CHAPTER II
REVIEW OF RELATED LITERATURE

For any specific research project to occupy a place in the development of a discipline, the researcher must be thoroughly familiar with both previous theory and research. To assure this familiarity, every research project in the behavioural sciences has as one of its early stage, a review of the theoretical and research literature.

The literature related to any problem helps the scholar to discover what is already known, which would enable the investigator to have a deep insight, clear perspective and a better understanding of the chosen problem and various factors connected with the study. 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 literature in any field forms the foundation upon which all future work will be built. If we fail to build upon the foundation of knowledge provided by the review of literature, the researcher might miss some work already done on the same topic.
The following review of literature addresses the effect of varied intensities of endurance training on physical and physiological parameters. Terms relevant to the study in this thesis are operationally defined.

The literature in any field forms the foundation upon which all future work will be built. If we fail to build upon the foundation of knowledge provided by the review of literature, the researcher might miss some works already done on the same topic.

**Studies on Selected variables**

Anderson, Sforzo & Sigg (2008) determined whether combined elastic and free weight resistance (CR) provides different strength and power adaptations than free weight resistance (FWR) training alone. Forty-four young, resistance-trained (4 +/- 2 years' experience) subjects were recruited from men's basketball and wrestling teams and women's basketball and hockey teams at Cornell University. Subjects were stratified according to team, then randomly assigned to the control (C; n = 21) or experimental group (E; n = 23). Before and after 7 weeks of resistance training, subjects were tested for lean body mass, 1 repetition maximum back squat and bench press, and peak and average power. The result indicated that, training with CR may be better than FWR alone for developing lower and upper body strength, and lower body power in resistance-trained individuals. Long-term
effects are unclear, but CR training makes a meaningful contribution in the short term to performance adaptations of experienced athletes.

Bellar et al (2011) investigated the effects of training combining elastic tension, free weights, and the bench press. Eleven college-aged men (untrained) in the bench press participated in the 13-week study. The participants were first given instructions and then practiced the bench press, followed by a one-repetition maximum (1RM) test of baseline strength. Subjects were then trained in the bench press for 3 weeks to allow for the beginning of neural adaptation. These results suggest that the addition of elastic tension to the bench press may be an effective method of increasing strength.

Berryman, Maurel & Bosquet (2010) compared the effects of 2 strength training methods on the energy cost of running (Cr). Thirty-five moderately to well-trained male endurance runners were randomly assigned to either a control group (C) or 2 intervention groups. All groups performed the same endurance-training program during an 8-week period. Intervention groups added a weekly strength training session designed to improve neuromuscular qualities. Sessions were matched for volume and intensity using either plyometric training (PT) or purely concentric contractions with added weight (dynamic weight training [DWT]). In conclusion, plyometric training were more effective than DWT in improving Cr in moderately to well-trained male endurance runners showing that athletes and
coaches should include explosive strength training in their practices with a particular attention on plyometric exercises.

Blazevich & Jenkins (2002) determined the effects of 7 weeks of high- and low-velocity resistance training on strength and sprint running performance in nine male elite junior sprint runners. The athletes continued their sprint training throughout the study, but their resistance training programme was replaced by one in which the movement velocities of hip extension and flexion, knee extension and flexion and squat exercises varied according to the loads lifted. The present results suggest a lack of velocity-specific performance changes in elite concurrently training sprint runners performing a combination of traditional and semi-specific resistance training exercises.

Bottaro, Martins, Gentil & Wagner (2009) investigated the acute hormonal response to three different rest periods between sets of a traditional lower body resistance training session in young women. Twelve healthy trained females (26.83+/−3.93 years) participated in the study. On three separate sessions of a lower body resistance exercise protocol, subjects were assigned in a random order a rest interval of 30s (P30), 60s (P60) or 120s (P120) between sets. The resistance exercise session consisted of four lower body exercises with three sets performed until contractile failure using 10-repetition maximum (RM) load. It was concluded that thus, the magnitude of acute GH responses in previously strength-trained women appears
greater with a 30-s rest interval between sets compared to longer rest periods of 60- or 120-s.

Brandenburg (2005) determined if explosive upper-body performance could be improved when it was preceded by conditioning contraction protocols that incorporate resistance exercise. Providing that performance was enhanced, it was also the intention to determine the optimal conditioning contraction load for enhancing performance. Eight recreationally trained men completed 4 experimental sessions. Each session consisted of a warm-up, 3 bench press throws (pre), a conditioning protocol, and 3 bench press throws (post). The different conditioning protocols consisted of 5 bench press repetitions using 100, 75, or 50% of 5 repetition maximum (5RM) strength. The fourth protocol, in which no repetitions were completed, acted as a control. Participants performed each conditioning protocol on a different day, and the order in which the protocols were performed was randomized. Average power, assessed during the bench press throws, was determined for the starting segment and the end segment (point of bar release) for each throw. Comparisons in average power, for each segment of the bench press 1RM, were made between the pre- and post conditioning protocol bench press throws. None of the conditioning protocols had an effect on bench press throw performance in either of the 2 segments of the movement. The results
suggest there is no performance advantage when explosive upper-body movement is preceded by resistance exercise of varying loads.

