CHAPTER - II

REVIEW OF RELATED LITERATURE

The review of related literature is instrumental in the selection of topic, formulation of hypothesis and deductive reasoning to the problem. It helps to get a clear idea and supports the findings with regard to the problem under study.

The literature in any forms the foundation upon which all future work will be built. “The review of literature is generally used as a basis for inductive reasoning for locating and synthesizing all the relevant literature on particular topic”. The research scholar has gone through the available related literature, which are relevant to the present study and have been presented in the context of strength training. 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.

Stock MS, Beck TW, et.al. (2011) studied to calculate test-retest reliability statistics for peak barbell velocity during the free-weight bench-press exercise for loads corresponding to 10-90% of the 1-repetition maximum (1RM). Twenty-one healthy, resistance-trained men (mean ± SD age = 23.5 ± 2.7 years; body mass = 90.5 ± 14.6 kg; 1RM bench press = 125.4 ± 18.4 kg) volunteered for this study. A minimum of 48 hours after a maximal strength testing and familiarization session, the subjects performed single repetitions of the free-weight
bench-press exercise at each tenth percentile (10-90%) of the 1RM on 2 separate occasions. For each repetition, the subjects were instructed to press the barbell as rapidly as possible, and peakbarbell velocity was measured with a Tendo Weightlifting Analyzer. The test-retest intraclass correlation coefficients (model 2,1) and corresponding standard errors of measurement (expressed as percentages of the mean barbell velocity values) were 0.717 (4.2%), 0.572 (5.0%), 0.805 (3.1%), 0.669 (4.7%), 0.790 (4.6%), 0.785 (4.8%), 0.811 (5.8%), 0.714 (10.3%), and 0.594 (12.6%) for the weights corresponding to 10-90% 1RM. There were no mean differences between the barbell velocity values from trials 1 and 2. These results indicated moderate to high test-retest reliability for barbell velocity from 10 to 70% 1RM but decreased consistency at 80 and 90% 1RM. When examining barbell velocity during the free-weight bench-press exercise, greater measurement error must be overcome at 80 and 90% 1RM to be confident that an observed change is meaningful.

Davis JN, Gyllenhammer LE, et.al., (2011) observed the effects of a circuit training (CT; aerobic + strength training) program, with and without motivational interviewing (MI) behavioral therapy, on reducing adiposity and type 2 diabetes risk factors in Latina teenagers. Thirty-eight Latina adolescents (15.8 ±1.1 yrs) who are overweight/obese were randomly assigned to: Control (C; n=12), CT (n=14) or CT+MI (n=12). The CT classes were held twice a week (60-90 minutes) for 16 weeks. The CT+MI group also received individual or group MI sessions every other week. The following were measured at pre- and post-intervention: strength by 1-repetition max; cardiorespiratory fitness (VO2max) by
submaximal treadmill test; physical activity by accelerometry; dietary intake by records; height, weight, waist circumference; total body composition by DEXA; visceral adipose tissue (VAT), subcutaneous adipose tissue (SAT) and hepatic fat fraction (HFF) by Magnetic Imaging Resonance (MRI); glucose/insulin indices by fasting blood draw. Across intervention group effects were tested using repeated measures ANOVA with post-hoc pairwise comparisons. CT and CT+MI participants, compared to Controls, significantly increased fitness (+16% & +15% vs. -6%; P=0.03), and leg press (+40% vs. +20%; P=0.007). Compared to Controls, CT participants also decreased waist circumference (-3% vs. +3%; P<0.001), SAT (-10% vs. 8%; P=0.04), VAT (-10% vs. +6%; P=0.05), fasting insulin (-24% vs. +6%; P=0.03) and insulin resistance (-21% vs. -4%; P=0.05). CT may be an effective starter program to reduce fat depots and improve insulin resistance in Latino youth who are overweight/obese, while the additional MI therapy showed no additive effect on these health outcomes.

Brown GA., et al, (2010) conducted a study on Oxygen consumption, heart rate, and blood lactate responses to an acute bout of plyometric depth jumps in college-aged men and women. Although plyometrics are widely used in athletic conditioning, the acute physiologic responses to plyometrics have not been described. The purpose of this study was to investigate the oxygen consumption, heart rate, and blood lactate responses to a single session of plyometric depth jumps. Twenty recreationally trained college-aged subjects (10 men, 10 women) participated in a single session of 8 sets of 10 box depth jumps from a height of 0.8 m with 3 minutes of passive recovery between each set. Plyometric depth
jumping elicited 82.5 +/- 3.1% and 77.8 +/- 3.1% of the measured maximal oxygen consumption (O2max) for women and men, respectively, with no difference in oxygen consumption in ml/kg/min or percent O2max between sexes or sets. Heart rate significantly increased (p < 0.05) from 68.1 +/- 2.9 beatsxmin-1 at rest to 169.6 +/- 1.2 beatsxmin-1 during depth jumping. Sets 5 to 8 elicited a higher (p < 0.05) heart rate (173.3 +/- 1.3 beatsxmin-1) than sets 1 to 4 (164.6 +/- 1.8 beatsxmin-1). Women exhibited a higher heart rate (p < 0.05) during sets 1 and 2 (169.9 +/- 2.8 beatsxmin-1) than men (150.7 +/- 4.4 beatsxmin-1). The blood lactate concentrations were significantly (p < 0.05) increased above resting throughout all sets (1.0 +/- 0.2 mmolxL-1 compared with 2.9 +/- 0.1 mmolxL-1), with no differences between sexes or sets. Plyometric depth jumping significantly increased oxygen consumption, heart rate, and blood lactate in both men and women, but no significant difference was found between the sexes. Plyometric depth jumping from a height of 0.8 m has similar energy system requirements to what Wilmore and Costill termed "Aerobic Power" training, which should enhance O2max, lactate tolerance, oxidative enzymes, and lactate threshold.

Trzaskoma L, et al, (2010) conducted a study on the effect of a short-term combined conditioning training for the development of leg strength and power. The aim of the study was to compare the effect of combined weight and pendulum training exercises with those isolated ones on muscle strength and vertical jump performance. A total of 38 young active men were divided into 4 groups performing different combinations of strength and power training and measured directly and 2 weeks after the training program. Weight training and pendulum
swing exercises, involving lower body during dynamic bounces, were used. Results of 1 repetition maximum (1RM) in full squat and squat jump with the barbell, maximal force measured during countermovement jump (CMJ), and hip and knee flexor and extensor isometric strength were analyzed. Significant differences (p < or= 0.05) in strength test (1RM squat, hip and knee flexor and extensor strength) were found when performing weight training (1RM-10.2%; maximal torques-23.2%). Positive significant increase (p < or= 0.05) in all strength and power parameters (maximal torques-from 2, 468.9 +/- 387.4 to 2, 712.4 +/- 501.6 Nxm; 1RM squat-from 93.9 +/- 15.0 to 111.4 +/- 15.6 kg; CMJ power-from 3, 050.7 +/- 478.5 to 3, 419.8 +/- 506.6 W; CMJ jump height-from 48.8 +/- 4.1 to 53.4 +/- 3.0 cm) after the training program was found when combined training was used. Seated safety position during the pendulum swing is responsible for significant training effect with reduced loads. Plyometric pendulum swing training combined with traditional training can be an alternative, effective method to increase muscle strength and power during short pre or in-season mesocycles.

