CHAPTER I
INTRODUCTION

Sport is a worldwide phenomenon today. The need and importance of performance in sports has increased rapidly in the last few decades. It has a very prominent role in modern society. It is important to an individual, a group, a nation and indeed the world. Throughout the world sports has a popular appeal among people of all ages and both sexes. The effects of training are widespread and may be observed throughout the body. There are a number of systematic changes primarily affecting the circulating and respiratory system. Training for sport has become increasingly scientific. Yet training is not just a science but also an art, the art of intelligent application of scientific methods produce a level of fitness for a particular activity. Training is usually defined as a systematic process of repetitive, progressive exercise or work, involving also the learning process & acclimatization. Regular exercise benefits players of all ages and sexes. Regular physical activity and exercise offer great benefits to players is a good reason to make exercise routine.¹

When repeated periods of exercise occur over a time certain physiological changes occur in the body, including changes in the respiratory, cardiovascular and muscular system, which allows better and improved performance. The amount of changes depends on the length of the exercise period as well as the intensity of the exercise and how often exercise occurs. Training needs to be specific to get the adaption a performer wants to achieve. Interval training creates different adaptations with changes to the work and recovery.²

Fitness is a very important aspect of cricket performance with physically prepared cricketers proven to perform better, more consistently and with fewer injuries. The physical attributes of strength, speed and endurance enables a cricketer to bat with power over long periods of time, bowl faster and with greater accuracy, and to field athletically. Every cricketer has a different role, position, action or

technique and fitness training should recognise these differences and be programmed accordingly. A well-structured training program for a cricketer must consider the individuals training history, injury history, training age, positional requirements, technical execution and training objectives.\(^3\)

**Endurance**

"Endurance" refers to your ability to exert yourself or remain active over time. It also refers to your ability to withstand fatigue, stress or pain. Endurance training helps improve cardiovascular, respiratory and muscular endurance during any aerobic or anaerobic exercise. While most people exclusively associate swimming, running and biking with endurance training, there's more to it than just three sports.\(^4\)

It is the ability to maintain repetitious movement of skeletal muscle (muscular). Endurance is of two kinds: **strength-endurance** (ability to continue successive movement with heavily loaded muscles for a long time), and **cardiorespiratory endurance** (underlying physiological fitness). A stronger person is able to sustain at given tasks/work for a longer duration than the weaker person. However, strength singularly does not provide an answer to muscular endurance. With training muscles can be made improve both in strength and endurance so that they recover faster after workout. By applying some form overloaded principle strength-endurance can be easily improved. In the cardio-respiratory endurance, exercise is carried out for a sufficient duration and intensity to place stress on the heart, circulatory and respiratory systems. Adjustment among these systems can be brought about by progressive training loads, enabling the individual to sustain moderate contraction of the skeletal muscles over longer periods of time.\(^5\)

**Cardiorespiratory fitness**

When the person performs any type of "cardio" exercise, person is not only burning calories but also improving your cardiorespiratory fitness. Cardiorespiratory fitness is a measure of how well the body is able to transport oxygen to the muscles during prolonged exercise, and also of how well the muscles are able to absorb and

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use the oxygen, once it has been delivered, to generate adenosine triphosphate (ATP) energy via cellular respiration (cellular respiration is a chemical process in body's cells that converts the energy stored in the food we eat into the ATP form of energy that is recruited for use by the muscles). Essentially, cardiorespiratory fitness level is a measure of the strength of the aerobic energy system. Cardiorespiratory fitness should start at the easier end of the intensity, duration, and frequency ranges given above and slowly increase them as he progress. For example, an absolute beginner might want to try starting out at an intensity of 55% of their maximum heart rate, for 20 minutes, three times a week. But if that is too hard don't despair! It's okay to reduce the intensity for a "breather" if that's what he needs to do to keep himself moving for the full 20 minutes. For example, if someone is jogging but can't do it for a complete 20 minutes at first it is absolutely fine to slow down and take walking breaks whenever he need. Think of it this way, if person can't finish the 20 minutes without stopping then his body is obviously being stressed beyond what it is accustomed to, and therefore person have subjected it to the desired overload. This will be enough to stimulate an adaptive response (person's body will realize that it needs to strengthen its cardiorespiratory system and adjust accordingly), and things will be slightly easier next time. Just finish the 20 minutes with as many breaks as he need and eventually he will find that the number of breaks person need decreases until he don't need any. Then he can gradually increase the intensity, duration, and frequency by changing them in the ways that the person should be comfortable with. Finally, try to make the cardiorespiratory exercise schedule that you enjoy so that person will continue to do it.\(^6\)

