Chapter – II

Review of Related Literature
CHAPTER II

REVIEW OF RELATED LITERATURE

The phrase "Review of Literature" consists of two words "Review" and "Literature". In research methodology the term literature refers to the knowledge of a particular area of any discipline which includes theoretical, practical and its research studies. The literature in any field forms the foundation upon which all future work will be built. If foundation of knowledge provided by the review of literature is not done adequately, one work is likely to be a shadow and might have done better by someone else.

A search for the reference materials would assist the investigator to determine the effectiveness of various combinations of the variables, methodology used and the results obtained. The review of related literature may be used as an important adjusts to the investigator by assisting in the interpretation of his own study (Clarke and Clarke, 1976). For this purpose, the investigator has traced out different types of research work such as unpublished theses, journals, research
quartiles, abstract cum souvenirs, relevant studies and variety of relevant books on physical education, sports sciences and internet sources to collect the review of related literature for this study.

*Perez-Gomez, et.al., (2008)* examined the effects of a training programme consisting of weight lifting combined with plyometric exercises on kicking performance, myosin heavy-chain composition (vastus lateralis), physical fitness, and body composition (using dual-energy X-ray absorptiometry (DXA)). The study was conducted by using 37 male physical education students who divided randomly into a training group (TG: 16 subjects) and a control group (CG: 21 subjects). The TG followed 6 weeks of combined weight lifting and plyometric exercises. In all subjects, tests were performed to measure their maximal angular speed of the knee during instep kicks on a stationary ball. Additional tests for muscle power (vertical jump), running speed (30 mtr. running test), anaerobic capacity (Wingate and 300 mtr. running tests), and aerobic power (20 mtr. shuttle run tests) were also performed. Training resulted in muscle hypertrophy (+4.3%), increased peak angular velocity of the knee during kicking (+13.6%), increased percentage of myosin heavy-chain (MHC) type IIa (+8.4%), increased 1 repetition maximum (1 RM) of inclined leg
press (ILP) (+61.4%), leg extension (LE) (+20.2%), leg curl (+15.9%), and half squat (HQ) (+45.1%), and enhanced performance in vertical jump (all p ≤ 0.05). In contrast, MHC type I was reduced (-5.2%, p ≤ 0.05) after training. In the control group, these variables remained unchanged. In conclusion, 6 weeks of strength training combining weight lifting and plyometric exercises results in significant improvement of kicking performance as well as other physical capacities related to success in Football.

Ronnestad, et.al., (2008) compared the effects of strength and plyometric training 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 programme 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 (1 RM) 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 (PP 20, PP 35, and PP 50, respectively), sprint acceleration, peak sprint velocity, and total
time on 40 mtr. sprint. There were no significant differences between the ST+P group and ST group. The intervention group significantly improved in all measurements except CMJ, while the control group showed significant improvements only in PP 20. There was a significant difference in relative improvement between the intervention group and control group in 1RM half squat, 4 BT, and SJ. However, a significant difference between groups was not observed in PP 20, PP 35, sprint acceleration, peak sprinting velocity, and total time on 40 mtr. 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.

Faigenbaum, et.al., (2007) compared the effects of a six week training period of combined plyometric and resistance training (PRT, n = 13) or resistance training alone (RT, n = 14) on fitness performance in boys (12-15 yrs.). The RT group performed static stretching exercises followed by resistance training whereas the PRT group performed plyometric exercises followed by the
same resistance training programme. The training duration per session for both groups was 90 min. At baseline and after training all participants were tested on the vertical jump, long jump, medicine ball toss, 9.1 mtr. sprint, pro agility shuttle run and flexibility. The PRT group made significantly (p< 0.05) greater improvements than RT in long jump (10.8 cm vs. 2.2 cm), medicine ball toss (39.1 cm vs. 17.7 cm) and pro agility shuttle run time (-0.23 sec vs. -0.02 sec) following the training. These findings suggest that the addition of plyometric training to a resistance-training programme may be more beneficial than resistance training and static stretching for enhancing selected measures of upper and lower body power in boys.

