CHAPTER – II

REVIEW OF RELATED LITERATURE

The literature in any field forms the foundation upon which all future work will be built. A study of relevant literature is an essential step to get a full picture of what has been done with regard to the problem under study. The review of the literature promotes a greater understanding of the problem and its crucial aspects and ensures the avoidance of unnecessary duplication. It also provides a competitive data based on the evaluation and interpretation of the significance of one’s findings. Study of the related literature implies locating; reading and evaluating reports of research as well as reports of casual observation and opinion that are related to the individuals planned research report.

So a number of books, journals and websites were referred. In the following pages, an attempt has been made to present briefly a few of the important researches and studies conducted abroad and in, India, as they have significant bearing on the present study. The reviews of the literature have been classified under the following headings:

1. Studies on physical fitness variables
2. Studies on physiological variable
3. Studies on skill and performance variables
2.1: Studies on physical fitness variables

Shellock FG and Prentice WE. (1985) constructed a study on “Warming-up and stretching for improved physical performance and prevention of sports-related injuries.” They state that the competitive and recreational athletes typically perform warm-up and stretching activities to prepare for more strenuous exercise. These preliminary activities are used to enhance physical performance and to prevent sports-related injuries. Warm-up techniques are primarily used to increase body temperature and are classified in 3 major categories: (a) passive warm-up - increases temperature by some external means; (b) general warm-up - increases temperature by nonspecific body movements; and (c) specific warm-up - increases temperature using similar body parts that will be used in the subsequent, more strenuous activity. According to their study the best of these appears to be specific warm-up because this method provides a rehearsal of the activity or event. They further state that the intensity and duration of warm-up must be individualized according to the athlete's physical capabilities and in consideration of environmental factors which may alter the temperature response. The majority of the benefits of warm-up are related to temperature-dependent physiological processes. An elevation in body temperature produces an increase in the dissociation of oxygen from haemoglobin and myoglobin, a lowering of the activation energy rates of metabolic chemical reactions, an increase in muscle blood flow, a reduction in muscle viscosity, an increase in the sensitivity of nerve receptors, and an
increase in the speed of nervous impulses. Warm-up also appears to reduce the incidence and likelihood of sports-related musculoskeletal injuries. Their study further states that improving flexibility through stretching is another important preparatory activity that has been advocated to improve physical performance. Maintaining good flexibility also aids in the prevention of injuries to the musculoskeletal system. Flexibility is defined as the range of motion possible around a specific joint or a series of articulations and is usually classified as either static or dynamic. Static flexibility refers to the degree to which a joint can be passively moved to the end-points in the range of motion. Dynamic flexibility refers to the degree which a joint can be moved as a result of a muscle contraction and may therefore not be a good indicator of stiffness or looseness of a joint. Finally they conclude by presenting the 3 basic categories of stretching techniques: (a) ballistic—which makes use of repetitive bouncing movements; (b) static—which stretches the muscle to the point of slight muscle discomfort and is held for an extended period; and (c) proprioceptive neuromuscular facilitation - which uses alternating contractions and stretching of the muscles. Each of these stretching methods is based on the neurophysiological phenomenon involving the stretch reflex.

Stone WJ, Steingard PM. (1993) had studied the year-round conditioning specifically designed for basketball. They state that the year-round conditioning 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. They have identified anaerobic power (stages I and II), aerobic power, muscular strength/power/endurance, and flexibility as the major components of conditioning for basketball. The conclude that the concept of year-round conditioning uses the principles of periodization in work and rest to achieve peak performance and avoid injury. They have also stated that there are unique problems associated with the various levels of competition that require diligent monitoring on the part of the coach to maximize physical condition and avoid overtraining.

**Nummela and Mero (1996)** investigated the effects of sprint training on the anaerobic performance characteristics in well-trained sprint runners employing the maximal anaerobic running test (MART). Another purpose was to study the applicability of mart in the prescription of sprint training. Nine male sprint runners performed the mart before and after a 10 week intensive training period. The present results suggested that sprint training induces an adaptive increase in the maximal anaerobic running power in well-trained male sprint runners.

**Delecluse C. (1997)** studied the influence of strength training on sprint running performance. Today, it is generally accepted that sprint performance, like endurance performance, can improve considerably with training. Strength training, especially, plays a key role in this process. Sprint performance will be viewed multi dimensionally as an initial acceleration phase (0 to 10 m), a phase
of maximum running speed (36 to 100 m) and a transition phase in between. Immediately following the start action, the powerful extensions of the hip, knee and ankle joints are the main accelerators of body mass. However, the hamstrings, the adductor magnus and the gluteus maximus are considered to make the most important contribution in producing the highest levels of speed. Different training methods are proposed to improve the power output of these muscles. Some of them aim for hypertrophy and others for specific adaptations of the nervous system. This includes general (hypertrophy and neuronal activation), velocity specific (speed-strength) and movement specific (sprint associated exercises) strength training. In developing training strategies, the coach has to keep in mind that strength, power and speed are inherently related to one another, because they are all the output of the same functional systems. As heavy resistance training results in a fibre type IIb into fibre type II a conversion, the coach has to aim for an optimal balance between sprint specific and nonspecific training components. To achieve this they must take into consideration the specific strength training demands of each individual, based on performance capacity in each specific phase of the sprint.

