Chapter II

REVIEW OF RELATED LITERATURE

The related literature reviewed for better understanding of the problem and to interpret the results has been presented in this chapter. The review was confined to the libraries of Manonmaniam Sundaranar University, Tirunelveli, Dr. Sivanthi Aditanar College of Physical Education, Tiruchendur and through the internet (web sources).

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. The reviews of the literature have been classified under the following headings:

1. Studies on speed components.
2. Studies on strength components.
3. Studies on power components.
4. Summary of the literature.

1. Studies on Speed Components

Simons et al. (2006) assessed the effects of resistance training and walking exercise on measures of functional fitness. Sixty-four volunteers (average age 83.5 years) from an independent-living facility were randomly assigned to walking, resistance training,
or control groups. Participants in the walking and resistance-training groups engaged in two exercise sessions per week for 16 weeks. Measures of functional fitness included upper and lower body strength, hip and shoulder flexibility, agility and balance, coordination, blood pressure, and resting heart rate. Both exercise groups showed significant improvements relative to control group in upper and lower body strength, shoulder flexibility, and agility and balance exercise.

Deane et al (2005) aimed to determining whether a hip flexor resistance-training program could improve performance on a variety of tasks. Thirteen men and eleven women completed an 8-week hip flexion resistance-training program. Eleven men and thirteen women served as controls. Isometric hip flexion strength, 40-yd dash time and the time for the first 10-yds, 4 x 5.8-m shuttle run time, and vertical jump height were evaluated at the beginning and end of the training and control period. Improvements were observed in the training group but not in the control group. An increase in hip flexion strength can help to improve sprint and agility performance for physically active, untrained individuals.

Paton and Hopkins (2005) studied the effect of combining 2 types of training on performance in the competitive phase. It was randomized 18 road cyclists to an experimental (n = 9) or control (n = 9) group for 4–5 weeks of training. The experimental group replaced
part of their usual training with twelve 30-minute sessions consisting of 3 sets of explosive single-leg jumps (20 for each leg) alternating with 3 sets of high-resistance cycling sprints (5 x 30 seconds at 60-70 min(-1) with 30-second recoveries between repetitions). The addition of explosive training and high-resistance interval training to the programs of already well-trained cyclists produces major gains in sprint and endurance performance, partly through improvements in exercise efficiency and anaerobic threshold.

**Cronin and Hansen (2005)** identified the relationship between strength and power and measures of first-step quickness (5-m time), acceleration (10-m time), and maximal speed (30-m time). The maximal strength (3 repetition maximum [3RM]), power (30-kg jump squat, countermovement, and drop jumps), isokinetic strength measures (hamstring and quadriceps peak torques and ratios at 60 degrees .s(-1) and 300 degrees .s(-1)) and 5-m, 10-m, and 30-m sprint times of 26 part-time and full-time professional rugby league players (age 23.2 +/- 3.3 years) were measured. To examine the importance of the strength and power measures on sprint performance, a correlational approach and a comparison between means of the fastest and slowest players was used. It was suggested that improving the power to weight ratio as well as plyometric training involving countermovement and loaded jump-squat training may be more effective for enhancing sport speed in elite players.
Tricoli et al (2005) tested to compare 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. Training volume was increased after 4 weeks. Pretesting and post testing consisted of squat jump (SJ) and countermovement jump (CMJ) tests, 10- and 30-m sprint speeds, and agility test, a half-squat 1RM, and a clean-and-jerk 1RM (only for WL). The WL program significantly increased the 10-m sprint speed. Both groups, WL and VJ, increased CMJ, but groups using the WL program increased more than those using the VJ program. On the other hand, the group using the VJ program increased its 1RM half-squat strength more than the WL group. Only the WL group improved in the SJ (9.5%). There were no significant changes in the control group.

Kotzamanidis (2005) investigated the effect of combined heavy-resistance and running-speed training program performed in the same training session on strength, running velocity (RV), and vertical-jump performance (VJ) of soccer players. Thirty-five individuals were divided into 3 groups. The first group (n = 12, combined group) performed a combined resistance and speed training program at the same training session, and the second one (n = 11, same resistance training group) performed the same resistance
training without speed training. The third group was the control group (n = 12, control group). Three jump tests were used for the evaluation of vertical jump performance: squat jump, countermovement jump, and drop jump. The 30-m dash and 1 repetition maximum (1-repetition tests were used for running speed and strength evaluation, respectively. It is concluded that the combined resistance and running-speed program provides better results than the conventional resistance training, regarding the power performance of soccer players.

