Chapter II

REVIEW OF RELATED LITERATURE

A review of literature relating to the studies on the differences as well as relationship of physical fitness, anthropometric and physiological variables to various sports proficiencies as the scholar could glean from the published reports available in the libraries of Lakshmibai National Institute of Physical Education (Deemed University), Gwalior (M.P.) and the University of Burdwan, Burdwan (W.B.), and Nikhil Banga Sikshan Mahavidyalaya, Bishnupur, Dist. Bankura (W.B.) are abstracted in this chapter to provide the background material for this study. The review of literature is divided into four sections. Studies pertaining to the physical fitness variables are included in Section I. Section II covers those studies pertaining to the anthropometric variables. Section III covers those studies pertaining to the physiological variables. Section IV covers those studies pertaining to both physical fitness, anthropometric and physiological variable.
Section I – Physical Fitness

Studies pertaining to the physical fitness components have been found reported in the professional literature.

Brown\(^1\) conducted the study on the effect of circuit training on the physical fitness on grade 5 girls. Two classes were tested on the AAHPER youth fitness test before and after eight weeks of regular physical education classes. The experimental class, chosen by chance, had a supplemental 10 minute circuit training programme before each class. Both classes showed significant gains in total score. The experimental group showed significant gains on all the tests except the 50 yard dash. The control group showed significant gains on all tests except the pull-ups (modified) and 50 yard dash. The mean difference between groups was not significant, but the experimental class made greater gains except in the shuttle run. The supplemental circuit training produced generally better but not significantly better result than the regular programme.

Uppal\(^2\) carried out a study on fifty four girl students studying in ninth, tenth and eleventh classes, aged between fourteen to seventeen years to see the effects of varied frequencies of speed training on sprinting speed. On the completion of six weeks' period, the following conclusions were drawn:

1. To bring about significant in sprinting at least three training units per week planned on alternate days are required.

2. For the development of sprinting speed training twice a week was found to be as effective as training five days a week.

3. Speed performance can be improved by training three or five days a week on a systematic programme of acceleration runs.

Panny\(^3\) investigated the effects of resistance running on speed, strength, power, muscular endurance and agility. The training programme consisted of four forty minutes session per week for six weeks.


Results indicated that:

1. A training programme of resistance running alone or supplemented by weight training, isometric contraction and repetitive sprinting would significantly increase speed, leg strength, leg power, muscular endurance and agility.

2. Resistance running supplemented by isotonic leg exercises, isometric contraction and repetitive sprinting will not improve standing broad jump ability as significant as speed, leg strength, leg power, muscular endurance and agility.

Jainmitra⁴ took fifty four randomly selected male subjects to determine the effects of selected exercise on the physical fitness of secondary adults. The subjects were divided into two groups, one experimental group and the other control. Experimental group was subjected to a training programme in selected exercises for six weeks. The study concluded that there were significant gains in mean of experimental group in abdominal and leg power and decreased in resting pulse rate.

Hooks\(^5\) has pointed out that weight training can improve strength and speed simultaneously. He suggested that weight training programme that overloads the muscle with enough weight to ensure strength gains, and at the same time, enable the muscle to contract successfully with a burst of speed, will produce increased strength and speed.

Socrates\(^6\) carried out a study on the comparison of three training programmes and their effects on five physical components. Grade eleven boys in physical education were measured in flexibility, agility, speed, muscle power and endurance of the legs (1 minute squat jump) before and after eight weeks participation in isometric weight training on regular physical education programme. The following conclusions were based on significant 't' ratio, weight training was superior to regular physical education programme for improving muscle power and endurance of arms and legs, isometric training was superior to the other programme for improving muscle power and endurance of the arms.

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Mazumdar\textsuperscript{7} studied the changes in motor fitness component and playing ability resulting among soccer players at two stages of physical education and conditioning programme.

He concluded that (i) during the first stage of physical education and conditioning programme speed, maximum leg strength, agility and playing ability were improved, (ii) during second stage only maximum leg strength and agility improved significantly, (iii) the break in between the stages of training diminishes the improvement of playing ability, maximum leg strength and agility. The speed was unaffected, (iv) the total years of physical education and conditioning programme was improved to be of value in improving motor fitness component and playing ability.

Viru\textsuperscript{8} and his associates trained students in nine groups employing different methods ranging from long uniform runs (20-30 min.) to fast interval training 40-50 minutes. They noted a significant increase in the heart volume as a result of interval training. A continuous run fartlek


\textsuperscript{8} A. A. Viru, V. Urgenstien and P. P. Pisuki, "Influence of Training Methods on Endurance", \textit{Track Technique} 47 (March 1972): 1494.
method was more effective in increasing oxygen carrying capacity of the blood.

Johnson\textsuperscript{9} conducted a study to investigate the effect of a season of intercollegiate soccer participation on selected components of physical fitness. The elements of physical fitness measured were agility, cardio-respiratory endurance, muscular strength of the legs and running speed. The subjects were 16 numbers of 1971 Smory University Soccer Team. The pre season practice and competitive season lasted approximately ten weeks. During that period, the subjects were engaged in a minimum of four practice or game situations per week. The Reasons schedule included thirteen games plus two pre season practice games. It was found that participation in the intercollegiate soccer programme is likely to course adaptation in the circulatory and respiratory system that will result in increased efficiency or improved cardio-respiratory endurance. It produced significant improvement in the agility, muscular strength of the legs and running speed.

