CHAPTER-I

INTRODUCTION
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The twenty first century is the most rapidly changing of all time. Rapidity of changes created unusual demands on individuals and on system of education. Today education must not only include the body and knowledge, but also to develop inquiring mind that will enable them to comprehend and accept what is to come tomorrow.

As Jacks, the British philosopher, puts it, living becomes an art only, “when work and play labour and leisure, mind and body, education and recreation, are governed by a single vision of excellence and a continuous passion for achieving it.”

In sports today best performance can only be achieved through a meticulously loosed on the scientific knowledge theoretical and methodical fundamentals of sport training.

The developing tendencies in international sport, specially in team games are identified as the increase in game tempo, tougher body game and greater variability in technique and tactics. An increased performance level can only be achieved by working and training of all major components i.e. Technique coordination, tactics, physical fitness and psychological qualities. Apart from these components, one more factor which is now a days known as coordinative abilities also play a greater role. A sportsman
can compete effectively only by a certain coordinative mastery of the technique.

Coordinative abilities enable the sports man to do a group of movements with better qualities and effect. The speed of learning of skill and its stability is directly dependent on the level of various coordinative abilities. Coordinative abilities are needed for maximal utilization of conditional abilities, technical skill and tactical skills.

Insufficient training of coordinative abilities limits the performance ability specially at higher levels. On the contrary, better developed coordinative ability provides an essential base for faster and effective learning, stabilization and variation in technique and their successful execution in game situation.

In different sports requirement of coordinative abilities are different and these abilities ensures higher movement efficiency and movement economy, whereas in some sports events they helps in higher movement frequency with high explosiveness and force application. In strength sports they help in putting maximum effort in a short time and at the right time. But, where the technique dominates the event these abilities help in better learning, stabilization, variability and autoimmunization. Apart from performance improvement, in team games coordinative abilities ensures an effective use of tactical abilities in the continuous changing situations.
In sports five coordinative abilities are of crucial importance. In different sports the relative importance of these abilities is however different. Physical education teachers and coaches should be well versed with the importance of coordinative abilities in putting up good performance in various physical education activities and sports. Differentiation ability enables the sportsman to perceive micro-differences regarding the temporal, dynamic, spatial aspect of movement execution and the differentiation can be in regards to an implement or movement like serve, movement serve, water feeling, etc. Orientation permits the sportsman to determine the position and movement of his own body and/or of a moving object (opponent, partner) with regard to space. Coupling or combination movement allows the sportsman to coordinate partial movement of his body with regard to space, time, and dynamics.

Reaction ability permits the sportsman to effective action quickly and purposefully according to a signal and for a sudden change in situation. Balance ability helps in keeping the total body in a certain position or to re-establish it. Rhythmic ability enables the sportsman perceive the externally given rhythm and to reproduce it in a motor action. It also denotes the ability to reproduce a rhythm, excising in motor memory in motor action.

