Chapter 1

Introduction
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"Life is my sports, May I experience more, and Earn some honors"

Basketball is one of today’s fastest team sports and is epitomized by grandiose manoeuvres such as slam dunk and blocked shot. These showcases of athletic ability clearly demonstrate the nature of the sports, in that speed, strength and power are all major determinants of successful basketball performances (Nick Stane, 2007). Although such characteristics are commonly associated with modern basketball athletes, it is interesting to consider basketball's evolution from its humble beginnings into one of the most popular and dynamic team sport of modern society.

Basketball has gained worldwide popularity and fascinated players and spectators with its dynamic characteristics as a team sport (Hoffman & Maresh, 2000). In this sport, players cover about 4500–5000m during a 40-minute game with a variety of multidirectional movements such as running, dribbling, and shuffling at variable velocities (Crisafulli et al, 2002). In order to execute running, dribbling, and shuffling like movements during performance, both aerobic and anaerobic metabolic systems appear to be involved throughout a game (Ciuti et al, 1996).

1.1 HISTORY OF BASKETBALL

Basketball was invented in 1891 by a Canadian born physical education instructor, James Naismith. Naismith’s original intention was to keep his football team in shape during the off season with an exciting new game that required both skill and physical ability (Bellis, 2007) with influences from ancient Aztec, Maya and Morari handball sports. The object of the game was to throw a soccer ball into a peach basketball suspended ten feet above the ground. Originally, every time a point was scored the ball would have to be retrieved, because the bottoms of the peach basket were intact at first.
Basketball's popularity increased rapidly from the first public game being played in Springfield, MA, USA, on March 11th 1892 to the formation of the professional league only six years later in 1898, known today as the National Basketball Association (NBA). It was not until 1903, however, that an open-ended net was introduced to put an end to manual retrieval of the ball from the basket after each goal scored.

The 1936 Berlin Olympics saw basketball being played for the first time as an official Olympic sports, where the States defeated Canada 19-8 for the gold medal. It was not until 1943 that the stereotypical basketball athlete began to emerge with Bob Kurland (7foot) and George Mikan (6 foot 10 inches) being among the first real big men to become a dominant force in the game. Similarly, the first black man, Charles Cooper, was drafted into the NBAA in 1950 and many more followed suit to such an extent that black athletes now dominate basketball in size, skill, and physical ability. As the game reached new heights, the skill level of players improved dramatically with Wilt Chamberlain's 1962 showcase -100 individual points in one game, leading his team to a 167-147 victory (Bellis, 2007). This was a far try from the first public basketball game in 1892, which had a score of 1-0.

The following years saw the spread of basketball throughout Europe with European countries starting to show their ability to play the game when the Soviet Union defeated the United States for the gold medal during the 1976 Olympics. Today basketball is played by over 450 million participants worldwide who enjoy the game at both competitive and grassroots levels (FIBA, 2007).

1.2 GAME OF BASKETBALL

The modern game varies in duration depending on the association governing over the competition. College teams competing in the National College Athletic Association (NCAA) play a 40 minute game divided into two, 20 minutes half while professional
teams competing in the NBA play a 48 minute game divided into four, 12 minute quarters. However, the International Basketball Federation (FIBA) endorses a game time of 40 minutes, divided into four, ten minute quarters, which is also adopted by Basketball New Zealand (BBNZ) and its associated competitions. At any stage during game play, an official can stop the game when a breach of the rules occurs. Similarly, the coach of either team can call ‘time-out’ from game play, which stops the game clock and is generally used to strategies upcoming offensive and / or defensive plays.