Taipale RS, Mikkola J, et.al., (2010) examined the effects of periodized maximal versus explosive strength training and reduced strength training, combined with endurance training, on neuromuscular and endurance performance in recreational endurance runners. Subjects first completed 6 weeks of preparatory strength training. Then, groups of maximal strength (MAX, n=11), explosive strength (EXP, n=10) and circuit training (C, n=7) completed an 8-week strength training intervention, followed by 14 weeks of reduced strength training. Maximal strength (1RM) and muscle activation (EMG) of leg extensors, countermovement
jump (CMJ), maximal oxygen uptake (VO(2MAX)), velocity at VO(2MAX) (vVO(2MAX)) running economy (RE) and basal serum hormones were measured. 1RM and CMJ improved (p<0.05) in all groups accompanied by increased EMG in MAX and EXP (p<0.05) during strength training. Minor changes occurred in VO(2MAX), but vVO(2MAX) improved in all groups (p<0.05) and RE in EXP (p<0.05). During reduced strength training 1RM and EMG decreased in MAX (p<0.05) while vVO(2MAX) in MAX and EXP (p<0.05) and RE in MAX (p<0.01) improved. Serum testosterone and cortisol remained unaltered. Maximal or explosive strength training performed concurrently with endurance training was more effective in improving strength and neuromuscular performance and in enhancing VO (2MAX) and RE in recreational endurance runners than concurrent circuit and endurance training.

Santos EJ, Janeira MA., et al, (2010) conducted a study on the effects of Plyometric Training followed by Detraining and Reduced Training Periods on Explosive Strength in Adolescent Male Basketball Players. The effects of plyometric training followed by detraining and reduced training periods on explosive strength in adolescent male basketball players. The aims of this study were to determine 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. All participants were assessed on squat jump, countermovement jump, Abalakov test, depth jump, mechanical power, and medicine ball throw at the beginning and at the end of the 10-week in-season plyometric training and on weeks 4, 8, 12, and 16 of the in-season detraining and reduced training periods. In the first phase of the study, the experimental group significantly increased all the assessed indicators (p < 0.05). In the following phase and in general all the groups maintained the previously achieved results. 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.

Maio Alves JM, Rebelo AN, et.al (2010) analyzed in their study the short-term effects of complex and contrast training (CCT) on vertical jump (squat and countermovement jump), sprint (5 and 15 m), and agility (505 Agility Test) abilities in soccer players. Twenty-three young elite Portuguese soccer players (age 17.4 +/- 0.6 years) were divided into 2 experimental groups (G1, n = 9, and G2, n = 8) and 1 control group (G3, n = 6). Groups G1 and G2 have done their regular soccer training along with a 6-week strength training program of CCT, with 1 and 2 training sessions.wk, respectively. G3 has been kept to their regular soccer training program. Each training session from the CCT program was
organized in 3 stations in which a general exercise, a multiform exercise, and a specific exercise were performed. The load was increased by 5% from 1 repetition maximum each 2 weeks. Obtained results allowed identifying (a) a reduction in sprint times over 5 and 15 m (9.2 and 6.2% for G1 and 7.0 and 3.1%, for G2; p < 0.05) and () an increase on squat and jump (12.6% for G1 and 9.6% for G2; p < 0.05). The results suggested that the CCT induced the performance increase in 5 and 15 m sprint and in squat jump. Vertical jump and sprint performances after CCT program were not influenced by the number of CCT sessions per week (1 or 2 sessions.wk). From the obtained results, it was suggested that the CCT is an adequate training strategy to develop soccer players' muscle power and speed.

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

Thomas et al, (2009) conducted a study to compare the effect of two plyometric training techniques on muscular power and agility in youth soccer players. Thirty males from a semiprofessional football club’s academy were randomly assigned to 6 weeks of depth jump (DJ) or counter movement jump (CMJ) training twice weekly. Participants in the DJ group performed drop jump with instructions to minimize ground–contact time while maximizing height. Participants in the CMJ group performed jumps from a standing start position with instructions to gain maximum jump height. Post training, both groups experienced improvements in vertical jump height (p< 0.05) and agility time (p< 0.05) and no change in sprint performance (p<0.05). There were no differences between the treatments groups (p=0.05) the study concludes that both depth jump and counter movement jump (CMJ) plyometric are worth while training activities for improving power and agility in youth soccer players.

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

**Sedano Campo S., et al, (2009)** conducted a study on effects of lower-limb plyometric training on body composition, explosive strength, and kicking speed in female soccer players. The aim of the present study was to examine 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 (CG, n = 10, age 23.0 +/- 3.2 yr) and plyometric group (PG, n = 10; age 22.8 +/- 2.1 yr). The intervention was carried out during the second part of the competitive season. Both groups performed technical and tactical training exercises and matches together. However, the CG followed the regular soccer physical conditioning program, which was replaced by a plyometric program for PG. Neither CG nor PG
performed weight training. Plyometric training took place 3 days a week for 12 weeks including jumps over hurdles, drop jumps (DJ) in stands, or horizontal jumps. Body mass, body composition, countermovement jump height, DJ height, and kicking speed were measured on 4 separate occasions. The PG demonstrated significant increases (p < 0.05) in jumping ability after 6 weeks of training and in kicking speed after 12 weeks. There were no significant times x group interaction effects for body composition. 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. However, players need time to transfer these improvements in strength to the specific task. Regular soccer training can maintain the improvements from a plyometric training program for several weeks.

Patterson C, Raschner C, et.al. (2009) investigated the power-load relationship and to compare power variables and bilateral force imbalances between sexes with squat jumps. Twenty men and 17 women, all members of the Austrian alpine ski team (junior and European Cup), performed unloaded and loaded (barbell loads equal to 25, 50, 75, and 100% body weight [BW]) squat jumps with free weights using a specially designed spotting system. Ground reaction force records from 2 force platforms were used to calculate relative average power (P), relative average power in the first 100 ms of the jump (P01), relative average power in the first 200 ms of the jump (P02), jump height, percentage of best jump height (%Jump), and maximal force difference between dominant and nondominant leg (Fmaxdiff). The men displayed significantly
higher values at all loads for P and jump height (p < 0.05). No significant differences were found in P01. The men had significantly higher P02 at all loads except 75% BW). Maximum P was reached at light loads (men at 25% BW and women at 0% BW), and P decreased uniformly thereafter. Individual power-load curves show a deflection point. It is proposed that the load where the power-load deflection point occurs be used as the power training load and not the load at which maximum P is reached. It is also proposed that loads not be described in %1-repetition maximum (RM), but as %BW. This system can be used to safely assess and train power with loaded jumps and free weights.