1.1 BODY COMPOSITION AND SPORTS

Composition of athlete’s body is almost important factor in the success of a team in all athletic endeavors
(Wilmore, 1982). Body composition plays an important role in achieving excellence in sports performance (Mathur and Salokun, 1985). The body is composed of water, protein, minerals, and fat. A two component model of body composition divides the body into a fat component and fat-free component. Body fat is the most variable constituent of the body. The total amount of body fat consists of essential fat and storage fat. Fat is in the marrow of bones, in the heart, lungs, liver, spleen, kidneys, intestines, muscles and lipid-rich tissues throughout the central nervous system is called essential fat, whereas fat that accumulates in adipose tissue is called storage fat. Essential fat is necessary for normal bodily functioning. The essential fat of women is higher than that of men because it includes sex-characteristic fat related to childbearing. Storage fat is located around internal organs (internal storage fat) and directly beneath the skin (subcutaneous storage fat). It provides bodily protection and serves as an insulator to conserve body heat. The relationship between subcutaneous fat and internal fat may not be the same for all individuals and may fluctuate during the life cycle. Body Composition is the technical term used to describe the different components that, when taken together, make up a person's body weight. Now one must keep in mind that body composition and body weight are two entirely different concepts and they are not interchangeable. Evaluation of body composition is a common and important component of overall physical fitness assessment. It is well established
that excess body fat is harmful to health but many misconceptions exist regarding the assessment and interpretation of such data. Studies on body composition in certain sports indicated that the athletes who were very lean but heavy because of a well-developed musculature were superior in performance in certain competitive sports activities, such as football, weight lifting and the shot put (Bullen, 1971). On the other hand, athletes who have substantial amount of adipose tissue have increased energy demands owing to the inert weight of fat, thus rendering the work more difficult to perform in endurance activities where the body has to move longer with greater weight (Buskirk and Taylor, 1957). It may be for the reasons that the long distance runner are found to be less endomorphic than other runners and their counterparts at a lower level of competition. Lean body mass differs from fat-free mass. Lean body mass represents the weight of muscles, bones, ligaments, tendons and internal organs. Since there is some essential fat in the marrow of bones and internal organs, the lean body mass includes a small percentage of essential fat. However, with the two-component model of body composition, these sources of essential fat are estimated and subtracted from total body weight to obtain the fat-free mass. Practical methods of assessing body composition such as skin folds, bioelectrical impedance analysis (BIA), and hydrostatic weighing are based on the two-component (fat and fat-free mass) model of body composition. The field of body composition assessment is developing rapidly on
several fronts. Some of the major areas are the estimation of fat and fat free body composition of the body and sources of variation in that composition associated with growth and senescence, physical activity and specific exercise training programs along with ethnic and gender patterns of fat distribution and differential development of musculoskeletal system. Health practitioners universally agree that too much body fat is a serious health risk. Problems such as hypertension, elevated blood lipids (fats and cholesterol), diabetes mellitus, cardiovascular disease, respiratory dysfunction, gall bladder disease and some joint diseases are all related to obesity. Also, some research suggests that excessive accumulation of fat at specific body sites may be an important health risk factor. For instance, it appears that extra fat around the abdomen and waist is associated with higher risk of diabetes, heart disease and hyperlipidemia. Individuals who accumulate a lot of fat around the waist (apple-shaped) are worse off than those who tend to accumulate fat in the thighs and buttocks (pear-shaped). The apple-shaped pattern of fat deposition is more commonly seen in men; whereas women tend to be pear-shaped.

The accurate appearance of body composition is an important component in a comprehensive program of total physical fitness. The evaluation of body composition permits quantification of the major structural components of the body - muscle, bone and fat. With respect to health fitness, it refers to the percentage of body weight that is composed
of fat as compared with fat-free or lean tissue. Having a high percentage of body fat is a serious detriment to fitness and health. Height and weight tables have been used traditionally to determine desirable body weight. Individuals whose body weight exceeds set standards for their sex, age, and physical stature by 10% to 20% are considered overweight, persons overweight by 20% of their optimum weight are obese, and those who are overweight by more than 50% of their optimum weight are considered morbidly obese or super obese. It should be noted that being overweight can be attributed to having an excess of either fatty tissue or lean tissue. For example, certain athletes such as football players could be classified as overweight however, when their body composition is examined, the excess weight is attributable to muscular development and their overall percentage of body fat is quite low (e.g., a professional football player can weight 250 pounds or more, yet have only 12 percent body fat or less). The important consideration with respect to health fitness is not the weight of the individual but how much fat the individual has (Malina, 2007).

It is highly important that professional and the public realize that a certain amount of adipose tissue or fat is essential for the body to function. Body fat also serves to protect internal organs. The goal of fitness programs is not the elimination of body fat but helping individuals attain desirable levels of body fat. The average percentage of body fat is 18% for men and 23% for women. With respect to
health fitness, the desirable level of the body fat for men is 12% or less and for women 18% or less. The percentage of body fat should not be less than 3% in men and 12% in women (the height percentage for women is necessary for the protection of the reproductive organs) extremely low percentages of body fat are hazardous to one’s health.