A team consists of ten players where only five will be allowed in game play while the other five are used as substitutions during the game. There are five playing positions: 1) the point guard (position 1) is responsible for calling the plays and directing the offence. It is the point guard’s job to bring the ball up the court and set up the play. Therefore, the point guard is usually the team’s best dribbler and passer (Lindsay, 2007); 2) the shooting guard (position 2) has similar duties as the point guard but usually does not bring the ball up the court. The shooting guard is usually one of the team’s best scorers as they are counted on to hit from the outside and take more field goal attempts than the point guard (Lindsay, 2007); 3) the power forward or ‘big’ forward (position 3) is usually bigger and stronger than other players and is known for their size, defense and rebounding (Lindsay, 2007); 4) the small forward (position 4) is not necessarily physically small. They are known primarily for their scoring and ball handling abilities. Often, the small forward is the most talented player on the team (Lindsay, 2007); 5) the centre (position 5) is important to both offence and defense ball play. The centre is usually the tallest player on the team and is the focal point of the team’s offence. Defensively, the centre is responsible for rebounding and blocking (Lindsay, 2007). The main substitute to come off the bench is known as the ‘sixth’ player and can play a variety of positions or one specific thing very well. This may include skills such as being a great long-range shooter, played solid defense, or being able to play a number of positions well (Lindsay, 2007).
The game of basketball has changed greatly in the past few years. No longer is basketball a game of slowly bringing the ball up court to set up a play. Basketball is now a game played at high speed and movement (FIBA, 2004). Players and teams are off and running at the sound of a whistle. And while the game is changing, so is the physical makeup of today’s basketball athlete. No longer is a basketball coach looking for the tall, slender built athlete. Coaches are now looking for players who can run like the wind, jump out of the gym and dominate both ends of the court. They are looking for athletes who are in top physical condition and who have the muscle and power to back up their game.

A point is scored in basketball when the basketball is thrown through the basket. If a basket is scored outside of the three-point arc, the bucket is worth three points. Whenever a field goal is made from within the three-point circle the bucket is worth two points. Foul shots, or free throw attempts, made from the free throw line are worth one point each (FIBA, 2004).

1.3 PHYSICAL FITNESS

Basketball is a sport with many complex demands that require a combination of fitness, skills, team tactics, and strategies. However key area that likely to play an important role in a basketball player’s success is fitness. Fitness is the capacity of heart, blood vessels, lungs and muscles to function at optimum efficiency (Mazzeo, 1985). Physical fitness is to the human body what fine tuning is to an engine. It is a physical state of well being that allows people to perform daily activities with vigor, reduce their risk of health problems related to lack of physical activity and establish a base of fitness for participation in a variety of physical activities. It enables us to perform up to our potential. Fitness can be described as a condition that helps look, feel and do best (Daniel et al.1993). More specially, it is: “the ability to endure, to bear up, to withstand stress, to carry on circumstances where an unfit person could not continue, and is a major basis for good health and well being”. People can only full fill their potential when their bodies are healthy and fit (Robert, 1993).
1.4 AEROBIC FITNESS

Basketball requires running for extended periods of time; therefore, players must be able to produce energy aerobically. "Aerobic fitness" refers to endurance, or the ability to sustain work for prolonged periods. The term "aerobic" implies the oxygen necessary to accomplish the work taken up by the individual during the activity. With longer exercise time, more aerobic metabolism is involved, and exercise lasting more than 12 minutes is mostly accomplished by aerobic metabolism (Fox 1981). In aerobic work, oxygen is obtained from the air and is transferred from the lungs to the blood and then to the muscles via the circulatory system. Maximal oxygen uptake or maximal aerobic power (VO2 max) is the indicator of aerobic fitness. As VO2 max increases, the level of aerobic fitness also increases (Fox 1981). Overall, the research indicates that team sport athletes perform numerous bouts of high-intensity efforts during a typical game. These high-intensity efforts appear to be related to playing position and the level of performance. Also, high-intensity activity has been shown to decrease in the latter stages of a game, which may be explained by several factors including fatigue and the tactical approach used. Maximal oxygen uptake and muscle buffer capacity in several studies are closely related to the ability to repeatedly perform high-intensity efforts through faster VO2 kinetics and an increased clearance of H+ from the muscle, which has an association with fatigue. These data collectively reinforce that a high aerobic capacity is beneficial for team sport athletes in helping them repetitively execute (and recover from) explosive high-intensity efforts (McInnes, Carlson, Jones, & McKenna, 1995).