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 the 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. Linear periodized resistance training consisted of 5 exercises per workout (4 lower body, 1 upper body) for 3 sets of 3-12 repetition
maximum (RM). Sprint/plyometric training consisted of 5-7 exercises per workout (4-5 plyometric exercises, 40-yd and 60-yd sprints) for 3-6 sets with gradually increasing volume (8 weeks) followed by a 2-week taper phase. Assessments for 1RM squat and bench press, vertical jump, broad jump, sprint speed, and body composition were performed before and following the 10-week training period. Significant increases were observed in both AS and MS groups in 1RM squat (12.0 vs. 14.6 kg), bench press (6.8 vs. 7.4 kg), vertical jump height (3.3 vs. 2.3 cm), and broad jump (17.8 vs. 15.2 cm). Similar decreases in peak 20, 40, and 60mtr. sprint times were observed in both groups (20 m: 0.14 vs. 0.11 seconds; 40 mtr.: 0.29 vs. 0.34 seconds; 60 mtr.: 0.45 vs. 0.46 seconds in AS and MS groups, respectively). However, when sprint endurance (the difference between the fastest and slowest sprint trials) had been analyzed and there was a significantly greater improvement at 60 mtr. in the MS group. 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 mtr. increased to a greater extent during training with the Meridian Elyte athletic shoe.
Herrero, et.al., (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 mtr. 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). Subjects were tested before and after the training programme, as well as once more after 2 weeks of detraining. A significant improvement (p < 0.05) in ST was observed after training (2.4 %) in EG while a significant slowing (p < 0.05) was observed (- 2.3 %) in EPG. Significant increases in EPG (p < 0.05) were observed in SJ (7.5 %) and CMJ (7.3 %) after training, while no significant changes in both jumps were observed after training and detraining for EG. A significant increase (p < 0.05) in MVC was observed after training (9.1 %) and after detraining (8.1 %) in EG. A significant increase (p < 0.05) in MVC was observed after training (16.3 %) in EPG. A significant increase (p < 0.01) in CSA was observed after training in EG (9.0 %) and in EPG (7.1 %). 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. However, EMS training alone did not result in any improvement in jumping explosive strength development or even interfered in sprint run.

Parthiban (2006) compared the effects of maximal resistance training with 60% intensity (MRT 60%), maximal resistance training with 80% intensity (MRT 80%), plyometric training with 60% intensity (PT 60%) and plyometric training with 80% intensity (PT 80%) on selected power and speed related parameters. For this purpose, forty male students studying bachelor's degree in physical education, health education and sports in H.H.The Rajah's College, Pudukkottai, Tamil Nadu, India were selected as subjects at random and they were divided randomly into four experimental groups of ten each, namely Group-I (MRT 60%), Group-II ((MRT 80%), Group-III (PT 60%), and Group-IV (PT 60%). The subjects of the experimental groups underwent their respective training programmes thrice per week for twelve weeks duration. The dependent variables selected for this study were anaerobic power, explosive power, elastic power, speed, stride length and speed endurance. All the subjects were tested prior to and immediately after the experimental period on
the selected dependent variables. The results of the study indicated that all experimental groups were improved significantly in selected criterion variables. Among the experimental groups, PT 60% was found to be better than the other groups in developing anaerobic power, explosive power, elastic power, speed, stride length and speed endurance.

Rahimi (2006) examined the effectiveness of six weeks of plyometric training, weight training and their combination on angular velocity during a 60-second test cycle ergometer. Based on their training, forty-eight male college students were divided into four groups: a plyometric training group (n=13), a weight training group (n=11), a plyometric plus weight training group (n=14), and a control group (n=10). A 15 and 60-second cycle ergometer test measured the angular velocity before and after a six-week training period. Subjects in each of the training groups were trained two days per week, whereas the control subjects did not participate in any training activity. The data was analyzed by a one-way analysis of variance (repeated measures design). The results showed that all the training treatments elicited significant (P<0.05) improvement in angular velocity. However, the combination-training group showed signs of improvement in the angular velocity that was significantly greater than the
improvement of the other two training groups (plyometric training and weight training). It was concluded that a combination of traditional weight training and plyometric drills (complex training) enhance angular velocity production in cycling. Therefore, complex training may help improving performance in sprint cycling that requires angular velocity, angular acceleration and power.