Gleim and McHugh (1997) in their study on “Flexibility and its effects on sports injury and performance” state that flexibility measures can be static [end of ROM (range of motion)], dynamic-passive (stiffness/compliance) or dynamic-active (muscle contracted, stiffness/compliance). Dynamic measures
of flexibility are less dependent on patient discomfort and are more objective. Acute and chronic changes in flexibility are likely to occur with stretching exercises, but it is difficult to distinguish between changes in stretch tolerance as opposed to changes in muscle stiffness. They say that the way of measuring the flexibility impacts these findings. They state that there is no scientifically based prescription for flexibility training and no conclusive statements can be made about the relationship of flexibility to athletic injury. The literature reports opposing findings from different samples, frequently does not distinguish between strain, sprain and overuse injury, and rarely uses the proper denominator of exposure. Importantly they say that there is basic scientific evidence to suggest that active warm-up may be protective against muscle strain injury but clinical research is equivocal on this point. Typically, specific flexibility patterns are associated with specific sports and even positions within sports. They have concluded by stating that the relationship of flexibility to athletic performance is likely to be sport-dependent. Decreased flexibility has been associated with increased in-line running and walking economy. Increased stiffness may be associated with increased isometric and concentric force generation, and muscle energy storage may be best manifested by closely matching muscle stiffness to the frequency of movement in stretch-shorten type contractions.

Mazzeti et.al. (2000) examined the hypothesis that "explosive" strength power resistance training (3-8 RM) would result in greater improvements in
peak and mean upper body power than hypertrophy resistance training (8-12 RM) in untrained women. Subjects was assigned to an explosive strength group (N = 17), a heavy-resistance group (N = 18), a calisthenics/manual resistance group (N = 14), or an aerobic training group (N = 11). It was found that explosive resistance training produced superior upper body strength and power gains than did heavy resistance, calisthenics, or aerobic training experiences.

Durham et.al., (2001) compared the effects of plyometric and weighted-plyometric training on lower body anaerobic power (modified 30-sec Bosco jump test). Strength-trained females (N = 14) performed four weeks of training after being divided into two groups. Depth jumps, split squats, and double-leg hops were performed. The weighted group increased added resistance from 20% to 40% 1 repetition maximum over the four weeks.

Matavulj et.al. (2001) determined the effect of plyometric training on jumping performance in junior basketball players. Three different training regimens were performed in order to study effects of plyometric training on elite junior basketball players. While the control group (CG) participated only in the regular mid season training activity, another two groups performed a limited amount of plyometric training employing drop jumps from the height of either 50 cm (EG-50) or 100 cm (EG-100). The height of the maximal vertical jump (CMJ), as well as the maximal voluntary force (F) and the rate of force
development (RFD) of hip and knee extensors were tested prior to and after the training. It was concluded that, a limited amount of plyometric training could improve jumping performance in elite junior basketball players, and this improvement could be partly related with an increase in force of hip extensors and RFD of knee extensors.

Trninić et. al. (2001) in their study analyzed the effects of a two-month developmental training cycle realised within a basketball season revealed statistically significant positive changes at the multivariate level in components of motor-functional conditioning (fitness) status of the sample of talented basketball cadets (15-16 years). The greatest correlations with discriminated function were found in variables with statistically significant changes at the non variant level, more explicitly in variables of explosive and repetitive power of the upper body and trunk, anaerobic lactic endurance, as well as in jumping type explosive leg power. The presented developmental conditioning training programme, although implemented within the competitive period, induced multiple positive fitness effects between the two control time points in this sample of basketball players. The authors suggest that, to assess power of shoulders and upper back, the test over grip pull-up should not be applied to basketball players of this age due to its poor sensitivity. Instead, they propose the under grip pull-up test, which is a facilitated version of the same test. The results presented in this article reinforce experienced opinion of experts that, in
the training process with youth teams, the developmental conditioning training programme is effectively applicable throughout the entire competitive season.

Wolfe et.al. (2004) investigated the existing research on single-set vs. multiple-set resistance training programs. Using the meta-analytic approach, we included studies that met the following criteria in our analysis: (a) at least 6 subjects per group; (b) subject groups consisting of single-set vs. multiple-set resistance training programs; (c) pretest and posttest strength measures; (d) training programs of 6 weeks or more; (e) apparently "healthy" individuals free from orthopedic limitations; and (f) published studies in english-language journals only. Sixteen studies generated 103 effect sizes (ESs) based on a total of 621 subjects, ranging in age from 15-71 years. The data indicated that trained individuals performing multiple sets generated significantly greater increases in strength (p < 0.001). For programs with an extended duration, multiple sets were superior to single sets (p < 0.05). This quantitative review indicates that single-set programs for an initial short training period in untrained individuals result in similar strength gains as multiple-set programs. However, as progression occurs and higher gains are desired, multiple-set programs are more effective.