\textsuperscript{9} Thomas Cole Johnson, "The Effect of a Season of Intercollegiate Soccer on Selected Components of Physical Fitness", \textit{Dissertation Abstracts International} 32 (May 1972): 3355-A.
Ross\(^{10}\) selected IWOA Motor Fitness Test and the AAHPER Youth Fitness Test to determine the changes in the physical fitness of junior and senior girls, after two semesters of physical education and after a period with no formal physical education. Significant gains occurred in abdominal strength, explosive power, co-ordination, flexibility and speed during the semesters of physical education but significant loss in physical fitness was noticed following the period of non-participation.

Mayers\(^{11}\) examined and compared the effect of training highly conditioned varsity soccer players on running circuit of 1.86-degree downhill and zero degree during a competitive season. The specific questions with which this study was concerned were the effects of downhill and level circuits on a varsity soccer player’s maximum running speed, stride length, stride frequency and leg strength. After five weeks of training the study concluded that

1. The downhill method of training significantly improved the stride length of the varsity soccer players.


2. The downhill method of training can be effectively used as a supplementary sprint training method.

Alexander et al.\textsuperscript{12} pointed out that due to heavy resistive isotonic exercises all the skinfold measurements were decreased and increased in all girth measurements except the wrist girth. The control group displayed marked differences in the triceps skinfold (decreases) and the wrist girth (increases) measurements. The experimental group significantly improved on the physical fitness index. While the control group did not improve. They also indicated that for physically conditioned young males exercising of this kind brings about changes in girth and skinfold measurements improves muscular strength and endurance and has a small positive effect on improvement of the cardio-vascular fitness level.

Comparative experimental studies pertaining to the performance variables found reported in the professional literature.

Delok\textsuperscript{13} studied the effects of specific resistance programme on strength and speed of a specific motor movement in the discus throw and freshmen non-athletes (N=30) were randomly designed into three groups on the basis of arm strength, test score: an experimental group with weight training, an experimental group with specific resistance (exergenic) and a control group. The training period was six weeks with pre and post-test administered. The data indicated that the specific resistance training programme was more effective than weight training in developing strength. Neither of the programmes appeared to be effective in increasing a specific motor movement of the discus throw (speed).

In a study Buck\textsuperscript{14} compared two programmes of weight training in regard to their effects upon the development of muscular strength and endurance. Forty nine male college students were tested before and after seven weeks of weight training on eleven calisthenics and barbell exercises requiring muscular strength and endurance. Upper arm girth

\textsuperscript{13} Dean E. Delok, "The Effects of a Specific Resistance Training Programme and a Weight Training Programme Upon Strength Involved in and Speed of Specific Motor Movement of Discus Throw", \textit{Completed Research in Health, Physical Education and Recreation} 10 (1968): 97.

\textsuperscript{14} Besuard V. Buck, "A Comparison of Two Programmes of Weight Training in Regard to Their Effects Upon the Development of Muscular Strength and Endurance", \textit{Completed Research in Health, Physical Education and Recreation} 5 (1963): 89.
measurement was taken with elbow fixed forcefully. Subjects were assigned randomly to a weight group (25), training with heavy weight and more repetitions. Both groups made substantial gains in each test. The weight had greater average in seven of the twelve sets with three significant, beyond the 0.02 level of confidence. The rap group was significantly superior in none of the tests.

Keith\textsuperscript{15} took thirty untrained college males participated in a ten weeks' study comparing the effects of three different types of training on 800 meter run performance. All subjects were engaged in 20-30 minutes of endurance running three times a week. In addition to the endurance running, subjects participated in either hill training, sprint training or weight training three days a week. The hill training consisted of repeated 30 seconds sprints upto an 8% graded hill. Sprint training included distance ranging from 50 to 300 training included cleans, squats, calf raises, leg extension and leg curls. Each exercise was performed in three sets of 8-10 R. M. Only the hill and sprint groups showed significant difference between pre-test and post-test 800 meter run performance. It

was concluded that concurrent weight on endurance training is not an
effective way to improve 800 meter run performance of untrained
subjects. Group comparison revealed that both hill and sprint training
resulted in significantly greater changes than weight training (P. L. .02).
Sprint training significantly improved Leg flexion torque at slow and fast
speeds. ANOVA results, however, failed to establish significant
difference between training groups on the adjusted post-test isokinetic
strength measures.

Tressel16 notified the effects of selected resistance exercise
programme upon muscular strength and speed. The training devices used
were: correct O-sizer, Exergenic and Weight training. Male college
students (N=120) were assigned to four groups with the groups assigned
to three treatment groups, plus one control group assigned by random
techniques. An initial and final test was administered. Larson Muscular
Strength Test was used as the measure of dynamic strength. Mc Cloy
Strength Test for boys was used to determine static strength and an
electric timer was used to measure speed. The results of the study

16 Lee J. Tressel, “The Effects of Selected Resistance Exercise Programme
Upon Muscular Strength and Speed”, Completed Research in Health, Physical
disclosed the treatments were equally effective in improving dynamic and static strength. All the three experimental groups improved significantly as compared to the control in all the individual dynamic strength measures and in the majority of the individual strength measures.

Drake\textsuperscript{17} studied the effects of physical conditioning on speed and strength in the performance of selected ice hockey skills. The subjects were divided into two equal groups on the basis of the initial and shot velocity test. The experimental group underwent a five weeks isometric exercise programme. The experimental group showed significant gains on the post-test both for the shot and six of the eight strength measures. The control group showed significant gains for one strength measure and wrist shot.