Paradisis GP, Bissas A, Cooke CB. (2009) in their study examined the effects of sprint running training on sloping surfaces (3 degrees) on selected kinematic and physiological variables. Fifty-four sport and physical education students were randomly allocated to one of two training groups (combined uphill-downhill [U+D] and horizontal (H)) and a control group (C). Pre- and posttraining tests were performed to examine the effects of 8 wk of training on the maximum running speed (MRS), step rate, step length, step time, contact time, eccentric and concentric phase of contact time (EP, CP), flight time, selected posture characteristics of the step cycle, and 6-s maximal cycle sprint test. MRS, step rate, contact time, and step time were improved significantly in a 35-m sprint test for the U+D group (P<.01) after training by 4.3%, 4.3%, -5.1%, and -3.9% respectively, whereas the H group showed smaller improvements, (1.7% (P<.05), 1.2% (P<.01), 1.7% (P<.01), and 1.2% (P<.01) respectively). There were no significant changes in the C group. The posture characteristics and the peak
anaerobic power (AWT) performance did not change with training in any of the groups. The U+D training method was significantly more effective in improving MRS and the kinematic characteristics of sprint running than a traditional horizontal training method.

Meylan C., et al (2009) conducted a study on the effects of in-season plyometric training within soccer practice on explosive actions of young players. In soccer, explosive actions such as jumping, sprinting, and changes of direction are essential to optimal performance not only in adults, but also in children's games. The purpose of the present investigation was to determine the influence of short-term plyometric training within regular soccer practice on explosive actions of early pubertal soccer players during the in-season. Fourteen children (13.3 +/- 0.6 years) were selected as the training group (TG) and 11 children (13.1 +/- 0.6 years) were defined as the control group (CG). All children were playing in the same league and trained twice per week for 90 minutes with the same soccer drills. The TG followed an 8-week plyometric program (i.e., jumping, hurdling, bouncing, skipping, and footwork) implemented as a substitute for some soccer drills to obtain the same session duration as CG. At baseline and after training, explosive actions were assessed with the following 6 tests: 10-meter sprint, agility test, 3 vertical jump tests (squat jump [SJ], countermovement jump [CMJ], contact test [CT] and multiple 5 bounds test [MB5]). Plyometric training was associated with significant decreases in 10-m sprint time (-2.1%) and agility test time (-9.6%) and significant increases in jump height for the CMJ (+7.9%) and CT (+10.9%). No significant changes in explosive actions after the 8-week period was recorded.
for the CG. The current study demonstrated that a plyometric program within regular soccer practice improved explosive actions of young players compared to conventional soccer training only. Therefore, the short-term plyometric program had a beneficial impact on explosive actions, such as sprinting, change of direction, and jumping, which are important determinants of match-winning actions in soccer performance.

Guadalupe-grau A et al, (2000) conducted a study on the strength training combined with plyometric jumps in adults: sex differences in fat bone axis adaptations. Leptin and osteocalcin play a role in the regulation of the fat bone axis and may be altered by exercise. To determine whether osteocalcin reduces fat mass in humans fed ad labium and if there is a sex dimorphism in the serum osteocalcin and leptin responses to strength training, we studied 43 male (age 23.9 2.4 yr, mean +/- SD) and 23 female physical education students (age 23.2 +/- 2.7 yr). Subjects were randomly assigned to two groups: training (TG) and control (CG). TG followed a strength combined with plyometric jumps training program during 9 weeks, whereas the CG did not train. Physical fitness, body composition (Dual–energy X ray absorptiometry). In the whole group of subjects (prétraining), the serum concentration of osteocalcin was positively correlated (r= 0.29-0.42, p < 0.05) with whole body and regional bone mineral content, lean mass, dynamic strength, and serum free testosterone concentration (r=0.32). However, osteocalcin was negatively correlated with leptin concentration (r= 0.37), fat mass (r= -0.31), and the percent body fat (r= -0.44). Both sexes experienced similar relative improvements in performance, lean mass (+ 4-5%), and whole body (+ 0.78%)
and lumbar spine bone mineral content (+1.2-2%), with training. Serum osteocalcin concentration was increased after training by 45 and 27% in men and women, respectively (p < 0.05). Fat mass was not altered by training. Vastus laterals type II MHC compositional at the start of the training program predicted 25% of the osteocalcin increase after training. Serum leptin concentration was reduced either training in women. In summer, while the relative effector’s strength training plus plyometric jumps in performance. Muscle hypertrophy, and osteogenesis are similar in men and women, serum leptin concentration is reduced only in women. The osteocalcin response to strength trainings is in reduced only in women. The osteocalcin response to strength training is, in part, modulated by the muscle phenotype (MHC isoform composition) despite the increase in osteocalcin, fat mass was not reduced.

Duncan et al. (2009) conducted a study to determine the effects of a 6 week circuit training intervention on body esteem and body mass index in British primary school children. Research examining the impact of physical activity on children’s body image has been limited and equivocal. The current researchers examined the effect of 6-week circuit based training on body esteem and body mass index (BMI) in 68 British children (34 boys and 34 girls, aged 10-11 years, 16% overweight, 7% obese). The body esteem scale for children (BES-C) was administered to both the intervention group and control group, pre, post and 6 weeks post the intervention. BMI was directly assessed from height and body mass pre-and post-intervention. The results of this study revealed that as compared to the control group, participation in 6 week circuit training significantly improved
body esteem scores post-intervention. However, these scores were not sustained 6 weeks post-intervention. The improvement in body esteem scores from pre to post-intervention was greater for girls as compared to boys. Additionally, BMI decreased significantly in the intervention group compared to the control group.

Cesar Mde C, Borin JP, et.al. (2009) investigated the effect of local muscle endurance training on maximal oxygen uptake and ventilatory threshold in young women. Nineteen untrained women, ranging in age from 18 to 26 years, were included in the study and assigned to two groups: the control group (n = 10), and the resistance training group (n = 9). The following variables were obtained at baseline and after 12 weeks: body mass; maximal oxygen uptake, maximal heart rate, maximal oxygen pulse, oxygen uptake at the ventilatory threshold, heart rate at the ventilatory threshold, and oxygen pulse at the ventilatory threshold assessed by cardiopulmonary exercise testing on treadmill; 1-repetition maximum (RM) tests in bench press, latissimus pull down, military press, lying barbell extension, standing barbell curls, leg press, knee extension, and hamstring curl.