Woolstenhulme (2004) measured vertical jump, anaerobic power, and shooting accuracy in 18 division I women basketball players (age 18-22 years) 6 hours following a morning strength training routine called a lift day (LD) and
on a control day in which no strength training was performed. Subjects had been strength trained for 4 weeks prior to testing. The strength training session on lift day was a full-body workout and included 7 exercises performed in 3-6 sets at loads ranging from a 5 to 12 repetition maximum (RM). These data suggested that in collegiate women basketball players, a previous bout of strength training has no negative effect on vertical jump height, anaerobic power, or shooting accuracy.

**Woolstenhulme et.al. (2006)** made a study to find whether the Ballistic stretching increases flexibility and acute vertical jump height when combined with basketball activity. In which they say that the stretching is often included as part of a warm-up procedure for basketball activity. However, the efficacy of stretching with respect to sport performance has come into question. They have determined the effects of 4 different warm-up protocols followed by 20 minutes of basketball activity on flexibility and vertical jump height. Subjects participated in 6 weeks (2 times per week) of warm-up and basketball activity. The warm-up groups participated in ballistic stretching, static stretching, sprinting, or basketball shooting (control group). They have asked 3 questions. First, what effect does 6 weeks of warm-up exercise and basketball play have on both flexibility and vertical jump height? They measured sit and reach and vertical jump height before (week -1) and after (week 7) the 6 weeks. Flexibility increased for the ballistic, static, and sprint groups compared to the
control group (p < 0.0001), while vertical jump height did not change for any of the groups. Their second question was what is the acute effect of each warm-up on vertical jump height? They have measured vertical jump immediately after the warm-up on 4 separate occasions during the 6 weeks (at weeks 0, 2, 4, and 6). Vertical jump height was not different for any group. Finally, their third question was what is the acute effect of each warm-up on vertical jump height following 20 minutes of basketball play? They measured vertical jump height immediately following 20 minutes of basketball play at weeks 0, 2, 4, and 6. Thus it was concluded that only the ballistic stretching group demonstrated an acute increase in vertical jump 20 minutes after basketball play (p < 0.05). Coaches should consider using ballistic stretching as a warm-up for basketball play, as it is beneficial to vertical jump performance.

Young (2006) investigated on the transfer of strength and power training to sports performance. The purposes of this review are to identify the factors that contribute to the transference of strength and power training to sports performance and to provide resistance-training guidelines. Using sprinting performance as an example, exercises involving bilateral contractions of the leg muscles resulting in vertical movement, such as squats and jump squats, have minimal transfer to performance. However, plyometric training, including unilateral exercises and horizontal movement of the whole body, elicits significant increases in sprint acceleration performance, thus
highlighting the importance of movement pattern and contraction velocity specificity.

**Bloomfield et al. (2007)** in their study titled “Effective speed and agility conditioning methodology for random intermittent dynamic type sports” compared the effectiveness of 2 methodologies for speed and agility conditioning for random, intermittent, and dynamic activity sports (e.g., soccer, tennis, hockey, basketball, rugby, and netball) A total of 46 (25 males and 21 females) untrained participants received (mean +/- SD) 12.2 +/- 2.1 hours of physical conditioning over 6 weeks between a battery of speed and agility parameter field tests. Two-way analysis of variance results indicated that both conditioning groups showed a significant decrease in body mass and body mass index, although PC achieved significantly greater improvements on acceleration, deceleration, leg power, dynamic balance, and the overall summation of % increases when compared to RC and NC (p < 0.05). PC in the form of SAQ exercises appears to be a superior method for improving speed and agility parameters; however, this study found that specialized SAQ equipment was not a requirement to observe significant improvements. Further research is required to establish whether these benefits transfer to sport-specific tasks as well as to the underlying mechanisms resulting in improved performance.
Castagna et.al. (2008) examined the effect of recovery mode on a repeated sprint ability in young basketball players. Sixteen basketball players (age, 16.8 +/- 1.2 years; height, 181.3 +/- 5.7 cm; body mass, 73 +/- 10 kgs; VO2 max, 59.5 +/- 7.9 ml x kg (-1) x min (-1)) performed in random order over two separate occasions 2 repeated sprint ability protocols consisting of 10 x 30-m shuttle run sprints with 30 seconds of passive or active (running at 50% of maximal aerobic speed) recovery. The results of this study show that during repeated sprinting, passive recovery enabled better performance, reducing fatigue. Consequently, the use of passive recovery is advisable during competition in order to limit fatigue as a consequence of repeated high intensity exercise.