Charles\textsuperscript{18} conducted a study on the effect of selected explosive weight training exercises upon leg strength, free running speed and explosive power. He took an experimental group of 20 fresh male volunteers who were selected randomly from transpline and handball

\textsuperscript{17} Clane J. Drake, “The Effects of Physical Conditioning on Speed and Strength on the Performance of Selected Ice Hockey Skills”, \textit{Completed Research in Health, Physical Education and Recreation} 9 (1967): 127.

classes. The experimental group went for a five week explosive weight training programme with four sessions per week and three circuits of exercise per session. The groups were tested before and after the programme. The experimental group made significant greater development in leg strength, but not in running speed and explosive power.

Lewis\textsuperscript{19} compared the methods of conditioning the strength, speed, endurance and selected basketball skills. Ninety male students participated in 12 weeks training and conditioning programme. The result was randomly placed in one of the three treatment group using combined isotonic and isometric exercise and the other group was the control group, which was given no conditioning exercise. It was found that the resistive exercise group made significant improvement than the other two groups.

Jessey\textsuperscript{20} carried out a study on the effects of three methods of training on physical fitness. These three groups each of male 17 students


at Rector High School were marched on AAHPER physical fitness test scores, age height, weight and length. The groups were assigned by chance to 11 weeks exercise programme in addition to regular physical education classes three times a week. The isometric exercise group used eight exercises requiring nine minutes per five days a week comparison within group by ‘t’ at the 0.05 level showed that groups improved significantly in physical fitness, strength and weight. The isometric exercise group had significant greater strength on the post-test than the calisthenics group.

Peter’s study was designed to determine the effectiveness of muscular strength and power development using the external pulley system and free weight training method with slow and fast speed of training. Twenty five high school boys and seven girls were randomly assigned to four groups, receiving three training sessions per week over a seven week period. Each subject was tested for strength and power before and after training programme. Analysis of co-variance indicated that fast

rate of training produced greater improvements in knee extensive strength (p. .05) and a fast rate of training produced the best gain in vertical jump performance.

Christ\textsuperscript{22} conducted a study to determine whether there was a significant difference between three days a week and five days a week physical education programme. The ‘t’ test was used to analyze the data. The results obtained a significant difference in favour of these students who were involved in the five day a week physical education programme over those involved in the three days a week programme.

Bose\textsuperscript{23} conducted a study on comparative effects of three types of training loads on jumping ability. Subjects were equated in three experimental groups and one control group, each consisting of twenty subjects. The training load was administered to three experimental groups three days a week for a period of 12 weeks, while no special programme was imparted to control groups. Load distribution for the experimental groups was as follows:

\begin{itemize}
    \item \textsuperscript{22} Wesley A. Christ, “A Five Day a Week Versus a Three Day a Week Physical Education Programmes”, \textit{Completed Research in Health, Physical Education and Recreation} 19 (1977): 111.
    \item \textsuperscript{23} Asim Kumar Bose, “Comparative Effects of Three Types of Training Loads on Jumping Ability”, (\textit{Unpublished Doctor’s Thesis}, Jiwaji University).
\end{itemize}
Group A: Strength 50%; Speed 25%; Endurance 25%;
Group B: Strength 40%; Speed 35%; Endurance 25%;
Group C: Strength 30%; Speed 45%; Endurance 25%;

The data was analyzed by applying ‘t’ ratio test to find out significant difference between pre test and post test means. The experimental Group B and C registered significant improvement whereas experimental group A could not prove significant result in running broad jump performance.

Lean\textsuperscript{24} studied the effect of three selected training programmes on running speed. An initial test and re-test measuring running speed for 30 yards dash was administered to three experimental groups and one control group. Following the initial test, the experimental group received a particular running programme including repetition sprinting, interspersed sprinting and stair running in addition to a standard weight training programme. The control group received only weight training in each class period. The 30 yards dash test was re-administered after 8 weeks of

\textsuperscript{24} Day Lean, “The Effect of Three Selected Training Programme on Running Speed”, \textit{Completed Research in Health, Physical Education and Recreation} 10 (1963): 58.
training. All groups improved significantly, while no differences were noted among different groups.

Roy\textsuperscript{25} compared the effects of acceleration running, resistance running and sand running on sprinting speed, explosive leg strength and length of the strides. 60 boys of Tripura were selected at random as subjects for this study. Age group of the subjects was fifteen to seventeen years. The subjects were divided at random in three experimental groups and one control group with 15 subjects in each group. Group A was trained with acceleration run, Group B with resistance run and Group C with sand running, while control Group D did nothing.

After a six week experimental period, following conclusions were drawn:

1. Sprinting speed and explosive leg strength can be improved by administering a training programme of acceleration running, resistance running and sand running.

2. Length of the stride can be improved by administering a programme of resistance running and sand running, whereas

\textsuperscript{25} Arunabha Roy, "Comparative Effects of Acceleration Running, Resistance Running and Sand Running on Sprinting Speed, Explosive Leg Strength and Length of Stride", \textit{(Unpublished Master's Thesis, Jiwaji University)}.  
acceleration running is not effective in improving the length of the stride.