Cardiovascular fitness is the ability of the heart and lungs to supply oxygen-rich blood to the working muscle tissues and the ability of the muscles to use oxygen to produce energy for movement. A person's ability to deliver oxygen to the working muscles is affected by many physiological parameters, including heart rate, stroke volume, cardiac output, and maximal oxygen consumption. As aerobic/anaerobic capacity increases, general metabolism rises, muscle metabolism is enhanced, haemoglobin rises, buffers in the bloodstream increase, venous return is improved stroke volume is improved, and the blood bed becomes more able to adapt readily to

\(^6\) Cardiorespiratory Fitness: Retrieved on August 12, 2014 from http://www.shapesense.com/Fitness and Exercise
varying demands. Each of these results of cardiovascular fitness/cardiorespiratory conditioning will have a direct positive effect on muscular endurance, and an indirect effect on strength and flexibility. To facilitate how a person does deliver oxygen to their working muscles, they need to train, or participate in activities that will build up the energy stores needed for their sport. This is referred to as metabolic training. Metabolic training is generally divided into two types: aerobic and anaerobic.7

Like any sport it is important for cricketers to have a cricket training programme that not only works on the skills of the game but also on fitness. A good cricket training schedule will allow players to be in the best condition possible for the matches and season ahead. The structure of cricket means that depending on what position a player plays in endurance and concentration are vital as well as having good strength and conditioning. A proper training programme will concentrate on these areas to ensure the player is in the best physical condition possible to perform when they enter the pitch either to bat, bowl or as a fielder. Cricket matches can last for very long periods of time, particularly at the highest levels during test matches. Players can be on the pitch for up to four hours at a time before a break in play which will test their concentration levels as well as fitness. The better physical condition a player is in the better their concentration will be and the more effective their performance, regardless of whether they are batting, bowling or fielding. As every player will be required to bat and field during a match, it is crucial that training encompasses all aspects of the game in order for them to perform. While the dynamics of the game mean that play is very stop start, as the bowler resets for every ball delivery, the players need to be focused and ready to explode into life once the batsman has played a shot. This applies to players in each position. The batsman must be able to sprint from one end of the pitch to the other; the fielders must be alert and agile to get to the ball as quick as possible and the bowlers must be able to sustain concentration and fitness throughout each of their bowling sessions, which can often last for three to four hours.

It is vital that a batsman has good sprint speed and endurance in order to run between each wicket after a shot has been played, especially as this may be the best

way of building up runs if they are struggling to find the boundary. A bowler may be required to bowl a lot of overs during a three to four hour period and this will test their endurance and power. This is particularly true of medium and fast bowlers. While fielders may go long periods of the game without touching the ball, it is still crucial that when they are called into action they are alert and can cover the ground as fast as possible. They need to be able to execute acrobatic catches and perform high intensity sprints to prevent the ball from reaching the boundary line, to perform fast run-outs or to limit the amount of runs a batsman can make while the ball is in the outfield.⁸

Endurance Fitness

Endurance fitness is the cornerstone of your cricket fitness; it helps you generate energy and resist fatigue, so you can perform effectively for the duration of the game. The benefits of endurance fitness are:-

- It enhances the capacity to repeat short bursts of activity over an extended period of time.
- It fuels the skill set so you have the energy to bat, bowl and field to your potential.
- It reduces the chances of injury as muscles do not fatigue so quickly.
- It enables the cricketer to maintain mental focus throughout a game.