1.4.1 Adaptations to Aerobic Endurance Training

There are several marked adaptations associated with the regular performance of endurance training. Aerobic endurance training produces increases in VO2 max [Rosiello(1987), Hickson, R.(1981) & Holloszy, J.O.,(1984)], but has no hypertrophy effect on muscle [Hickson, R(1988)]. Muscle fibre size has actually been shown to decrease [Terados, N. J. M. (1986) & Kraemer, W.J (1995)]. Capillary supply to the
muscles has been shown to change in response to endurance training through an increase in the capillary to muscle fibre ratio [Tesch, P.A. (1992) & Hoppeler, H., (1985)]. There is an increase in the number as well as the size of mitochondria, the latter of which is associated with an increase in certain enzymes [Holloszy, J.O., (1984)]. These increases are most apparent in the type 1 fibres as they have the highest content of mitochondria. Smaller increases in muscle and blood lactate levels are produced at the same relative exercise intensity after completing an endurance training programme [Holloszy, J.O., (1984) & Hickson, R. (1981)]. Glycogen is depleted less rapidly when trained than when untrained [Holloszy, J.O., (1984)]. The decreased use of carbohydrate during sub maximal exercise is compensated for by a proportional increase in fat oxidation [Holloszy, J.O., (1984) & Hoppeler, H., (1985)]. There is also a decrease in heart rate response during sub maximal exercise [Hickson, R. (1981)]. Several of these adaptations are in direct contrast to those associated with strength training.

1.5 STRENGTH TRAINING

Strength training is also known as resistance training (Clayne, 1979). It is a common component of sports and physical fitness programme for young people. Some adolescents and pre-adolescents may use strength training as a means to enhance muscle size and to simply improve appearance (Clayne, 1979). Strength training programme may include the use of free weight, weight machines, elastic tubing, or body weight. In addition to the obvious goal of getting stronger, resistance training programmes may be undertaken to improve long-term health.

1.5.1 Strength Training Adaptations

Effective strength training programme create muscle hypertrophy which is due to an increase in myofibrillar protein content [Tesch, P.A. (1992)]. This hypertrophy is often associated significantly with that of the fast twitch (FT) and slow twitch (ST) fibre types. Strength training produces certain neuromuscular adaptations [Sale,
D.G. (1992)]. These adaptive changes are associated with the coordination of the agonist, synergists, and antagonists [Sale, D.G. (1992)]. It has also been shown that mitochondrial volume density decreases as muscle mass increases [MacDougall, D. (1979)]. In contrast to aerobic endurance training there is a decrease in capillary density, within muscle, from strength training which emphasizes high-load, low-repetition exercises [Tesch, P.A. (1992)]. Strength training at moderately high loads with greater repetitions may cause an increase in absolute capillarization but increases in hypertrophy will result in a maintained or decreased capillary density [Tesch, P.A. (1992)]. There has been some evidence from studies on animals that suggests an increase in the number of vesicles which store acetylcholine in the neuron's terminal [Kraemer, W.J (1988)]. A greater force production by the associated motor unit would result, if the increases in the number vesicles also corresponds to an increase, in the secretion of acetylcholine [Kraemer, W.J (1988)].

1.6 CONCURRENT TRAINING FOR PERFORMANCE IMPROVEMENT

The phenomenon of concurrent training, or simultaneously training for strength and endurance, was first described in the scientific literature in 1980 by Robert C. Hickson (Nader, 2006).

Concurrent strength and endurance training is more effective in improving athletic performance than are either endurance or strength training separately. This is contrary to previous studies, which found combined training inhibits muscle and power improvements (Colorado Springs, 2003).