The training group underwent resistance strength training. Loading during training followed the concept of maximum repetitions. Each session was defined as the performance of three sets of 15RM with a 60-second rest between sets and exercises. No significant changes were observed in the control group before and after 12 weeks (p > 0.05). All 1RM tests increased after training (p < or = 0.01) in the training group, but no significant change was observed in body mass (p > 0.05). Cardiopulmonary variables showed no significant differences before and after resistance training (p > 0.05). These findings indicate that the local
muscle endurance training realized produces no improvement in cardiorespiratory capacity in young women.

**Villarreal et al, (2008)** compared the low and moderate plyometric training frequency produces greater jumping and sprinting gains compared with high frequency, forty two students were randomly assigned to 1 of 4 groups: control 14 sessions of DJ training and 28 sessions of DJ training. The training protocols included DJ from 3 different heights 20,40 and 60 cm. Maximal strength, vertical height in counter movements jumps and DJs and 20m sprint timers tests were carried out before and after 7 weeks of plyometric training. No significant difference was observed among the groups in pre training in any of the variables tested. No significant changes were observed in the control groups in any of the variables tested at any point. Short-term plyometric training using moderate training frequency and volume of jumps produce similar enhancements in jumping performance, but greater training efficiency compared with high jumping training frequency. In addition, similar enhancements in jumping performance, but greater training frequency. In addition, similar enhancements 20 m sprint time, jumping contact times and maximal strength were observed in both a moderate and low number of training sessions per week compared with high training frequencies, despite the fact that the average number of jumps accomplished in 7s was 25 and 50% of the that performed in 28s. These observations may have considerable practical relevance for the optimal design of plyometric training program for athletes, given that a moderate volume is more efficient than a higher plyometric training volume.
**Vescovi JD., et al, (2008)** compared the effort of a plyometric program on vertical landing force and jumping performance in college women. Subjects were assigned to one of the three groups; a experimental group I (E.G-I), experimental group –II (E.G.-II) and control group (CG). The EG-I, EG-II groups participated in two packages of plyometric training in 50 minutes session for 6 weeks and 60 minute. No specific training is given for control group. The E.G –I included a warm ups, 30-35 min, and a 5 –min cool down. The E.G.- I I included a 5-7 min warm –up 35- 40 min and a 5-7 min cool down’ comparisons were, made using Mann- Whitney u test. Results showed in the intervention group (-222.8 +/- 610.9 N), but was not statistically different (P= 0.122); compared to the change observed in the control group (54.6+/-257.6N) there was no difference in the absolute change values between groups for counter movement jump height (1.0+/−2.8 cm vs. −0.2 +/−1.5 cm, p=0.696). it was concluded, although not statistically significant, the mean absolute reduction in vertical ground reaction force in the training group is clinically meaning full. Eight of the 10 women in the training group reduced vertical ground reaction force by 17.18 %: however, improvements in jumping performance were not absorbed. This indicates that programs aimed at enhancing performance must be designed differently from those aimed at reducing landing forces in recreationally athletic women.

**Sáez, DeVillarreal E. et al, (2008)** conducted a study on the effect of plyometric training on chair-rise, jumping and sprinting performance in three age groups of women. The main purpose of this study was to investigate the influence of 8-wk per iodized plyometric training (PT) on chair-rise, jumping and sprinting
performance in three groups of women of different age (40-50; 50-60; 60-70 years). This study involved a group of 55 women between the ages of 40 and 70 with no PT experience participating in a gymnastic program and recreational activity that did not involve jumping and who had participated since five years. All tests to determine the values of strength endurance, vertical jumping performance (VJP) and velocity were carried out before (PRE), after (POST) and following 8 weeks of rest (DETRAINING) of the 8 weeks of PT. The performance tests were completed in 3 days. The primary finding of this investigation indicates that low impact PT using moderate volume of jumps produced similar enhancements in the three age groups of women in jumping and chair-rise performance (30 CST) (ranging 15-24 %). There were no enhancements in 10 m-sprint time in any of the age groups. In addition, 8 weeks of detraining following an 8 week PT program resulted in similar decreases in chair-rise and jumping performance in all training groups, whereas no further changes were observed in 10-m sprint time. The low impact PT proposed appears to be an optimal stimulus for improving VJP and 30 CST during short-term training periods in untrained middle-aged and elderly women.

**Ronnestad BR., et al, (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. There were no significant differences between the ST+P group and ST group. Thus, the groups were pooled into 1 intervention group. The intervention group significantly improved in all measurements except CMJ, while the control group showed significant improvements only in PP20. There was a significant difference in relative improvement between the intervention group and control group in 1RM half squat, 4BT, and SJ. However, a significant difference between groups was not observed in PP20, PP35, sprint acceleration, peak sprinting 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.

Perez-Gomez J, et al, (2008) conducted a study on effects of weight lifting training combined with plyometric exercises on physical fitness, body composition, and knee extension velocity during kicking in football. The effects of a training program 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)) was examined in 37 male physical education students 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 in-step kicks on a stationary ball. Additional tests for muscle power (vertical jump), running speed (30 m running test), anaerobic capacity (Wingate and 300 m running tests), and aerobic power (20 m 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 < or = 0.05). In contrast, MHC type I was reduced (-5.2%, p < or = 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 (soccer).

Marques MC, et al., (2008) conducted a study on changes in strength and power performance in elite senior female professional volleyball players during the in-season: a case study. It is often recommended that in-season training programs aim to maintain muscular strength and power developed during the off-season. However, improvements in performance may be possible with a well-
designed training regimen. The purpose of this case report is to describe the changes in physical performance after an in-season training regimen in professional female volleyball players in order to determine whether muscular strength and power might be improved. Apart from normal practice sessions, 10 elite female volleyball players completed 2 training sessions per week, which included both resistance training and plyometric exercises. Over the 12-week season, the athletes performed 3-4 sets of 3-8 repetitions for resistance and plyometric exercises during each training session. All sessions were supervised by one of the investigators as well as by the team head coach. Muscular strength and power were assessed before and after the 12-week training program using 4 repetition maximum bench press and parallel squat tests, an overhead medicine ball throw (BTd), as well as unloaded and loaded countermovement jumps (CMJs). Strength improved by 15% and 11.5% in the bench press and parallel squat, respectively (p < 0.0001). Distance in the BTd improved by 11.8% (p < 0.0001), whereas unloaded and loaded CMJ height increased between 3.8 and 11.2%. The current findings suggest that elite female volleyball players can improve strength and power during the competition season by implementing a well-designed training program that includes both resistance and plyometric exercises.