Cricket is not a continuous steady state sport - there are frequent changes in running speed and intensity of effort, plus various strength and power movements like batting, bowling and fielding the ball at pace. Players, therefore, require a 'fuel mix' of aerobic and anaerobic energy to sustain performance. The intensity and the duration of an activity determine the extent to which each energy system is used. In general, certain activities can be classified as being fuelled by aerobic or anaerobic energy.

Aerobic training

A sound level of aerobic fitness provides a platform for anaerobic training. Although running is specific to cricket, it is better to combine various modes of exercise including cycling, rowing, and swimming. The intensity of exercise for aerobic training should be light to moderate (for example a 4-6 out of 10 level of effort). However, there is a limit to the level of endurance fitness that can be achieved through steady-paced training. This develops the aerobic energy system and as we can see from above, it is vital that training also develops the anaerobic system. The next step is to introduce interval training.9

Aerobic capacity will be improved by a training program that is designed to progressively overload the cardiovascular and respiratory systems, and to stress the oxidative capacities of the muscles; that is, their ability to utilize oxygen. The program should be specific to the sport or event; that is, runners run and swimmers swim. The principal training methods used to develop aerobic capacity are continuous/uniform training, Fartlek training and interval training. The two most common training methods used for developing aerobic fitness are continuous training and aerobic interval training. There are a number of popular modifications of these two techniques.

Aerobic interval training

In common with Fartlek training, in long-interval training there are periods of work interspersed with periods of recovery. To achieve a specific effect there are a number of variables that can be manipulated. These include the:

- Duration of each interval and rest period
- Intensity of the interval
- Duration of the recovery interval
- Number of work/rest intervals per session.

The key to effective and specific overload is the work: rest ratio. For aerobic training, long intervals are used with a work: rest ratio of 1:1. Each exercise interval would typically be 2–5 minutes in length and be done at a sub-maximal pace. The

number of intervals to be completed would be four to eight repetitions. Interval training allows work of a high quality to be performed as the recovery periods delay the onset of fatigue. Also, the athlete can complete more work than in an equivalent continuous training session. Effective interval training depends on identifying the level of fitness of the athlete and setting the appropriate variables. A period of continuous training may be required to build aerobic fitness before introducing intervals. As there are a number of variables available it can be easy to build progression into an interval training program. Measuring and monitoring training adaptations is achieved through the use of cards or charts to record each of the variables involved. It can be effective to use a heart rate monitor as the rest periods would allow the work intensity to be recorded.

Interval training involves the breakdown of the training period into intervals of exercise or work, followed by intervals of rest or relief. The major variables that are manipulated in interval training are time (duration) and intensity. These can be adjusted to provide improvements in both aerobic and anaerobic training.10

In aerobic training, the duration of the exercise interval needs to be long enough to allow athletes to reach their maximal oxygen uptake (VO₂max), but be short enough not to bring on fatigue. It is usually suggested that both brief and longer periods of exercise be included in interval training programs. The intensity should allow athletes to reach their VO₂max, but the rest intervals should usually be active, such as walking or jogging slowly. This helps to remove accumulated lactic acid from the blood, and allows athletes to train longer. Two factors that are important here are training time and training distance. Training time is the rate at which the work is to be completed. Aerobic interval training involves moderate-duration and high-intensity 'pace or tempo’ training: 85–90 per cent of maximum heart rate, very near to lactate threshold for 30–60 minutes in bouts of 4–10 minutes.11

Continuous training

The most common form of aerobic training is called continuous training. In this form of training, the heart rate is elevated and maintained by using jogging, power walking, cycling, swimming, aerobic floor classes, or any other form of exercise that elevates the heart rate. It should be performed continuously for a minimum of 20 minutes. Continuous training is generally of a long duration and moderate intensity: 70–85 per cent of maximum heart rate for 30 minutes to 2 hours. Although continuous training is effective in producing a training effect, it might not necessarily replicate the performance requirements. In other words, it might not be specific enough for the requirements of some sports or positions, or it might be too difficult to train at the same level as the competition requires. Consequently, other forms of aerobic endurance training have been developed.12