Strength, endurance, and power are the key factors in athletic performance (Colorado Springs, 2003). Knowing how to maximize each component to create the most effective programme, is often difficult to achieve. On one hand, endurance training increases capillary density (the muscle's ability to receive oxygen) and decreases the ratio of fast-twitch fibers (strength muscles) to slow-twitch fibers (endurance muscles).
On the other hand, strength training causes fiber hypertrophy (the muscle to get bigger), decreases capillary density, and increases the ratio of fast-twitch fibers to slow-twitch fibers (Colorado Springs.2003). The training by strength and endurance concurrently showed improvements in vertical jump, anaerobic power, and aerobic capacity (Colorado Springs.2003).

Strength/power athletes may perform endurance exercise in order to maintain an optimal body weight or to reduce body fat levels. Aerobic endurance exercises are an effective and efficient method of reducing body fat (Mc.cardle.2001). Another possible benefit of aerobic training for strength/power athletes is the increased tolerance for exercise in the heat and during hyperthermia in aerobically trained individuals. In extreme heat, 15 to 20% of the cardiac output may be distributed to the skin for heat dissipation (Mc.cardle.2001). This limits the blood flow to the working muscles. Aerobically-trained individuals have an increased sensitivity and capacity of the sweating response so that they are better able to regulate their body temperatures (Mc.cardle.2001).

1.7 PHYSIOLOGICAL REQUIREMENTS FOR BASKETBALL PLAYERS

Year-round conditioning specifically designed for basketball has reached a high level of sophistication over the past several decades. There is growing evidence that it can contribute to improved performance and reduced injury. The major components of conditioning for basketball have been identified as anaerobic power (stages I and II), aerobic power, muscular strength/endurance, and flexibility (Kazimierz Mikolajec 2003).

Physiologically basketball requires energy from both the aerobic and anaerobic energy systems. This combination of energy requirements is often referred to as an integration of energy supply systems on a continuum over time. The anaerobic supply involves the delivery of energy for physical activity at a high rate, without oxygen but it only has a limited time of supply. This anaerobic system can be classified into the ATP-
CP (adenosine triphosphate-creatine phosphate) and the lactate systems (McArdle et al. 1991).

The ATP-CP system provides immediate energy for quick bursts of activity such as driving to the basket, jumping, shooting, dribbling and rebounding. McInnes et al. (1995) also note high intensity run efforts occurring on average once every 21 seconds during "live time" for a 1.7 second duration which is similar to the 1-4 sec reported by MacLean (1984). This short burst of energy (2-4secs) is provided by the breaking of high level energy phosphate bonds as ATP is changed to ADP. When used maximally however this system is limited to approximately 10-15 seconds (McArdle et al. 1991, Stone and Steinguard 1993 and Sheller and Rask 1993). Basketball does often require high intensity periods of work longer than this and then uses the lactate or aerobic system.

A series of fast breaks or fast paced passages of play will result in the athlete calling on the anaerobic lactate metabolism (Stone and Steinguard 1993). This involves anaerobic glycolysis to release ATP and produce lactic acid. It also allows energy supply with the use of sufficient oxygen for at or near maximal exercise intensities over 30-60 seconds.

These anaerobic energy sources are rapidly replenished in the recovery periods. Recovery from maximal effort using the ATP-CP and lactic system take approximately 3 minutes and up to one hour respectively. The more prolonged recovery with the lactic system is due to the elevated levels of blood lactate (McArdle et al. 1991, Stone and Steinguard 1993), the more intense is the work periods and the shorter the recovery periods the greater the aerobic contribution to maintain performance (McArdle et al. 1991).

The Aerobic system replenishes ATP by aerobic metabolism of carbohydrate and fat. This oxidative system is called into use to meet endurance requirements of the game and aid in the recovery from the anaerobic efforts. The aerobic capacity is normally
active in exercise of more than a few minutes duration and is seen as a very important aspect of basketball (McInnes et al. 1995, Smith and Thomas 1991).