Gabbett et.al., (2008) investigated the specificity of skill-based conditioning games and compared the effectiveness of skill-based conditioning games and instructional training for improving physical fitness and skill in junior elite volleyball players. Twenty-five junior volleyball players (mean age +/- SE, 15.6 +/- 0.1 years) participated in this study. Heart rate data were collected on all players during the australian junior volleyball championships. After the competition, players were randomly allocated into a skill-based conditioning games group (n = 12) or an instructional training group (n = 13). Each player participated in a 12-week training program that included 3 organized court training sessions per week. Skill-based conditioning games induced improvements in vertical jump, spike jump, speed, agility, upper-body
muscular power, and estimated maximal aerobic power, whereas technical instruction improve to only spike jump and speed. The results of this study show that skill-based conditioning games offer a specific training stimulus to simulate the physiological demands of competition in junior elite volleyball players. Although the improvements in physical fitness after training were greater with skill-based conditioning games, instructional training resulted in greater improvements in technical skill in these athletes.

Santos and Janeira (2008) in their study evaluated the effects of a complex training program, a combined practice of weight training and plyometrics, on explosive strength development of young basketball players. Twenty-five young male athletes, aged 14-15 years old, were assessed using squat jump (SJ), counter movement jump (CMJ), Abalakov test (ABA), depth jump (DJ), mechanical power (MP), and medicine ball throw (MBT), before and after a 10-week in-season training program. Both the control group (CG; n = 10) and the experimental group (EG; n = 15) kept up their regular sports practice; additionally, the EG performed two sessions per week of a complex training program. The EG significantly improved in the SJ, CMJ, ABA, and MBT values (p < 0.05). The CG significantly decreased the values (p < 0.05) of CMJ, ABA, and MP, while significantly increasing the MBT values (p < 0.05). Their results support the use of complex training to improve the upper and lower body explosive levels in young basketball players. In conclusion, this study showed that more strength conditioning is needed during the sport
practice season. Furthermore, they have also concluded that complex training is a useful working tool for coaches, innovative in this strength-training domain, equally contributing to a better time-efficient training.

De Salles et al. (2009) made a research on the rest interval between sets in strength training. Strength training has become one of the most popular physical activities for increasing characteristics such as absolute muscular strength, endurance, hypertrophy and muscular power. For efficient, safe and effective training, it is of utmost importance to understand the interaction among training variables, which might include the intensity, number of sets, rest on interval between sets, exercise modality and velocity of muscle action. The researchers have indicated that the rest interval between sets is an important variable that affects both acute responses and chronic adaptations to resistance exercise programmes. The science citation index (SCIELO), national library of medicine, MEDLINE, scopus, sport discus and CINAHL databases were used to locate previous original scientific investigations. The researchers examined both acute responses and chronic adaptations, with rest interval length as the experimental variable. In terms of acute responses, a key finding was that when training with loads between 50% and 90% of one repetition, maximum 3-5 minutes' rest between sets allowed for greater repetitions over multiple sets. Furthermore, in terms of chronic adaptations, resting 3-5 minutes between sets produced greater increases in absolute strength, due to higher intensities and volumes of training. Similarly, higher levels of muscular power
were demonstrated over multiple sets with 3 or 5 minutes versus 1 minute of rest between sets. 1-minute rest intervals might be sufficient between repeated attempts; however, from a psychological and physiological standpoint, the inclusion of 3- to 5-minute rest intervals might be safer and more reliable. When the training goal is muscular hypertrophy, the combination of moderate-intensity sets with short rest intervals of 30-60 seconds might be most effective due to greater acute levels of growth hormone during such workouts. Finally, the research on rest interval length in relation to chronic muscular endurance adaptations is less clear. Training with short rest intervals (e.g. 20 seconds to 1 minute) resulted in higher repetition velocities during repeated sub maximal muscle actions and also greater total torque during a high-intensity cycle test. Both findings indirectly demonstrated the benefits of utilizing short rest intervals for gains in muscular endurance. In summary, the rest interval between sets is an important variable that should receive more attention in resistance exercise prescription. When prescribed appropriately with other important prescriptive variables (i.e. volume and intensity), the amount of rest between sets can influence the efficiency, safety and ultimate effectiveness of a strength training programme.

Meckel et al. (2009) in their study compared the performance indices of repeated sprint tests (RSTs) (12 x 20 m) during different stages of basketball game. Twelve young (17 +/- 0.5 year) basketball players performed three RSTs (after a warm-up, at half-time and after a full game) and aerobic power test,
each on different days. Ideal (fastest) sprint time (IS) was significantly faster at half-time ($p < 0.007$) compared to after warm-up. There was no difference between IS after the warm-up and after a full game. Total (accumulative) sprint time (TS) was significantly faster at half-time ($p < 0.03$) compared to after the warm-up. There was no difference between TS after the warm-up and after a full game. No differences were found in the performance decrement (PD) between the three RSTs. The findings suggest that a more intense warm-up is needed for better repeated sprint performance at the initial phases of the game and that the aerobic system is important to intensity maintenance, mainly during the last stages of the game.