Burleson, O'Bryant, Stone, Collins & Triplett-McBride (1998) compared the effect of weight training (WT) and treadmill (TM) exercise on post exercise oxygen consumption (VO2), 15 males performed a 27-min bout of WT and a 27-min bout of TM exercise at matched rates of VO2. WT consisted of performing two circuits of eight exercises at 60% of each subject's one repetition maximum with a work/rest ratio of 45 s/60 s. The results suggest that, during the first 30 min following exercise, WT elicits a greater elevated post exercise VO2 than TM exercise when the two activities are performed at matched VO2 and equal durations. Therefore, total energy expenditure as a consequence of WT will be underestimated if based on exercise VO2 only.

Carter et al (2007) examined the effects of an 8-week course of high volume upper extremity plyometric training on the isokinetic strength and throwing velocity of a group of intercollegiate baseball players. Twenty-four Division I collegiate baseball players were recruited to participate in this study. Throwing velocity, isokinetic peak torque, isokinetic functional strength ratios, and time to peak torque were measured pre- and post training. Subjects were rank-ordered according to concentric internal rotation (IR) strength and were assigned randomly to either the plyometric training group (PLY) or the control group (CON). In conclusion, the Ballistic Six training
protocol can be a beneficial supplement to a baseball athlete's off-season conditioning by improving functional performance and strengthening the rotator cuff musculature.

Channell & Barfield (2008) compared the effects of a ballistic resistance training program of Olympic lifts with those of a traditional resistance training program of power lifts on vertical jump improvement in male high school athletes. Twenty-seven male student athletes were recruited from a high school football program at a small, rural school in the Southeast. The subjects were divided into an Olympic training group (OT, n = 11), a power training group (PT, n = 10), and a control group (n = 6). The result indicated that Olympic lifts as well as power lifts provide improvement in vertical jump performance and that Olympic lifts may provide a modest advantage over power lifts for vertical jump improvement in high school athletes.

Chelly (2009) investigated the effects of voluntary maximal leg strength training on peak power output (Wpeak), vertical jump performance, and field performances in junior soccer players. Twenty-two male soccer players participated in this investigation and were divided into 2 groups: A resistance training group and a control group. Before and after the training sessions (twice a week for 2 months), Wpeak was determined by means of a cycling force-velocity test. Squat jump (SJ), countermovement jump (CMJ), and 5-jump test (5-JT) performances were assessed. It was concluded that, the resistance
training group showed improvement in Wpeak, jump performances and all sprint running. Both typical force-velocity relationships and mechanical parabolic curves between power and velocity increased after the strength training program. Leg and thigh muscle volume and CSA of RTG remained unchanged after strength training. Back half squat exercises, including adapted heavy loads and only 2 training sessions per week, improved athletic performance in junior soccer players.

Chelly et al (2010) determined the effect of in season short term plyometric training programme. The subjects (23 men, age 19 ± 0.7 years, body mass 70.5 ± 4.7 kg, height 1.75 ± 0.06 m, body fat 14.7 ± 2.6%) were randomly assigned to a control (normal training) group (Gc; n = 11) and an experimental group (Gex, n = 12) that also performed biweekly plyometric training. A force-velocity ergometer test determined PP. Characteristics of the squat jump (SJ) and the countermovement jump (CMJ) (jump height, maximal force and velocity before take-off, and average power) were determined by force platform. Video-camera kinematic analyses over a 40-m sprint yielded running velocities for the first step (VS), the first 5 m (V5m) and between 35 and 40 m (Vmax). We conclude that biweekly plyometric training of junior soccer players (including adapted hurdle and depth jumps) improved important components of athletic performance relative to standard in-season training. Accordingly, such exercises
are highly recommended as part of an annual soccer training program.

Christou, Smilios, Sotiropoulos, Volakis, Pilianidis & Tokmakidis (2006) examined the effects of a progressive resistance training program in addition to soccer training on the physical capacities of male adolescents. Eighteen soccer players were separated in a soccer (SOC; n = 9) and a strength-soccer (STR; n = 9) training group and 8 subjects of similar age constituted a control group. All players followed a soccer training program 5 times a week for the development of technical and tactical skills. In addition, the STR group followed a strength training program twice a week for 16 weeks. The program included 10 exercises, and at each exercise, 2-3 sets of 8-15 repetitions with a load 55-80% of 1 repetition maximum (1RM). The selected variables were measured at the beginning, after 8 weeks, and at the end of the training period. The above data show that soccer training alone improves more than normal growth maximum strength of the lower limbs and agility. The addition of resistance training, however, improves more maximal strength of the upper and the lower body, vertical jump height, and 30-m speed. Thus, the combination of soccer and resistance training could be used for an overall development of the physical capacities of young boys.

Coelho, Hamar & Araújo (2003) compared physiological responses to 2 high-speed resistance training (RT) protocols in
untrained adults. Both RT protocols included 12 repetitions for the same 6 exercises, only differing in continuous (1 x 12) or discontinuous (2 x 6) mode. For discontinuous mode, there was a 15-second rest interval between sets. We hypothesized that the 2 x 6 protocol was less physiologically demanding than the 1 x 12 protocol. Fifteen untrained adults randomly performed the protocols on 2 different days while heart rate (HR), blood lactate (BL), rate of perceived exertion (RPE), and concentric phase mean power (CPMP) were measured. It was concluded that the discontinuous protocol was significantly less physiologically demanding, although similar or higher CPMP values were obtained. These findings may help foster long-term adherence to RT in untrained individuals.