Adams, et al (2002) studied the linear effects of four weeks of strength training followed by four weeks of power training on agility and power in strength trained women (N = 14). After strength training, there were no significant improvements in power (vertical and standing long jumps) or agility. After the power training cycle, significant improvements in both power and agility were observed. Strength (1 RM leg squat) improved at the end of both training stages; by 25% after strength training and by a further 11% after power training.

Blazevich and 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 (i.e. 30-50% and 70-90% of 1-RM in the high- and low-velocity training groups, respectively). This was despite significant improvements in 20 m acceleration time. 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.

Young et al (2001) investigated the straight sprint training transferred to agility performance tests that involved various change-of-direction complexities and if agility training transferred to straight sprinting speed. Thirty-six males were tested on a 30-m straight sprint and 6 agility tests with 2-5 changes of direction at various angles. The subjects participated in 2 training sessions per week for 6 weeks using 20-40-m straight sprints (speed) or 20-40-m change-of-direction sprints (3-5 changes of 100 degrees) (agility). Conversely, the agility training resulted in significant improvements in the change-of-direction tests but no significant improvement in straight sprint performance. It is concluded that straight speed and agility-training methods are specific and that they produce limited transfer to the other. These findings have implications for the design of speed and agility training and testing protocols.
Harris (2000) examined the effects of three different resistance-training methods on a variety of performance variables representing different portions of the force velocity curve, ranging from high force to high-speed movements. The groups were high force, high power and combination training group. Group HF trained using 80-85% of the 1RM values. Group HP trained using 30% of peak isometric force. Group COM used combination-training protocol. HF group improved significantly in squat, ¼ squat, mid thigh pull and MK. HP group in ¼ squat, mid thigh pull, VJ, MK and SLJ. And the Com group in squat, ¼ squat, mid thigh pull, VJ, MK, VJP and 10yd. These results indicate that when considering the improvement of a wide variety of athletic performance variables requiring strength, power and speed combination training produces superior results.

Hoff and Berdahl (2000) tested the load dependent strength training effects on power production and performance. The literature proposes that light loads (30% 1 RM) and heavy loads (85% 1 RM) are the appropriate loads to improve dynamic athletic performance, usually the vertical jump. It was concluded that improving vertical jumping height involved more than just the training load in resistance training. The specificity of the training effects of resistance exercises is again demonstrated in this investigation. There is little to no carry-over of training benefits to
actual dynamic performance. However, why sprint times improved and the specifically targeted vertical jump did not is not addressed. One could propose that sprinting is improved by strength training, but since the training employed only the half-squat, which is more related to vertical jumping and less so to sprinting, the effects are puzzling.

**Newberry & Flowers (1999)** tested the three groups of 12 males who underwent different training regimens: sprint training alone (12 x 40-yd, 25-second rest, three days per week), sprint training plus strength training (5 x 12 repetitions of 50% 1-RM, two days per week), and no training (control). Both training groups were significantly in better condition than the no training group. The resistance-training group displayed a significantly higher percentage of maximal velocity than the sprint-only group. There were no significant differences between groups in sprint speed.

**Blazevich and Jenkins (1998)** tested and compared well-trained athletes who were performing low-velocity, high-force resistance training and sprint running training (ST) when recruited, with subjects who were performing low-velocity, high-force resistance training but not sprint training (NST) when recruited. Eleven male sprint runners and eight male weight-trained athletes who were not currently performing sprint training, or any other additional training, participated in the study; all subjects had a minimum of two years
resistance training experience. Tests included 1. running speed (20 m time after a 50 m acceleration distance and 20 m acceleration time from a stationary start), 2. isokinetic hip flexor/extensor torque (and torque adjusted for body mass), angle of peak torque, time to reach peak torque and torque acceleration energy at low moderate and high speeds and 3. maximum squat lift. The results of the present study suggest that athletes who perform low-velocity, high force training concurrently with high-velocity training are superior in tests of isokinetic strength at high velocities when compared to athletes who only perform low-velocity, high force training. This may be due to training or genetic factors.

