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 had gone through the available related literature, which were relevant to the present study and collected reviews pertinent to plyometric training and resistance training.

2.1 STUDIES ON EFFECT OF PLYOMETRIC EXERCISES

Miller et al. (2006) conducted a study on the effects of a 6 weekplyometric training program on agility. Subjects were divided into two groups, a plyometric training and a control group. The plyometric training group performed in a six week plyometric training program and the control group did not perform any plyometric training techniques. All subjects participated in two agility tests: T-test and Illinois Agility Test, and a force plate test for ground reaction times both pre and post testing. Univariate ANCOVAs were conducted to analyze the change scores (post – pre) in the independent variables by group (training or control) with pre scores as covariates. The Univariate ANCOVA revealed a significant group effect $F_{2,26} = 25.42$, $p=0.0000$ for the T-test agility measure. For the Illinois Agility test, a significant group effect $F_{2,26} = 27.24$, $p = 0.000$ was also found. The plyometric training group had quicker post test times compared to the control group for the agility tests. A significant group effect $F_{2, 26} = 7.81$, $p = 0.002$ was found for the Force Plate test. The plyometric training group reduced time on the ground on the post test compared to the control group. The results of this study show that plyometric training can be an effective training technique to improve an athlete's agility.

Chimera et al. (2004) conducted a study on the effects of plyometrictraining on muscle-activation strategies and performance of the lower extremity during jumping exercises. Twenty healthy National Collegiate Athletic Association Division I female athletes were selected. A pretest and posttest control group design was used. Experimental subjects performed plyometric exercises 2 times per week for 6 weeks. Surface electromyography was used to assess preparatory and reactive activity of the vastusmedialis and vastuslateralis, medial and lateral hamstrings, and hip abductors and adductors. Vertical jump height and sprint speed were assessed with the VERTEC and infrared timing devices, respectively. Multivariate analyses of variance revealed significant ($P<.05$) increases in firing of adductor muscles during the preparatory phase, with significant interactions for area, mean, and peak. A Tukey honestly significant difference post hoc analysis revealed significant increases in preparatory adductor area, mean, and peak for experimental group. A significant ($P = .037$) increase in preparatory adductor-to-abductor muscle coactivation in the experimental group was identified, as well as a trend ($P = .053$) toward reactive quadriceps-to-hamstring muscle coactivation in the experimental group. Pearson correlation coefficients revealed significant between-groups adaptations in muscle activity patterns pretest to posttest. Although not significant, experimental and control subjects had average increases of 5.8% and 2.0% in vertical jump height, respectively. The increased preparatory adductor activity and abductor-to-adductor coactivation represent preprogrammed motor strategies learned during the plyometric training. These data strongly support the role of hip-musculature activation strategies for dynamic restraint and control of lower extremity alignment at ground contact. Plyometric exercises should be incorporated into the training regimens of female athletes and may reduce the risk of injury by enhancing functional joint stability in the lower extremity.

Raj Kumar & Harish Kumar (2005) attempted to find the effect ofsix weeks of two types of plyometric circuit training programmes on jumping performance of female college level players and athletes were compared. Circuit Training Programme-I used depth jumping in combination with hopping and hurdling while Circuit Training Programme-II comprised only of depth jumping from boxes varying in heights from 15-45cms. The results show that gains in jumping abilities as a result of CTP-II are much higher than the gains accruing as a result of CTP-I. The amount of gain in abilities is not uniform. The gain varies from ability to ability. CTP-II has proved more effective in improving the jumping abilities of the subjects because it is more saturated with depth jumping exercises.

Turner, Owings, and Schwane (2003) determined whether a 6-weekregimen of plyometric training would improve running economy (i.e., the oxygen cost of submaximal running). Eighteen regular but not highly trained distance runners (age 5 29 6 7 [mean 6 *SD*] years) were randomly assigned to experimental and control groups. All subjects continued regular running training for 6 weeks; 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·s21; men: 2.68, 3.13, and 3.58 m·s21),V˙ O2max, 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 (208) sled: maximal jump height with and without countermovement and efficiencies of series of 40 submaximal countermovement and static jumps. The plyometric training improved economy (*p* , 0.05). Averaged values (m·ml21·kg21) for the 3 running speeds were: (a) experimental subjects—5.14 6 0.39 pretraining, 5.26 6 0.39 posttraining; and (b) control subjects—5.10 6 0.36 pretraining, 5.06 6 0.36 posttraining. TheV˙ O2max 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. We conclude that 6 weeks of plyometric training improves running economy in regular but not highly trained distance runners; the mechanism must still be determined.

Ratamess et al. (2007) examined the combined effects of resistanceand sprint plyometric training with or without the Meridian Elyte athletic shoe on muscular performance in women. Fourteen resistance-trained women were randomly assigned to one of 2 training groups: (a) an athletic shoe (N = 6) (AS) group or (b) the Meridian Elyte (N = 8) (MS) group. Training was performed for 10 weeks and consisted of resistance training for 2 days per week and 2 days per week of sprint/plyometric training. 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.