Cramer, Stout, Culbertson & Egan (2007) examined the effects of 3 days of isokinetic resistance training combined with 8 days of creatine monohydrate supplementation on PT, mean power output (MP), ACC, surface electromyography (EMG), and mechanomyography (MMG) of the vastus lateralis muscle during maximal concentric isokinetic leg extension muscle actions. Twenty-five men (mean age +/- SD = 21 +/- 3 years, stature = 177 +/- 6 cm, and body mass = 80 +/- 12 kg) volunteered to participate in this 9-day, double-blind, placebo-controlled study and were randomly assigned to either the creatine (CRE; n = 13) or placebo (PLA; n = 12) group. The CRE group ingested the treatment drink (280 kcal; 68 g carbohydrate; 10.5 g
creatine), whereas the PLA group received an isocaloric placebo (70 g carbohydrate). Two servings per day (morning and afternoon) were administered in the laboratory on days 1-6, with only 1 serving on days 7-8. Before (pre; day 1) and after (post; day 9) the resistance training, maximal voluntary concentric isokinetic leg extensions at 30, 150, and 270 degrees x s(-1) were performed on a calibrated Biodex System 3 dynamometer. These results indicated that 3 days of isokinetic resistance training was sufficient to elicit small, but significant, improvements in peak strength (PT) and ACC for both the CRE and PLA groups. Although the greater relative improvements in PT and ACC for the CRE group were not statistically significant, these findings may be useful for rehabilitation or strength and conditioning professionals who may need to rapidly increase the strength of a patient or athlete within 9 days.

De Villarreal, González-Badillo & Izquierdo (2008) examined the effect of 3 different plyometric training frequencies (e.g., 1 day per week, 2 days per week, 4 days per week) associated with 3 different plyometric training volumes on maximal strength, vertical jump performance, and sprinting ability. Forty-two students were randomly assigned to 1 of 4 groups: control (n = 10, 7 sessions of drop jump (DJ) training, 1 day per week, 420 DJs), 14 sessions of DJ training (n = 12, 2 days per week, 840 DJs), and 28 sessions of DJ training (n = 9, 4 days per week, 1680 DJs). The training protocols included DJ
from 3 different heights 20, 40, and 60 cm. These observations may have considerable practical relevance for the optimal design of plyometric training programs for athletes, given that a moderate volume is more efficient than a higher plyometric training volume.

De Villarreal, Kellis, Kraemer & Izquierdo (2009) discussed a meta-analysis of 56 studies with a total of 225 effect sizes (ESs) was carried out to analyze the role of various factors on the effects of plyometrics on VJH performance. The inclusion criteria for the analysis were a) studies using plyometric programs for lower-limb muscles, b) studies employing true experimental designs and valid and reliable measurements, and c) studies including enough data to calculate ESs. The responses identified in this analysis are essential and should be considered by strength and conditioning professionals with regard to the most appropriate dose-response trends for optimizing plyometric-induced gains.

De Villarreal, Requena & Cronin (2012) attempted to gain a clear picture of the magnitude of sprint performance improvements expected after chronic plyometric training (PT) and to identify specific factors that influence the treatment effects. A total of 26 studies with a total of 56 ES met the inclusion criterion. It was concluded that, no extra benefits were found to be gained from doing plyometrics with added weight. The loading parameters identified in this analysis should be considered by the professional sprinters and specialized
trainers with regard to the most appropriate dose-response trends PT to optimized sprint performance gains.

Diallo, Dore, Duche & Van Praagh (2001) examined the effectiveness of plyometric training and maintenance training on physical performances in prepubescent soccer players. Twenty boys aged 12-13 years was divided in two groups (10 in each): jump group (JG) and control group (CG). JG trained 3 days/week during 10 weeks, and performed various plyometric exercises including jumping, hurdling and skipping. The subsequent reduced training period lasted 8 weeks. However, all subjects continued their soccer training. Maximal cycling power (Pmax) was calculated using a force-velocity cycling test. Jumping power was assessed by using the following tests: countermovement jump (CMJ), squat jump (SJ), drop jump (DJ), multiple 5 bounds (MB5) and repeated rebound jump for 15 seconds (RRJ15). These results demonstrate that short-term plyometric training programmes increase athletic performances in prepubescent boys. These improvements were maintained after a period of reduced training.

Dorgo, King & Rice (2009) investigated the effects of a manual resistance training (MRT) program on muscular strength and endurance and to compare these effects with those of identically structured weight resistance training (WRT) program. To do this, 84 healthy college students were randomly assigned to either an MRT
group and engaged in a 14-week training program. Each participant's performance was assessed before and immediately after the 14-week training period. It was concluded that, the improvements in muscular strength and muscular endurance after a 14-week MRT program in the present study were similar to those produced by a WRT program, and well-designed MRT exercises seem to be effective for improving muscular fitness.