Basketball does involve an integration of these energy systems described and so the physiological tests used must aim to specifically focus on each of these systems. The test should also include task specificity as well as relate to the requirements of basketball.

**Summary of skills and components of the game requiring different energy requirements:**

- **(ATP-CP)** Moves involving speed, acceleration, explosiveness, changing direction e.g. rebounding, lay ups, jump shooting, shot blocking, blocking out, holding position.
- **(Lactic Anaerobic)** Maximum anaerobic efforts of 30-60 seconds e.g. fats breaks, defensive presses, running offensive plays, continuous dribbling, repeated bouts of running with short periods of rest.
- **(Aerobic)** Continuous play- Game lasting 48 minutes involves high aerobic component.

1.7.1 Anaerobic Capacity

From the aspect of energy demands and energy sources engaged, it can be stated that basketball undoubtedly appertains to the group of anaerobic sports, if being on play for the entire game time, on average accomplish 6000-7000 meters of running, perform up to 40 various jumps, 280 movement direction changes, 120 ball catches, 80 passes, 16 shooting for a goal, and 36 dribbling (S. Trini Coll. Antropol. 25. 2001).

Modes of motion, such as running backwards and sideward's, accelerating, decelerating, and changing direction accentuate the metabolic loading during competition (Reilly, 1997) causing anaerobic metabolism to become increasingly taxed during a game. In the past rugby union has been described as primarily anaerobic in nature (McLean, 1992). To a certain extent this I supported by the findings of Deutsch et al. (2007), especially for backs, where work- to- rest ratios (mean work ~ 5 s, mean rest ~ 80 to 110 s) indicate that the PCr system plays an important role (Balsom, Sejer, Sjodin, & Ekblom, 1992b). Although the mean work period for forwards is also ~ 5 s, the mean rest duration
of approximately 30 to 40 s would in most cases only result in partial replenishment of the PCr stores (Gaitanos, Williams, Boobis, & Brooks, 1993) and place more emphasis on the anaerobic glycolytic pathway (Deutsch, Kearney, & Rehrer, 2007). However, it is now well known that most of the time during match play is spent in low intensity activities and it is the high intensity activities, such as sprinting and physical collisions, that place considerable demands on the anaerobic energy system (Deutsch, Maw, Jenkins, & Reabum, 1998).

1.7.2 Aerobic capacity

Aerobic fitness means you can jog or run for a long time at moderate pace without getting too tired. Anaerobic fitness means you can keep going longer at high intensities before your legs and body slow down (S. Trini Coll. Antropol. 2001). Both are important in basketball, especially if you are likely to play the whole game. When you optimize all elements of basketball fitness - running fitness, strength, and power, you can claim to be at peak fitness (S. Trini Coll. Antropol. 2001).

Early literature has classified basketball as deriving 85% of its energy expenditure from the phosphagen stores (ATP & PCr) and 15% of its energy from anaerobic glycolysis (Fox, 1984). However, a closer analysis of basketball competition (Abdelkrim, El Fazaa, & El Ati, 2007; McInnes, Carlson, Jones, & McKenna, 1995; Taylor, 2003) reveals that anaerobic energy supply is indeed only a minor contributor to the overall energy requirements of basketball. Additionally, in elite rugby union players it appears that they require aerobic conditioning to facilitate the recovery between high-intensity bouts, where energy is derived from predominantly anaerobic sources (Duthie, Pyne, & Hooper, 2005). As suggested by Tomlin & Wenger (2001), a higher oxygen uptake during sprinting results in less reliance on anaerobic glycolysis and thus superior power maintenance. The normal duration of team sport games (40 - 90 min) provides further reinforcement that aerobic metabolism is predominant. Based on the research, a vast
The majority of the energy required during a team sport game is provided through aerobic metabolism.