**Jensen (1997)** investigated effect of combined endurance, strength and sprint training on maximal oxygen uptake, isometric strength and sprint performance in female elite handball players during a season. Eight female handball player from the Norwegian national team and were tested for maximal oxygen uptake, maximal isometric strength and maximal running velocity on four occasions during a year. In conclusion with our training model, where strength training had priority in the first part of the training period, followed by a period where sprint and endurance training had priority, we were able to increase both maximal oxygen uptake and maximal running velocity in female elite handball players in the period with the most important tournament.
Delecluse et al (1995) analyzed the effect of high-resistance (HR) and high-velocity (HV) training on the different phases of 100-m sprint performance. Two training groups (HR and HV) were compared with two control groups (RUN and PAS). The HR and HV group trained 3 d.wk-1 for 9 wk: two strength training sessions and one running session. There was a run control group that also participated in the running sessions (1 d.wk-1) and a passive control group. Running speed over a 100-m sprint was recorded every 2 m. The HV group improved significantly in total 100 m time (compared with the RUN and PAS groups). The HR program resulted in an improved initial acceleration phase (compared with PAS).

Summary

The studies reviewed in this section mostly to find out the development of the speed and agility performances. The effect of the use of weight training methods was proven to be more useful than the other training methods.

2. Studies on Strength Components

Manolopoulos (2006) examined the effect of a soccer (strength and technique) training program on kinematics and electromyographic (EMG) muscle activity during an instep kick. Ten amateur soccer players (aged 19.9+/−0.4 years, body mass 74.8+/−
9.1 kg, height 177.4+/−6.7 cm) constituted the experimental group (EG) whereas 10 players (age 21.6+/−1.3 years, weight 71.5+/−6.7 kg, height 175.2+/−3.4 cm) served as controls (CG). Maximum isometric leg press strength, 10-m sprint performance and maximum speed performance on a bicycle ergometer were also measured. Training had insignificant effects on EMG values, apart from an increase in the averaged EMG of the vastus medialis whereas maximum isometric strength and sprint times significantly improved after training (P<0.05). The present results suggest that the application of the training programs using soccer-specific strength exercises would be particularly effective in improving of soccer kick performance.

Gonzalez, et al (2005) examined the effects of 3 resistance training volumes on maximal strength in the snatch (Sn), clean & jerk (C&J), and squat (Sq) exercises during a 10-week training period. Fifty-one experienced (>3 years), trained junior lifters were randomly assigned to one of 3 groups: a low-volume group (LVG), a moderate-volume group (MVG), and a high-volume group (HVG). All subjects were trained 4-5 days a week with a periodized routine using the same exercises and relative intensities but a different total number of sets and repetitions at each relative load: LVG (1,923 repetitions), MVG (2,481 repetitions), and HVG (3,030 repetitions). It is understand that performing at a moderate volume is more effective and efficient than performing at a higher volume.
McCurdy et al (2005) investigated to compare the effects of short-term unilateral resistance training (UL) and bilateral resistance training (BL) with free weights on several tests of unilateral and bilateral lower-body strength and power in men and women. Thirty-eight untrained men and women completed the study. The groups were trained 2 days per week for 8 weeks with free weights and 2 days per week for 5 of the 8 weeks with plyometric drills. The resistance-training program consisted of a progression from 3 sets of 15 repetitions at 50% of the subject's predicted 1 repetition maximum (1RM) to 6 sets of 5 repetitions at 87% 1RM. Training volume and intensity were equal for each group. The free-weight squat was used to measure unilateral and bilateral strength. The results indicate that UL and BL are equally effective for early phase improvement of unilateral and bilateral leg strength and anaerobic power in untrained men and women.

Goto et al (2004) tested the long-term effects of resistance-training regimens with varied combinations of high- and low-intensity exercises. The long-term effects of periodized training protocols with the above regimens on muscular function were investigated. Male subjects were assigned to either hypertrophy/combi (HC) or hypertrophy/ strength (HS) groups and performed leg press and extension exercises twice a week for 10 weeks. During the first 6 weeks, both groups used the hypertrophy-type regimen to gain
muscular size. During the subsequent 4 weeks, HC and HS groups performed combi-type and strength-type regimens, respectively. Muscular strength, endurance, and cross sectional area (CSA) was examined after 2, 6, and 10 weeks. The results suggest that a combination of high- and low-intensity regimens is effective for optimizing the strength adaptation of muscle in a periodized training program.