A high percentage of body fat is associated with numerous health problems. Obesity contributes to an increased with other cardiovascular risk factors including hypertension. An increase incidence of diabetes, elevated serum blood cholesterol levels, respiratory problems, low back pain, and certain psychological problems are found among individuals with a high percentage of body fat. Mortality is higher at younger age, and life expectancy is decreased for chronically obese individuals.

The problem of obesity is widespread. It is estimated that more than 50% of the adult population and about 40% of the school-age population in the United States is overweight. Moreover, overweight children typically grow up to be overweight adult. Determination of the cause of obesity is important. In most cases obese can be attributed to overeating and a lack of physical activity. In a few cases however obesity can be the result of disease. When dealing with obesity particularly individuals who are super obese it is important that a physician be consulted. A physical examination and careful monitoring of eating and exercise habit are helpful in determining the cause of the problem. A
qualified physician can offer guidance in designing and implementing a sound fitness program of obesity. (Thygerson and Thygerson, 2009)

Body composition is primarily influenced by nutrition and physical activity. Although body composition is genetically related to body type the nature and amount of food consumed and the extent of participation in physical activity exert a profound influence on body composition. Overeating and low levels of physical contribute of poor body composition. Individuals who are fat tend to eat more and are more sedentary.

Body fat exists in two storage sites, or depots. The first depot, termed essential fat, is the fat stored in the marrow of bones and in heart, lungs, liver, spleen, kidneys, intestines, muscles, and lipid-rich tissues of the nervous system. This fat is required for normal physiological functioning. In the heart, for example, the quantity of dissectible fat determined from cadaver studies represents about 18.4g, or 5.3%, for an average heart weight of 349g in males, and 22.7g, or 8.6%, for an average heart weight of 256g in females (Womack, H.C, 1983). Standard body weight scales provide a measure of total weight, but don't determine the lean-to-fat ratio of that weight. Standing on most scales can tell you only if you weigh more than the average person, but not if that weight is fat or muscle. Based only on scale weight, a 250-pound athlete with 8% body fat may be considered "overweight" by a typical weight
Such charts are not a good indication of ideal body weight for general health or for athletic performance. The ideal weight and fat-lean ratio varies considerably for men and women and by age, but the minimum percent of body fat considered safe for good health is 5 percent for males and 12% for females. The average adult body fat is closer to 15 to 18% for men and 22 to 25% for women. Athletes tend to be at low end of this scale due to their increased lean weight (muscle mass). While low levels of body fat seem to be related to improved performance, body composition alone is not a great predictor of sports success. A linebacker needs to have enough body mass (lean and fat weight) to generate high forces and avoid injury. Body fat among elite athletes varies largely by sport. There is little evidence of any benefit when men drop under 8% and women drop under 14 percent body fat. Body composition, specifically body fat% is of great interest to athletes and is often negatively associated with athletic performance (Gomez, 2004; Malina, 2007; Sigurbjorn, Evans, Saunders, Obgurn, Lewis and Cureton 2000). The appraisal of body composition can provide valuable information for both the athlete and coach in monitoring sequentially the influences of training and nutrition. Therefore, the determination of body composition is important in terms of a training plan as well as success in the game (Kurt et.al., 2010).

Different types of physique have specific advantages in specific sports. For instance, throwers at different levels of competitions are heavier and taller with long muscular arm
and wider shoulders. In shot-put, discus and hammer throwing, greater body weight is beneficial because during throwing the object forward and upward, an equal and opposite reactive force is exerted on the throws, pushing him/her backward and downward. In different events of athletics and different games, specific physique is determined, for eg. In basketball and volleyball the average height of players are more as compared to hockey and soccer players.