Walklate et al. (2009) investigated whether supplementing regular group training with short sessions of badminton-specific agility-sprint training conferred any greater changes in performance than regular training alone. Twelve national level badminton players completed a set of performance tests in the week before and after a 4-week training period. Performance tests consisted of 10- and 20-meter sprints, a multistage fitness test, a 300-meter shuttle run, and a novel badminton sprint protocol. After pre testing, pair-matched participants were randomly assigned into regular or supplementary training groups. Both groups undertook regular national squad training consisting of 4 2-hour sessions per week. In addition, the supplementary group completed a high-intensity sprint-training regime consisting of 7 to 15 repeats of badminton-specific sprints twice per week. The result of this study showed
that the supplementing regular training with sessions of short-duration sprint training appears to lead to worthwhile increases in repeated-agility sprint performance with national level badminton players.

Ziv and Lidor (2009) examined the physical attributes, physiological characteristics, on-court performances and nutritional strategies of female and male elite basketball players. This study included relevant information on physical and physiological variables, such as height, weight, somatotype, relative size, aerobic profile, strength, anaerobic power, agility and speed. Six main findings emerged from our review: (i) differences in physical attributes exist among playing positions and skill levels (e.g. guards tend to be lighter, shorter and more mesomorphic than centres); (ii) maximum aerobic capacity (VO₂ max) values of female and male players are 44.0-54.0 and 50-60 ml/kg/min, respectively; (iii) male and female players of higher skill levels tend to have higher vertical jump values; (iv) the more skilled female and male players are faster and more agile than the less skilled players; (v) guards tend to perform more high-intensity movements during game play compared with forwards and centres; and (vi) a water deficit of 2% of bodyweight can lead to reduced physical and mental performance during an actual game. Five limitations associated with the testing protocols used in the studies are outlined, among them the lack of a longitudinal approach, lack of tests performed under physical exertion conditions, and lack of studies using a time-motion analysis.
In addition, three practical recommendations for the basketball coach and the strength and conditioning coach are presented. It was concluded that the data emerging from these studies, combined with the knowledge already obtained from the studies on physical and physiological characteristics of elite basketball players, should be applied by basketball and strength and conditioning coaches when planning training programmes for elite basketball players.

**Taşkin (2009)** determined the effect of circuit training directed toward motion and action velocity over the sprint-agility and anaerobic endurance. A total of 32 healthy male physical education students with a mean age of 23.92 +/- 1.51 years were randomly allocated into a circuit training group (CTG; n = 16) and control group (CG; n = 16). A circuit training consisting of 8 stations was applied to the subjects 3 days a week for 10 weeks. Circuit training program was executed with 75% of maximal motion numbers in each station. The FIFA Medical Assessment and Research Centre (F-MARC) test battery, which was designed by FIFA, was used for measuring sprint-agility and anaerobic endurance. Pre- and post training testing of participants included assessments of sprint-agility and anaerobic endurance. Following training, there was a significant (p < 0.05) difference in sprint-agility between pre- and post testing for the CTG (pretest = 14.76 +/- 0.48 seconds, posttest = 14.47 +/- 0.43 seconds). Also, there was a significant (p < 0.05) difference in anaerobic endurance between pre- and post testing for the CG (pretest = 31.53 +/- 0.48 seconds, posttest = 30.73 +/- 0.50 seconds). In conclusion, circuit training,
which is designed to be performed 3 days a week during 10 weeks of training, improves sprint-agility and anaerobic endurance.

**Chaouachi et.al (2009)** in their study “Lower limb maximal dynamic strength and agility determinants in elite basketball players” examined the relationship between squat 1 repetition maximum (1RM) and basketball-relevant tests and the variables that influence agility (T-test) in elite male professional basketball players (n = 14, age 23.3 +/- 2.7 years, height 195.6 +/- 8.3 cm, body mass 94.2 +/- 10.2 kg). T-test performance was significantly related to body mass (r = 0.58, p = 0.03) and to percentage of body fat (r = 0.80, p < 0.001). A significant negative correlation was observed between T-test and 5-jump test performance (r = -0.61, p = 0.02). Squat 1RM was significantly related to 5-, 10-, and 30-m sprint times. Stepwise correlation analysis showed percentage of body fat was the best single predictor factor (p < 0.05) of agility. Squat 1RM performance was the best single predictor of 5-m and 10-m sprint times (p < 0.05). In light of the present study's findings, agility should be regarded as a per se physiological ability for elite basketball players. Consequently, basketball-specific agility drills should be stressed in elite basketball training. Given the association between squat 1RM performance and short sprint times, squat exercises should be a major component of basketball conditioning.
Ziv and Lidor (2010) reviewed a series of studies (n=26; 15 observational and 11 experimental) examining vertical jump (VJ) performances in female and male basketball players. Information on the tests used in these studies and their specific protocols, and the training programs conducted to improve VJ ability in elite basketball players, was assessed. It was found that vertical jump values varied greatly, from 22 to 48 cm in female players and from 40 to 75 cm in male players. In conclusion, short plyometric training sessions as part of the strength and conditioning program were found to enhance VJ performances in basketball players.