3. Resistance running was superior to acceleration running and sand running in improving the length of the stride.

Taddonic\textsuperscript{26} compared the physical fitness of two fifth grade self-contemned classes one with no physical education curriculum and the other with a curriculum of 15 minutes daily period of calisthenics. Physical fitness was determined with the AAHPER Youth Fitness Test. Analysis included per and post experimental within group changes and between group differences. Post-experimental results yield (a) some significant changes within groups; (b) no significant differences in mean change in favour of the experimental group.

Carr\textsuperscript{27} studied the effect of isometric contraction and progressive body conditioning exercises on physical fitness and badminton achievement of college women. One group was given progressive body conditioning exercises and the other was not.

\textsuperscript{26} Domonick A. Taddonic, "Effect of Daily Fitness Minute Period of Calisthenics Upon the Physical Fitness of Fifth Grade Boys and Girls", \textit{Research Quarterly} 37 (March 1966): 276.

conditioning exercises for fifteen minutes and the second group was given isometric exercises for five minutes followed by badminton instruction. The third group had regular instructions in badminton for full period. He concluded that body conditioning exercises and isometric did not effect significant improvement than badminton instruction alone.

Rosenstein and Frost\textsuperscript{28} concluded study of the physical fitness of senior high school boys and girls participation in selected physical education programme in New York State and found that pupils participating in good programme improved significantly more in physical fitness than participating in poor programme. The greater improvement was in strength with some gains in agility, balance and endurance.

\textbf{Section II – Anthropometric Variables}

Studies pertaining to the anthropometric variables have been found reported in the professional literature.

\textsuperscript{28} Irwin Rosenstein and Ruivban B. Frost, “Physical Fitness of Senior High School Boys and Girls Participating in Selected Physical Education Programme in New York State”, \textit{Research Quarterly} 35 (October 1964): 588.
In a differential study of body build and body composition of non-dancers, Dolgener, Spasoff and John\(^{29}\) concluded that dancers were significantly heavier and had larger chest, ankle and elbow diameter than did the non-dancers.

Sinning and Lindberg\(^{30}\) after an intensive study on 14 members of college women gymnasts concluded that women gymnasts in comparison to other college women tend to be smaller with the exception of circumference over upper trunk and arm as well as skeletal diameters of the arm.

Wear and Miler\(^{31}\) studied the relationship of physique and developmental levels, as determined by the Watzel grid, to performance in Fitness Test of junior high school boys. They found that subjects who were medium on physique and normal in development to be the best performers and the subjects of heavy physique to be the poorest performers.


Jones\textsuperscript{32} after an intensive study of motor performance in adolescent boys concluded that height correlated very well with muscular strength and physical ability when closely associated with the variables of weight and mesomorphy.

Garrity\textsuperscript{33} in a study involving college women found a general tendency for the subjects classified as mesomorphic ectomorphs to perform in a more efficient manner on physical fitness test. The ecto-endomorph group was consistently low in all test items.

Thornsen\textsuperscript{34} studied the motor performance of women and found height alone is related to strength measure especially if there is a fair amount of mesomorphy in structure.


\textsuperscript{33} Marie H. Garrity, “Relationship of Somatotype of College Women to Physical Fitness Performance”, \textit{Research Quarterly} 57 (October 1966): 340-352.

In his study comparing American Negro and Caucasian females, Terrel\textsuperscript{35} came to the conclusion that the Negro females have significantly longer legs, longer arms and hands, longer feet, wider shoulder girdle and narrow pelvic girdle than Caucasians and therefore they proved better in 50-yard dash and soft ball throw for distance.

Cureton\textsuperscript{36} reported that those who had small, short trunks and long legs and arms were relatively weak in heavy sustained work. Some of these, however, were capable of considerable speed and endurance at light athletic work, he found typical trackmen to have a slight skeletal framework with a relatively longer upper leg ratio and a longer leg to trunk relationship.

In an attempt to develop scientific criteria for the selection of budding athletes based on the morphological status, Kansal\textsuperscript{37} studied 246

\textsuperscript{35} Ruth E. Terrel, "Relationship of Pre and Post Puberty Anthropometric Measurements and Physical Fitness Test Scores of American Negro and Caucasian Females as Measured by the AAHPER Physical Fitness Battery", \textit{Completed Research in Health, Physical Education and Recreation} 10 (1968): 73.


male students ranging the age from 11 to 17 years. He concluded that body measurements showed significant degree of relationship with individual performance tests.

In the study of predicting ability in basic modern dance skills through Anthropometric and physical fitness measurements, Voll\(^{38}\) studied height, weight, sitting height, tibial height and upper leg length of 24 female dancers and concluded that ability in basic motor dance skills could be predicted from selected anthropometric measurements.

In a relationship study, Tahomont\(^{39}\) studied effect of somatotype on anaerobic power of 160 women ranging from 18 to 35 years of age and concluded that somatotype components and their interactions showed significant correlation at five percent level, but the degree of relationship was too small to be of practical value.

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Khayamleashi\textsuperscript{40} made a relationship study on 53 male subjects between hip width, leg length, and weight to the total movement response time. He found that obtained correlations were low and not significant except for leg length.

Baacke\textsuperscript{41} utilized data from 87 male students of high school to determine the relationship of selected anthropometric and physical performance measures to performance in the running hop, step and jump. He concluded that all the variables as measured in the study showed significant relationship with criterion beyond the 0.05 level of confidence.