Astorino et al (2004) tested the changes in physical fitness parameters during a competitive field hockey season. Division III female field hockey athletes completed tests of muscular strength, body composition, and maximal oxygen uptake (Vo(2)max) during each phase of their season. Muscular strength was assessed using 1 repetition maximum (RM) leg and bench press tests. Body composition was assessed by anthropometry (skinfolds [SKF]), circumferences ([CC]), and bioelectrical impedance analysis (BIA). Incremental treadmill testing was administered to assess Vo(2)max. In conclusion, preseason training was effective in decreasing %BF and increasing Vo(2)max, yet muscular strength was lost. Coaches should incorporate more rigorous in-season resistance training to prevent strength decrements. Moreover, these data support the superior levels of muscular strength and leanness in these athletes compared with age-matched peers.
Vincent et al (2002) examined the effect of 6 months of high- or low-intensity resistance exercise on muscular strength and endurance and stair climbing ability in adults aged 60 to 83. Sixty-two men and women completed the study protocol. Subjects were matched for strength and randomly assigned to a control (n = 16), low-intensity (LEX), or high-intensity (HEX) group. Six months of progressive, whole-body resistance training was given. Subjects were trained at 50% of their one-repetition maximum (1RM) for 13 repetitions (LEX) or 80% of 1RM for eight repetitions (HEX) three times per week for 24 weeks using resistance machines. One set each of 12 exercises was performed. These data indicate that significant and similar improvements in strength, endurance, and stair climbing time can be obtained in older adults as a consequence of high- or low-intensity resistance exercise training. These findings may have an effect on how resistance exercise is prescribed to older adults.

Newton et al (2002) examined the effects of mixed-methods resistance training on young and older men to determine whether similar increases in muscle power were elicited. Effects of 10 wk of a periodized resistance-training program designed to increase muscle size, strength, and maximal power on isometric squat strength, time course of force development, muscle fiber characteristics, and muscle activation (iEMG), as well as force and power output during squat jumps, were compared in young (YM) and older men (OM). Although
the results of this study confirm age-related reductions in muscle strength and power, the older men did demonstrate similar capacity to young men for increases in these variables via an appropriate periodized resistance-training program that includes rapid, high-power exercises.

Faigenbaum et al (2002) compared the effects of 1 and 2 days per week of strength training on upper body strength, lower body strength, and motor performance ability in children. Twenty-one girls and thirty-four boys volunteered to participate in this study. Participants’ strength were trained either once per week or twice per week for 8 weeks at a community-based youth fitness center. One repetition maximum (IRM) strength on the chest press and leg press, handgrip strength, long jump, vertical jump, and flexibility were assessed at baseline and post training. Only participants who had strength trained twice per week made significantly greater gains in IRM chest press strength, compared to the control group (11.5 and 4.4% respectively). Participants who were trained once and twice per week made gains in IRM leg press strength (14.2 and 24.7%, respectively) that were significantly greater than control group gains (2.4%). On average, participants who were strength trained once per week achieved 67% of the IRM strength gains. No significant differences between groups were observed on other outcome measures. These findings support the concept that muscular
strength can be improved during the childhood years and favor a training frequency of twice per week for children participating in an introductory strength-training program.

**Fagan and Doyle-Baker (2000)** tested the effects of maximum strength and power training combined with plyometrics on athletic performance. Ss (M = 19; F = 14) were randomly assigned to two training groups; maximum strength (85-90% 1 RM) and plyometrics, or maximum power (30% 1 RM jump squats) and plyometrics. Female competitive soccer players served as a control group. Training was performed twice a week for 10 weeks. Both groups improved in lower body power and strength. Both forms of training were equally effective in increasing squat strength to perform plyometrics. However, sprint speed over distances of 5-40 meters did not change, therefore, this form of training was very specific and did not carry-over to a useful athletic pursuit.

**Hortobagyi et al (1991)** examined simultaneous training for strength and endurance during a 13-week, 3-day a week program of hydraulic resistive circuit training and running. Eighteen college males (U.S. Army ROTC) were placed into low resistance (LR) or high resistance (HR) groups, and 10 college males were controls and did not train. Pre and posttests included strength, physical fitness, and anthropometry. It is concluded that gains in strength were somewhat compromised by the simultaneous run training, and that
improvements in strength and run performance were independent of LR and HR training intensity.