Interest in body composition has developed in players with the increased application in parallel with the increased application of scientific methods and in sports medicine and exercise studies. The relationship between work capacity and body fat is of most concern to those involved in sports and physical education. Body composition helps to determine the biological age of the athletes, predicting the possibility of the success of them in specific sports. The evaluation of body composition permits quantification of the major structural components of the body-muscle, bone and fat. To study this section hydrometry, densitometry, somatometry or anthropometry is the main methods. Bale (1991) studies the anthropometric measurements and performance of 18 junior female national basketball players of England. There were studies according to their playing positions and found that the central position players had taller physique and body compositions, followed by the forwards and guards. It was concluded that the central
positioned players were taller, had longer limbs, wider hips and had more lean body mass.

The Olympic basketball players are the tallest followed by the national team, the state level and district level players (Sodhi and Sidhu 1984). In general, there was a gradient of decreasing body size from the national team players to state level players through the district level players and the controls. The first mentioned were found to have proportionality longer upper and lower extremities, shorter trunk, broader hips and more slender chest. The somatotype indicated that the rating of ectomorphic components was greater in the case of the state level players than in the case of the other groups. However, it is interesting to note that the rating of mesomorphic component was not greater in these players. The Indian basketballers were therefore less muscular than their Olympic competitors. The lack of ectomesomorphic physique among Indians may be a limiting factor for their better performance in the International competitions. In body composition, the basketballers had less of body fat than the controls. The state level players seemed to have less fat, with more strongly developed knees and a better developed musculature in the limbs. The basketballers are tall with longer upper and lower extremities which make them suitable to catch the ball with jumps, provide them with a wider reach during the passes and make it easier for them while throwing the ball into the basket. This also helps
them to rebound and also to guard the ball to impede the action of an opponent.

1.2 PSYCHOMOTOR ABILITIES AND SPORTS

Exploring the possibilities of psychomotor abilities the mystery of body and mind has long occupied researchers within fields such as phenomenology, psychology and cognitive science. The traditional psychological approach is that the relationship is dualistic. The faculty of reason is separate from and independent of what we do with our bodies. This means that reason must be independent of perception and bodily movements. Intelligence is here seen as the ability to think abstractly, combine and solve mental problems. The theory was put forth as a way of distinguishing humans from animals, before the emergence of the evolutionary theory, which showed that human capacities grow out of animal capacities. Today it is becoming a well-known and generally accepted thesis that human beings perceive, learn and experience through bodily movement. George Lakoff and Mark Johnson states in the Philosophy In The Flesh that “Our sense of what is real begins with and depends crucially upon our bodies, especially our sensorimotor apparatus, which enables us to perceive, move and manipulate”. In that way our bodies are the foundation for the way we experience and interact with our surroundings. The theory of motor coordination is the basis for understanding the motor of coordination abilities. Motor coordination is part and parcel of actions regulation.
Coordinative abilities have also important and strong links with the motor skills as the motor coordination focus the basis of both. These abilities enable the sportsperson to do a group or set of movement with better quality and effect. Many studies had been done in the field of coordinative physiology, and psychomotor abilities, but they had not been done by taking all the three together. So, the researcher had decided to do research by opting this problem.

1.3 PHYSIOLOGY AND SPORTS

Sports Physiology is the study of the effects of training on the bodies of athletes. Coaches can improve training methods by knowing how and why specific training regimens and conditions affect athletes' performances. Understanding the internal effects of exercise on athletes sets the stage for designing fitness training programs that match the physical demands of specific sports. Internal changes in athlete's bodies are one piece of the training puzzle. Solid fitness training plans should combine important pieces of mental training, sport biomechanics and other aspects of performance. Key training principles, such as overload, specificity, and recovery are heavily rooted in this field. Effects of body composition, flexibility training, hydration, carbohydrate loading etc. on athletic performance are a few topics explored in this field. Exercise physiologists, physicians, and athletic trainers can apply research findings from studies in this field to advise athletes.
on topics concerning nutrition, body composition, sport-related injuries, and other issues related to sports. A word of caution in order to understand the effects of training, scientists must zoom in under lab conditions. Athletes and coaches must consider how well artificial conditions apply to training athletes in the real world, rather than "proving facts", sport scientists piece together clues from studies to form theories. Be careful not to take theories possible explanations as the gospel when training athletes always zoom out into the real world of competition. As much as possible, coaches should consider how applications of research fit with those from other sport sciences, and temper research findings with personal experience and good judgment when training athletes. Professional organizations, such as the American College of Sports Medicine, make position stands or consensus statements that coaches and athletes can use as guide lines and sports training principles.