Koshida S, Urabe Y, et.al. (2008) mentioned that previous studies have suggested that resistance training exercise under unstable conditions decreases the isometric force output, yet little is known about its influence on muscular outputs during dynamic movement. In their study they investigated the effect of an
unstable condition on power, force, and velocity outputs during the bench press. Twenty male collegiate athletes (mean age, 21.3 +/- 1.5 years; mean height, 167.7 +/- 7.7 cm; mean weight, 75.9 +/- 17.5 kg) participated in this study. Each subject attempted 3 sets of single bench presses with 50% of 1 repetition maximum (1RM) under a stable condition with a flat bench and an unstable condition with a Swiss ball. Acceleration data were obtained with an accelerometer attached to the center of a barbell shaft, and peak outputs of power, force, and velocity were computed. Although significant loss of the peak outputs was found under the unstable condition (p < 0.017), their reduction rates remained relatively low, approximately 6% for force and 10% for power and velocity outputs, compared with previous findings. Such small reduction rates of muscular outputs may not compromise the training effect. Prospective studies are necessary to confirm whether the resistance training under an unstable condition permits the improvement of dynamic performance and trunk stability.

Impellizzeri FM, et al., (2008) was conducted a study on the effect of plyometric training on sand versus grass on muscle soreness and jumping and sprinting ability in soccer players. The lower impact on the musculoskeletal system induced by plyometric exercise on sand compared to a firm surface might be useful to reduce the stress of intensified training periods or during rehabilitation from injury. The aim of this study was to compare the effects of plyometric training on sand versus a grass surface on muscle soreness, vertical jump height and sprinting ability. Parallel two-group, randomized, longitudinal (pretest-post-test) study. 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. No training surface x time interactions were found for sprint time (p>0.87), whereas a trend was found for SJ (p = 0.08), with both groups showing similar improvements (p<0.001). On the other hand, the grass group improved their CMJ (p = 0.033) and CMJ/SJ (p = 0.005) significantly (p<0.001) more than players in the sand group. In contrast, players in the sand group experienced less muscle soreness than those in the grass group (p<0.001). Plyometric training on sand improved both jumping and sprinting ability and induced less muscle soreness. A grass surface seems to be superior in enhancing CMJ performance while the sand surface showed a greater improvement in SJ. Therefore, 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.

Goodman CA, Pearce AJ, et.al. (2008) compared in their study that 1RM strength, and upper body and trunk muscle EMG activity during the barbell chest press exercise on a stable (flat bench) and unstable surface (exercise ball). After familiarization, 13 subjects underwent testing for 1RM strength for the barbell chest press on both a stable bench and an exercise ball, each separated by at least 7 days. Surface EMG was recorded for 5 upper body muscles and one trunk muscle from which average root mean square of the muscle activity was calculated for the whole 1RM lift and the concentric and eccentric phases. Elbow
angle during each lift was recorded to examine any range-of-motion differences between the two surfaces. The results show that there was no difference in 1RM strength or muscle EMG activity for the stable and unstable surfaces. In addition, there was no difference in elbow range-of-motion between the two surfaces. Taken together, these results indicate that there is no reduction in 1RM strength or any differences in muscle EMG activity for the barbell chest press exercise on an unstable exercise ball when compared to a stable flat surface. Moreover, these results do not support the notion that resistance exercises performed on an exercise ball are more efficacious than traditional stable exercises.

De Villarreal ES, et al, (2008) conducted a study on Low and moderate plyometric training frequency produces greater jumping and sprinting gains compared with high frequency. The purpose of this study was to examine 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. Maximal strength (1 repetition maximum [1RM] and maximal isometric strength), vertical height in countermovement jumps and DJs, and 20-m sprint time tests were carried out before and after 7 weeks of plyometric training. No significant difference was observed among the groups in pre-training
in any of the variables tested. No significant changes were observed in the control group in any of the variables tested at any point. Short-term plyometric training using moderate training frequency and volume of jumps (2 days per week, 840 jumps) produces similar enhancements in jumping performance, but greater training efficiency (approximately 12% and 0.014% per jump) compared with high jumping (4 days per week, 1680 jumps) training frequency (approximately 18% and 0.011% per jump). In addition, similar enhancements in 20-m-sprint time, jumping contact times and maximal strength were observed in both a moderate and a low number of training sessions per week compared with high training frequencies, despite the fact that the average number of jumps accomplished in 7S (420 jumps) and 14S (840 jumps) was 25 and 50% of that performed in 28S (1680 jumps). 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.

Chtara M., et al, (2008) conducted a study on the effect of concurrent endurance and circuit resistance training sequence on muscular strength and power development. The purpose of this study was to examine the influence of the sequence order of high intensity endurance training and circuit training on changes in muscular strength and anaerobic power. Forty eight physical education students (ages,21.4 +/-1.3 years) were assigned to w of 5 groups: no training controls (C, n =9), endurance training (E,n=10), circuit training (S,n=9), endurance before circuit training in the same session, ( E+S,n=10), and circuit before endurance training in
the same session (S+E n=10). Subjects performed 2 sessions per week for 12 weeks. Resistance type circuit training targeted strength endurance (Weeks 1-6) and explosive strength and power (weeks 7-12). Endurance training sessions included a 5 repetition run at the velocity associated with VO2 max (VO2 max) for duration equal to 50% of the time to exhaustion at VO2 max; recovery was for an equal period at 60% of VO2 max. Maximal strength in the half squat, strength endurance in the 1-leg half squat and hip extension, and explosive strength and power in a5 jumps test and countermovement jump were measured pre- and post-testing. No significant differences were shown following training between the S+E and E+S groups for all exercise tests. However, both S+E and E+S groups improved less than the S group in 1 repetition, maximum (p <0.01), right and left 1-leg half squat (0<0.02), 5 jump test (p < 0.01), peak jumping force (p <0.05 peak jumping power (p<0.02), and peak jumping height (p< 0.05). The intra session sequence did not influence the adaptive response of muscular strength and explosives strength and power. Circuit training alone induced strength and power improvements that were significantly greater than when resistance and endurance training were combined, irrespective of the intra session sequencing.