Wilmore\textsuperscript{42} and others conducted a study on body composition changes with a 10 week performance of jogging. The following conclusion was drawn that the changes in body composition induced by training are as follows: (1) a decrease in total body fat, (2) no change or slight increase in lean body weight and (3) a small decrease in total body

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weight. For the most part these changes particularly that of fat loss are more pronounced for obese men and women than for the already ‘lean’ individual. It is important to note that more calories are expended in running than walking, because weight is directly related to how much calories are expended during training.

In a comparative study of anthropometric measurements of upper and lower one third of a group of gymnasts, determining them as good and bad gymnasts respectively, Read\(^43\) concluded that good gymnasts were significantly more ponderous than poor gymnasts and found to possess a proportionally greater chest breadth than chest depth.

In their study on 166 Olympic track and field competitors and eight swimmers at the 1960 Rome Olympic, Correnti and Zouli\(^44\) observed significant difference in age, height and weight among various events. It was also observed that within certain events body shapes or form was similar but size varied. They also observed relationships between body proportions, dimensions and performance.


Carter\textsuperscript{45} rated members of the 1964 San Diego state football team and 20 university of Iowa football players according to the health criteria. It appears from his result that preponderance of endo-mesomorphs is a pre-requisite of success in football.

Sheldon and associates\textsuperscript{46} have made many interesting observations regarding the somatotype of college football players in America. They have brought out the probable nature of somatotypes, which are successful in case of players playing at various field positions.

In a study of Junior High School athletes Shelly\textsuperscript{47} found that those athletes who were outstanding in football were largely mesomorphic or mid types, and that they were taller and heavier than others.


Wiley\textsuperscript{48} compared 12 years old non-athletes and football players and found no difference between the somatotype means, but football players were taller and heavier than the non-athletes.

In a comparative study of physical structure of Olympic athletes, Carter and associates\textsuperscript{49} concluded that rowers were heavier and taller, and had greater sitting height, leg length, shoulder and hip width and thigh girth than most other sportsmen. Gymnasts were lighter and shorter and had shorter arms and legs, smaller hip breadth and thigh and calf girth than other athletes. Swimmers, hockey players, fencers and cyclists were intermediate on most variables, with a few differences among themselves.

In a comparative study of physique of Olympic athletes, Tanner\textsuperscript{50} concluded that there are very striking differences in body size, shape and structure between competitors in different events. It was observed that


sprinters were relatively short and very muscular men compared with middle distance runners. The 110 m. hurdlers were large, long legged sprinters. High jumpers were tall men. The throwers of discuss, shot, javelin and hammer differed greatly in physique from other athletes. The weight lifters had a physique that was some ways similar to the throwers.

In order to determine the relationship of physique and body composition to the performance in basketball, Sidhu and Grewal\textsuperscript{51} studied 78 female basketball players, where 25 players were of the state level, 20 of the inter-university and 33 players of distant level. They concluded that state level players were tallest, heaviest with biggest trunks, longest upper extremities, and broadest shoulders, followed by inter-university and district level players.

In the study of two males and six female members of the Canadian National Rowers Team, Fu and Morrison\textsuperscript{52} found that rowers were taller and heavier than athletes of other sports.


Puhl and associates\textsuperscript{53} studied players of eight men football team of national level and players of 14 women university world games volleyball teams. They concluded that men volleyball players were taller and heavier.

In a comparative study of somatotype in female gymnasts and distance runners from a college population, Berans\textsuperscript{54} concluded that gymnasts were significantly heavier and they had larger humerus and femur diameter than that of distance runners. Gymnasts were also found to be mesomorphic-ectomorph while distance runners were balanced ectomorph. Further it was concluded that gymnasts had a balance mesomorph somatotype, while less accomplished gymnasts showed equal meshomorphy and ectomorphy.

In his investigation of factors affecting cardio-vascular efficiency using college women as subjects, Abdo\textsuperscript{55} came to the conclusion that


\textsuperscript{54} Marilyn I. Berans, “A Comparison of Somatotype in Female Gymnasts and Distance Runners”, \textit{Completed Research in Health, Physical Education and Recreation} 20 (1978): 214.

excess weight had adverse effect on cardio-vascular efficiency while leg length had positive effect. Ponderal index correlated significantly with cardio-vascular efficiency.

In relationship study between soccer playing ability and selected measures of structure and physical, physiological performance in college men, Amusa\textsuperscript{56} concluded that height was considered good predictor of soccer playing ability.

In a relationship study of anthropometric measurement and body composition to the performance in selected sports on twenty subjects each, from the discipline of inter-collegiate football, basketball and volleyball, Manilal\textsuperscript{57} concluded that calf girth showed significant relationship to the playing ability in football, whereas weight, sitting height, upper arm girth and chest girth did not show significant relationship to playing ability in football.


Joseph\textsuperscript{58} conducted a study on the relationship of power, agility, flexibility and measurements of selected body segments to volleyball playing ability of college male players as subjects. He concluded that power, arm length and leg length are significantly related to playing ability.

Selder\textsuperscript{59} conducted a study on anthropometric cardio-vascular and motor performance characteristics of university ice hockey players' characteristics of physique, motor and cardio-vascular fitness was reported for 14 university hockey players. Most of the players were dominant mesomorphs with low adipose measurement.

Mathew\textsuperscript{60} conducted a relationship study of selected anthropometric measurements to performance on Brady Volleyball Test on university level volleyball players and found that height, weight and arm length showed significant higher relationship to performance on


\textsuperscript{60} Pius Mathew, “Relationship of Selected Anthropometric Measurements to Performance on Brady Volleyball Test”, (Unpublished Master's Thesis, Jiwaji University).
Brady Volleyball Test and low relationship of leg length and upper body length with the performance on Brady Volleyball test at 0.05 level of confidence.