Farinatti, Simão, Monteiro & Fleck (2009) investigated the effect of resistance exercise order on the oxygen uptake (Vo2) and energy expenditure (EE). Ten trained women (age, 22 +/- 2 years; body mass index, 21 +/- 2 kgxm; peak Vo2, 42.2 +/- 2.9 ml kg min) volunteered for the study. Data were collected in 5 nonconsecutive days: (day 1) assessment of the peak Vo2 in a maximum effort ramp treadmill protocol; (days 2 and 3) determination of 10 repetition maximum (10RM) for the bench press (BP), machine shoulder press (SP), and pulley triceps extension (TE); and (days 4 and 5) performing 3 sets of each exercise with 3-minute rest intervals between sets and exercises until fatigue using 10RM in 2 sequences of opposite order (sequence A [SEQA]: BP, SP, TE; sequence B [SEQB]: TE, SP, and BP). Total Vo2 was assessed during all exercises, recovery intervals, and for 20 minutes after the end of the sequences. In conclusion, the Vo2 was lower for a given exercise when it was performed first as compared with last in a training session for the upper limbs. However, these
differences did not affect the overall Vo2 or EE during sequences performed in the opposite exercise order.

Herrero, Izquierdo, Maffiuletti & García-López (2006) compared the effects of four-week training periods of electromyostimulation (EMS), plyometric training (P), or combined EMS and P training of the knee extensor muscles on 20 m sprint time (ST), jumping ability (Squat jump [SJ] and Countermovement jump [CMJ]), maximal isometric strength (MVC), and muscle cross-sectional area (CSA). Forty subjects were randomly assigned to one of the four treatment groups: electromyostimulation (EG), plyometric (PG), combined EMG, and P (EPG), that took place 4 times per week, and a control group (CG). In conclusion, EMS combined with plyometric training increased the jumping height and sprint run in physically active men. In addition, EMS alone or EMS combined with plyometric training leads to increase maximal strength and to some hypertrophy of trained muscles.

Hill-Haas, Bishop, Dawson, Goodman & Edge (2007) discussed the effect of altering the rest period on adaptations to high-repetition resistance training is not well known. Eighteen active females were matched according to leg strength and repeated-sprint ability and randomly allocated to one of two groups. Both groups performed the same total training volume and load. Each group trained 3 days a week for 5 weeks [15- to 20-repetition maximum (RM), 2 - 5 sets].
These results suggest that when training volume and load are matched, despite a smaller increase in strength, 5 weeks of training with short rest periods results in greater improvements in repeated-sprint ability than the same training with long rest periods.

Hoffman et al (2005) explored the effects of 5 weeks of eccentrically loaded and unloaded jump squat training in experienced resistance-trained athletes during the strength/power phase of a 15-week periodized off-season resistance training program. Forty-seven male college football players were randomly assigned to 1 of 3 groups. One group performed the jump squat exercise using both concentric and eccentric phases of contraction (CE; n = 15). A second group performed the jump squat exercise using the concentric phase only (n = 16), and a third group did not perform the jump squat exercise and served as control (CT; n = 16). The result indicated that, the eccentric phase of this ballistic movement appears to have important implications for eliciting these strength gains in college football players during an off-season training program.

Humburg, Baars, Schröder, Reer, & Braumann (2007) investigated the effects of a 1-set and 3-set strength training program. The subjects were untrained men and women who were randomly signed into 1 of 3 groups: 10 subjects trained during the first 9 weeks (training period 1) with 1 set and 8-12 repetitions per set. After the break (9 weeks), they trained with 3 sets and 8-12 repetitions in
training period 2. Twelve subjects started with the 3-set program and continued with the 1-set regime after the break. It was concluded that, depending on the goals of each trainee, these differences between the effects of different strength training volumes indicate that it may be worth spending more time on working out with a 3-set strength training regime.

Hunter, Seelhorst & Snyder (2003) compared the cardiovascular and energy expenditure demands of "Super Slow" (SST) and traditional (TT) resistance training. 7 resistance-trained young men (24.3 +/- 3.8 years) had energy expenditure (using indirect calorimetry) and heart rate evaluated during and for 15 minutes after a workout on separate days. Blood lactate levels were also evaluated before and after each intervention. It was concluded that, no significant repeated measures analysis main effect was found for either resting energy expenditure or respiratory exchange ratio. The metabolic and cardiovascular stimuli were low with SST. Traditional resistance training increases energy expenditure more than SST does and thus may be more beneficial for body weight control.

Impellizzeri et al (2007) compared the effects of plyometric training on sand versus a grass surface on muscle soreness, vertical jump height and sprinting ability. After random allocation, 18 soccer players completed 4 weeks of plyometric training on grass (grass group) and 19 players on sand (sand group). Before and after
plyometric training, 10 m and 20 m sprint time, squat jump (SJ), countermovement jump (CMJ), and eccentric utilization ratio (CMJ/SJ) were determined. Muscle soreness was measured using a Likert scale. It was concluded that, plyometric training on different surfaces may be associated with different training-induced effects on some neuromuscular factors related to the efficiency of the stretch-shortening cycle.

Izquierdo, Häkkinen, Ibáñez, Kraemer & Gorostiaga (2005) determined the effects of a 16-week training period (2 days per week) of resistance training alone (S), endurance training alone (cycling exercise) (E), or combined resistance (once weekly) and endurance (once weekly) training (SE) on muscle mass, maximal strength (1RM) and power of the leg and arm extensor muscles, maximal workload (W(max)) and submaximal blood lactate accumulation by using an incremental cycling test were examined in middle-aged men. The data indicate that low-frequency combined training of the leg extensors in previously untrained middle-aged men results in a lower maximal leg strength development only after prolonged training, but does not necessarily affect the development of leg muscle power and cardiovascular fitness recorded in the cycling test when compared with either mode of training alone.