Physiological exercise testing is important in volleyball to help identify potential talent but also to provide the players, trainers and coaching staff with some profiles for the players and a measure for evaluating training programs. Testing physiological requirements for volleyball has become more specific over the past decade with further advances in both sports science technology and general understanding of the physiological requirements for testing volleyball. However despite this progress in testing procedures and knowledge there still appears limited research regarding the
analysis and critical appraisal of tests used specifically for volleyball. Many laboratory and field tests for physiological assessment do exist, however to be thorough in reviewing physiological status it is important to assess all components of the sport, specifically measuring each energy system. The other main component of the game not covered within this review is skill. These tasks can be assessed with testing procedures that exist but the coaching staff normally specializes in this area and thus generally will devise their own skill assessment. It is important also to note the musculoskeletal screening assessments involving information regarding the players muscle balance, core stability and general flexibility. This testing is normally done separate to the fitness based testing and is performed by physical educationists, trainers, physiotherapists, coaches and researchers. Together all of this information provides a perfect combination to ensure analysis of every physical component of the game.

Maximum Aerobic capacity (VO_2 max) is very important concept in the field of exercise physiology; it is defined as the volume of oxygen consumed at maximum effort in the last 30 sec breathing air of sea-level. Aerobic capacity or VO_2 max is related to body size, body fat%, diffusion capacity, functional capacity of cardiovascular system, the cellular metabolic process and cardiac output. Sex difference in VO_2max is attributed to a lower blood Hb concentration and low lean body mass in females after the onset of puberty. At full maturity, average North American
female is approximately 13 cm shorter, 15-18 kg lighter with 25% body fat as compared to 15% body fat in male. The relationship of aerobic capacity and chronological age is evident. A positive relationship with age exists in the first 18 years of life in both male and female sedentary group and reaches a peak at the age of 25 yrs (40-45 ml/kg/min) and then decline to 20-30 ml/kg/min at the age of 60 yrs. This is due to reduction of absolute aerobic power and partly for an increase in body weight after 30 yrs of age. Training can improve VO₂ max from 0-44%. Effect of training on VO₂ max depends on (a) Initial level of fitness (b) Type of training (duration, intensity and volume) (c) Physical characteristics of the person. Environmental factors viz. altitude, hot, cold, pollution etc. affect VO₂ max. about 70% of VO₂ max is determined by the genetic endowment of the individual. Dietary manipulation/ supplementation affect VO₂ max. lack of optimal diet reduces max O₂ uptake by affecting the growth of the individual. No change or slight decrease in oxygen consumption at sub-maximal exercise. The decrease is due to an increase in mechanical efficiency. A decrease in O₂ consumption is most pronounced in comparisons of highly trained athletes and untrained individuals. The difference is also evident between good and average runners. At maximal effort, VO₂ max is increased. The increment is due to an increased oxygen delivery to the working muscles through an increased cardiac output and by an increased oxygen extraction from the blood by the
skeletal muscles. The average improvement of 5-20% can be anticipated for college male and female student following 8-12 weeks of methodical training. Several studies have shown that even when the VO₂ max is not much increased significant improvement in anaerobic threshold level is possible, provided the training schedule is administered at anaerobic threshold. Significant improvement in VO₂ max may not be possible when the runner reaches a plateau. It is, therefore, suggested that more emphasis should be given to improve the anaerobic threshold level of athletes (Pralay Majumdar, 2005).