Rahimi and Behpur (2005) compared the effects of three different training protocols such as plyometric training, weight training, and their combination on the vertical jump performance, anaerobic power and muscular strength. Based on their training, forty-eight male college students were divided into 4 groups: a plyometric training group (n=13), a weight training group (n=11), a plyometric plus weight training group (n=14), and a control group (n=10). The vertical jump, the fifty-yard run and maximal leg strength were measured before and after a six-week training period. Subjects in each of the training groups were trained 2 days per week, whereas control subjects did not participate in any training activity. The data was analyzed by one way analysis of variance (repeated-measures design). The results showed that all the training treatments elicited significant (P<0.05) improvement in all the tested variables. However, the combination-training
group showed signs of improvement in the vertical jump performance, the 50-yard dash, and leg strength was significantly greater than the improvement in the other 2 training groups (plyometric training and weight training). This study provides support for the use of a combination of traditional weight training and plyometric drills to improve the vertical jumping ability, anaerobic power and muscular strength.

Tricoli, et al., (2005) discussed regarding the efficiency of training methods that improve lower-body power. Heavy resistance training combined with vertical jump (VJ) training is a well-established training method; however, there is a lack of information about its combination with Olympic weightlifting (WL) exercises. Therefore, the purpose of this study was to compare the short-term effects of heavy resistance training combined with either the VJ or WL programme. 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 programme 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 6 RM half-squat
exercises. Training volume was increased after 4 weeks. Pretesting and post testing consisted of squat jump (SJ) and countermovement jump (CMJ) tests, 10 and 30 mtr. sprint speeds, an agility test, a half-squat 1RM, and a clean-and-jerk 1RM (only for WL). The WL programme significantly increased the 10 mtr. sprint speed (p < 0.05). Both groups, WL and VJ, increased CMJ (p < 0.05), but groups using the WL program increased more than those using the VJ programme. On the other hand, the group using the VJ programme increased its 1RM half-squat strength more than the WL group (47.8 and 43.7%, respectively). Only the WL group improved in the SJ (9.5%). There were no significant changes in the control group. In conclusion, Olympic WL exercises seem to produce broader performance improvements than VJ exercises in physically active subjects.

Fletcher, et al. (2004) determined the effect of combined weight and plyometric programmes on golf drive performance. Eleven male golfer's full golf swing was analyzed for club head speed (CS) and driving distance (DD) before and after an 8-week training programme. The control group (n=5) continued their normal training, while the experimental group (n=6) performed 2 sessions per week of weight training and plyometrics. Controls showed no significant (p ≥ 0.05) changes, while the experimental
subjects showed a significant increase (p<0.05) in CS and DD. The changes in golf drive performance were attributed to an increase in muscular force and an improvement in the sequential acceleration of body parts contributing to a greater final velocity being applied to the ball. It was concluded that specific combined weights and plyometrics training can help to increase CS and DD in club golfers.

Rubenstein (2004) compared the effects of a four-week general resistance training programme (G) to a four-week, combined plyometrics and general resistance training programme (GP) on shot speed on - goal (SS) in Division I Women's Soccer players. Eight members of the Manhattan College Women's Soccer team (19-22 yrs) were randomly assigned to either G (n=4) or GP (n=4). Prior to and subsequent to training, each subject was tested for SS using radar (Sports Radar 3500). Briefly, subjects were asked to kick the ball (size 5, inflated to 6-1.01 atmospheres) maximally to a target 18 ft away. Only trials that fell within 10-degree angle of trajectory relative to the device (visual inspection) were accepted as supported by the manufactures manual. All subjects took a running start (3-4 steps). Three trials were averaged for each subject and the means were compared using dependent 't'-tests. Neither group improved
significantly (p>.05), however GP showed trends (p=.06) favouring increased SS (47.4 ± 2.0 mph PRE vs. 48.0 ± 2.0 mph POST) while G decreased slightly (50.2 ± 4.9 mph PRE vs. 49.8 ± 2.8 mph POST).

**Amandam (2003)** determined whether a 6-week regimen of plyometric training would improve running economy (i.e., the oxygen cost of sub maximal running). Eighteen regular but not highly trained distance runners (age = 29 ± 7 [means ± SD] years) were randomly assigned to experimental and control groups. All subjects continued regular running training for 6 weeks and experimental subjects also did plyometric training. Dependent variables measured before and after the 6-week period were economy of running on a level treadmill at 3 velocities (women: 2.23, 2.68, and 3.13 m.s⁻¹; men: 2.68, 3.13 and 3.58m.s⁻¹), VO₂max, and indirect indicators of ability of muscles of lower limbs to store and return elastic energy. The last were measurements during jumping tests on an inclined (20°) sled: maximal jump height with and without countermovement and efficiencies of series of 40 sub maximal countermovement and static jumps. The plyometric training improved economy (p<0.05), averaged values (m.m¹⁻¹.kg⁻¹) for the 3 running speeds were: (a) experimental subjects -5.14± 0.39 (pre-training) and
5.26 ±0.39 (post-training); and (b) control subjects -5.10 ± 0.36 (pre training) and 5.06 ± 0.36 (post training). The VO_{2\text{max}} did not change with training. Plyometric training did not result in changes in jump height or efficiency variables that would have indicated improved ability to store and return elastic energy. It was concluded that 6 weeks of plyometric training improves running economy in regular but not highly trained distance runners.