Jackson, Hickey & Reiser (2007) investigated the effects of a resistance training modality on cycling performance, 23 trained club-
level cyclists were placed into high resistance/low repetition (H-Res), low resistance/high repetition (H-Rep), or cycling-only groups for a 10-week program. All 3 groups followed the same cycling plan, but the H-Res and H-Rep groups added resistance training. Testing pre and post consisted of a graded incremental lactate profile test on an ergometer, with blood lactate being sampled. VO2 values were measured to determine economy. Maximum strength testing of 4 strength exercises targeting the lower extremity musculature was conducted with the H-Res and H-Rep groups. It is possible that with this population, various factors such as acute fatigue, strength, and aerobic gains from the cycling training, in addition to well-developed bases of strength and conditioning from previous training, reduced differences between groups in both strength gains and cycling performance.

Khlifa et al (2010) examined 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. In conclusion, it appears that loads added to standard plyometric training program may result in greater vertical and horizontal-jump performances in basketball players.

Kraemer et al (2001) determined the effects of resistance training programs on strength, power, and military occupational task performances in women were examined. Untrained women aged were matched and randomly placed in total or upper-body resistance training, field, or aerobic training groups. Two periodized resistance training programs (with supplemental aerobic training) emphasized explosive exercise movements using 3- to 8-RM training loads (TP, UP), whereas the other two emphasized slower exercise movements using 8- to 12-RM loads (TH, UH). The FLD group performed plyometric and partner exercises. Subjects were tested for body composition, strength, power, endurance, maximal and repetitive box lift, 2-mile loaded run, and U.S. It was concluded that, Strength training improved physical performances of women over 6 months and adaptations in strength, power, and endurance were specific to the subtle differences in the resistance training programs (strength/power vs strength/hypertrophy). Upper- and total-body resistance training resulted in similar improvements in occupational task performances, especially in tasks that involved upper-body musculature.
Kubo et al (2007) investigated the effects of plyometric and weight training protocols on the mechanical properties of muscle-tendon complex and muscle activities and performances during jumping. Ten subjects completed 12 wk (4 d.wk(-1)) of a unilateral training program for plantar flexors. They performed plyometric training on one side (PT; hopping and drop jump using 40% of 1RM) and weight training on the other side (WT; 80% of 1RM). Tendon stiffness was measured using ultrasonography during isometric plantar flexion. Three kinds of unilateral jump heights using only ankle joint (squat jump: SJ; countermovement jump: CMJ; drop jump: DJ) on sledge apparatus were measured. During jumping, electromyographic activities were recorded from plantar flexors and tibial anterior muscle. Joint stiffness was calculated as the change in joint torque divided by the change in ankle angle during eccentric phase of DJ. These results indicated that the jump performance gains after plyometric training are attributed to changes in the mechanical properties of muscle-tendon complex, rather than to the muscle activation strategies.

Langford, McCurdy, Ernest, Doscher & Walters (2007) compared the effects of 10 weeks of resistance training with an isotonic bench press machine and 2 types of free-weight bench press exercises on several measures bench press strength. Specificity was investigated by comparing the ability to transfer strength gained from a type of
training that differed from the mode of testing. Forty-nine men participated in the study. The subjects completed a pretest on the machine (MB), barbell (BB), isokinetic (IB), and log (LB) bench press to determine baseline strength and completed 10 weeks of training on the MB, BB, or LB. The 3 groups were tested to see whether differential training effects occurred from pre- to posttest scores on the BB, MB, LB, and peak force on the IB. By multivariate analysis, the trial-by-group interaction was not statistically significant. The findings of this study showed that all 3 training groups significantly improved in strength during short-term training on the MB, BB, and LB. These data lend evidence that improved strength after training on the MB, BB, and LB equally transfers to strength gains on any of the 4 modes of testing. These results should be considered when including similar exercises varying in stability into the training program to improve strength.

Macdonald, Lamont & Garner (2012) compared the effects of resistance training (RT), plyometric training (PT), and CT on lower body strength and anthropometrics. Thirty recreationally trained college-aged men were trained using 1 of 3 methods: resistance, plyometric, or complex twice weekly for 6 weeks. The participants were tested pre, mid, and post to assess back squat strength, Romanian dead lift (RDL) strength, standing calf raise (SCR) strength, quadriceps girth, triceps surae girth, body mass, and body fat percentage. Diet
was not controlled during this study. The results suggest that CT mirrors benefits seen with traditional RT or PT. Moreover, CT revealed no decrement in strength and anthropometric values and appears to be a viable training modality.

Maffiuletti, Dugnani, Folz, Di Pierno & Mauro (2002) investigated the influence of a 4-wk combined electromyostimulation (EMS) and plyometric training program on the vertical jump performance of 10 volleyball players. Training sessions were carried out three times weekly. Each session consisted of three main parts: EMS of the knee extensor muscles (48 contractions), EMS of the plantar flexor muscles (30 contractions), and 50 plyometric jumps. Subjects were tested before (week 0), during (week 2), and after the training program (week 4), as well as once more after 2 wk of normal volleyball training (week 6). Different vertical jumps were carried out, as well as maximal voluntary contraction (MVC) of the knee extensor and plantar flexor muscles. In conclusion, when EMS resistance training is proposed for vertical jump development, specific work out (e.g., plyometric) must complement EMS sessions to obtain beneficial effects.