**Summary**

The studies reviewed in this section mostly to find out the development of the strength performance. The effect of the different weight training methods was proven to be more useful for development of upper and lower body strength.

**3. Studies on Power Components**

**Surakka (2006)** evaluated and compared the effects of training either with a light load or without any load in a 16-week power-type strength training intervention in sedentary middle-aged subjects. A total of 85 subjects participated in the study. In a supervised 22-week training intervention, including 16 weeks of power-type strength training, 42 subjects trained without any external load. Subjects were comparable concerning their training attendance, and anthropometric and physiological characteristics. Training effects were evaluated by measuring Vertical Squat Jump (VSJ), 20-metre Running Time (20 mRT), Maximal Anaerobic Cycling Power of leg muscles (MACP), and Maximal Oxygen Uptake (V.O (2 max)) before and after the intervention. To conclude, the external loads of 2.2 kg, in total, increased the efficiency of power-type
strength training in vertical jumps and in anaerobic power in leg muscles, but not in sprint running.

Clark (2006) investigated the acute effects of a single set of contrast preloading on a loaded countermovement jump training session. The aim of this research was to assess the effect of a single set of contrast preloading on peak vertical displacement (PD) during a loaded countermovement jump (LCMJ) training session. Nine strength-trained males participated in 2 randomly assigned; crossover design testing sessions consisting of 5 sets of 6 repetitions of 20-kg loaded countermovement jump with 3-minute rest intervals between sets. The control group performed 1 set of 20-kg, whereas the jump squat group performed 1 set of 40-kg loaded countermovement jump. These results suggest that a single set of preloading exercises enhances performance during a lower-body explosive power training session; however, the effects of a single preloading set may not peak until midway through the training session.

Baker (2005) investigated the acute effect on power output of alternating an agonist and antagonist muscle exercise during complex training. Twenty-four college-aged rugby league players who were experienced in combined strength and power training served as subjects for this study. They were equally assigned to an experimental (Antag) or control (Con) group and were no different in
age, height, body mass, strength, or maximal power. This result may affect power training and specific warm-up strategies used in ballistic sports activities, with increased emphasis placed upon the antagonist muscle groups.

Kalapotharakos et al (2005) evaluated the effects of a 12 week heavy resistance training in vertical jump and functional performance in healthy, inactive, older women. Seventeen sedentary older women were assigned either to a control (C), or to a heavy resistance training (RT). The RT group trained knee extensors and flexors at 80% of 1-repetition maximum (1-RM), 3 days per week for 12 weeks. Both groups were evaluated in 1-RM lower body strength, squat jump (SJ) and countermovement jump (CMJ) height, and chair rising time, before and after the training period. Muscle power improved after a short-term heavy resistance training, as measured by vertical jump and chair rising performance, in inactive older adults. The gains in muscle strength may contribute to the gains in chair rising time, SJ and CMJ height.

De Vos et al (2005) tested the optimal load for increasing muscle power during explosive resistance training in older adults. One hundred and twelve healthy older adults were randomly assigned to either explosive resistance training at 20% (G20), 50% (G50), or 80% (G80) one repetition maximum (1RM) for 8-12 weeks or to a non-training control group (CON). Participants were trained twice
per week (five exercises; three sets of eight rapidly concentric and slow eccentric repetitions) using pneumatic resistance machines. Peak muscle power may be improved similarly using light, moderate, or heavy resistances, whereas there is a dose-response relationship between training intensity and muscle strength and endurance changes. Therefore, using heavy loads during explosive resistance training may be the most effective strategy to achieve simultaneous improvements in muscle strength, power, and endurance in older adults.

**Henwood et al (2005)** investigated the effects of a short-term high-velocity varied resistance training programme on physical performance in healthy community-dwelling adults aged 60-80 years. Subjects undertook exercise (EX) or maintained customary activity (controls, CON) for 8 weeks. The EX group was trained 2 days/week using machine weights for three sets of eight repetitions at 35, 55, and 75% of their one-repetition maximum (the maximal weight that an individual could lift once with acceptable form) for seven upper- and lower-body exercises using explosive concentric movements. Fourteen EX and 10 CON subjects completed the study. Dynamic muscle strength significantly increased in the EX group for all exercises following training, as did knee extension power. Progressive resistance training that incorporates rapid rate-of-force development movements may be safely undertaken in healthy older adults. It
results in significant gains in muscle strength, muscle power, and physical performance.