1.7.3 Speed

Basketball game requires a lot of "Speed, Endurance and Strength" training in any comprehensive programme (S. Trini Coll. Antropol. 2001). The part of the programme outlined here is confined mostly to the weights and strength development. One will need to do cardio training to develop aerobic fitness early pre-season and then build up anaerobic fitness with wind sprints, shuttles, sprints, and intervals to be fully prepared for the season start (S. Trini Coll. Antropol 2001).

1.7.4 Flexibility

Flexibility is the ability to move muscles through their full range of motion about a joint. Flexibility should be considered an important component of basketball conditioning, not just for its role in performance enhancement.

The flexibility programme should be performed before (as part of the warm up) and after (as part of the cool down) each workout (Pushparajan A. 2000). Before performing flexibility exercises, it is recommended that the players perform 5-10 minutes of continuous aerobic exercise to increase blood flow to the active musculature, increase body and muscle temperature, and increase speed of neural conduction. The warm-up period before performing the flexibility exercise will prevent injuries (potential for muscle pulls or spasms) and enhance the adaptability of the muscles. Tendons and ligaments to the stretching exercise (Pushparajan A. 2000).

1.7.5 Body Mass and Body Composition

The game of basketball is a complex motor multi-structured team activity, based on the symbiosis of cyclic and acyclic movements of individual players with and without the ball where the performance quality of which is directly related status (fitness) of athletes and their body composition (Trininic 1995).
1.7.6 Muscular Strength and Endurance

The internal load players have to sustain in practice and games is determined by the role in the game, by the style of team play, and the intensity requirements of play. Basketball is primarily a sport of agility, the latter being a complex combination of several motor abilities. (Slavko Trninic.05/2003). For optimal performance during play at an elite level a variety of areas must be addressed. These include the high skill level, flexibility, muscular strength, endurance and importantly the specific use of both the aerobic and anaerobic energy systems (Derek chan.1999).

1.8 NEED FOR THE STUDY

For a basketball athlete to be successful on the court, proper specific fitness has to be given during the trainings as required for the basketball specific. When those requirements are fulfilled, the athlete will reach his maximum performance with his potential skill level. Hence it is necessary to implement a new strategic concurrent aerobic and strength training in varied scheduling for the basketball male players of inter collegiate level.

1.9 STATEMENT OF THE PROBLEM

The main purpose of this exploratory study was to find out the effects of varied combinations of concurrent aerobic and strength training programme on selected skill performance and fitness related parameters of male basketball players.

1.10 OBJECTIVES OF THE STUDY

1. To find out the effects of concurrent aerobic and strength training programme performed during the same session on selected skill performance and fitness related parameters of male basketball players.
2. To find out the effects of concurrent aerobic and strength training programme performed on the same day on selected skill performance and fitness related parameters of male basketball players.

3. To find out the effects of concurrent aerobic and strength training programme performed on the alternate days on selected skill performance and fitness related parameters of male basketball players.

4. To compare the effects of concurrent aerobic and strength training programme performed during the same session with that of same day training programme on selected skill performance and fitness related parameters of male basketball players.

5. To compare the effects of concurrent aerobic and strength training programme performed during the same session with that of alternate days training programme on selected skill performance and fitness related parameters of male basketball players.

6. To compare the effects of concurrent aerobic and strength training programme performed in the same day training programme with that of alternate days training programme on selected skill performance and fitness related parameters of male basketball players.

7. To compare the effects of concurrent aerobic and strength training programme performed on the alternate day training programme, on the same day training programme and during the same session training programme with that of control group.

1.11 HYPOTHESIS

1. The concurrent aerobic and strength training programme performed during the same session may not improve the selected skill performance and fitness related parameters of male basketball players.
2. The concurrent aerobic and strength training programme performed on the same day may not improve the selected skill performance and fitness related parameters of male basketball players.

3. The concurrent aerobic and strength training programme performed on the alternate days may not improve the selected skill performance and fitness related parameters of male basketball players.