Makaruk, Winchester, Sadowski, Czaplicki & Sacewicz (2011) examined the effects of unilateral and bilateral plyometric exercise on peak power and jumping performance during different stages of a 12-week training and detraining in women. Forty-nine untrained but
physically active female college students were randomly assigned to 1 of 3 groups: unilateral plyometric group (n = 16), bilateral plyometric group (BLE; n = 18), and a control group (n = 15). Peak power and jumping ability were assessed by means of the alternate leg tests (10-second Wingate test and 5 alternate leg bounds), bilateral leg test (countermovement jump [CMJ]) and unilateral leg test (unilateral CMJ). Performance indicators were measured pretraining, midtraining, post training, and detraining. Differences between dependent variables were assessed with a 3 × 4 (group × time) repeated analysis of variance with Tukey's post hoc test applied where appropriate. These results suggest that unilateral plyometric exercises produce power and jumping performance during a shorter period when compared to bilateral plyometric exercises but achieved performance gains last longer after bilateral plyometric training.

Markovic (2007) determined the precise effect of plyometric training (PT) on vertical jump height in healthy individuals. Meta-analyses of randomised and non-randomised controlled trials that evaluated the effect of PT on four typical vertical jump height tests were carried out: squat jump (SJ); countermovement jump (CMJ); countermovement jump with the arm swing (CMJA); and drop jump (DJ). These results justify the application of PT for the purpose of development of vertical jump performance in healthy individuals.
Markovic, Jukic, Milanovic & Metikos (2007) evaluated the effects of sprint training on muscle function and dynamic athletic performance and to compare them with the training effects induced by standard plyometric training. Male physical education students were assigned randomly to 1 of 3 groups: sprint group (SG; n = 30), plyometric group (PG; n = 30), or control group (CG; n = 33). Maximal isometric squat strength, squat- and countermovement jump (SJ and CMJ) height and power, drop jump performance from 30-cm height, and 3 athletic performance tests (standing long jump, 20-m sprint, and 20-yard shuttle run) were measured prior to and after 10 weeks of training. We conclude that short-term sprint training produces similar or even greater training effects in muscle function and athletic performance than does conventional plyometric training.

Moir, Sanders, Button & Glaister (2007) assessed the effect of periodized resistance training on accelerative sprint performance. Sixteen physically active men participated in a randomized controlled study. An experimental group (n = 10) completed an 8-week periodized resistance training intervention, while a control group (n = 6) did not train. Pre- and post-training measures of 20-m straight-line sprint time, including a 10-m split, maximum strength, and explosive strength, were recorded. Flight time, stance time, stride length, and stride frequency were quantified from digitized video recordings of the first three strides of the 20-m sprint. It was concluded that, the
change during the 0-10m interval was accompanied by a reduction in stride frequency during the first three strides.

Potdevin, Albery, Chevutschi, Pelayo & Sidney (2011) examined in pubescent swimmers the effects on front crawl performances of a 6-week plyometric training (PT) in addition to the habitual swimming program. Swimmers were assigned to a control group (n = 11, age: 14.1 ± 0.2 years; G(CONT)) and a combined swimming and plyometric group (n = 12, age: 14.3 ± 0.2 years; GSP), both groups swimming 5.5 h · wk(-1) during a 6-week preseason training block. Results suggested a positive effect of PT on specific swimming tasks such as dive or turn but not in kicking propulsion. Because of the practical setup of the PT and the relevancy of successful starts and turns in swimming performances, it is strongly suggested to incorporate PT in pubescent swimmers’ training and control it by jump performances.

Rana et al (2008) investigated the effects of a six-week (16-17 training sessions) low velocity resistance training program (LV) on various performance measures as compared to a traditional strength (TS) and a traditional muscular endurance (TE) resistance training program. Thirty-four healthy adult females were randomly divided into 4 groups. Each subject was pre- and post tested for 1 repetition maximum (1RM), muscular endurance, maximal oxygen consumption (VO2max), muscular power, and body composition. In conclusion, muscular strength improved with LV training however, TS showed a
larger improvement. Muscular endurance improved with LV training, but not above what TE or TS demonstrated. For all other variables, there were no significant improvements for LV beyond what demonstrated.

Ratamess et al (2007) examined the combined effects of resistance and sprint/plyometric training with or without the Meridian Elyte athletic shoe on muscular performance in women. Fourteen resistance-trained women were randomly assigned to one of 2 training groups: (a) an athletic shoe (N = 6) (AS) group or (b) the Meridian Elyte (N = 8) (MS) group. Training was performed for 10 weeks and consisted of resistance training for 2 days per week and 2 days per week of sprint/plyometric training. These results indicated that similar improvements in peak sprint speed and jumping ability were observed following 10 weeks of training with either shoe. However, high-intensity sprint endurance at 60 m increased to a greater extent during training with the Meridian Elyte athletic shoe.

Rhea, Alvar, Ball & Burkett (2002) compared the effect single and multiple sets of weight training for strength gains in recreationally trained individuals. Sixteen men groups and trained 3 days per week for 12 weeks. One repetition maximum (1RM) was recorded for bench press and leg press at pre-, mid-, and posttest. Subjects trained according to daily undulating periodization (DUP), involving the bench press and leg press exercises between 4RM and 8RM. Training
intensity was equated for both groups. The results demonstrate that for recreationally trained individuals using DUP training, 3 sets of training are superior to 1 set for eliciting maximal strength gains.