**Masamoti, et.al., (2003)** examined the acute effects of plyometric exercise on one repetition maximum (1 RM) squat performance in trained male athletes. Twelve men (mean age ±SD: 20.5± 1.4 years) volunteered to participate in 3 testing sessions separated by at least 6 days of rest. During each testing session the 1 RM was assessed on back squat exercise. Before all the 3 trials subject warmed up on a stationary cycle for 5 minutes and performed static stretching. Subjects then performed 5 sub maximal sets of 1-8 repetitions before attempting a 1 RM lift. Subjects rested for at least 4 minutes between 1 RM trials. During the first testing session (T1) subjects performed a series of sets with increasing load until their 1 RM was determined. During the second and third testing sessions subject performed in counterbalanced order either 3 double-leg tuck jumps (TJ) or 2
depth jumps (DJ) 30 seconds before each 1 RM attempt. The average 1 RM lifts after T1 and testing sessions with TJ or DJ were 139.6 ± 29.3 kg., 140.5 ± 25.6 kg., and 144.5 ± 30.2 kg., respectively (T1<DJ; p<0.05). These data suggest that DJ performed before 1 RM testing may enhance squat performance in trained male athletes.

_Bride, et.al., (2002)_ examined the effect of an 8-week training programme with heavy-versus light-load jump squats on various physical performance measures and electromyography (EMG). Twenty-six athletic men with varying levels of resistance training experience performed sessions of jump squats with either 30% (JS 30, n = 9) or 80% (JS 80, n = 10) of their one repetition maximum in the squat (1 RM) or served as a control (C, n = 7). An agility test, 20 mts sprint, and jump squats with 30% (30 J), 50% (50 J), and 80% (80 J) of their 1 RM were performed before and after training. Peak force, peak velocity (PV), peak power (PP), jump height, and average EMG (concentric phase) were calculated for the jumps. There were significant increases in PP and PV in the 30 J, 50 J, and 80 J for the JS 30 group (p< = 0.05). The JS 30 group also significantly improved in the 1 RM with a trend towards improved 20 mts sprint times. In contrast, the JS80 group significantly improved both PF and PP in
the 50J and 80J and more significantly in the 1 RM but ran significantly slower in the 20-m sprint. In the 30 J, the JS 30 group’s percentage increase in EMG activity was significantly different from the C group. In the 80 J, the JS 80 group’s percentage increase in EMG activity was significantly different from the C group. This investigation indicates that training with light-load jump squat’s results in increased movement velocity capabilities and that velocity-specific change in muscle activity may play a key role in this adaptation.

Maffiuletti, et.al, (2002) investigated the influence of a 4-week combined electro myo stimulation (EMS) and plyometric training programme on the vertical jump performance of 10 volleyball players. Training sessions were carried out three times per week. 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 programme (week 4), as well as once more after 2 week 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 the week 2, MVC significantly increased (+20% knee extensors, +13%
plantar flexors) as compared to baseline (<0.05). After the 4-week training programme, the different vertical jumps considered were also significantly higher compared to pre training (< 0.001), and relative gains were between 8-10% (spike counter movement jump) and 21% (squat jump). The significant increases in maximal strength and explosive strength produced by the training programme were subsequently maintained after an additional 2 weeks of volleyball training. EMS combined with plyometric training has proven useful for the improvement of vertical jump ability in volleyball players. This combined training (approximately 2 weeks) modality produced rapid increases of the knee extensors and plantar flexors maximal strength. These adaptations were then followed by an improvement in general and specific jumping ability, likely to affect performance on the court. 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.

Adams, et.al., (2001) investigated the effects of four weeks of plyometric vs. weighted plyometric training on vertical jump in trained females (n=14). The subjects were divided into two groups. The plyometric group performed depth jumps, split squats, and double-leg hops twice a week. The weighted-plyometric group
performed the same exercises with the addition of a weight equivalent to 20% of one repetition maximum in the fourth week, and 40% of one repetition maximum in the fourth week. Both groups performed 3 x 6 squats one day per week after plyometric training. Both groups improved vertical jump with no difference between them.