1.4 STATEMENT OF THE PROBLEM

The purpose of the study is to determine the relationship of selected coordinative, psychomotor and physiological abilities to the performance in volleyball. Hence the statement is stated as under:

"RELATIONSHIP OF SELECTED COORDINATIVE, PSYCHOMOTOR AND PHYSIOLOGICAL VARIABLES TO THE PERFORMANCE OF THE VOLLEYBALL PLAYERS".

1.5 OBJECTIVES

1. To study the relationship of coordinative ability to the performance in volley ball.

2. To study the relationship of psychomotor ability to the performance in volley ball.

3. To study the relationship of physiological ability to the performance in volley ball.
4. To find out the partial relationship of volleyball performance between two of the three variables.

5. To find out the multiple co-relation between volleyball performance and composite score of all the three variables.

1.6 HYPOTHESES

On the basis of available literature and scholars understanding of the problem it is hypothesized that:

1. There would be no significant relationship of selected Coordinative abilities to the performance in volleyball.

2. There would be no significant relationship of selected Psychomotor abilities to the performance in volleyball.

3. There would be no significant relationship of selected Physiological abilities to the performance in volleyball.

4. There would be no significant partial relationship of volleyball performance between the two of the three variables.

5. There would be no significant multiple co-relation between volleyball performance and composite score of all the three variables.

1.7 DELIMITATIONS

1. This study is delimited to Interuniversity Volleyball Male players only who had represented their university team in Inter University North Zone tournament.
2. The study is delimited to 100 male volleyball players only.

3. The study is delimited to the following Coordinative Ability:-
   a) Orientation ability
   b) Differentiation ability
   c) Reaction ability
   d) Balance ability
   e) Rhythm ability

4. The study will be delimited to following Psychomotor Ability:-
   a) Speed
   b) Agility
   c) Speed of movement
   d) Response Time

5. The study will be delimited to following physiological variables:
   a) BMI
   b) VO₂ Max
   c) Vital Capacity

1.8 LIMITATION

Variation in performance due to motivational factors which affect the study will be considered as limitation of study.

1. Certain factors like diet, rest, sleep etc. was beyond the control of the investigator and were considered as limitation of the study.
2. As the subjects came from different socio-economic groups, their dietary habits, life style, routine of study and play was different which were considered as limitations of the study.

3. No special technique was used to motivate the subjects during the administration of the tests.

1.9 SIGNIFICANCE OF THE STUDY

The present study is likely to reveal which of the coordinative, psychomotor and physiological abilities have relevance for jumping sport or footwork like volley ball. The study will also indicate the difference in their dominance in footwork activities. After having identified the various coordinative, psychomotor and physiological abilities, the experts in these sports will be in a position to prepare a specific training program for these coordinative abilities in order to improve the performance in volleyball which otherwise is likely to stagnate at higher levels because of poor coordinative, psychomotor and physiological exploitation of the sportsman. These are some other significance; which are as follows:

1. The current study would be helpful in determining the relationship of coordinative, psychomotor and physiological abilities to performance of volleyball players.

2. This study will also be helpful in further comparing of the percentage required in the game of volleyball for maximum performance.
3. The result of the study will be helpful to the higher authority to understand the importance of coordinative, psychomotor and physiological abilities.

4. It will also help the professional working as physical education teacher, activity coordinator, coach and the players itself to identify these abilities which contribute to the performance required throughout the game situation.

5. The results of the study will add new dimensions of knowledge in the field of physical education and sports with special reference to volley ball players.

6. The study will help to quantify the coordinative, psychomotor and physiological status of volley ball players.

7. The study also reveals the role played by crucial coordinative, psychomotor and physiological variables contributing to volley ball performance.

8. The result of study may be helpful for scanning of future potential volley ball players on the basis of coordinative, psychomotor and physiological variables.

1.10 Definition of Important Terms

(A) **Coordinative Abilities**: “Coordinative abilities are understood as relatively stabilized and generalized patterns of motor control and regulation process.”