Isotonic muscle action refers to an exercise performed at a variable speed with fixed resistance. The term isotonic (iso + tonic = same tension) implies constant tension. Isotonic muscle training involves contractions where tension is equal throughout the range of motion. It involves the contraction and shortening of a muscle to allow movement. The isotonic contraction (meaning equal tension) is a contraction in which the stimulated muscle changes length, either eccentrically (by lengthening) or concentrically (by shortening), without changing volume, thereby moving the body segment to which it is attached. Consequently, isotonic contraction (also called dynamic contraction) is subdivided into concentric and eccentric. An isotonic exercise is performed against resistance, here the load remains constant but the resistance varies with the angle of the point.13

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Advantages of Isotonics

The advantages of isotonics are numerous, affordable, and accessible to most people. They can be highly motivational as a person increases the weights. Isotonic also provide exercise for the entire range of motion in both concentric and eccentric phases. There are improvements to the circulatory and neurologic systems. Isotonic can be varied easily to meet the demands desired, and the results are experienced quickly. Regarding application to musculoskeletal rehabilitation, muscle loading is accomplished at the weakest points in the range of motion.

Ergometer bicycles are exercise bicycles that are stationary. There are two different types of ergometer bicycles: the first type of bicycle resembles a normal bicycle and the exercise is done in an upright, seated position; the second type is known as a recumbent ergometer with the legs stretched forward. The recumbent bicycles are slightly better for the back, as the back is resting on a backrest.

Tips for Exercising with an Ergometer Bicycle:

- Always adjust the bicycle according to your height.
  - Seat height: You should be able to touch the pedal, which is furthest away, with the entire sole of your foot with your knee only slightly bent.
  - Handlebars: Correctly positioned handlebars take some of the strain off your back.
- Always step on the pedal with the entire foot and not just with the toes. Pedal clips make the exercise easier and should be used if provided.
- Keep your back straight when exercising.
- Always make sure that the ergometer bicycle is completely stable.

Advantages of an Ergometer Bicycle

- Ergometer bicycles are very effective for exercising the thigh muscles.
- Ergometer bicycles are good for the joints and do not put a lot of strain on the knees.
Isokinetic exercise

Isokinetic (meaning equal rate of motion or equal speed) muscular activity is a comparatively new concept in the field of training. An isokinetic contraction is a contraction in which the muscle contracts maximally at a constant speed over a full range of movement against a variable resistance. This type of contraction can only be accomplished with the use of speed apparatus (machine) such as mini-gym, electromechanical dynamometer etc. These isokinetic devices keep the velocity of the movement constant and match their resistance to the athlete’s effort, permitting maximum tension to be exerted throughout the range of movement. This technique based on the maxim- the harder you pull, the harder will the gym resist; in other words, the resistance is always related to the applied force. It increases muscular

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endurance for movements that require fast speed, and produces less muscle soreness.15

An isokinetic contraction is a dynamic contraction but the speed of the entire movement is controlled by the machine. Any exercise involving the contraction of muscles can be isokinetic if the dynamometer is being used. Isokinetic muscle action refers to a muscle action performed at a constant angular joint velocity. Unlike other types of weight training, there is no specified resistance to meet; rather, the velocity of movement is controlled. The resistance offered by an isokinetic dynamometer cannot be accelerated; any force applied against the machine results in an equal reaction force.

Isokinetic muscle training is a type of contraction where the speed of movement is fixed and resistance varies with the force exerted. In other words, the harder an individual pushes or pulls, the more resistance is felt. It involves muscle contractions that shorten the muscle at a constant speed. This method is mostly used for sports training or rehabilitation following an injury. This form of training usually requires the use of a machine. The user applies force to this machine, and the machine will produce a reading of how much force or resistance was applied. Exercise is a planned, structured and repetitive physical activity. Exercise not only conditions the body, but it also improves health, maintains fitness and helps rehabilitate injured parts of the body. Exercise includes cardiovascular activities like running or walking as well as weight training. All workouts should begin with a warm-up routine and end with a cool-down segment that includes stretching exercises. Each of these activities should be done for 3 to 5 minutes. There are three main techniques used for muscle training. At rest, the rate of oxygen uptake of an average healthy adult is 0.25 liters per minute. During regular aerobic exercise, this value can increase by about 10 to 20 times, depending on the fitness and genetics. Supramaximal exercise is exercise that goes beyond 100 percent of the amount of oxygen that the muscles can take up, at which point the body no longer creates energy through oxygen, and thus switches to anaerobic metabolism to continue producing energy. Researchers often use

supramaximal exercise as a variable to observe the chemical and physiological changes that occur in athletes during exercise.\textsuperscript{16}