**Durham, et. al., (2001)** studied the effects of plyometric and weighted – plyometric training on lower body anaerobic power. Strength – trained females (n=14) performed four weeks of training after being divided into two groups. The PT group performed depth jumps, split squats, and double – leg hops. The weighted group increased added resistance from 20 % to 40 % of one repetition maximum over the four weeks. Both groups increased number of jumps, average jump height, and peak jump height. Power output and fatigue index did not change. There was no significant difference in any variables between the two groups.

**Fagan and Baker (2000)** investigated with nineteen males and fourteen females who were randomly assigned to two training groups such as maximum strength (85-90% 1 RM) and plyometrics, or maximum power (30% 1 RM jump squats) and plyometrics. Female competitive soccer players (N = 6 ) served as
a control group. Training was given 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 distance 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. Strength training only has specific effects on the trained exercises.

Kraemer, et.al. (2000) examined the effects of sprint/plyometric training with the Meridian Elite-style shoe on various performance parameters. Seventeen healthy men were randomly assigned to either an athletic-shoe training group (AS) or a meridian elite-shoe training group (MS). Both the groups participated in an eight week training programme consisting of weight training and sprint/plyometric training. Anthropometry, muscular strength, speed, power and rate of power development assessments were performed prior and after training. Both the groups demonstrated similar increases in 1RM squat and bench press, power output, and rate of force development during jumping. Both the group demonstrated similar improvement in 40-yard dash times, but the MS group showed greater improvement in 60-yards dash times (4 Vs 2% respectively). The
MS group significantly increased their vertical jump height, whereas only a trend \( p = 0.08 \) for improvement was observed in the AS group. Rate of sub maximal force development of the plantar flexor muscles in the dorsi flexed position improved to a greater extent in the MS group. Compared to the two previous studies, this newly designed model of strength shoe showed a lower incidence of pain and injury. In conclusion, the results of the study indicated that the Meridian Elite shoes may have an ergogenic effect on performance when used during eight weeks of sprint / plyometric training.

**Rimmer** and **Sleivert (2000)** studied the effects of sprint-specific plyometric programme on sprint performance. Twenty six male subjects completed the training over eight weeks. A plyometrics group \((N=10)\) performed sprint-specific plyometric exercises, while a sprint group \((N=7)\) performed sprints. A control group \((N=9)\) was included. The subjects performed sprints over 10 and 40 metres distances before (pre) and after (post) training. For the plyometric group, significant decreases in time occurred over the 0-10 metres. \((\text{pre} \ 1.96 \pm 0.10 \ \text{sec}, \ \text{post} \ 1.91 \pm 0.08 \ \text{sec}, \ p=0.001)\) and 0-40 metres. \((\text{pre} = 5.63 \pm 0.18 \ \text{sec}, \ \text{post} = 5.53 \pm 0.20 \ \text{sec}, \ p=0.001)\) distances, but the improvements in the sprint were not significant over either the 0-10 metres. \((\text{pre} \ 1.95 \pm 0.06 \)
sec, post 1.93 ± 0.05 sec) or 0-40 metres distance (pre 5.62 ± 0.14 sec, post 5.55± 0.10 sec). The magnitude of the improvements in the plyometric training group was not however, significantly different from that of the in-sprint group. The control group showed no changes in sprint times. There were no significant changes in stride length or frequency, but ground contact time decreased at 37 metres by 4.4% in the plyometrics group only. It is concluded that sprint specific plyometrics programme can improve 40 metres sprint performance to the same extent as standard sprint training, possibly shortening ground contact time.

According to Jeffrey, et.al., (1999) changes in muscle power output and fiber characteristics following an 8 week plyometric and aerobic exercise programme. Male subjects (n=19) were randomly assigned to either group 1 (plyometric training) or group 2 (plyometric training and aerobic exercise). The plyometric training consisted of vertical jumping, bounding, and depth jumping. Aerobic exercise (at 70% maximum heart rate) was formed for 20 minutes immediately following the plyometric work outs. Muscle biopsy specimens were collected from the muscles vastus lateralis before and after training. Type I and type II fibers were identified and cross-sectional areas were calculated. Peak
muscle power output, measured using a countermovement vertical jump, significantly increased from pre training to post training for group 1 (2.8%) and group 2 (2.5%). Each group demonstrated a significant increase in fiber area from pre training to post training for type 1 (group 1, 4.4%; group 2, 6.1%) and type II (group 1, 7.8%; group 2, 6.8%). Following the plyometric training, there is an increased power output that may in part be related to muscle fiber size.