Villarreal, González-Badillo, and Izquierdo (2008) examined theeffect 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, and60 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 differences were 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 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.

Hossini et al. (2012) compared three methods of plyometric trainingon muscles power among female students. Thirty three participants (age, 16.8 ± 3.7 yrs; weight, 56.26 ± 6.9; height, 155.96 ± 7.2) selected for this study. The subjects were randomize in three groups included over handle jump (N=11), drop jump (N=11) and high jump groups (N=11). All of the groups performed plyometric training in separate protocols for 18 sessions, 3 times per week and at least 30 minutes activity after warm up. The subjects measured in two sessions before and after training sessions. The result of the study revealed that a significantly improvement in pretest and post test in three methods of groups. The finding of the study provided evidence that no significant difference between three methods of plyometric (OJ, DJ and HJ groups) on muscles power is detected. Therefore, the plyometric training can use to improvement in muscles power in female students.

Gehri (1998) determined which plyometric training technique is bestfor improving vertical jumping ability, positive energy production, and elastic energy utilization. Data were collected before and after 12 weeks of jump training and were analyzed by ANOVA. Subjects (N = 28) performed jumps under 3 testing conditions-squat jump, countermovement jump, and depth jump-and were randomly assigned to 1 of 3 groups: control, depth jump training, or countermovement jump training. The 12-week program resulted in significant increases in vertical jump height for both training groups. The depth jump group significantly improved their vertical jump height in all 3 jumps. None of the training methods improved utilization of elastic energy. In activities involving dynamic stretch-shorten cycles, drop jump training was superior to countermovement jump training due to neuromuscular specificity. This study provides support for the strength and conditioning professional to include plyometric depth jump training as part of the athlete's overall program for improving vertical jumping.

de Villarreal, et al., (2009) has done a research on plyometric training improves vertical jump height (VJH). However, the effectiveness of plyometric training depends on various factors. A meta-analysis of 56 studies with a total of 225 effect sizes (ESs) was carried out to analyze the role of various factors on the effects of plyometrics on VJH performance. The inclusion criteria for the analysis were a) studies using plyometric programs for lower-limb muscles, b) studies employing true experimental designs and valid and reliable measurements, and c) studies including enough data to calculate ESs. Subjects with more experience in sport obtained greater enhancements in VJH performance ($p < 0.01$). Subjects in either good or bad physical condition benefit equally from plyometric work ($p < 0.05$), although men tend to obtain better power results than women after plyometric training ($p < 0.05$). With relation to the variables of performance, training volumes of more than 10 weeks and more than 20 sessions, using high-intensity programs (with more than 50 jumps per session), were the strategies that seemed to maximize the probability of obtaining significantly greater improvements in performance ($p < 0.05$). To optimize jumping enhancement, the combination of different types of plyometrics (squat jump + countermovement jump + drop jump) is recommended rather than using only 1 form ($p < 0.05$). However, no extra benefits were found to be gained from doing plyometrics with added weight. The responses identified in this analysis are essential and should be considered by strength and conditioning professionals with regard to the most appropriate dose-response trends for optimizing plyometric-induced gains.

Moran, et al., (2009) studied plyometric training on an athletic performance perspective it may be beneficial to undertake drop jump training when fatigued (principle of "specificity" of training), such endurance fatigue may expose the body to a greater risk of injury if it causes an increase in peak impact accelerations. This study aimed to determine if endurance fatigue resulted in an increase in tibial peak impact acceleration and an associated change in knee kinematics when completing plyometric drop jumps. Fifteen females performed drop jumps from 3 heights (15, 30, and 45 cm) when fatigued and nonfatigued. Treadmill running was used to induce endurance fatigue. The following variables were assessed: tibial peak impact acceleration, knee angle at initial ground contact, maximum angle of flexion, range of flexion, and peak knee angular velocity. Fatigue resulted in significantly greater ($p < 0.05$) tibial peak impact acceleration and knee flexion peak angular velocity in drop jumps from 15 and 30 cm, but not from 45 cm. Fatigue had no effect on any of the knee angles assessed. The neuromuscular system was affected negatively by endurance fatigue at 15 and 30 cm, indicating that coaches should be aware of a potential increased risk of injury in performing drop jumps when fatigued. Because from the greater drop height of 45 cm the neuromuscular system had a reduced capacity to attenuate the impact accelerations per se, whether nonfatigued or fatigued, this would suggest that this height may have been too great for the athletes examined.