Isokinetic exercises are performed with a specialized apparatus, which provides variable resistance to a movement. This ensures that no matter how much effort is exerted, the movements take place at a constant speed. They are often used to test and improve muscular strength and endurance, more so after an injury. They work on the idea that the highest degree of muscle contraction is to be achieved, but at the same time, there should be free range of movements in the limbs.

Those who have access to a range of free weights or fixed weights can pursue progressive resistance. Working out with lighter weights through more isotonic repetitions will make muscles stronger and more able to handle challenges across their entire range of motion. The main isokinetic exercise example for non-professional athletes is isokinetic exercise bikes. These can be useful for a wide range of people.

Benefits

- Since it is possible to control the resistance, it is possible to set the level of resistance in order to challenge the body, but not strain or pull the muscles of the arms or legs.
- The benefits derived from the workout are maximized.
- The range of motion increases considerably after making them a part of your daily workout schedule.
- Although they do not directly target the abdomen, chest, or buttocks, these areas do benefit indirectly.\textsuperscript{17}

As isokinetics have a fixed speed with a variable resistance throughout the ROM, the velocity is constant at a preselected dynamic rate where resistance varies to exactly match the force applied at every point in the ROM. This accommodation allows maximal dynamic loading throughout the entire ROM. By controlling the velocity of exercise, maximum resistance throughout the full ROM

is developed by exercising at that velocity. Keep in mind that isokinetic and isotonic exercises are essentially opposites.\textsuperscript{18}

**Isokinetic Training**

- Isokinetic exercise combines the advantages of dynamic (full range of motion) and static (maximum force exerted) exercise.
- Uses an accommodating resistance that matches force exerted.
- Reduces likelihood of muscle soreness-no eccentric component.
- Limited in ability to produce muscle hypertrophy-no eccentric component.

**FIGURE-2. HUMAC NORM: CYBEX**

The State Director of Coaching for the Victorian Cricket Association, Frank Tyson, in his book “The Cricket Coaching Manual” (1985), uses the terms general endurance, speed endurance and speed to describe the aspects of the energy continuum that all cricketers need to train. General endurance is related to energy derived from purely aerobic processes and can be developed by daily running over long distance at a high intensity (i.e., greater than 50% of an individual’s maximum). Greater endurance will enable the cricketer to survive a long day in the field or at the crease without experiencing undue fatigue. Speed endurance involves the ability to repeat short bursts of effort and incorporates the lactic acid energy system for energy to complete the short bursts, and aerobic energy to recover between each effort. Interval training involving repeated over a set distance in a set time, with prescribed recovery periods is advocated as the best form of training to improve speed endurance. Tyson advocates distances between 27-73 meters with work to rest ratio of 1:4 or 1:6. It is probable that ratios of 1:2 or 1:3 will provide a greater overload on the energy systems involved and produce a greater training effect. Speed, synonymous with the phosphogen energy system is best improved by acceleration sprints and attention to running technique.

The major difference between fitness training for serious and elite cricketers is the availability of time. For many club cricketers only one night per week is made available for training. Training for these cricketers must be carried out on an individual basis away from the club environment. The principles of training are no different for these groups; the levels of achievement are much higher for the elite. The club cricketer is usually looking for maintenance fitness, (i.e. A fitness level that will

<table>
<thead>
<tr>
<th>Type</th>
<th>Intensity</th>
<th>Repetitions</th>
<th>Sets</th>
<th>Speed</th>
<th>Frequency</th>
<th>Length of program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isokinetic strength</td>
<td>Maximum contraction</td>
<td>2-15</td>
<td>3</td>
<td>24-180°.sec⁻¹</td>
<td>3-5 days/week</td>
<td>6 week or more</td>
</tr>
<tr>
<td>Isokinetic endurance</td>
<td>Maximum contraction</td>
<td>Until fatigued</td>
<td>1</td>
<td>≥180°.sec⁻¹</td>
<td>3-5 days/week</td>
<td>6 week or more</td>
</tr>
</tbody>
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enable him or her to continue to play the game without adverse physical effects). The elite cricketer, however, is aiming for a fitness level that will enable skilled performance to be further developed.