Khlifa et.al. (2010) studied the “Effects of a plyometric training program with and without added load on jumping ability in basketball players” The purpose of this investigation was to examine the effect of a standard plyometric training protocol with or without added load in improving vertical jumping ability in male basketball players. Twenty-seven players were randomly assigned to 3 groups: a control group (no plyometric training), plyometric training group (PG), and loaded plyometric group (LPG, weighted vests 10-11% body mass). Before and after the 10-week training program, all the players were tested for the 5-jump test (5JT), the squat jump (SJ), and the countermovement jump (CMJ). The PG and LPG groups performed 2 and 3 training sessions per week, during the first 3 and the last 7 weeks, respectively. The results showed that SJ, CMJ, and 5JT were significantly improved only in the PG and LPG groups. The best effects for jumps were observed in LPG (p <
0.01), which showed significantly higher gains than the PG (p < 0.05). In conclusion, it appears that loads added to standard plyometric training program may result in greater vertical and horizontal-jump performances in basketball players.

Fröhlich et.al (2010) attempted to “Outcome effects of single-set versus multiple-set training--an advanced replication study” made an assumption that single-set training (SST) can be regarded as an equal alternative to multiple-set strength training. On the basis of 72 primary studies, the meta-analysis dealt with the problem of single-set vs. multiple-set training (MST). The effectiveness of these training methods was examined depending on various interventions. Apart from qualitative decision aspects, the effectiveness was checked on the basis of effect size. Generally speaking, it can be stated that MST, depending on factors like age, training experience, duration of the study, etc., offers several advantages over single-set regimes (F = 3.71; df = 1; p = 0.06; eta(2) = 0.02), especially when combined with periodization strategies, and it can be applied very successfully for increasing maximal strength in long-time effects. Therefore, the outcome effects of both methods are the same in short-time interventions. For longer-time interventions (F = 15.74; df = 1; p < 0.05; eta(2) = 0.12) and for advanced subjects with the goal of optimizing their strength gain, however, multiple-set strategies are superior (F = 7.32; df = 1; p < 0.05; eta(2) = 0.06).
Tsimahidis et.al (2010) studied on the “The effect of sprinting after each set of heavy resistance training on the running speed and jumping performance of young basketball players” The purpose of this study was to investigate the effect of a 10-week heavy resistance combined with a running training program on the strength, running speed (RS), and vertical jump performance of young basketball players. Twenty-six junior basketball players were equally divided in 2 groups. The control (CON) group performed only technical preparation and the group that followed the combined training program (CTP) performed additionally 5 sets of 8-5 repetition maximum (RM) half squat with 1 30-m sprint after each set. The evaluation took place before training and after the 5th and 10th weeks of training. Apart from the 1RM half squat test, the 10- and 30-m running time was measured using photocells and the jump height (squat, countermovement jump, and drop jump) was estimated taking into account the flight time. The 1RM increased by 30.3 +/- 1.5% at the 10th week of training for the CTP group (p < 0.05), whereas the CON group showed no significant increase (1.1 +/- 1.6%, p > 0.05). In general, all measured parameters showed a statistically significant increase after the 5th and 10th weeks (p < 0.05), in contrast to the CON group (p > 0.05). This suggests that the applied CTP is beneficial for the strength, RS, and jump height of young basketball players. The observed adaptations in the CTP group could be attributed to learning factors and to a more optimal transfer of the strength gain to running and jumping performance.
2.2: Studies on Physiological Variable

**Stewart and crutin (1976)** studied the effect of eight-week interval training on cardio-respiratory parameters and tested for changes in sub maximal heart rate and VO$_2$ max. It was tested that as a result of eight weeks of interval training in boys aged ten to twenty years there were significant improvements in sub maximal heart rate and VO$_2$ max.

**Kanil and Sulin (1984)** in his study investigated the effects of a conditioning programme in selected physiological variables of college women gymnasts. Ten women gymnasts at the Oklahoma state university were tested prior to and following a three month conditioning programme. The conditioning programme consisted of running, warm up including stretching flexibility exercise, formal gymnastic training and strength training. A modified Balke treadmill protocol was used to determine the anaerobic threshold and maximal oxygen uptake. Also measured were resting on blood pressure, resting heart rate, percent body fat by skin folded and under water weighing and strength. The result of this study revealed significant improvement in anaerobic threshold heart rate, maximal oxygen uptake, blood pressure, percent body fat from both skin folded and underwater weighing and all strength measures except for right leg strength.
Bell et al. (1994) in their study with the aims of the investigation that (i) to examine the physiological status of players according to playing unit; and (ii) to quantify the changes arising from a four-month training programme. Maximal/peak oxygen uptake was assessed using an incremental test to exhaustion during treadmill running. Anaerobic performance was measured using the 30s Wingate test. Standard deviation scores illustrated that aerobic and anaerobic performances were of roughly the same magnitude before training (-0.35 v -0.29, p > 0.05), but that after training the dominant performance was anaerobic (+0.11 v +1.48, p < 0.01).