Bonacci, et al., (2009) evaluated on endurance sports such as running, cycling and triathlon has long been investigated from a physiological perspective. A strong relationship between running economy and distance running performance is well established in the literature. From this established base, improvements in running economy have traditionally been achieved through endurance training. More recently, research has demonstrated short-term resistance and plyometric training has resulted in enhanced running economy. This improvement in running economy has been hypothesized to be a result of enhanced neuromuscular characteristics such as improved muscle power development and more efficient use of stored elastic energy during running. Changes in indirect measures of neuromuscular control (i.e. stance phase contact times, maximal forward jumps) have been used to support this hypothesis. These results suggest that neuromuscular adaptations in response to training (i.e. neuromuscular learning effects) are an important contributor to enhancements in running economy. However, there is no direct evidence to suggest that these adaptations translate into more efficient muscle recruitment patterns during running. Optimization of training and run performance may be facilitated through direct investigation of muscle recruitment patterns before and after training interventions. There is emerging evidence that demonstrates neuromuscular adaptations during running and cycling vary with training status. Highly trained runners and cyclists display more refined patterns of muscle recruitment than their novice counterparts. In contrast, interference with motor learning and neuromuscular adaptation may occur as a result of ongoing multidiscipline training (e.g. triathlon). In the sport of triathlon, impairments in running economy are frequently observed after cycling. This impairment is related mainly to physiological stress, but an alteration in lower limb muscle coordination during running after cycling has also been observed. Muscle activity during running after cycling has yet to be fully investigated, and to date, the effect of alterations in muscle coordination on running economy is largely unknown. Stretching, which is another mode of training, may induce acute neuromuscular effects but does not appear to alter running economy. There are also factors other than training structure that may influence running economy and neuromuscular adaptations. For example, passive interventions such as shoes and in-shoe orthoses, as well as the presence of musculoskeletal injury, may be considered important modulators of neuromuscular control and run performance. Alterations in muscle activity and running economy have been reported with different shoes and in-shoe orthoses; however, these changes appear to be subject-specific and non-systematic. Musculoskeletal injury has been associated with modifications in lower limb neuromuscular control, which may persist well after an athlete has returned to activity. The influence of changes in neuromuscular control as a result of injury on running economy has yet to be examined thoroughly, and should be considered in future experimental design and training analysis.

2.2 STUDIES ON EFFECT OF RESISTANCE TRAINING

Anderson & Kearney (1982) conducted a study on effects of threeresistance training programs on muscular strength and absolute and relative endurance. Three sets of Ss: (a) a high-resistance-low-repetition (HL) group (N = 15) performed three sets of 6-8 RM per session; (b) a medium-resistance-medium-repetition (MM) group (N = 16) performed two sets of 30-40 RM per session; and (c) a low-resistance-high-repetition (LH) group (N = 12) performed one set of 100-150 RM, trained three times per week for nine weeks. Strength (1 RM), absolute, and relative endurance were assessed before and after the training period. The 20% improvement in 1 RM strength in the HL group was significantly greater than the 8% (MM) and 5% (LH) changes in the other two groups. In terms of absolute endurance, the LH (41%) and MM (39%) groups improved significantly more than the HL (28%) group. When relative endurance was considered it was found that the HL group actually decreased (7%) while the MM group improved by 22% and the LH group improved by 28%. Those differences were significant. These results show that resistance training in untrained males produces changes in strength and endurance irrespective of the protocol. However, those forms of training which favoured strength development (high resistance) produced strength improvement only while those which favored endurance development (high repetitions) produced endurance and to a much lesser extent strength. The major anomaly was that the HL group actually decreased in relative endurance.

Paula et al. (1998) assessed whether resistance training modifiedthe changes in joint range of motion developed through flexibility training. Young adult Ss (M = 26; F = 15) were allocated to one of four groups: i) resistance training, ii) flexibility training, iii) resistance and flexibility training, and iv) no training. There was no change in either muscle strength or flexibility in the control group. Muscle strength improved in both resistance-training groups. Flexibility improved in both flexibility training groups but was unchanged in the resistance training only group.

Dorgo (2012) compared hamstring (H) and quadriceps (Q) strengthchanges in men and women, as well as changes in conventional and functional H:Q ratios following an identical 12-week resistance training program. An isokinetic dynamometer was used to assess 14 male and 14 female participants before and after the intervention, and conventional and functional H:Q ratios were calculated. Hamstring strength improved similarly in men and women, but improvement in quadriceps strength was significantly greater in men, while women showed only modest improvements. For the conventional and functional H:Q ratios, women showed significantly greater improvements than men. Both men and women were able to exceed the commonly recommended 0.6 conventional and 1.0 functional H:Q ratios after the 12-week lower-body resistance training program.

Brenner, et al. (2000) attempted to find the effect of Creatine Supplementation During Resistance Training in Women. Sixteen collegiate women lacrosse players consumed either creatine (C, n 5 7) or a placebo (P, n 5 9) for 5 weeks during their preseason conditioning program (20 g · d21 for 1 week and 2 g · d21 for 4 weeks). Pre- and posttesting consisted of body composition, muscle endurance test, blood lactate response to the endurance test, 1 repetition maximum (1RM) bench press and leg extension, and blood glutamyltransferase (GGL) and blood urea nitrogen (BUN). Testing revealed that 1RM bench press significantly increased in both groups, with the C group improving significantly more than the P group (6.2 6 2.0 and 2.8 6 1.8 kg). Percent body fat by skinfold decreased significantly more in C than the P group (21.2 6 0.9 and 0.3 6 0.8), but was not different by group by hydrodensitometry. No significant differences between groups were found for all other measures, but significant time effects were noted for body weight gain (0.5 6 3.2 kg), 1RM leg extension (1.4 6 4.1 kg), BUN (0.07 6 0.03 mmol · L21), total work during the muscle endurance test (283.5 6 387.3 watts), and fat-free mass by skinfold (0.7 6 1.2 kg). In summary, a regime of dietary creatine supplementation significantly improved upper-body strength gain and decreased the percent body fat as assessed by skinfold in women athletes engaged in a resistance-training program.