Rajasekaran (1999) examined the effects of maximum strength and speed training in series and parallel on elastic strength components such as speed, explosive power, leg strength, back strength, stride frequency and anaerobic capacity. For this purpose, forty five male students studying bachelor's degree in Physical Education and Sports, Department of Physical Education, Annamalai University, Annamalai Nagar, Tamil Nadu, India, were selected as subjects at random and they were divided randomly into three groups of fifteen each, namely Group–I (series training), Group–II (parallel training) and Group–III (control group). The subjects of the experimental groups underwent their respective training programmes four days per week for twelve weeks duration. All the subjects were tested prior to and immediately after the experimental period on the selected
dependent variables. The results of the study indicated that all experimental groups were improved significantly the selected criterion variables. Leg strength and back strength showed no significant difference between series and parallel groups. However the increase of leg strength was in favour of parallel group.

*Sundaramoorthy (1999)* conducted a study to find out the effects of isolated and combined weight and plyometric training on selected strength parameters, speed and power. Forty five men students studying Master's Degree in Physical Education at Dr.Sivanthi Aditanar College of Physical Education, Thiruchendur, Tamil Nadu, India were selected as subjects at random and were divided into three groups consisting of 15 subjects each. Group-I underwent weight training, Group II underwent plyometric training, and Group III underwent combined weight and plyometric training. Arm strength, leg strength, explosive strength, strength endurance, speed and elastic power were selected as dependent variables. The dip strength test, leg dynamometer, vertical jump, sit-ups, 50 meters run and bunny hops tests were administered to test the aforesaid variables separately. The results of the study indicated that arm strength, leg strength, explosive strength, strength endurance, speed and elastic power were improved significantly by weight
training, plyometric training and combined weight and plyometric training programmes. No significant difference existed among weight training, plyometric training and combined weight and plyometric training groups in improving the selected dependent variables. However trend was in favour of combined weight and plyometric training group in improving explosive strength, strength endurance, speed and elastic power whereas the trend was in favour of weight training group in improving arm strength and leg strength.

**Gehri, et.al., (1998)** conducted a study to determine which plyometric training technique is the best for improving vertical jumping ability, positive energy production and elastic energy utilization. Data were collected before and after 12 weeks of jump training and were analysed by ANOVA. Subjects (n = 28) performed jump under 3 testing conditions, squat jump, counter movement jump and depth jump. This study proved the efficiency to include plyometric depth jump training as part of the athlete's overall programme for improving vertical jumping ability and concentric contractile performance.

**Holcomb, et.al., (1996)** conducted a study to investigate effectiveness of a modified plyometric programme on power and vertical jump. Fifty one college-age men underwent pre and post
testing to determine power and vertical jump height. The modified plyometric depth jump programme (n=10), was compared to a control (n=9) a counter movement jump programme (n=10), a weight training programme (n=12), and a conventional plyometric depth jump programme (n=10). The test jumps were the counter movement jump (CMJ) and a static jump (SJ). The subjects were trained 3 days a week for 8 weeks. All groups improved in both peak power and vertical jump. The counter movement jump and peak power increased in all training groups but decreased in the control group. ANOVA with repeated measures were used to compare pre and post test scores for all training groups. No significant differences were found for power and vertical jump height between various training methods, but these results should provide a guide for athletes seeking improvements in power and vertical jump.

Lyttle, et. al., (1996) examined the relative effectiveness of two leading forms of athletic training in enhancing dynamic performance in various tests. Thirty three men who participated in various regional level sports, but who had no previously performed resistance training, were randomly assigned to a maximal power training programme, a combined weight and plyometric programme or a non-training control group. The
maximal power group performed weighted jump squats and bench press throws using a load that maximized the power output of the exercise. The combined group underwent traditional heavy weight training in the form of squats, and bench press and plyometric training in the form of depth jumps and medicine ball. The training consisted of two sessions a week for eight weeks. Both types of training groups were equally effective in enhancing a variety of performance measures such as jumping, cycling, throwing and lifting.