Ronnestad, Kvalme, Sunde & Raastad (2008) compared the effects of combined strength and plyometric training with strength training alone on power-related measurements in professional soccer players. Subjects in the intervention team were randomly divided into 2 groups. Group ST (n = 6) performed heavy strength training twice a week for 7 weeks in addition to 6 to 8 soccer sessions a week. Group ST+P (n = 8) performed a plyometric training program in addition to the same training as the ST group. The control group (n = 7) performed 6 to 8 soccer sessions a week. Pretests and posttests were 1 repetition maximum (1RM) half squat, countermovement jump (CMJ), squat jump (SJ), 4-bounce test (4BT), peak power in half squat with 20 kg, 35 kg, and 50 kg (PP20, PP35, and PP50, respectively), sprint acceleration, peak sprint velocity, and total time on 40-m sprint. The results suggest that there are no significant performance-enhancing effects of combining strength and plyometric training in professional soccer players concurrently performing 6 to 8 soccer sessions a week compared to strength training alone. However, heavy strength training leads to significant gains in strength and power-related measurements in professional soccer players.
Rubley, Haase, Holcomb, Girouard & Tandy (2011) measured the effects of low-frequency, low-impact plyometric training on vertical jump (VJ) and kicking distance in female adolescent soccer players. Sixteen adolescent soccer players were studied (age 13.4 ± 0.5 years) across 14 weeks. The control group (general soccer training only) had 6 subjects, and the plyometric training (general soccer training plus plyometric exercise) group had 10 subjects. All subjects were tested for VJ and kicking distance on 3 occasions: pre-test, 7 weeks, and 14 weeks. Data were analyzed using a 2 (Training) × 3 (Test) analysis of variance (ANOVA) with repeated measures on the factor test. These results provide strength coaches with a safe and effective alternative to high-intensity plyometric training.

Salonikidis & Zafeiridis (2008) diagnosed the presence of laterality in tennis lateral movements and (ii) to compare the effects of plyometric training (PT), tennis-specific drills training (TDT), and combined training (CT) on performance in tennis-specific movements and power/strength of lower limbs. Sixty-four novice tennis players (21.1 +/- 1.3 years) were equally (n = 16) assigned to a control (C), PT, TDT, or CT. Training was performed 3 times/week for 9 weeks. Testing was conducted before and after training for the evaluation of reaction time (single lateral step), 4-m lateral and forward sprints, 12-m forward sprints with and without turn, reactive ability, power, and strength. TDT improved all 4-m and 12-m sprint performances,
whereas CT appeared to incorporate the advantage of both programs and improved most tests items. Tennis coaches should be aware that each training regimen may induce more favorable changes to different aspects of fitness.

Santos & Janeira (2011) determined the effects of (a) plyometric training on explosive strength indicators in adolescent male basketball players and (b) detraining and reduced training on previously achieved explosive strength gains. Two groups were formed: an experimental and a control group. The former was submitted to a 10-week in-season plyometric training program, twice weekly, along with regular basketball practice. Simultaneously, the control group participated in regular basketball practice only. At the end of this period, the experimental group was subdivided into 2 groups: a reduced training group and a detraining group. In conclusion, plyometric training showed positive effects on upper- and lower-body explosive strength in adolescent male basketball players. Moreover, we can state that both detraining and a reduced training program indistinctly contribute to maintenance of strength levels. These results highlight the unique power that basketball-specific training seems to have on the sustainability and maintenance of sport performance.

Saunders et al (2006) discussed short term plyometric training. Fifteen highly trained distance runners VO(2)max 71.1 +/- 6.0 ml.min(-1).kg(-1), mean +/- SD) were randomly assigned to a
plyometric training (PLY; n = 7) or control (CON; n = 8) group. In addition to their normal training, the PLY group undertook 3 x 30 minutes PLY sessions per week for 9 weeks. Running economy (RE) was assessed during 3 x 4 minute treadmill runs (14, 16, and 18 km.h(-1)), followed by an incremental test to measure VO(2)max. There were no significant differences in cardio respiratory measures or VO(2)max as a result of PLY. In a group of highly-trained distance runners, 9 weeks of PLY improved RE, with likely mechanisms residing in the muscle, or alternatively by improving running mechanics.

Sedano Campo (2009) examined how explosive strength, kicking speed, and body composition are affected by a 12-week plyometric training program in elite female soccer players. The hypothesis was that this program would increase the jumping ability and kicking speed and that these gains could be maintained by means of regular soccer training only. Twenty adult female players were divided into 2 groups: control group and plyometric group. It could be concluded that a 12-week plyometric program can improve explosive strength in female soccer players and that these improvements can be transferred to soccer kick performance in terms of ball speed.

Sedano, Matheu, Redondo & Cuadrado (2011) determined the effects of a 10-week plyometric training program on explosive strength, acceleration capacity and kicking speed in young elite soccer
players. Twenty-two players participated in the study: control group (CG), (N.=11; 18.2 ± 0.9 years) and treatment group (TG) (N.=11; 18.4 ± 1.1 years). Both groups performed technical and tactical training exercises and matches together. However, the CG players followed the regular physical conditioning program, which was replaced by a plyometric program for TG. Plyometric training took place three days a week and included jumps over hurdles, horizontal jumps and lateral jumps over hurdles. Jumping ability, 10 m sprint and kicking speed were measured on five separate occasions. The main findings revealed that a 10-week plyometric program may be an effective training stimulus to improve explosive strength compared to a more conventional physical training program.