Andrea et al. (2007) compared the effects of plyometric training andtraditional weight training on aesthetic jumping ability, lower-body strength, and power in collegiate dancers. Eighteen female dancers who were enrolled in a minimum of one intermediate or advanced ballet or modern class at Skidmore College volunteered to participate in the study. Twelve subjects were randomly assigned to a plyometric (n = 6) or traditional weight training (n = 6) group. The remaining six subjects served as a self-selected control group. The plyometric group performed 3 sets of 8 repetitions of 4 different lower-body plyometric exercises twice a week. The weight training group performed 3 sets of 6 to 8 repetitions of 4 lower-body isotonic exercises twice a week. The control group refrained from all forms of strength training. Each subject maintained her normal dance classes throughout the six week intervention. All subjects were tested prior to and following the six-week training period. Testing consisted of assessments of jumping skill and lower-body strength and power. Strength was assessed via 3 one-repetition maximum tests: leg press, leg curl, and leg extension. Power was assessed with a Wingate anaerobic power test and vertical jump height tests. Aesthetic jumping ability was assessed via an evaluation by dance faculty at Skidmore College on ballon, jump height, ability to point the feet in the air, and overall jumping ability. There were no differences in the descriptive measures of jumping ability, strength or power among the groups at the start of the study. The plyometric group significantly increased leg press strength (37%), standing vertical jump height (8.3%), and aesthetic jump height (14%). The weight training group significantly increased leg press strength (32%), leg curl strength (23%), mean anaerobic power (6%), aesthetic jump height (22%), and aesthetic ability to point the feet in the air (20%). No significant changes were seen in the control group. The results of this study indicate that either plyometric training or traditional lower-body weight training can be useful in improving variables applicable to dance. This study also supports the notion that short-term dance training alone may not be sufficient to elicit improvements in these variables.

Jothi, et al. (2010) assessed the effect of eight weeksconcurrent strength and plyometric training in enhancing the selected biomotor abilities. For the purpose of this study, thirty male volleyball specialization students from the department of physical education and sports sciences, Annamalai University, aged 20 to 22 years took part in the study. Subjects were randomly assigned to either concurrent training (n=15) or control (n=15) group. The training regimen lasted for eight weeks. The selected criterion variables were assessed using standard tests and procedures, prior to and immediately after the training programme. Analysis of covariance was employed to establish the degree of significant modification on chosen criterion variables. The findings of the study revealed that eight weeks of concurrent training had an effectiveness of 4.13% on leg strength, 11.81% on strength endurance, 0.40% on speed, and 7.53% on anaerobic power. These findings suggest that the concurrent strength and plyometric training programme have statistically significant influence in developing the selected criterion variables.

Prabhakaran et al. (1999) studied the effects of a supervised,intensive (85% of one repetition maximum (1-RM)) 14 week resistance training programme on lipid profile and body fat percentage in healthy, sedentary, premenopausal women. Twenty four women (mean (SD) age 27 (7) years) took part in the study. Subjects were randomly assigned to either a non-exercising control group or a resistance exercise training group. The resistance exercise training group took part in supervised 45-50 minute resistance training sessions (85% of 1-RM), three days a week on non-consecutive days for 14 weeks. The control group did not take part in any structured physical activity. Two way analysis of variance with repeated measures showed significant ($p < 0.05$) increases in strength (1-RM) in the exercising group. There were significant ($p < 0.05$) decreases in total cholesterol (mean (SE) 4.68 (0.31) v 4.26 (0.23) mmol/1 (180 (12) v 164 (9) mg/dl)), low density lipoprotein (LDL) cholesterol (2.99 (0.29) v 2.57 (0.21) mmol/l (115 (11) v 99 (8) mg/dl), the total to high density lipoprotein (HDL) cholesterol ratio (4.2 (0.42) v 3.6 (0.42)), and body fat percentage (27.9 (2.09) v 26.5 (2.15)), as well as a strong trend towards a significant decrease in the LDL to HDL cholesterol ratio ($p = 0.057$) in the resistance exercise training group compared with their baseline values. No differences were seen in triglycerides and HDL cholesterol. No changes were found in any of the measured variables in the control group. These findings suggest that resistance training has a favourable effect on lipid profile and body fat percentage in healthy, sedentary, premenopausal women.