It appears that the approach of performing long continuous running progressing into interval running is appropriate for pre-season cricket training. The progression from strength to power and endurance is attained by reducing the weights involved and increasing the repetitions and sets for each exercise. There is usually a change from exercise involving large muscle groups to those involving smaller more specific isolated muscles.¹⁹

RESEARCH QUESTION

Whether there is any effect of isotonic and isokinetic training on cardiovascular and pulmonary functions?

OBJECTIVES OF STUDY

Since the research scholar conceptualized a detailed investigation in terms of the analytical study of isotonic and isokinetic endurance training on cardiovascular and pulmonary functions, the following specific objectives were set for the study:

➢ To investigate the effect of isotonic training programme on cardiovascular and pulmonary functions.
➢ To investigate the effect of isokinetic training programme on cardiovascular and pulmonary functions.

DELIMITATIONS

➢ The study was delimited to 15 school going children age ranging between 15 to 18 years selected from L.N.I.P.E. cricket academy.
➢ The study was further restricted to 10 weeks of training (Thrice in a week).
➢ The study was further delimited to the following cardiovascular & pulmonary variables:

✓ CARDIOVASCULAR VARIABLES:
  • Endurance
  • Heart Rate
  • Blood Pressure

✓ PULMONARY VARIABLES:
  • Vital Capacity
  • Peak Flow Rate
  • Respiratory Rate
  • Forced Vital Capacity
  • VO₂ max
  • Forced Expiratory Volume1
- Maximum Voluntary Ventilation
- Breath Holding Capacity
- Minute Ventilation

LIMITATIONS

➢ Certain factors like habits, life style, routine work, diet, etc. might have affected the result of this investigation. These factors were considered as limitations for the study.

➢ The knowledge of previous experience in training might have affected the performance of cricketers hence this was also considered as limitation for the study.

➢ The emotional stages of the subjects and motivational factors which might have had influence on the result of the study were also considered as limitation.

HYPOTHESES

On the basis of knowledge gained from available literature, research findings and the scholar's own understanding of the subject area, the following hypotheses were formulated:

➢ There was a significant effect of isotonic training programme on selected cardiovascular and pulmonary functions.

➢ There was a significant effect of isokinetic training programme on selected cardiovascular and pulmonary functions.
DEFINITION OF TERMS

TRAINING

Sports training is a process of preparation of a sportsman, based on scientific and pedagogical principles, for higher performances.

ISOTONIC TRAINING

It can be defined the training in which the muscle either shortens or lengthens while contracting, as a result there is a change in external length of the muscle.

In the isotonic type of contraction the muscle shortens with varying tension while lifting a constant load.

ISOKINETIC TRAINING

Isokinetic contraction the tension developed by the muscle while shortening at constant speed is maximal over the full range of motion.

Isokinetic exercises are dynamic muscle activity performed at a constant angular velocity; torque and tension remain constant while muscles shorten or lengthen.

ENDURANCE

Endurance is the result of physiological capacity of the individual to sustain movement over a period of time. It is the ability to continue successive movements in situations where the muscle or muscle groups being used and loaded heavily.

CARDIOVASCULAR ENDURANCE

Cardiovascular endurance as the moderate contraction of large muscle groups for relatively longer periods of time; during which maximum adjustments of the cardiorespiratory system are necessary.  