In their study on national level archers, Sundarajan, Pande and Salaudden\textsuperscript{61} concluded that physical measurements, i.e., height, weight, bi-acromial diameter and arm length were correlated with the performance of the individual archers at the varying distance. Further it was concluded that the physical measurements correlated also with the total performance score.

In a study relating to physical measurements to swimming speed in male age group swimmers, Spargue\textsuperscript{62} concluded that most consistent physical measures were foot length and biceps size. In each case longer feet were associated with slower times and longer biceps were associated with faster.


In a study on 64 college age males, Pease\textsuperscript{63} concluded that speed of hand was only significant predictor of the ability to shoot in basketball.

In an intensive study of 17 female volleyball players of Indian Volleyball Team, Grewal and Sidhu\textsuperscript{64} observed that by taking age, height, weight and ponderal index along with the Hirata's method of "Absolute Evaluating Method of Physique" the women volleyball players in national level can be selected.

In a study of 30 college men Golding\textsuperscript{65} did not find significant correlation between anthropometric measurements and cardio-vascular step test. However, body shape and body composition inversely correlated with Harvard Step Test scores.

In a relationship study on 20 male soccer players Chakrabortty\textsuperscript{66} concluded that strength, speed, endurance were significantly correlated

\textsuperscript{63} G. Dale Pease, "Relationship of Selected Hand and Wrist Measurements to Ability to Shoot in Basketball", \textit{Perceptual Motor Skills} 52 (December 1981): 793.


\textsuperscript{66} Debandnanda Chakrabortty, "Relationship of Selected Motor Components and Physique Characteristics to Performance in Soccer", \textit{(Unpublished Master's Thesis}, Jiwaji University).
with performance in soccer. The physique characteristics, i.e., height, weight, foreleg length, thigh length, shoulder width, trunk length, ponderal index and crural index were not found significantly related to the performance in soccer.

Campbell$^{67}$ conducted research on the relationship of selected measures of physical performance and structure to quality of performance in college football. He tested 40 male members of the 1978 Springfield College Football Squad. They were tested for height, weight, 10, 20, 30 and 40 yard dash, vertical jump, agility, upper body strength and lateral movement. In addition, each player had a game performance score, measured by the grading of game film selected at random. No relationship was found between height, weight and performance.

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In his study on male collegiate track and field athletes, Godden\textsuperscript{68} concluded that there were no significant relationships between the anthropometric measurements and speed in the 50 yard dash.

In a relationship study of the leg strength/body weight ratio and length of the lower limb segments, to the vertical jump on 49 male college students, Wells\textsuperscript{69} concluded that none of the relationships studied provided to be statistically significant.

In his study of 89 high school level swimmers Albrecht\textsuperscript{70} did not find significant relationship between physique measures and swimming success.

In his investigation on human body dimensions and applied hydrodynamics and selection criteria for top swimmers using 63 students from Academy of Physical Education of Amsterdam and nine Dutch

\textsuperscript{68} Keith Godden, “The Relationship of Selected Anthropometric Measurements of Leg and Foot to Speed and Vertical Jump of Male Collegiate Track and Field Athletes”, \textit{Completed Research in Health, Physical Education and Recreation} 21 (1979): 306.


\textsuperscript{70} Robert C. Albrecht, “The Relationship Between Certain Physique and Flexibility Measures and High School Swimming Success”, \textit{Completed Research in Health, Physical Education and Recreation} 1 (1959): 56.
competitive Olympic level swimmers as subjects, Clarys and associates\textsuperscript{71} came to the conclusion that shape, composition and dimensions of the body exert little or no influence on the hydrodynamic resistance in independent crawl locomotion.

In their study on different athletes of different sports, Singh and associates\textsuperscript{72} concluded that gymnasts were found to be the highest, tallest and leanest than that of the swimmers and footballers. It was also concluded that sitting height and all the girth measurements except upper arm girth of gymnasts, were lower.

Dutler\textsuperscript{73} concluded that the measures and indices, which were significantly larger at the 0.05 level for good vaulters, were tibial height, chest girth, shoulder girth, shoulder width, grip strength, leg power and speed, ilio spinal height, thigh length plus shoulder girth and sitting height.


\textsuperscript{73} David Christian Dutler, “Anthropometric Strength and Performance Attitudes Among Good and Poor Vaulters”. \textit{Completed Research in Health, Physical Education and Recreation} 7 (1965): 50.
In a comparative study, Gangadharan\textsuperscript{74} studied selected anthropometrics measurements, i.e., height, chest girth, upper arm girth, thigh girth, calf girth and weight of 60 athletes of different sports and concluded that volleyball players were significantly taller than hockey players. The groups did not differ significantly in any other anthropometric measurements undertaken in this study.

Hosler, Morrow Jr. and Jackson\textsuperscript{75} studied 180 collegiate women volleyball players and concluded that women volleyball players tended to be slightly taller, heavier, broader shoulder and narrower hips.

In his study on good and poor college women bowlers Sabel\textsuperscript{76} concluded that said groups were significantly different in all anthropometric variables undertaken in this study, i.e., height, weight and arm length at one and five percent level.