Kraemer (2001) examined the effects of resistance trainingprograms on strength, power, and military occupational task performances in women Untrained women aged (mean 6 SD) 23 6 4 yr were matched and randomly placed in total- (TP, *N* 5 17 and TH, *N* 5 18) or upper-body resistance training (UP, *N* 5 18 and UH, *N* 5 15), field (FLD, *N* 5 14), or aerobic training groups (AER, *N* 5 11). Two periodized resistance training programs (with supplemental aerobic training) emphasized explosive exercise movements using 3- to 8-RM training loads (TP, UP), whereas the other two emphasized slower exercise movements using 8- to 12-RM loads (TH, UH). The FLD group performed plyometric and partner exercises. Subjects were tested for body composition, strength, power, endurance, maximal and repetitive box lift, 2-mile loaded run, and U.S. Army Physical Fitness Tests before (T0) and after 3 (T3) and 6 months of training (T6). For comparison, untrained men (*N* 5 100) (MEN) were tested once. Specific training programs resulted in significant increases in body mass (TP), 1-RM squat (TP, TH, FLD), bench press (all except AER), high pull (TP), squat jump (TP, TH, FLD), bench throw (all except AER), squat endurance (all except AER), 1-RM box lift (all except aerobic), repetitive box lift (all), push-ups (all except AER), sit-ups (all except AER), and 2-mile run (all). Strength training improved physical performances of women over 6 months and adaptations in strength, power, and endurance were specific to the subtle differences (e.g., exercise choice and speeds of exercise movement) in the resistance training programs (strength/power vs strength/hypertrophy). Upper- and total-body resistance training resulted in similar improvements in occupational task performances, especially in tasks that involved upper-body musculature. Finally, gender differences in physical performance measures were reduced after resistance training in women, which underscores the importance of such training for physically demanding occupations.

Hoffman JR, etal. (2009)examined the efficacy of periodization and to compare different periodization models in resistance trained American football players. Fifty-one experienced resistance trained American football players of an NCAA Division III football team (after 10 weeks of active rest) were randomly assigned to 1 of 3 groups that differed only in the manipulation of the intensity and volume of training during a 15-week offseason resistance training program. Group 1 participated in a nonperiodized (NP) training program, group 2 participated in a traditional periodized linear (PL) training program, and group 3 participated in a planned nonlinear periodized (PNL) training program. Strength and power testing occurred before training (PRE), after 7 weeks of training (MID), and at the end of the training program (POST). Significant increases in maximal (1-repetition maximum [1RM]) squat, 1RM bench press, and vertical jump were observed from PRE to MID for all groups; these increases were still significantly greater at POST; however, no MID to POST changes were seen. Significant PRE to POST improvements in the medicine ball throw (MBT) were seen for PL group only. The results do not provide a clear indication as to the most effective training program for strength and power enhancements in already trained football players. Interestingly, recovery of training-related performances was achieved after only 7 weeks of training, yet further gains were not observed. These data indicate that longer periods of training may be needed after a long-term active recovery period and that active recovery may need to be dramatically shortened to better optimize strength and power in previously trained football players.

Faigenbaum AD, etal. (2007) evaluated the efficacy of an after-school resistance training program on improving the physical fitness of middle school-age boys. 22 boys (M = 13.9 yr., SD = .4 yr.) participated in a periodized, multiple-set, 9-wk. (2x/week) resistance training program. All subjects were pre- and post-tested on their 10-repetition maximum squat, 10-repetition maximum bench press, vertical jump, medicine ball toss, flexibility, and also percentage of body fat and the progressive aerobic cardiovascular endurance run (PACER). Statistical analysis indicated that subjects significantly improved performance on the squat (19%), bench press (15%), flexibility (10%), vertical jump (5%), medicine ball toss (12%), and the PACER (36%). Although this design minus a control group limits interpretation, this after-school resistance-training program can improve muscular fitness and cardiovascular fitness in boys and should be replicated with appropriate experimental controls.

Dixon CB, etal. (2006) determined whether acute resistance exercise increases serum malondialdehyde (MDA) levels postexercise, and if so, whether resistance exercise training status influences the magnitude of the exercise-induced lipid peroxidation response. Twelve recreationally resistance-trained (RT) and 12 untrained (UT) men who did not have resistance exercise experience in the past year participated in this study. All subjects completed an 8-exercise circuit resistance exercise protocol consisting of 3 sets of 10 repetitions at 10 repetitions maximum for each exercise. Blood samples were obtained pre-exercise, at 5 minutes postexercise, and at 6, 24, and 48 hours postexercise. At pre-exercise, MDA (nmol.ml(-1)) averaged 3.41 +/- 0.25 (RT) and 3.20 +/- 0.25 (UT) and did not differ ($p > 0.05$) either between groups or over time. Creatine kinase (IU.L(-1)) was significantly ($p < 0.05$) elevated 5 minutes postexercise (170.6 +/- 25.8), 6 hours postexercise (290.3 +/- 34.4), 24 hours postexercise (365.5 +/- 49.9), and 48 hours postexercise (247.5 +/- 38.5) as compared with pre-exercise (126.4 +/- 20.2) for both groups. There was no difference ($p > 0.05$) in CK activity between groups. This study indicated that moderate-intensity whole-body resistance exercise had no effect on serum MDA concentration in RT and UT subjects.

