bicondylar widths are encircled on their respective rows. Now are triceps skinfold divided by ten was subtracted from upper arm circumference and the value of calf skinfold in mm divided by ten was subtracted from calf circumference and the closest values to these corrected upper arm circumference and calf circumference are also encircled in their respective rows in the mesomorphy rating scale. The average deviation column of the encircled height column was counted. This deviation number of the column was moved to the right or left as the case may be, from the value four (4) in the mesomorphy component rating and the closest rating score provides the mesmorphy rating of the swimmers"**(Kansal Devinder,2008).**

Score

Mesomorphy was recorded to the rating box. (see table IV).

3.13.32. Ectomorphy

Purpose

To measure the ectomorphy of the swimmers.

Equipment used

Heath-carter method

Description

"For assigning the third component or ectomorphy, first of all swimmer's ponderal index (P.I) in the form of height divided by cube root three divided by weight was calculated . Then the closest value to this computed ponderal index (P.I) was encircled in the metric unit Health-carter (L) scale or third component scale. The rating

below this encircled value provides the ectomorphy rating of the swimmers" **(Kansal Devinder,2008)**

Score

Ectomorphy was recorded to the rating box. (see table IV)

The Heath Carter Somatotyping rating scale was presented in Table IV

Table IV
HEATH – CARTER SOMATOTYPE RATING SCALES

HEATH – CARTER SOMATOTYPE RATING SCALES

NAME………………………………………………………..……..AGE………………………………SEX: M   F   S.No…………………………….

OCCUPATION……………………………………....………ETHNIC GROUP…………………………………….DATE…………………………

PROJECT……………………………………….…..   MEASURED BY ………………………………………..

Skinfols	Mm
Triceps	= ☐
Subcapular	= ☐
Suprailiac	= ☐
Ts¹	= ☐
Calf	= ☐
TS1x170.18/Ht.cm=	☐

TOTAL SKINFOLDS (mm) or TS (Triceps + Subscapular + Suprailiac) x 170.18/height

Upper Limit	10.9	14.9	18.9	22.9	26.9	31.2	35.8	40.7	46.2	52.2	58.7	65.7	73.2	81.2	89.7	98.9	108.9	119.7	131.2	143.7	157.2	171.9	187.9	204.0
Midpoint	9.0	13.0	17.0	21.0	25.0	29.0	33.05	38.0	43.5	49.0	55.5	62.0	69.5	77.0	85.5	94.0	104.0	114.0	125.5	137.0	150.5	164.0	180.0	196.0
Lower limit	7.0	11.0	15.0	19.0	23.0	27.0	31.3	35.9	40.8	46.3	52.3	58.8	65.8	73.3	81.3	89.9	99.0	109.0	119.8	131.3	143.8	157.3	172.0	188.0
ENDO	½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½	12

Height cm= ☐	139.7	143.5	147.3	151.1	154.9	158.8	162.6	166.4	170.2	174.0	177.8	181.6	185.4	189.2	193.0	196.9	200.7	204.5	208.3	212.1	215.9	219.7	223.5	227.3
Humerus.cm= ☐	5.19	5.34	5.49	5.64	5.78	5.93	6.07	6.22	6.37	6.51	6.65	6.80	6.95	7.09	7.24	7.38	7.53	7.67	7.82	7.97	8.11	8.25	8.40	8.55
Femur.cm= ☐	7.41	7.62	7.83	8.04	8.24	8.45	8.66	8.87	9.08	9.28	9.49	9.70	9.91	10.12	10.33	10.53	10.74	10.95	11.16	11.36	11.57	11.78	11.99	12.12
UAG2 ☐ -T3 =☐	23.7	24.4	25.0	25.7	26.3	27.0	27.7	28.3	29.0	29.7	30.3	31.0	31.6	32.2	33.0	33.6	34.3	35.0	35.6	36.3	37.0	37.6	38.3	39.0
CG4 ☐ – C5 =☐	27.7	28.5	29.3	30.1	30.8	31.6	32.4	33.2	33.9	34.7	35.5	36.3	37.1	37.8	38.6	39.4	40.2	41.0	41.7	42.5	43.3	44.1	44.9	45.6

D = ☐ ± & - /8 = ☐ ±

MESO* — ½, 1, 1½, 2, 2½, 3, 3½, 4, 4½, 5, 5½, 6, 6½, 7, 7½, 8, 8½, 9

Weight = ☐	Upper limit	39.65	40.74	41.43	42.13	42.82	43.48	44.18	44.84	45.53	46.23	46.92	47.58	48.25	48.94	49.63	50.33	50.99	51.68
Ht./3√Wt = ☐	Midpoint	and	40.20	41.09	41.79	42.48	43.14	43.84	44.50	45.19	45.89	46.32	47.24	47.94	48.60	49.29	49.99	50.68	51.34
	Lower limit	below	39.66	40.75	41.44	42.14	42.83	43.49	44.19	44.85	45.54	46.24	46.93	47.59	48.26	48.95	49.64	50.34	51.00

If weight is in pounds multiply it by 0.4536 — **ECTO** — ½, 1, 1½, 2, 2½, 3, 3½, 4, 4½, 5, 5½, 6, 6½, 7, 7½, 8, 8½, 9

1.TS= Total of 3 skinfolds, mm.
2.UAG = Upper Arm Girth, cm
3.T=Triceps skinfold cm
4.CG= Calf girth,cm
5.C=Calf sinfold in cm

SOMATOTYPE RATING

ENDOMORPHY	MESOMORPHY	ECTOMORPHY

RATED BY……………………………..

*MESOMORPHY= (±D±)+ Where D = sum of column deviation - /8 and C is the correction necessary when the subjects height is not the same as the column height.

3.14. STATISTICAL TECHNIQUE

The collected data were analyzed using Multiple Regression method as explained by Thomas and Nelson (1990). The SPSS PC (version 15) was used to determine the prediction equation

The prediction formula resulting from multiple regression was basically an extension of the two variable regression model, Y= a+bx. In this research study, there were thirty two predictor variables and hence the following statistical regression equation was used. The backward regression method was used for the selection of variables **(Thomas and Nelson, 1990).**

$$Y' = a + b_1x_1 + b_2x_2 + \ldots\ldots\ldots\ldots\ldots b_nx_n$$

Where Y' = Y predictor

a = Constant

b_1, b_2 = Beta weights for predictor variables

x_1, x_2 = Predictor variables