Chtara M, Chaouachi A, et.al., (2008) examined the influence of the sequence order of high-intensity endurance training and circuit training on changes in muscular strength and anaerobic power. Forty-eight physical education students (ages, 21.4 +/- 1.3 years) were assigned to 1 of 5 groups: no training controls (C, n = 9), endurance training (E, n = 10), circuit training (S, n=9), endurance before circuit training in the same session, (E+S, n=10), and circuit before endurance
training in the same session (S+E, n=10). Subjects performed 2 sessions per week for 12 weeks. Resistance-type circuit training targeted strength endurance (weeks 1-6) and explosive strength and power (weeks 7-12). Endurance training sessions included 5 repetitions run at the velocity associated with Vo2max (Vo2max) for a duration equal to 50% of the time to exhaustion at Vo2max; recovery was for an equal period at 60% Vo2max. Maximal strength in the half squat, strength endurance in the 1-leg half squat and hip extension, and explosive strength and power in a 5-jump test and countermovement jump were measured pre- and post-testing. No significant differences were shown following training between the S+E and E+S groups for all exercise tests. However, both S+E and E+S groups improved less than the S group in 1 repetition maximum (p<0.01), right and left 1-leg half squat (p<0.02), 5-jump test (p<0.01), peak jumping force (p<0.05), peak jumping power (p<0.02), and peak jumping height (p< 0.05). The intrasession sequence did not influence the adaptive response of muscular strength and explosive strength and power. Circuit training alone induced strength and power improvements that were significantly greater than when resistance and endurance training were combined, irrespective of the intrasession sequencing.

Berning JM, Coker CA, Briggs D. (2008) determined in the study whether a conventional barbell with chains compared to a conventional barbell without chains would affect the performance of an Olympic Clean. The subjects were also asked regarding their perception of how chains affected their lifting. Four male and 3 female competitive weightlifters who used chains as part of their training participated in the study. The testing protocol compared the
subjects' lifting 80% and 85% of their 1 repetition maximum (1RM) using conventional barbells and their lifting 80% and 85% of their 1RM using chains (75% conventional barbells + 5% chains and 80% conventional barbells + 5% chains, respectively). Video analysis evaluated the bar's vertical displacement and velocity and the rate of force production. Vertical ground reaction forces for the first-pull, unweighting, and second-pull phases of the lift were evaluated by using a force plate. After testing, the subjects completed a 2-item questionnaire asking individual perception of the effects of the chains. The results showed no significant difference for condition for any of the variables examined. In contrast, all subjects perceived that the chains required a greater effort. In conclusion, the results indicated that the addition of chains provided no greater value over lifting conventional barbells alone in the performance of the Olympic Clean, although the subjects perceived the chains to have a positive effect.

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

Stemm JD., et al, (2007) investigated the difference of land- and aquatic-based plyometric training on vertical jump performance. Plyometric training is a popular method by which athletes may increase power and explosiveness. However, plyometric training is considered a highly intense and potentially damaging activity particularly if practiced by the novice individual or if overdone. The purpose of this study was to compare 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. Participants trained twice a week for 6 weeks, and all training sessions were monitored. Pre- and post-test data were collected on maximum vertical jump height. A 2x3 analysis of variance with repeated measures was used to compare vertical jump height among the 3 groups. Results suggested that the aquatic- and land-based groups significantly (p < 0.05)
outperformed the control group in the vertical jump. No significant difference was found in vertical jump performance between the aquatic- and land-based groups. 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.

**Ratamess NA., et al, (2007)** conducted a study on the effects of ten weeks of resistance and combined plyometric/sprint training with the Meridian Elite athletic shoe on muscular performance in women. The purpose of this investigation was to examine the combined effects of resistance and sprint/plyometric training with or without the Meridian Elite 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. 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 60-m sprint times were observed in both groups (20 m: 0.14 vs. 0.11 seconds; 40 m: 0.29 vs. 0.34 seconds; 60 m: 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) was analyzed, there was a significantly greater improvement at 60 m 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 m increased to a greater extent during training with the Meridian Elyte athletic shoe.

Poston B, Holcomb WR, et.al. (2007) investigated in their study, the effect of mechanical vibration on acute power output in the bench press exercise. Ten male subjects who were experienced in resistance training participated in this study. Each subject performed 3 sets of 3 repetitions in the bench press exercise using a load equal to 70% of 1 repetition maximum in each of 2 sessions separated by 3 days. One session served as the experimental (vibration) condition, whereas the other session served as the control (no vibration) condition. The intervention (vibration or control) was applied between sets 2 and 3. The vibration was applied by a vibrating barbell apparatus held by the subjects while lying supine on a bench. The only difference between the 2 conditions was the vibration of the barbell apparatus during the vibration condition. Peak and average power were calculated during each bench press set to determine whether power output differed following vibration compared to control. Average power was significantly higher
for the vibration condition compared to the control (525 +/- 74 vs. 499 +/- 71 W; p = 0.01). There was also a trend toward an increase in peak power in the vibration condition (846 +/- 168 by vs. 799 +/- 149 W; p = 0.06). In general, peak and average power output were higher following the vibration intervention compared to control. However, the sets prior to vibration application during the vibration condition also demonstrated higher power outputs compared with the control condition, which contributed to the main effect for the vibration condition. These results suggest that factors other than the vibration intervention influenced task performance during the vibration condition. We suggest that psychological factors related to the novelty of the vibration intervention were involved. These factors may partially explain the conflicting results of previous investigations that examined vibration as an exercise intervention.

Markovic G., (2007) postulated on the answer of the question in a meta-analytical review,’ Does plyometric training improve vertical jump height’? In his study he determined the precise effect of plyometric training (PT) on vertical jump height in healthy individuals. Meta-analyses of randomized and non-randomized 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). Studies were identified by computerized and manual searches of the literature. Data on changes in jump height for the plyometric and control groups were extracted and statistically pooled in a meta-analysis, separately for each type of jump. A total of 26 studies yielding 13 data points for SJ, 19 data points for CMJ, 14 data points
for CMJA and 7 data points for DJ met the initial inclusion criteria. The pooled estimate of the effect of PT on vertical jump height was 4.7% (95% CI 1.8 to 7.6%), 8.7% (95% CI 7.0 to 10.4%), 7.5% (95% CI 4.2 to 10.8%) and 4.7% (95% CI 0.8 to 8.6%) for the SJ, CMJ, CMJA and DJ, respectively. When expressed in standardized units (ie, effect sizes), the effect of PT on vertical jump height was 0.44 (95% CI 0.15 to 0.72), 0.88 (95% CI 0.64 to 1.11), 0.74 (95% CI 0.47 to 1.02) and 0.62 (95% CI 0.18 to 1.05) for the SJ, CMJ, CMJA and DJ, respectively. PT provides a statistically significant and practically relevant improvement in vertical jump height with the mean effect ranging from 4.7% (SJ and DJ), over 7.5% (CMJA) to 8.7% (CMJ). These results justify the application of PT for the purpose of development of vertical jump performance in healthy individuals.