2.3 STUDIES ON EFFECT OF COMBINED TRAINING

Singh (2012) observed the effects of a combined training program(weight training and plyometrics) on explosive strength development in adolescents Taekwondo players. 30 Taekwondo state level players (E.G. n=15 and C.G. n= 15) aged 14 to 15 years volunteered to take part in this study. The experimental group underwent resistance training program followed by plyometrics training program three days in a week for six weeks. The subjects were assessed before and after 6 weeks of training program for upper and lower extremities explosive strength. The results of the present study support the use of complex training to improve the upper and lower body explosive strength level in the adolescents.

Rahmi and Behpur (2005) compared the effects of 3 differenttraining protocols-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 trained 2 days per week, whereas control subjects did not participate in any training activity. The data was analyzed by a 1-way analysis of variance (repeated-measures design). The results showed that all the training treatments elicited significant ($P<0.05$) improvement in all of the tested variables. However, the combination training group showed signs of improvement in the vertical jump performance, the 50 yard dash, and leg strength that 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, explosive performance in general and leg strength.

Sankarmani et al. (2012) compared the effects of weight trainingwith and without plyometrics. Subjects were 40 intercollegiate athletes assigned to two training groups randomly, plyometric weight training and weight training. Each group completed a 6-week training program. There was more significant improvement in anaerobic power and muscle strength for the athletes trained with plyometric weight training methods than weight training alone. There was significant improvement of vertical jump height, 50 yard dash and 1RM squat performance in plyometrics and weight training group than the weight training group alone. Plyometric with weight training is more effective in improving vertical jump, 50 yard dash and 1 RM squat performance in athletes than the weight training alone.

Vallimurugan (2012) assessed the effect of complex training onselected physiological variables of women sports participants. To achieve the purpose of the present study, thirty women sports participants from Idhaya Engineering College for Women, Tamilnadu, India were selected as subjects and their ages were from 18 to 24 years. The subjects were divided into two equal groups. The groups were assigned as complex training and control group in an equivalent manner. The experimental group was participated the training for a period of twelve weeks to find out the outcome of the training package. Analysis of covariance (ANCOVA) was applied to find out the means difference between two groups. The result reveals that the complex training group showed significant improvement on all selected variables among women sports participants. It was also found that the experimental group shown significant improvement on all the selected variables than the control group.

Singh, et al. (2012) attempted to find out the effects ofplyometrical and resistance training and their combination on flexibility of state level adolescent male athletes. So experimental method was used is the study. The present study was conducted on athletes studying in school of Ambala city from 13 to 18 years. As per the requirement of the study the players have been divided into three groups. i.e., control group and experimental group 1, and, experimental group 2. These subjects will be the players who have participated at state level competitions in athletes and each group comprised of 66 subjects. All the instruments to be used in this investigation should be found to be quite precise and reliable. For plyomeric training the researcher is going to use the following instruments. i.e. medicine ball, skipping ropes and wooden boxes of different size. For resistance training the researcher is going to use the following instruments. i.e. bar-bell, rubber plates of different weights, fixed bar (for pull-ups), adjustable bench (for bench press) and mats (for sit-ups). For testing the statistical significance of the difference between the group means and Analysis of co-variance (ANCOVA) test was employed and further to access the significant improvement Level of Significant Difference (LSD) Test has been employed. To test the proposed hypothesis the level confidence chosen was at 0.05 level of significance. The results show that plyometric training is better than resistance as well as combination to improve flexibility.

Karim et al. (2011) examined the effects of eight weeks of strengthtraining, Plyometric, and combination training on dynamic balance in teenage Handball player. 40 teenage Handball players with the means and standard deviation between the ages of 93.16 years, weight of 39.72 kg and with the height of 73.176 and any signs of lower body damage, arterial disorders participated voluntarily. The day before training for eight weeks, subject's dynamic balance is measured by SEBT test. During eight weeks in which 3 groups did their especial trainings, Control group were asked to continue their daily activities. Descriptive statistics, one way ANOVA and Tukey's post hoc test were used at significance level of (for statistical analysis of the given data. Results showed that strength trainings, Plyometric and combinational have significant increase in subjects achievement distance in eight directions SEBT. Also, combination of strength training and plyometric and plyometric training in comparison with strength training creates more improvement in subject's dynamic balance.

Faigenbaum et al. (2007) compared the effects of a six weektraining period of combined plyometric and resistance training (PRT, n =13) or resistance training alone (RT, n = 14) on fitness performance in boys (12-15 yr). The RT group performed static stretching exercises followed by resistance training whereas the PRT group performed plyometric exercises followed by the same resistance training program. 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 m 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 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.