Vanrenterghem and Clercq (2004) investigated the contribution that each of the major lower-limb joints makes to vertical jump performance as jump height increases and to comment on the previously mentioned uncertainty. Adult males were asked to perform a series of submaximal (LOW and HIGH) and maximal (MAX) vertical jumps while using an arm swing. Force, motion, and electromyographical data were recorded during each performance and used to compute a range of kinematic and kinetic data, including ankle, knee, and hip joint torques, powers, and work done. It was found that the contribution to jump height made by the ankle and knee joints remains largely unchanged as jump height increases. It was concluded that the role of submaximal and maximal jumps can be differentiated in terms of their effect on ankle, knee, and hip joint muscles and may be of some importance to training regimens in which these muscles need to be differentially trained.

Jensen (2003) conducted a study on kinetic analysis of complex training rest interval effect on vertical jump performance. Repeated measures ANOVA determined a difference (p ≤ 0.05) between genders and that jump performance immediately following the squat exercise was hindered (0.66 m), but no effect (p > 0.05) was found comparing subsequent jumps (0.72-0.76 m) to the pre-squat
condition (0.74 m). In conclusion, complex training does not appear to enhance jumping performance significantly and actually decreases it when the jump is performed immediately following the strength training set; however, a nonsignificant trend toward improvement seemed to be present. Therefore to optimize jump performance it appears that athletes should not perform jumps immediately following resistance training. It may be possible that beyond 4 minutes of recovery performance could be enhanced; however, that was not within the scope of the current study.

**Miszko et al (2003)** determined whether power training was more efficacious than strength training for improving whole-body physical function in older adults and to examine the relationship between changes in anaerobic power and muscle strength and changes in physical function. Thirty-nine men and women with below-average leg extensor power were randomly assigned to control (C), strength-training (ST) or power-training (PT) groups. The ST and PT groups met 3 days per week for 16 weeks; the C group maintained usual activity and attended three lectures during the course of the study. Maximal strength was significantly greater for the ST group than for the C group (p = .015) after the intervention. There was no significant difference between groups for peak anaerobic power. Power training was more effective than strength training for improving physical function in community-dwelling older adults.
**Fielding et al (2003)** tested the hypothesis that a high-velocity resistance-training program (HI) would increase muscle power more than a traditional low-velocity resistance-training program (LO). A randomized trial comparing changes in skeletal muscle power and strength was conducted after 16 weeks of HI or LO. Training was performed three times per week. Improvements in lower extremity peak power may exert a greater influence on age-associated reductions in physical functioning than other exercise interventions.

**Gorostiga et al (2002)** tested the explosive type strength training on force production, sprint performance, endurance and serum hormones in soccer players. Soccer players in two groups performed soccer and explosive-strength training or soccer training alone (control) for 11 weeks. The explosive-strength group significantly improved the low portion of the load vertical jumping curve, the amount of serum testosterone, in the first four weeks, 5-m sprint training. Endurance adaptation was not compromised.

**Jones (2003)** investigated the current practice of complex training using a lower body combination of exercises. Eight strength trained men performed 2 conditions: heavy resistance exercise or control in a counter-balanced order. Both conditions involved 4 sets of 6-jump trials in a form of counter-movement and drop jump height (3-CMJ/ 3-DJ). The control condition involved the same procedure,
but no exercise separated the first 2-sets. There were no significant main effects (p > 0.05) for any CMJ performance variable or EMG activity regardless of muscle or phase of jump. From a practical point of view, undertaking a bout of HRE had no adverse effects on subsequent plyometric performance and so some of the advantages of complex training still remain.

**Osteras et al (2002)** investigated whether the mechanism of this increase is a change in the force-velocity relationship and the mechanical power output. A group of 19 cross-country skiers were randomly assigned to either a high resistance-training group or a control group. Upper body endurance was tested on a ski ergometer. The high-resistance-training group was trained for 15 min on three occasions a week for 9 weeks. Training consisted of three series of five repetitions using 85% of one repetition maximum (1RM), with emphasis on high velocity in the concentric part of the movement. It is concluded that the increased exercise economy after a period of upper body high resistance training can be partly explained by a specific change in the force-velocity relationship and the mechanical power output.