*Wilson, et.al., (1996)* was performed in an effort to gain greater insights into the adaptations invoked by plyometric and weight training. Forty-one trained males were randomly allocated into a control, plyometric, or weight-training group. The experimental groups trained for 8 weeks, performing either heavy lifts or dynamic plyometric exercises. The following test items were performed prior to and at the completion of the training period: (a) vertical jump (b) a series of iso-inertial concentric and eccentric tests (c) push-up tests and (d) maximal bench press and squat lifts. Plyometric training significantly enhanced the rate of eccentric lower body force production. The weight training group showed enhanced concentric function. These results were attributed to the specific stresses imposed by the differing forms
of training and were discussed with reference to methods of enhancing training induced adaptations and the types of movements such training would tend to facilitate.

Adams, et al., (1995) conducted a study to investigate the effect of six weeks of squat, plyometric and squat plyometric training on power production. The purpose of this study was to compare the effectiveness of three training programmes Squat (S), Plyometric (P) and Squat-Plyometric (SP) in increasing hip and thigh power production as measured by vertical jump. Forty eight subjects were divided equally into 4 groups: ‘S’, ‘P’, ‘SP’ and control ‘C’. The subjects trained two days a week for a total of seven weeks which consisted of a week in technique learning period followed by six weeks of periodized ‘S’, ‘P’, or ‘SP’ training programmes. Hip and thigh power were tested before and after the training using the vertical jump test and the alpha level was set at .05. Statistical analysis of the data revealed a significant increase in hip and thigh power production, as measured by vertical jump in all three treatment groups. The ‘SP’ group achieved statistically greater improvement than the ‘S’ or ‘P’ groups. Examination of the mean scores shows that the ‘S’ group increased 3.30 centimeters in vertical jump, the ‘P’ group increased 3.81 centimeters and the ‘SP’ group increased 10.67
centimeters. The results indicated that both the 'S' and 'P' trainings are necessary for improving hip and thigh power production as measured by vertical jumping ability.

**Jeyaseelan (1995)** compared the effects of plyometric training on arm strength, arm endurance and arm explosive power of high school boys. For this purpose, 30 boys free from deformities and alignments were selected at random as subjects. Their age ranged from 13 to 15 years. The subjects were divided into experimental group which underwent the prescribed plyometric training programme three days per week for eight weeks and the control group which did not involve in any specific training programme. The data collected from the two groups prior to and after the experimentation were statistically analyzed for significant difference by applying the analysis of covariance (ANCOVA). Finally, it was concluded that all the selected variables were significantly improved due to plyometric training when compared to the control group.

**Reddy (1993)** conducted a study on the effects of plyometric and weight training followed by plyometric training on power, speed, stride length and stride frequency. Forty five boys were selected at random and put into one of the three groups (n=15). Group I underwent plyometric training, Group-II underwent
weight training followed by plyometric training and Group III acted as control. The training period lasted for 12 weeks duration. The subjects were tested on the power, speed, stride length and stride frequency. Performance in power, speed, stride length and stride frequency improved significantly for both plyometric and weight training followed by plyometric training when compared with the control group, and a non significant difference existed between the experimental groups.

*Wilson, et.al., (1993)* determined three theoretically optimal resistance training modalities resulted in the greatest enhancement in the performance of a series of dynamic athletic activities. The three training modalities included (1) traditional weight training (2) plyometric training and (3) explosive weight training at the load that maximized mechanical power output. Sixty-four previously trained subjects were randomly allocated to four groups that included the above three training modalities and a control group. The experimental groups were trained for 10 weeks performing heavy squat lifts, depth jumps, or weighted squat jumps. All subjects were tested prior to training, after 5 weeks of training and at the completion of the training period. The test items included 1) 30 mtr. sprint 2) vertical jumps performed with and without a counter movement 3) maximal
cycle test 4) iso-kinetic leg extension test, and 5) a maximal isometric test. The experimental group which had been trained with the load that maximized mechanical power achieved the best overall results in enhancing dynamic athletic performance recording statistical significant (P<0.05) improvements on most test items.