Section III- Physiological Variables

Bolt\textsuperscript{77} selected 71 volunteers and randomly assigned to them one of two jogging regimens, e.g., slow jog regimen and fast jog regimen and the third (non-jog) continued their sedentary habits. The subjects trained thrice a week for twelve weeks. It was concluded that slow jog regimen and fast jog regimen of training significantly improved cardio-vascular fitness.

Srivastava\textsuperscript{78} conducted a study to determine the comparative effects of intensive and extensive interval running methods on aerobic and anaerobic capacities in high school boys. Students were divided into three groups, i.e., two experimental groups and one control group. Aerobic capacity was measured by the distance covered by a subject in Cooper's 12 Minute Run and Walk Test as per procedure laid out in the manual of the test. Anaerobic capacity was measured by the explosive work done by the subject in leaping through eight stairs in two steps covering a vertical

\textsuperscript{77} S. M. Bolt, "Two Jogging Programmes of Different Speed Related to the Cardio-Vascular Fitness of the Middle Aged Man", \textit{Dissertation Abstracts International} 33:3 (November 1972): 2149-A.

\textsuperscript{78} Vijoy Kumar Srivastava, "Comparative Effects of Intensive and Extensive Interval Running Methods on Aerobic and Anaerobic Capacities", \textit{(Unpublished M. Phil. Dissertation)}, Jiwaji University.)
distance of 1.60 meters as pronounced by Margaria Power Test. The analysis of data reveals that both intensive and extensive running methods proved to be effective in improving both aerobic and anaerobic capacities within an experimental period of six weeks.

Dobie\textsuperscript{79} investigated effectiveness of a conditioning programme on selected tennis skills and the cardio-vascular efficiency of twenty two women inter-collegiate tennis players. They were ranked 9 matched by the Hewitt Tennis Achievement Tests and randomly placed into control and experimental groups. Both groups participated twice a week in a continuous and strenuous 20 minutes conditioning programme. The paired ‘t’ test was used to analyse the data. Both groups improved significantly in cardio-vascular efficiency. But there was no significant difference between them. Only the experimental group improved significantly more than the control group.

Rao and Uppal\textsuperscript{80} observed that haemoglobin in the blood increased as a result of endurance training. They also concluded that exercise caused an increase in the number of leucocytes in the circulatory blood.

Uppal\textsuperscript{81} selected 80 untrained subjects and divided them equally into three experimental and one control group. To determine the effect of interval training and two continuous load methods on cardio-respiratory and physiological parameters. One group was given interval training, the second Fartleek and the third group was given slow continuous running for a period of ten weeks. The load was progressively increased. He found that all the three groups had equal training effects of maximal oxygen intake, vital capacity, leg strength, +ve breath holding time, slow continuous and fartleek methods indicated significant improvements in cardio-vascular endurance when compared to interval training.


\textsuperscript{81} Arun Kumar Uppal, "Comparative Effects of Two Duration Load Methods and Interval Running Method on Cardio-Respiratory Endurance and Selected Physiological Variables (\textit{Unpublished Doctor's Thesis}, Jiwaji University).
Abraham\textsuperscript{82} investigated the effects of six weeks training programmes on selected physiological variables (haemoglobin, pulse rate, vital capacity, cardio-vascular endurance and peak expiratory rate flow) of professional college students. The data was collected before and after the experiment and analysed with the help of ‘t’ test. The study concluded that cardio-vascular endurance and peak expiratory flow rate improved due to training. There was a significant reduction in resting pulse rate. There was no significant changes in haemoglobin content and vital capacity after six weeks of training.

Mayer\textsuperscript{83} conducted a study on adult males (N=52) and described as sedentary who participated in a period of eight weeks in prescribed exercise programmes of either running, swimming, calisthenics or sports activity, while a group of control subjects continued to follow their normal routines. Subjects were pre-tested and post-tested on parameters of cardio-vascular fitness, lean body mass, serum cholesterol content of

\textsuperscript{82} K. Mathew Abraham, "Effects of Six Weeks of Training on Selected Cardio-Respiratory Variables of Training of Professional College Students", (Unpublished Doctor’s Thesis, Jiwaji University).

blood. A statistically significant difference was found between the increase in cardio-vascular fitness on the running group.

Stamp\textsuperscript{84} studied the effect of an interval running programme on selected physiological variables in which pulse rate was one of the variables. The work load consisted of running bout on a graded treadmill with a specified interval rest period. Statistical analysis of data indicated significant lowering of heart rate.

Uppal and Tunidian\textsuperscript{85} studied the comparative effect of different frequencies of endurance training on cardio-respiratory endurance. According to their findings, the cardio-respiratory endurance of secondary school students could be effectively improved by administering a progressive programme of interval training. To bring about significant improvement in cardio-respiratory endurance various frequencies of training namely twice, thrice and five days a week was employed. Endurance training workouts using interval running method administered

\textsuperscript{84} Noma D. Stamp, “The Effect of an Interval Running Programme on Cardio-Respiratory Efficiency Body Adipose Tissue and Body Weight of College Freshman Women”, \textit{Completed Research in Health, Physical Education and Recreation} 10 (1968): 99.

three and five days a week were more effective in developing cardio-
respiratory endurance as compared to workouts twice a week.

Gentry\textsuperscript{86} carried out a study to determine the effects of nine weeks
aerobic jogging programme on selected cardio-vascular functions of
young male college students through a time course evaluation procedure.
Pre-test and post-test administered at the end of third, sixth and nineth
weeks were employed in order to evaluate the effects of the training
programme. Significant decreases were observed in resting diastolic blood
pressure and steady state of heart rate, while no change occurred in
exercise cardiac index and resting heart rate.