4. The concurrent aerobic and strength training programme performed during the same session may not be better than the same day training programme in developing the selected skill performance and fitness related parameters of male basketball players.

5. The concurrent aerobic and strength training programme performed during the same session may not be better than the alternate days training programme in developing the selected skill performance and fitness related parameters of male basketball players.

6. The concurrent aerobic and strength training programme in the same day may not be better than the alternate days training programme in developing the selected skill performance and fitness related parameters of male basketball players.

7. The concurrent aerobic and strength training programme on the alternate day, on the same day and during the same session may not be better than the control group in developing the selected skill performance and fitness related parameters of male basketball players.

1.12 **DELIMITATIONS**

The study was delimited to the following aspects:

1. The study was delimited to eighty male basketball players of inter collegiate level only.
2. The subjects were assigned at random to one of the four groups, in which the first group (n=20, CASAD group) performed the combined aerobic and strength programme on alternate days, the second one (n=20; CASSD group) performed the combined aerobic and strength training programme on the same day, the third one (n=20; CASSTS group) performed a combined aerobic and strength training programme during the same training session and the fourth one was the control (n=20; CONTROL group).

3. The age of the selected male basketball players ranged from 18-25 yrs.

4. The selected criterion variables were delimited to skill related and fitness related parameters.

5. The training period was delimited to 12 weeks.

6. The data was collected prior and after 12 weeks of training programme.

1.13 LIMITATIONS

The study was limited to the following aspects:

1. Certain factors like lifestyle, daily routine work, diet and other factors which may have an effect on the results of the study were not taken into consideration.

2. The differences in socio-economic status and educational background of the male basketball players were not taken into consideration.

3. The heredity of the subjects and its influence on the selected criterion variables were not taken into consideration.

1.14 SIGNIFICANCE OF THE STUDY

The significance of the study were as follows; a) this study would be useful for the basketball players to combine aerobic and strength training to improve the basketball skill performance as well as fitness related parameters, b) the study would bring up the
possibilities of new similar researches in future, c) the study would add to the quantum of knowledge in the area of sports training, and d) the study would help in choosing what type of concurrent training can be taken to the coaching aspects.

1.15 OPERATIONAL DEFINITIONS OF TERMS

1.15.1 Varied combinations
Varied combinations means scheduling of aerobic and strength training on alternate days, on the same day, and during the same session.

1.15.2 Speed
Speed is the ability of a person to execute motor movements with high speed in the shortest period of time. It is equal to the distance covered per unit of time.

1.15.3 Flexibility
Flexibility is the ability of a muscle to perform movements with large range of motion.

1.15.4 Muscular Strength
Strength is the ability of a muscle to expert or release force by contraction enabling a person to overcome resistance or to act against resistance.

1.15.5 Muscular Strength and Endurance
The ability of a muscle to exert sub maximal force repeatedly over a period of time. (E.g. curl-ups)

1.15.6 Leg Explosive Power
Power is the ability of muscle to release maximum force in the shortest period of time. It is equal to force multiplied by speed. It is the combination of strength and speed.
1.15.7 **Aerobic capacity**

Aerobic capacity is the highest amount of oxygen consumed during maximal exercise in activities that use the large muscle groups in the legs or arms and legs combined.

1.15.8 **Percent body fat**

Percent body fat is the amount of fat tissue in human body as a percentage of total body weight.

1.15.9 **Lean body mass**

The lean body mass is defined as total body weight subtracted by weight of fat. i.e., LBM = Body weight – fat weight.

1.15.10 **Arm Circumference**

Arm circumference denotes the measurement taken midway between acromion and olecranon processes.

1.15.11 **Thigh Circumference**

Thigh circumference denotes the measurement taken at maximum level of the midpoint on the lateral surface of the thigh, midway between trochanterion and tibiae laterale.

1.15.12 **Calf circumference**

Calf circumference denotes the measurement taken at maximum circumference of the calf.