Apostolidis et al. (2004) aimed a twofold study: a) To describe the physiological and technical characteristics of elite young basketball players, b) To examine the relationship between certain field and laboratory tests among the players. Thirteen male players of the junior's basketball national team (age: 18.5 +/- 0.5 years, mass: 95.5 +/- 8.8 kg, height: 199.5 +/- 6.2 cm, body fat: 11.4 +/- 1.9%, means +/- SD) performed a run to exhaustion on the treadmill, the Wingate test and two types of vertical jump. On a separate day, the field tests (control dribble, defensive movement, speed dribble, speed running, shuttle run and dribble shuttle run) were conducted. To conclude these players presented a moderate VO₂ max and anaerobic power.

Vamvakoudis et al. (2004) examined the effects of prolonged basketball skills training on maximal aerobic power, isokinetic strength, joint mobility,
and body fat percentage, in young basketball players, and controls of the same age. Twenty basketball players and 18 control boys participated in the study. All subjects were tested every 6 months (18 months total, 11(1/2), 12, 12(1/2), 13 years old) for VO₂ max. Results showed that the basketball group had lower heart rate in all ages and higher VO₂ max in the initial test compared with the control in submaximal intensity. However, the basketball group had a higher VO₂ max on each of the 6-month follow-up measurements, compared to the control group (p < 0.001). In conclusion, regular basketball training increased aerobic power.

Sallet et al. (2005) investigated to evaluate the physical and physiological characteristics of different first (group “A”) and second division (group “B”) professional basketball players, and to relate them to playing position and level of play. A total of 58 players was divided into group “A” and group “B” groups and were assessed for physical characteristics, maximal treadmill test and a 30 s all-out test. The sample included 22 centers, 22 forwards and 14 guards. They have concluded that many physical differences, most notably size, exist between players as a function of their playing position. However, these differences have no relationship to the level of play of professional players. General aerobic capacity is fairly homogeneous between playing position and level of play, even if there are observable VO₂ max differences due to inter-individual profiles. On the other hand, anaerobic
capacity seems to be a better predictor of playing level even though it is not clear whether such capacity comes from specific training in group “A”, or from initial selection criteria.

Cormery et.al. (2008) examined by collecting data on professional basketball players during the last 10-year period, the differences in aerobic capacity in function of the playing position and the impact on these parameters of the change in time regulation of 2000, which shortened the time allowed to attempt a field goal by 6 s and divided the duration of play in four quarters. Professional basketball players were tested twice a year between 1994 and 2004, (n = 68) were studied for anthropometric characteristics and were submitted to an incremental exercise test on a cycle ergo meter. Statistical analyses were carried out to determine the interaction between the playing position and the effect of the change in time regulation on the physiological characteristics of the players. It was concluded that anthropometric measurements were different in function of the playing position, the centres being taller and heavier than the forwards and the guards. Guards exhibited the highest VO$_2$ max (54.0 (SE 1.6) ml/min/kg) and were the most affected by the change in time regulation of 2000 with a 19.5% increase. Significant main effects of "before" versus "after" rule changes were found for maximal and submaximal O$_2$ consumption, which were increased by 12.8% at the ventilatory threshold, 7.3% at respiratory compensation point and 7.8% at VO$_2$ max. While anthropometric characteristics remained constant during the last decade, the
change in rule of 2000 may have contributed in modifying the physiological profile of basketball players, by generally increasing their level of fitness.

Delextrat and Cohen (2008) studied whether the changes in the rules of the game instituted in 2000 have modified the physiological factors of success in basketball. The performances of eight elite male players and eight average-level players were compared in order to identify which components of fitness among agility, speed, anaerobic power, anaerobic capacity, and upper body strength were key determinants of performance in modern basketball. Each subject performed seven tests, including vertical jump (VJ), 20-m sprint, agility T test, suicide sprint, 30-second Wingate anaerobic test (WANT), isokinetic testing of the knee extensors, and one repetition maximum (1RM) bench press test. The statistical difference in the anaerobic performances was assessed by student's t test. The main results showed that, compared to average-level players, elite-level players achieved significantly better performances in the agility T test (+6.2%), VJ test (+8.8%), peak torques developed by knee extensors (+20.2%), and 1RM bench press (+18.6%, p < 0.05). In contrast, no significant difference between groups was observed on 20-m sprint, suicide run, and parameters of the WANT (p > 0.05). These results emphasized the importance of anaerobic power in modern basketball, whereas anaerobic capacity does not seem to be a key aspect to consider. In this context, coaches are advised to avoid using exercises lasting >/=30 seconds in their physical
fitness programs, but instead to focus on short and intense tests such as VJ, agility T test, and sprints over very short distances (5 or 10 m).

Caldwell and Peters (2009) investigated seasonal variations in physiological fitness of semiprofessional soccer players over a 12-month period. Thirteen male players were tested five times over a 12-month period using bioelectrical impedance, a 20-m multistage fitness test, counter movement standing vertical jump, 15-m sprint test, Illinois's agility test, and sit and reach test. Significant deconditioning was apparent in all fitness variables from end of season one season to preseason training of the next season. Aerobic fitness, vertical jump, percent body fat, agility, and sprint performance improved from preseason to mid season. Significant increases in vertical jump, sprint, and agility performance were shown from mid season onward.