Fatouros, et.al., (1992) conducted a study to investigate the effect of plyometric training and weight training on force-power parameters of vertical jumping. For this purpose, thirty one male (20.1 + / -1.4 yrs) were subjects to determine if plyometric alone or in combination with weight training would increase force power parameters in vertical jump. Subjects were randomly assigned to either a plyometric training (P) (n=11), weight training (wt) (n=10), or p+wt (pwt) (n=10) group. Training involved progressive intensity increase 60-85% of 1RM, three times a week for thirteen weeks. Dependent variables (Mean leg force, mean leg power and ground time) were compared prior to and after the training. All groups demonstrated significant changes as a result of the training. An ANCOVA was utilized since pre-training values had not been similar at the starting of the training programme. Mean leg force increased 373 N for the 'PWT' group, 237 N for the 'P' group and 181 N for the 'WT' group.
The increases ranged from 17.5–42.6%, average power increased 17 W/KG (PWT), 11.9 W/KG(P) and 11.5 W/KG(WT) which represents improvement of 23–40%. Average ground time decreased by 0.103 seconds, 0.067 seconds and 0.055 seconds for the ‘PWT’, ‘P’ and ‘WT’ groups respectively. ANCOVA revealed that ‘PWT’ training significantly increased force power parameters and decreased ground reaction time compared to both ‘WT’ and ‘P’. These results suggest that plyometrics in conjunction with weight training can produce greater gains in vertical jumping compared to plyometrics or weight training alone.

Conroy (1991) conducted a study to investigate plyometric training and its effect on speed, strength and power of inter-collegiate athletes. Twenty-one female and thirty male track and field athletes at Ohio Northern University served as subjects. The subjects were divided by gender and track group (power or endurance) and randomly assigned to either an experimental group which participated in plyometric training or a control group which did not perform any of these drills. The experimental group trained three times per week with each session lasting 20-40 minutes. Each subject was tested three times during the 14 week study. A repeated measures analysis of variance with three between factors and one within factors was used in comparing the
variables among the groups for pre-test, mid-test and post-testing periods. The between factors were gender (males/females) track group (power/endurance) and treatment group (control/experimental) and the within factor was the three test periods. A total of six assessment tests were administered. The skin fold measurement showed a four-way interaction between gender (male greater than female), between test periods (post test greater than pre-test), between track group (power greater than endurance) and between control and experimental groups. No other test demonstrated any significant differences between the groups. The 40 yard-dash showed a three-way interaction for the experimental group between gender and between track groups. The test for flexibility also showed a three-way interaction between test period between gender and between track groups. Iso-kinetic testing for power (180, 240 and 300 degrees) and the standing long jump showed a significant result for gender and track group. Iso-kinetic testing for strength (60 degrees) and the vertical jump test showed significant results for gender test period and track group. No other significant results were found.
Blakey and Southard (1987) conducted a study to determine the effects of plyometric exercise (depth drops) combined with weight training on dynamic leg strength and leg power. Thirty one University student volunteers were attached at random to three groups according to height of drop. The subjects in each group were classified into two conditions according to leg strength body weight ratio. All groups were administered a dynamic leg strength test and Margaria anaerobic power test prior to and after an eight week plyometric and weight training programme. A two-way ANOVA revealed no significant interactions for length and Margaria power scores. The t-test for mean difference between pre and post test scores demonstrated significant gains in both strength and power for each group. It was concluded that weight training will improve leg strength and power. Furthermore, coaches and athletes should be apprised that neither the level of strength nor height of drop variable altered the resultant training effects of the combination of programme used in this study.

Pothemus, et.al., (1980) examined the effects of plyometric training drills on strength gains of Collegiate Football Players. Plyometric exercises including depth jumping from a height of 45 cms were used in conjunction with weight training over six
weeks. For this group-I performed only conventional weight training exercises, group-II performed weight training and plyometric exercises and group-III performed weight training and undertook plyometric drills while wearing ankle weights. Each group was assessed on its performance in power clean, bench press, half squat and military press. The results of the study showed that group-III (weight training and plyometric drills with ankle weight) significantly (P<.01) improved in all the four tests.

Blattner and Noble (1979) conducted a study on 48 volunteer male subjects to find out the effects of Isokinetic and plyometric training on vertical jumping performance. The subjects (N=48) were randomly assigned to one of the three groups (n=16). Group I was trained with isokinetic exercise, Group II was trained with plyometric exercise and Group III was the control. Subjects in the training group were trained three times a week for eight weeks. The isokinetic group performed three sets of 10 repetitions per set of depth jump from a height of 34 inches with added resistance beginning with weeks 3, 5 and 7 of 10, 15 and 20 pounds respectively. Prior to and at the end of the training period, all the subjects were given a vertical jump and reach test. The analysis of covariance was used to compare post-test scores with the effect of pre-test differences. Results showed
that both the training groups improved significantly in vertical jump capacity. However no significant difference existed among the training groups.