Markovic G, et al, (2007) investigated on the effects of sprint and plyometric training on muscle function and athletic performance. The purpose of this study was to evaluate 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. Both experimental groups trained for 3 days a week: SG performed maximal sprints over distances of 10-50 M., whereas PG performed
bounce-type hurled jumps and drop jumps. Participants in the CG group maintained their daily physical activities for the duration of the study. Both SG and PG significantly improved drop jump performance (15.6 and 14.2%). SJ and CMJ height (approximately 10 and 6%) and standing long jump distance (3.2 and 2.8%) whereas the respective effect size ES were moderate high ranged between 0.4 and 1.1. In addition, SG also improved isometric squat strength (10%ES=0.4) and SJ and CMJ power (4%ES and 7% ES=0.4), as well as sprint (3.1%;ES=0.9) and agility (4.3%;ES=1.1) Performance. We conclude that short term sprint and athletic performance then does conventional plyometric training. This study provides support for the use of sprint training as an applicable training method of improving explosive performance of athletes in general.

Langford GA, McCurdy KW, et.al. (2007) in their study 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 multivariate and subsequent univariate analyses of variance tests indicated
statistically significant effects from pre- to posttest for peak force on the IB test and the BB, MB, and LB. Correlations among the strength tests were high (0.92 > \( r \leq 0.97 \)) and moderate between the strength tests and IB peak force (0.62 > \( r \leq 0.83 \)). Mean 3 repetition maximum MB strength was 8% higher than BB strength, which was 3% higher than LB strength, indicating differences in the amount of stabilization required to control the resistance. 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.

**Hori N, Newton RU, Andrews WA, et.al. (2007)** compared in their study the power output values obtained from 4 different methods and to examine the relationships between these values. Male semiprofessional Australian rules football players (n = 30) performed hang power clean and weighted jump squat while ground reaction force (GRF)-time data and barbell displacement-time data were sampled simultaneously using a force platform and a linear position transducer attached to the barbell. Peak and mean power applied to the barbell was obtained from barbell displacement-time data (method 1). Peak and mean power applied to the system (barbell + lifter) was obtained from 3 other methods: (a) using GRF-time data (method 2), (b) using barbell displacement-time data (method 3), and (c) using both barbell displacement-time data and GRF-time data
The peak power values (W) obtained from methods 1, 2, 3, and 4 were (mean +/- SD) 1,644 +/- 295, 3,079 +/- 638, 3,821 +/- 917, and 4,017 +/- 833 in hang power clean and 1,184 +/- 115, 3,866 +/- 451, 3,567 +/- 494, and 4,427 +/- 557 in weighted jump squat. There were significant differences between power output values obtained from method 1 vs. methods 2, 3, and 4, as well as method 2 vs. methods 3 and 4. The power output applied to the barbell and that applied to the system was significantly correlated (r = 0.65-0.81). As a practical application, it is important to understand the characteristics of each method and consider how power output should be measured during the hang power clean and the weighted jump squat.

Cowley PM, Swensen T, Sforzo GA. (2007) conducted a study to evaluate the influence of platform (unstable vs. stable, stability ball vs. flat bench) on strength and work capacity during barbell chest-press exercise. We also sought to determine the effects of a barbell chest-press training program performed on a stability ball or flat bench on strength, work capacity, and abdominal power. Fourteen young women (20 - 23 yr) performed a 1 repetition maximum (1RM) barbell chest-press and the YMCA bench press test (YBT) on a stability ball and flat bench, as well as two field tests measuring abdominal power. The women were then assigned to perform 3 weeks of barbell chest-press training on a stability ball (SB group) or flat bench (FB group); assignment was balanced based on 1RM strength. Barbell chest-press training included 3 sets of 3 - 5 repetitions at loads greater or equal to 85 % of 1RM. The 1RM barbell chest-press, YBT, front abdominal power test (FAPT), and side abdominal power test (SAPT) were used
to evaluate changes in strength, work capacity, and abdominal power, respectively.

The chest-press tests were completed on both platforms following the training program. Platform (stability ball vs. flat bench) had no influence on strength, but work capacity was initially 12% lower on the stability ball compared to the flat bench. In response to training, both groups significantly increased strength and work capacity, and there were no group differences. The increase in 1RM strength was 15% and 16% on the stability ball and flat bench for the SB group, and 16% and 19% for the FB group, respectively. The increase in work capacity was 32% and 13% on the stability ball and flat bench for the SB group, and 27% and 26% for the FB group, respectively. Both groups significantly improved on the FAPT, and there were no group differences. Performance on the FAPT improved by 5% for the SB group, and 22% for the FB group. Performance on the SAPT did not change. Barbell chest-press training performed on either the stability ball or flat bench increased strength and work capacity, and these changes were transferable across platforms. Thus, the stability ball is an effective platform for barbell chest-press training in untrained women over a short duration.

Myer GD., et al, (2006) determined the effects of plyometric vs. dynamic stabilization and balance training on power, balance, and landing force in female athletes. Neuromuscular training protocols that include both plyometrics and dynamic balance exercises can significantly improve biomechanics and neuromuscular performance and reduce anterior cruciate ligament injury risk in female athletes. The purpose of this study was to compare the effects of
plyometrics (PLYO) versus dynamic stabilization and balance training (BAL) on power, balance, strength, and landing force in female athletes. Either PLYO or BAL were included as a component of a dynamic neuromuscular training regimen that reduced measures related to ACL injury and increased measures of performance. Nineteen high school female athletes participated in training 3 times a week for 7 weeks. The PLYO (n = 8) group did not receive any dynamic balance exercises and the BAL (n = 11) group did not receive any maximum effort jumps during training. Pre training vs. post training measures of impact force and standard deviation of center of pressure (COP) were recorded during a single leg hop and hold. Subjects were also tested for training effects in strength (isokinetic and isoinertial) and power (vertical jump). The percent change from pretest to posttest in vertical ground reaction force was significantly different between the BAL and PLYO groups on the dominant side (p < 0.05). Both groups decreased their standard deviation of center of pressure (COP) during hop landings in the medial/lateral direction on their dominant side, which equalized pretested side to side differences. Both groups increased hamstrings strength and vertical jump. The results of this study suggest that both PLYO and BAL training are effective at increasing measures of neuromuscular power and control. A combination of PLYO and BAL training may further maximize the effectiveness of preseason training for female athletes.

Kotzamanidis, C., (2006) examined in a study on the effect on plyometric training on running performance and vertical jump in pre pubertal boys. The purpose of this study was to investigate the effect of plyometric training on
running velocity (RV) and squat jump (SJ) in prepubescent boys. Fifteen boys (11.1+/− 0.5 years) followed a 10 weeks plyometric program (JUMP group). Another group of 15 boys (10.9+/− 0.7 years) followed only the physical education program in primary school and was used as the control group (CONT group). Running distances (0-10M, 10-20 M, and 20-30 M and 0-30m), were selected as testing variables to evaluate the training program. The total number of humps was initially 60 per session, which was gradually increased over a period off 10 weeks to 100 per session. Results revealed significant difference between CONT and JUMP groups in RV and SJ. in JUMP group the velocity for the running distances 0-30, 10-20 and 20-30 m increased (P < 0.05), but nor for the distance 0-10 m (P >0.05). Additionally, the SJ performance of the JUMP group increased significantly as well (P < 0.05). There was no change in either RV or SJ for the CONT group. These results indicate that plyometric exercise can improve SJ and RV in pre-pubertal boys. More specifically, this program selectively influenced the maximum velocity phase, but not the acceleration phase.