20 Harison H Clarke; op.cit.p-152.
Endurance can generally be defined as the ability of the body to resist. However in athletic events requiring great endurance, the main limitation is the ability of the circulatory system to supply oxygen to the working muscles and to keep the muscle cells free from waste products. This particular process is depending upon cardiovascular endurance.\textsuperscript{21}

**HEART RATE**

The number of ventricular beats per minute is heart rate. Heart rate is usually determined from pulse rate which is the number of pressure waves per minute along the carotid artery at the neck or the radial artery at the wrist.\textsuperscript{22}

**BLOOD PRESSURE**

Blood pressure is the pressure exerted on the wall of the arteries as the heart pumps the blood through the body.

**SYSTOLIC BLOOD PRESSURE**

When the left ventricle contracts and pushes the blood into the aorta the highest pressure produced is known as the systolic blood pressure.

**DIASTOLIC BLOOD PRESSURE**

When complete cardiac diastolic occurs and the heart is resting following the ejection of blood, the least pressure within the arteries is termed as diastolic blood pressure.\textsuperscript{23}

**VITAL CAPACITY**

The maximum volume of gas that can be expelled from the lungs following the maximal inspiration is called vital capacity.\textsuperscript{24}

Vital capacity is the maximum amount of air, which can be transported in one voluntary expiration.\textsuperscript{25}

\textsuperscript{23} Clarke, Physical Fitness Research Digest, p.8.
\textsuperscript{24} Astrand and Rodahl, Text Book of Work Physiology, p.199.
**PEAK FLOW RATE**

Forced Ventilatory Capacity is also called the Peak-Flow rate, is the maximum of air flow that could be expired out forcefully after a deepest possible inspiration.

The maximal volume of gas that can be exhaled from full inspiration as forcefully and rapidly as possible.

**RESPIRATORY RATE**

It is a number of breaths take in a minute or number of inspiration and expiration in a minute.\(^\text{26}\)

**FORCED VITAL CAPACITY**

Forced vital capacity is the determination of the vital capacity from a maximally forced expiratory effort.

**MAXIMAL O\textsubscript{2} CONSUMPTION**

\((\text{VO}_2 \text{ max})\)

Maximum oxygen uptake \((\text{VO}_2 \text{ max})\) refers to the highest rate at which oxygen can be taken up and consumed by the body during intense exercise.\(^\text{27}\)

**FORCED EXPIRATORY VOLUME I**

The maximum volume of air that can be expired from the lungs in a specific time interval when starting from maximum inspiration.

The volume of air that can be forcibly expelled in a fixed period after full inspiration.


\(^{27}\)Ibid., p.550.
MAXIMUM VOLUNTARY VENTILATION

The maximum volume of gas that a person can inhale and exhale by voluntary effort per minute by breathing as quickly and deeply as possible. It is measured in pulmonary function tests.

A measure of the maximum amount of air that can be inhaled or exhaled in one minute. For the comfort of the person, this is done over a 12 second time period, which is then extrapolated to a value for a minute (expressed as liters/minute).

BREATH HOLDING CAPACITY

Breath holding time is the duration of time through which one can hold his breath without inhalation or exhalation. This is estimated in seconds.28

Positive Breath Holding

Holding the breath as long as it is comfortable after full inspiration before starting smooth expiration.

Negative Breath Holding

Holding the breath as long as it is comfortable after slow and complete expiration before starting smooth inspiration.

MINUTE VENTILATION

Minute ventilation, or breathing, is the exchange of air between the atmosphere and the lungs. As air moves into and out of the lungs, it travels from regions of high pressure to regions of low pressure.

SIGNIFICANCE OF THE STUDY

The results of this study may be significant in the following ways:

➢ The study may be of immense benefit for coaches, trainers and cricketers for preparing the training programme.

➢ Findings of this study may add to existing literature of Physical Education, Exercise Physiology and Sports Training.

➢ The study may provide a base for planning training programme for cricketers at various levels.

➢ The findings of present study may also help the coaches, cricketers and exercise scientists who are in great need of an additional investigation of this problem.

➢ This study may give an opportunity and encouragement to the interested coaches to conduct further studies on different aspects of cricketers.

➢ This study may add to the guidelines and information about means and methods suitable for developing endurance.