Metaxas et al. (2009) in their study examined and compared the cardiorespiratory performance and isokinetic muscle strength between Greek soccer and basketball players of different divisions before starting the training season. Study participants included 100 soccer players and 61 basketball players, who were assigned according to the kind of sport and division. All participants underwent anthropometric measurements and performed an exercise test on a treadmill to determine maximal oxygen uptake (VO2 max). Peak torque for quadriceps and hamstring muscles was measured on an isokinetic dynamometer at angular velocity of 60 degrees/s (-1), 180 degrees/s (-1), and
300 degrees/s (-1). Conclusively, the higher VO₂ max reached by professional soccer and basketball players compared to semi professional and amateur ones and between the soccer and basketball players of the same division can be attributed to the different duration of the maintenance period and to the effect of the training session on each sport, respectively. Finally, a higher level of muscle strength would be preferable in soccer and basketball and would reduce the risk for injuries in the maintenance and rebuilding training periods.

2.3: Studies on Skill and Performance Variables

Riezebos et.al. (1983) in their study about the relationship of selected variables to performance in women’s basketball, twenty women were measured on physiological, anthropometric, motor fitness and skill related variables in order to provide a current profile of elite female basketball players. Performance of each subject was evaluated, firstly, to determine the relationship between performance and selected variables and secondly to determine which variables best discriminated between the top and lower ranked performers. The profile of the elite female player had changed considerably subsequent to rule changes. The better basketball players exhibited a superior aerobic power and anaerobic capacity, were more accurate shooters and possessed less body fat. The factors which best discriminated between high and low performers were accuracy shooting, percent fat and VO₂ max. These
variables could be used in a test battery to assist in the selection and development of potential basketball players.

**Joshi (1986)** investigated the effects of warm-up exercises on physical fitness and skilled performance of basketball players. Fifteen boys and 15 girls in the age group of 15 to 19 years were given intense advanced coaching for the duration of two months. There is no significant increase in cardio-pulmonary reserve, Harvard’s Fatigue index and anaerobic capacity. Due to the exercises, there is an improvement in the skilled performance which is indicated as a decrease in the number of mispasses, decrease in the number of mistakes, decrease in the number of fouls and increase in the percentage shooting.

**Shoenfelt (1991)** assessed the effect weight training has on the accuracy of free-throw shots immediately following a weight-training session. On alternating days of the week for eight weeks, 14 members of a women's varsity intercollegiate basketball team engaged in a weight-training program, and an aerobics exercise program. Each day immediately following the conditioning, the players shot two sets of 10 free throws. Analysis indicated that the immediate effects of weight training are beneficial for free-throw shooting than aerobic exercise.

**Bogdanis et.al (2007)** evaluated and compared the effectiveness of two different off-season, short-term basketball training programs on physical and
technical abilities of young basketball players. Twenty-seven adolescent basketball players (14.7+/-0.5 years; Tanner stage: 3.5+/-0.5) were randomly divided into a specialized basketball training group (Special, n=10), a mixed basketball plus conditioning training group (mixed, n=10) and a control group (n=7). Training included five sessions per week (100-120 min each) and was performed for four weeks. Maximal oxygen uptake was similarly improved after special (4.9+/-1.8%) and mixed (4.9+/-1.4%), but there was no effect on the ventilatory threshold. Performance in four basketball technical skills was similarly increased (by 17-27%) in both groups, with a tendency for greater improvement of the special groups in the technical skills of shooting and passing. These results indicate that a special basketball training program, performed exclusively on-court was as effective as a mixed training program in terms of aerobic and anaerobic fitness improvement.

Wang et al. (2009) described the skills and offensive tactics frequently used in pick-up basketball games. 65 participants were recruited from public basketball courts. Participants' performances were videotaped and coded. Results indicated that the passing skills most frequently observed in the games were chest pass, overhead pass, and bounce pass. For dribbling, crossover dribble and change-of-pace dribble were frequently observed. Jump shot, set shot, and lay up were also frequently used. The offensive tactics frequently used included drive, cut, and set screen. The study may be beneficial for helping young people prepare to play pick-up basketball games.
2.5: Summary of Literature

The reviews were presented under the two sections such as one group that undergoes specific training package with anaerobic exercises and the other group being the control group that undergoes the normal workouts without the specific training package. All the research studies were presented in the section proves that anaerobic training contributed significantly. The research studies reviewed are from many journals available in the websites such as www.fiba.com, www.pubmed.gov, www.athletic-training.com, www.youth-basketball-tips.com and www.ask-the-coach.com etc., also references from several web sites on training programme dealt with speed, strength, power and other trainings.

It is also observed from the review of literature that there is no similar research was ever done on the effect of anaerobic exercises on the specific pre-season training package on the selected physical, physiological and skill performance variables on the college level male basketball players. This inference has motivated the researcher to attempt a study on specific pre-season training with the help of anaerobic exercises.