Stemm & Jacobson (2007) compared vertical jump performance after land- and aquatic-based plyometric training. A convenience sample of 21 active, college-age (24 +/- 2.5 years) men were randomly assigned to 1 of 3 groups: group I, aquatic; group II, land; and group III, control. Training for the AQ and LN groups consisted of a 10-minute warm-up followed by 3 sets of 15 squat jumps, side hops, and knee-tuck jumps separated by 1-minute rests. The aquatic group performed the exercises in knee-level water adjusted to parallel the axis of the knee joint (+1 in.). The land group performed identical plyometric exercises on land. The control group engaged in no training. It was concluded that aquatic training resulted in similar
training effects as land-based training, with a possible reduction in stress due to the reduction of impact afforded by the buoyancy and resistance of the water upon landing.

Swanik et al (2002) determined the effect of plyometric training of the shoulder internal rotators on proprioception, kinesthesia, and selected muscle performance characteristics in female swimmers. Twenty-four female division I swimmers were evaluated before and after a 6-week plyometric training program. Proprioception and kinesthesia were assessed for internal and external rotation at 0 degrees, 75 degrees, and 90% of the subject’s maximum external rotation. The Biodex II was used to assess strength characteristics at 60 degrees /s, 240 degrees /s, and 450 degrees /s. Plyometric training sessions (2 times/week) involved 3 sets of 15 repetitions with a trampoline, weighted balls, and elastic tubing. This study suggests that plyometric activities may facilitate neural adaptations that enhance proprioception, kinesthesia, and muscle performance characteristics.

Takahashi et al (2008) determined the effects of resistance training on natural killer cell activity (NKCA) in young people, a study was conducted among healthy female university students. 22 healthy non athlete female university students who volunteered to participate in the study. Six women were assigned to exercise group. The exercise groups carried out resistance training for both the upper and lower
parts of the body using ankle and wrist weights for 8 weeks. This study showed that resistance training improved physical fitness, muscle strength, and NKCA in young female subjects. Regarding the effects of exercise frequency on NKCA, this study suggests that exercise carried out three of four times a week might be associated with an increase in NKCA.

Thomas, French & Hayes (2009) compared the effects of two plyometric training techniques on power and agility in youth soccer players. Twelve males from a semiprofessional football club’s academy were randomly assigned to 6 weeks of depth jump (DJ) or countermovement jump (CMJ) training twice weekly. Participants in the DJ group performed drop jumps with instructions to minimize ground-contact time while maximizing height. The study concludes that both DJ and CMJ plyometrics are worthwhile training activities for improving power and agility in youth soccer players.

Tricoli, Lamas, Carnevale & Ugrinowitsch (2005) compared the short-term effects of heavy resistance training combined with either the VJ or WL program. Thirty-two young men were assigned to 3 groups: WL = 12, VJ = 12, and control = 8. These 32 men participated in an 8-week training study. The WL training program consisted of 3 x 6RM high pull, 4 x 4RM power clean, and 4 x 4RM clean and jerk. The VJ training program consisted of 6 x 4 double-leg hurdle hops, 4 x 4 alternated single-leg hurdle hops, 4 x 4 single-leg hurdle hops, and 4
x 4 40-cm drop jumps. Additionally, both groups performed 4 x 6RM half-squat exercises. Training volume was increased after 4 weeks. Pretesting and posttesting consisted of squat jump (SJ) and countermovement jump (CMJ) tests, 10- and 30-m sprint speeds, an agility test, a half-squat 1RM, and a clean-and-jerk 1RM (only for WL). In conclusion, Olympic WL exercises seemed to produce broader performance improvements than VJ exercises in physically active subjects.

Yasuda et al (2011) investigated the combined effect of low-intensity blood flow restriction and high-intensity resistance training on muscle adaptation. Forty young men (aged 22-32 years) were randomly divided into four groups of ten subjects each: high-intensity resistance training (HI-RT, 75% of one repetition maximum [1-RM]), low-intensity resistance training with blood flow restriction (LI-BFR, 30% 1-RM), combined HI-RT and LI-BFR (CB-RT, twice-weekly LI-BFR and once-weekly HI-RT), and nontraining control (CON). In conclusion, none of the variables in the CON group changed. Our results show that low-intensity resistance training with BFR-induced functional muscle adaptations is improved by combining it with HI-RT.

Summary of Literature

The review of literature helped the investigator to spot out relevant topics and variables. Further the literature helped the
investigator to frame the suitable hypothesis leading to the problems. The latest literature also helped the investigator to support her findings with regard to the problem. Further the literature collected in the study will also help the research scholar understanding in the similar areas.

All the research studies were presented in the section proves that there is a significant improvement on physical and physiological parameters due to plyometric training, weight training and combination of training.

The research studies reviewed are from many journals available in the websites such as pubmed, Science Direct Journals, ERIC websites etc., employ the physical variables such as speed, explosive power, agility, muscular endurance, and physiological variables such as resting pulse rate and breath holding time that too among student athletes at college level.

The review of literature helped the researcher from the methodological point of view too. It was learnt that most of the research studies cited in this chapter on the varied intensities of training would effectively improve the various physical and physiological parameter.