**Fincher (2001)** evaluated the effect of a single-set, high-intensity resistance-training program on gains in the time that collegiate football players were able to maintain a constant power output that stressed anaerobic energy systems. Ss were randomly
assigned to a single-set high-intensity maximally-exhaustive training group or a traditional multiple-set group. The multiple-set group did not attempt extra lifts to achieve maximum exhaustion. Training lasted for 10 weeks. Gains in time before failure for upper and lower body exercises improved significantly for both groups. The one-set high-intensity group gained significantly more than did the multiple-set group.

Choi et al (1997) investigated the comparative effects between power-up type and bulk-up type in strength training. Power-up strength training is employed to mainly improve strength and power while bulk-up training is for muscular hypertrophy. Power-up training (the repetition method) was characterized by longer inter-set intervals while performing 5 sets of 90% of 1 RM. Bulk-up training (the interval method) consisted of shorter inter-set intervals while performing 9 sets of 40-80% (multi-poundage) of 1 RM. Two groups of six males were trained twice per week for 8 weeks. Power-up training showed a greater rate of improvement in all dynamic (1 RM), isometric, and isokinetic knee extension forces under maximal effort but less change in the cross-sectional area of the quadriceps femoris and average knee-extension force. The rate of decrease in 50 consecutive knee extension trials was less in the bulk-up trained group. The two types of training produced different effects (Strength and Power).
Hetzler et al (1997) examined the effects of strength training on anaerobic power in 30 pubescent male athletes, specifically the vertical jump (VJ), (40-yd), and Wingate tests. Subjects were assigned to an experienced training group (ETG), a novice group (NTG), or control (Con), 10 in each group, ETG and NTG trained 12 weeks with free weights and machines, 3 sessions a week. It was concluded that strength training as practiced in this study increased VJ but did not improve the other measures of anaerobic power.

McBride et al (1997) investigated to compare muscle strength and power characteristics between individuals involved in competitive power lifting and Olympic lifting. This study involved a group of 7 power lifters (PL) and a group of 6 Olympic lifters (OL); there were no significant differences in height, weight, or % body fat. This study suggests that while 1-RM squat strength was similar in both groups, there was a significant difference in the ability to generate power particularly in tests involving additional loads. The data may indicate the influence of high force and velocity characteristics associated with Olympic-style lifts in the development of muscle power.

Porcari et al (1996) determined the effectiveness of training in strength shoes Seventy-two college age men were randomized into either a control group (CG), a Strength Shoe group
(SSG), or a regular shoe group (RSG), SSG and RSG trained 3 times a week for 10 weeks and followed identical programs as prescribed by the manufacturer. SSG wore the strength shoe while RSG wore their own shoes. All subjects were pre-and post-tested for 40-ys dash time, vertical jump, standing broad jump, and right and left calf girth. Repeated measures ANOVA revealed that SSG had significantly different from either CG or RSG. There were no within or between group differences for the other variables as a result of training. These results indicate there was a tendency for the type of training used in the present study to improve performance. However, these improvements were independent of the type of training in strength shoes resulted in an increased rate of injury compared to training in regular athletic shoes.

Rash et al (1996) studied the effect of light-resistance, high-repetition weight lifting to the effect of heavy-resistance low-repetition weight lifting on vertical jump and broad jump improvement. The subjects were 29 college age football players participating at the NCAA Division II level. There was no significant difference, between light and heavy groups, pre-or post-test, on vertical jump and three jump broad jump. There was a significant, change in power with resistance training when pre-training vertical jump was compared to post-training for all subjects. There was no significant, change in power, as measured by the three jump broad
jump, when pre-training three jump broad jump was compared to post-training for all subjects.

Summary

This section gives an insight into the number and range of how weight-training methods has been administered for the development of power parameters. It was also found out that most of the studies enhanced power parameters of the subjects.

4. Summary of the literature

The reviews were presented under the three sections such as studies on speed \( n=15 \), strength \( n=10 \) and power \( n=20 \) parameters. All the research studies were presented in this section prove that weight-training methods contribute significantly for better improvement in speed, strength and power (athletic performance) variables.

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 analysis and experimental design as the appropriate methods for finding out the remediation.

The present study may serve as a foundation and main ingredient for future research and investigation in weight training methods for enhancing the athletic performance variables.