Steward\textsuperscript{87} made an attempt to see changes in physical work
capacity as a result of physical training. He employed fifteen minutes
interval training, four times per week for eight weeks. Physical work
capacity was measured by maximum oxygen uptake determined during
treadmill exercise. There was significant reduction in sub-maximal heart

\textsuperscript{86} Roy B. Gentry, “The Effects of Nine Weeks Aerobic Jogging Programme on
Selected Cardio-Vascular Functions of Young Male College Students Through a Time
Course Evaluation Procedure”, \textit{Dissertation Abstracts International} 33 (January
1973): 3352-A.

\textsuperscript{87} Kerry J. Steward, “Changes in Physical Working Capacity as a Result of
Physical Training in Children with Reference to the Methods of Assessing Such
rate after training. The decrease in heart rate (sub-maximal) was almost identical on the bicycle ergometer and treadmill. The improved cardiovascular adaptation to sub-maximal exercise after training indicated a possible improvement in physical work capacity even Vo$_2$ max remained unchanged.

De Vries$^{88}$ selected 118 university students to study the effects of three work intensity training programmes on cardio-respiratory fitness. The methods of training employed were the crest load training procedure, continuous running and high intensity running. It was concluded that three training groups showed significant gains in cardio-respiratory fitness.

Dulin$^{89}$ conducted a study on the effects of interval and continuous training on the cardio-vascularatory fitness at deconditioned mature males. He found that neither exercise programme, interval running nor continuous training was superior to other in terms of promoting cardiovascular fitness of the participants.


James\textsuperscript{90} studied the effect of four conditioning treatments on skill development and cardio-vascular efficiency in selected physical education activity courses and found that the skill attained was not apparently effected by the supplement of treatment.

**Section IV- Physical Fitness, Anthropometric and Physiological Variables**

Stanley\textsuperscript{91} investigated on morphological, cardio-respiratory and bio-medical model of endurance running performance. It was concluded that selected cardio-respiratory performance, body size, composition and structure and bio-medical variables contribute significantly to endurance running performance in trained adult recreational runners. As hypothesized the degree of contribution of the cardio-respiratory measures as determinants of endurance performance was greater than the


contributions of the body size, composition and structure and running mechanical variables.

The purpose of Amusa and Sohi\(^92\) study was to examine the changes in muscular strength, muscular endurance, muscular power, speed, agility, cardio-respiratory endurance and body composition in college soccer players following a twenty weeks training. The study concluded that all the muscular capacities, speed, agility and cardio-respiratory endurance improved significantly, whereas a reduction in fat percentage was also seen. Relationship studies pertaining to physical and performance variables showing significant co-relation in the fitness and sports proficiencies found reported in the professional literature.

Joe\(^93\) selected 40 junior high school boys participating in a weight training programme two days a week for six months. Seventeen boys served as a control group. The test items were consisted of the junior amateur athletic union physical fitness test, anthropometric measurements, the California test for personality. The experimental group


registered a significant difference at the 0.05 level of confidence, over the
c control group in anthropometric measurements and the five out of six
physical fitness test items, while no significant improvement was found in
personality test.

Mc Namara's\textsuperscript{94} study was designed to compare the effects of three
physical fitness training programmes on selected psychological and
somatic (body composition, posture, flexibility, muscular strength,
muscular endurance and cardio-vascular endurance) variables on both
males and females. Three treatments (Army Readiness, Calisthenics and
Weight Training) were administered for ten weeks. Statistical analysis of
data indicated that physical fitness training enhanced all the somatic
variables irrespective of training programme.

Davis\textsuperscript{95} attempted to analyze the effects of training and
conditioning for the 200 yard crawl stroke events upon the physical
condition of non-varsity swimmers. Selected measures of cardio-vascular
condition, general physical fitness, gross strength, motor fitness, strength

\textsuperscript{94} Michael Joseph Mc Namara, "The Effects of Three Conditioning
Programme on Selected Physical, Psychological Parameters of College Students",

\textsuperscript{95} Jack F. Davis, "Effect of Training and Conditioning for Middle Distance
Swimming Upon Various Physical Measures", \textit{Research Quarterly} 30 (December
of the muscle groups primarily utilized in swimming the crawl stroke and the strength decrements of the muscles were taken before and after experimental period in order to evaluate the effects of this period. In addition, the relationship between speed in swimming the 200 yard crawl stroke events and the various selected tests were studied. As a result of the training and the conditioning programmes, scores on test batteries used to measure physical fitness, motor fitness and gross strength improved significantly. No significant difference was obtained for cardio-vascular condition. Further no co-efficient of correlation was obtained that was sufficiently high to be of value for prediction of swimming time.

Sorenson\textsuperscript{96} conducted a study to compare the effects of conventional high repetition and modified high repetition weight training programme on strength and cardio-vascular endurance. Fifty four male students were randomly divided into three groups. Group A followed a conventional weight training programme and served as a control group. Group B followed a modified high repetition weight training programme.

Group C followed a high repetition weight training programme. No significant differences were found among or within groups except for bench press, where Group A and B were superior to Group C and dead lift where Group A was superior to Group C.

Alteri97 Selected 63 college females between 17 and 22 years of age to study the effects of endurance and interval running on selected physiological parameters. Analysis of data revealed that due to endurance and interval running, resting pulse rate and resting systolic and diastolic blood pressure were lowered significantly.