Herrero J.A., et al, (2006) conducted a study on electro-miyo stimulation and plyometric training effects on jumping and sprint time. This study compared the effects of four week training periods of electro-miyo stimulation (EMS), plyometric training (P), or combined EMS and P training of the knee extends or muscles on 20 M sprint time (ST), jumping ability (squat jump) (SJ) and countermovement hump (CmJ), maximal isometric strength (MVC), and muscle cross sectional area (CSA), forty subjects were randomly assigned to one of the four treatment groups: electro-miyo stimulation (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 program, as well as once more after 2 wk 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 humps 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 < 0.05) in CSA was observed after training in EG (9.0%) and in EPG (7.1%). EMS combined with plyometric training increased the humping height and sprint run in physically active men. In addition, DMS 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.

Cribb PJ, Williams AD, Carey MF, Hayes A. (2006) observed in a study where a double-blind protocol, 13 male, recreational bodybuilders supplemented their normal diet with either WI or C (1.5 gm/kg body wt/d) for the duration of the program. Strength was assessed by 1-RM in three exercises (barbell bench press, squat, and cable pull-down). Body composition was assessed by dual energy X-ray absorptiometry. Plasma glutamine levels were determined by the enzymatic method with spectrophotometric detection. All assessments occurred in the week
before and the week following 10 wk of training. Plasma glutamine levels did not change in either supplement group following the intervention.

Spurrs, Murphy and watsford. (2003) conducted a study to examine whether changes in running performance resulting from plyometric training were related to alterations in lower leg muscles tedious stillness (MTS). 17 male runners were pre and post-tested for lower leg MTS, maximum isometric force, rate of force development, 5-bound distance test (5BT), counter movement jump (CMJ) height, RE, Vo (2 max), lactate threshold [Th (cla)], and a 3-km time. The subjects were randomly split into an experimental (E) group which completed 6 weeks of plyometric training in conjunction with their normal running training, and a control(C) group which trained as normal. Following the training period, the E group significantly improved 3-km performance and RE at each of the tested velocities, while no changes in Vo (2 max) or Th (la) were recorded. CMJ height, 5 BT and MTS also increased significantly. No significant changes were observed in any measures for the C group. The result clearly demonstrated that a 6-week plyometric programme led to improvements in 3-km running performance. It is postulated that the increase in MTS resulted in improved RE which is believed to make changes in 3km running performance, as there were no corresponding alternations in Vo (2 max) or Th (la).

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

Millet GP., et al, (2002) conducted a study on the effects of concurrent endurance and strength training on running economy and VO(2) kinetics, The purpose of this study was to examine the influence of a concurrent HWT+ endurance training on CR and the VO(2) kinetics in endurance athletes. Fifteen triathletes were assigned to endurance + strength (ES) or endurance – only (E) training for 14 wk. The training program was similar, except ES performed two HWT sessions a week. Before and after the training period, the subjects performed 1) and incremental field running test for determination of VO(2max) and the velocity associated (V(VO2max)), the second ventilatory threshold (VT2)); 2) a 3000 –m run at constant velocity, calculated to require 25% of the difference
between VO(2max) and VT(2), to determine CR and the characteristics of the VO(2) kinetics; 3) maximal hopping tests to determine maximal mechanical power and lower-limb stiffness; 4) maximal concentric lower-limb strength measurements. Results showed that After the training period, maximal strength were increased (P<0.01) in ES but remained unchanged in E. Hopping power decreased in E(P<0.05). After training, economy (P<0.05) and hopping power (P<0.001) were greater in ES than in E. VO(2max), leg hoping stiffness and the VO(2) Kinetics were not significantly affected by training either in ES or E.

**Diallo (2001)** examined the effectiveness of plyometric training and maintenance training on physical performances in prepubescent soccer on players was examined. Twenty boys aged 12-13 years were divided into two groups (10 in each): Jump group (JG) and control group (CG). JG trained 3 days/week during 10weeks, and performed various plyometric exercises including jumping, hurdling and skipping. However, all subjects continued their soccer training. Maximal cycling power (P max) was calculated using a force-velocity cycling test. Jumping power was assessed by using the following tests: counter movement jump (CMJ), squat jump (SJ), drop jump (DJ), multiple 5 bounds (MB5) and repeated rebound jump for 15 seconds (RRJ15). Running velocities included; 20, 30 and 40m (v20, v30, v40m). Body fat percentage (BF percent) and lean leg volume were estimated by anthropocentric before training; except for BF percent all baseline anthropometrics characteristics were similar between JG and CG. After the training program P max, CMJ, SJ, MB5, RRJ15 and v20M, performances increased in the JG. During this period, no significant performance increase was
obtained in the CG. After the 8 week of reduced training, except P max for CG, any increase was observed in both groups. 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.

Trzaskoma Z, Wit A, et.al. (1992) observed in their study, the effects of conventional weight-training (control) with an experimental programme. The training programme consisted of 12 sessions, 3 a week for 4 weeks. The experimental group (n = 12) performed sets of forearm flexion with a barbell until a 20% decline in maximal force was noted. The controls (n=11) trained according to established weight-training principles. Isometric tests were performed on both the right and left forearm flexors and during forearm flexion with a barbell: the tests were continued for a 3-week post-experimental period. The subjects were matched on all tests at the start of the experiment. Larger reductions in muscle torque within the training sessions were noted among the experimental subjects--19.8 +/- 2.0, 16.9 +/- 1.9 and 18.0 +/- 1.8% for right, left and combined elbow flexion respectively, compared to 11.8 +/- 2.7, 14.9 +/- 4.1 and 13.4 +/- 3.1% for the controls. The volume of training (number of lifts) was 30.4% higher for the experimental subjects. Muscle strength increased in both groups (P less than 0.05). The controls improved by 12.7 +/- 6.9, 24.9 +/- 22.1, 18.3 +/- 12.3 and 30.3 +/- 11.1% for right, left, combined isometric strength and the barbell test respectively. These did not differ significantly from the corresponding results for the experimental group--7.6 +/- 8.8, 17.0 +/- 12.4, 11.8 +/- 9.3 and 29.1 +/- 10.6% (P
greater than 0.05). Neither the decrease in force during a single training session nor the volume of training were related to the training effect expressed as an increase in muscle force (P greater than 0.05). The effectiveness of the conventional programme in producing similar improvements in muscle strength to the experimental programme suggests that a high volume of training is unnecessary for strength gains.