Grau (2009) determined whether osteocalcin reduces fat mass inhumans fed ad libitum 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 wk, whereas the CG did not train. Physical fitness, body composition (dual-energy X-ray absorptiometry), and serum concentrations of hormones were determined pre- and posttraining. In the whole group of subjects (pretraining), 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. Vastuslateralis type II MHC composition at the start ofthe training program predicted 25% of the osteocalcin increase after training. Serum leptin concentration was reduced with training in women. In summary, while the relative effects of 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 training is, in part, modulated by the muscle phenotype (MHC isoform composition).

Myer et al. (2006) compared the effects of plyometrics (PLYO) versusdynamic stabilization and balance training (BAL) on power, balance, strength, and landing force in female athletes. Either PI-,YO 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 *in* = 81 group did not receive any dynamic balance exercises and the BAL *in* - 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 bold. Subjects were also tested for training effects in strength (isokinetic and isoinertial) and power (vertical jump). The percent change from pretest to post test in vertical ground reaction force was significantly different between the BAL and PLYO groups on the dominant side *ip*< 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.

Vossen (2000) compared dynamic pushup (DPU) and plyometricpush-up (PPU) training programs on 2 criterion measures: (a) the distance achieved on a sitting, 2-handed medicine ball put, and (b) the maximum weight for 1 repetition of a sitting, 2-handed chest press. Thirty-five healthy women completed 18 training sessions over a 6-week period, with training time and repetitions matched for the DPU (*n* 5 17) and PPU (*n* 5 18) groups. Dynamic push-ups were completed from the knees, using a 2-second-up–2-second-down cadence. Plyometric push-ups were also completed from the knees, with the subjects allowing themselves to fall forward onto their hands and then propelling themselves upward and back to the starting position, with 1 push-up completed every 4 seconds. The PPU group experienced significantly greater improvements than the DPU group on the medicine ball put (*p* 5 0.03). There was no significant difference between groups for the chest press, although the PPU group experienced greater increases.

Lephart et al. (2005) investigated the effects of an 8 weekplyometric and basic resistance training program on neuromuscular and biomechanical characteristics in female athletes. Twenty seven high school female athletes participated either in a plyometric or a basic resistance training program. Knee and hip strength, landing mechanics, and muscle activity were recorded before and after the intervention programs. In the jump-landing task, subjects jumped as high as they could and landed on both feet. Electromyography (EMG) peak activation time and integrated EMG of thigh and hip muscles were recorded prior to (preactive) and subsequent to (reactive) foot contact. Both groups improved knee extensor isokinetic strength and increased initial and peak knee and hip flexion, and time to peak knee flexion during the task. The peak preactive EMG of the gluteus medius and integrated EMG for the gluteus medius during the preactive and reactive time periods were significantly greater for both groups. Basic training alone induced favourable neuromuscular and biomechanical changes in high school female athletes. The plyometric program may further be utilised to improve muscular activation patterns.

Santos and Janeira (2008) evaluated the effects of a complextraining program, a combined practice of weight training and plyometrics, on a explosive strength development of young basketball players. Twenty-five young male athletes, aged 14–15 years old, were assessed using squat jump (SJ), countermovement jump (CMJ), Abalakov test (ABA), depth jump (DJ), mechanical power (MP), and medicine ball throw (MBT), before and after a 10-week in-season training program. Both the control group (CG; n = 10) and the experimental group (EG; n = 15) kept up their regular sports practice; additionally, the EG performed 2 sessions per week of a complex training program. The EG significantly improved in the SJ, CMJ, ABA, and MBT values (p , 0.05). The CG significantly decreased the values (p , 0.05) of CMJ, ABA, and MP, while significantly increasing the MBT values (p , 0.05). The results support the use of complex training to improve the upper and lower body explosivity levels in young basketball players. In conclusion, this study showed that more strength conditioning is needed during the sport practice season. Furthermore, we also conclude that complex training is a useful working tool for coaches, innovative in this strength-training domain, equally contributing to a better time-efficient training.

David et al. (2006) examined the effects of complex training andconventional training in developing linear power among school children have been compared. For this purpose a group of 72 boys of 14 to 16 years of age was selected at random out of a universe of 200 children, who were medically fit. AAHPERD youth fitness test was conducted to assign the 72 boys into 3 different groups of 24 each namely complex training group, conventional training group and control group by using snake system based on their performance rankings. To verify that the groups were equated, mean and standard deviations were also calculated and assigned the groups for different treatments on random basis as A, B and C. With this setting, complex training was given to group A and conventional training was given to group B and group C control group did not participate in any of the training programmes, for a period of 12 weeks duration. This process was repeated and for a period of every two-week the data was collected along with pre-test, mid-test and post-test data from the experimental groups and control group on selected motor performance variables. A two way Analysis of Variance (ANOVA) was applied to determine the differences if any among the training methods and duration intervals for experimental and control groups. The Duncan Multiple Range Test (DMRT) was applied wherever applicable on the results of ANOVA to find the hierarchy among the methods of training and the duration intervals. As a result of the above analysis, the boys trained through complex training method gave more significant increase in the linear power as compared to conventional training method and „No" training group that is control group. It was concluded that the linear power developed through complex training method was much faster than conventional training method within 12 weeks of training period. In fact, it was twice better than the other.