(i) **Orientation Ability**: “Orientation ability is the ability to analyze and change the position and
movement of the body in space and time related to defined action”

“This is the ability to determine the body position and its parts in time and space in relation to gravity, playing field, other players with ball equipment etc.”

(ii) **Differentiation Ability:** “It is the ability to achieve a high accuracy and economy (time adjustment) of separate body movement and mechanical phase of total movement. It is based upon conscious, precise distention between force; space and time parameters of the motor process and these existing in the athletes mind.”

According to Singh “Differentiation ability is the ability to achieve a high degree of accuracy and economy to separate body movements, and movement phase in a action. It depends upon the sportsmen’s capacity to precisely differentiate between minute differences of movement compared to the movement appropriate for the study.”

(iii) **Reaction Ability:** “According to Singh reaction ability is the ability to react quickly and effectively to a signal.”

“Reaction ability is the ability to initiate quickly and to perform rapid and well direct actions following a signal.”
**(iv) Balance Ability:** “Signer defined balance as the ability to maintain body position which is necessary for the successful performance of sport skill.”

“Balance may be defined as the ability of the individual to maintain his neuromuscular system in a static condition.”

**(v) Rhythm Ability:** “It is the ability to preview the externally given rhythm and to reproduce it in motor action. It also denotes the ability to reproduce a rhythm, existing in motor memory, in motor action.”

**(B) Psychomotor Abilities**

Stallings (1982) defined, “Those abilities that influence the capacity to manipulate and control objects.”

**(i) Speed**

Theiss and Schnabel (1987) give the following definition of speed “It is the performance prerequisite to do motor actions under given conditions in minimum of time”.

**(ii) Agility**

According to Singh “Agility is defined as the ability of the body parts to change direction rapidly and accurately”.

**(iii) Response Ability**

Response ability is the ability to initiate quickly and perform rapid and well-directed actions following a signal.
According to Singh, “Response ability is the ability to react quickly and effectively to a signal”.

(iv) **Speed of Movement**

It is the ability to rapidly change the body’s momentum from one direction to another. This requires either acceleration in any direction from dead stop or deceleration in the direction one is traveling and acceleration in a new direction. Based on Isaac Newton’s second law, acceleration/deceleration is proportional to the ratio of force to mass.

(C) **Physiological Variables**

Pralay Majumdar has defined “Exercise Physiology as the study of how exercise alters the structure and function of human body.”

(i) **Vital Capacity**

Dill has defined “Vital capacity is the maximal volume of air that can be forcefully exhaled from the lungs following a maximal inspiration. Maximal volume of air forcefully expired after maximal inspiration.”

(a) **Forced vital capacity (FVC)**

Forced vital capacity (FVC) is the volume of air that can forcibly be blown out after full inspiration, measured in liters. FVC is the most basic maneuver in spirometry tests.
(b) **Peak Expiratory Flow (PEF)**

Peak Expiratory Flow (PEF) is the maximal flow (or speed) achieved during the maximally forced expiration initiated at full inspiration.

(c) **Peak Inspiratory Flow (PIF)**

Peak Inspiratory Flow (PIF) is the maximal flow achieved during the maximally forced inspiration. It is a measure that reflects respiratory drive, the higher its value, the greater the respiratory drive in the presence of coordinated thoraco-abdominal or even moderately discoordinated thoraco-abdominal movements.

(ii) **VO$_2$ max.**

Bye, had written the volume of oxygen we can consume while exercising at our maximum capacity can measure fitness. VO$_2$ max is the maximum amount of oxygen in millimeters, one can use one minute per kilogram of body weight.

VO$_2$ max is defined as, “The height rate of oxygen consumption attainable during maximal or exhaustive exercise.

(iii) **Body Mass Index (BMI)**

According to Katch and Katch, “Body Mass Index (BMI) is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity. It is defined as the weight in kilograms divided by the square of the height in meters (km/m$^2$). For eg. An adult weight 70 kg and height 1.75 m will have BMI=70(kg)/1.75$^2$(m$^2$) = 22.9.”