Ross et al. (2009) examined the independent and combined effectsof resistance and treadmill sprint training on maximal sprint velocity and power. Twenty-five male athletes (age = 19.8 6 1.5 years, height =181.2 6 7.9 cm, body mass = 88.9 6 10.9 kg) were matched for 30-m sprint times and assigned to 1 of 3 training groups: 1) sprint training only (ST), 2) resistance training only (RT), or 3) combined sprint and resistance training (SRT) for 7 weeks. Periodized resistance training was performed 4 d_wk21 (3–4 sets of 6–10 repetitions). The treadmill sprint training program was performed 2 d_wk21 and consisted of 8–12 sets of maximal sprints for 40–60 m at 0–25% of each athlete's body mass, with rest intervals of 2–3 minutes on a treadmill that was user driven and that enabled loading via a magnetic braking system. Peak 30-m sprint times, power and average velocity attained during maximal sprint trials on the treadmill, and 1-repetition maximum (1RM) squat were determined pre and post training. The 30-m sprint times improved significantly only in the SRT group, and a trend for improvement (p =0.06) was observed in the ST group. All groups significantly increased treadmill sprint velocity. However, the SRT and ST groups increased significantly more than RT. Only the SRT group increased treadmill sprint peak power. All training groups increased 1RM squat strength significantly by 6.6–8.4 kg, with no differences observed between groups. The results of this study showed that 7 weeks of sprint training on a newly designed treadmill resulted in significant kinematic and kinetic improvements in sprint performance.

2.4 EFFECTS OF TRAINING ON BIOCHEMICAL VARIABLES

LeMura et al. (2000) evaluated the effects of various modes oftraining on the time-course of changes in lipoprotein-lipid profiles in the blood, cardiovascular fitness, and body composition after 16 weeks of training and 6 weeks of detraining in young women. A group of 48 sedentary but healthy women [mean age 20.4 (SD 1) years] were matched and randomly placed into a control group (CG, n = 12), an aerobic training group (ATG, n = 12), a resistance training group (RTG, n= 12), or a cross-training group that combined both aerobic and resistance training (XTG, n = 12). The ATG, RTG and XTG trained for 16 weeks and were monitored for changes in blood concentrations of lipoprotein-lipids, cardiovascular fitness, body composition, and dietary composition throughout a 16 week period of training and 6 weeks of detraining. The ATG significantly reduced blood concentrations of triglycerides (TRI) ($P < 0.05$) and significantly increased blood concentrations of high-density lipoprotein-cholesterol (HDL-C) after 16 weeks of training. The correlation between percentage fat and HDL-C was 0.63 ($P < 0.05$), which explained 40% of the variation in HDL-C, while the correlation between maximal oxygen uptake (VO2max) and HDL-C was 0.48 ($P < 0.05$), which explained 23% of the variation in HDL-C. The ATG increased VO2max by 25% ($P < 0.001$) and decreased percentage body fat by 13% ($P < 0.05$) after 16 weeks. Each of the alterations in the ATG had disappeared after the 6 week detraining period. The concentration of total cholesterol (TC), TRI, HDL-C and low density lipoprotein-cholesterol in the blood did not change during the study in RTG, XTG and CG. The RTG increased upper and lower body strength by 29% ($P < 0.001$) and 38%, respectively. The 6 week detraining strength values obtained in RTG were significantly greater than those obtained at baseline. The XTG increased upper and lower body strength by 19% ($P < 0.01$) and 25% ($P < 0.001$), respectively. The 6 week detraining strength values obtained in XTG were significantly greater than those obtained at baseline. The RTG, XTG and CG did not demonstrate any significant changes in either VO2max, or body composition during the training and detraining periods. The results of this study suggest that aerobic-type exercise improves lipoprotein-lipid profiles, cardiorespiratory fitness and body composition in healthy, young women, while resistance training significantly improved upper and lower body strength only.

Unciti et al. (2012) evaluated the interactions of a higher protein(HP) *vs.* a lower protein (LP) diet with or without a concomitant progressive resistance training program (RT) on body composition and lipoprotein profile in hypercholesterolemic obese women. Retrospective study derived from a 16-week randomized controlled-intervention clinical trial. Twenty five sedentary, obese (BMI: 30-40 kg/m2) women, aged 40-60 with hypercholesterolemia were assigned to a 4-arm trial using a 2 x 2 factorial design (Diet x Exercise). Prescribed diets had the same calorie restriction (-500 kcal/day), and were categorized according to protein content as: lower protein (< 22% daily energy intake, LP) *vs.* higher protein (≥ 22% daily energy intake, HP). Exercise comparisons involved habitual activity (control) *vs.* a 16-week supervised whole-bodyresistance training program (RT), two sessions/wk. *Results:* A significant decrease in weight and waist circumference was observed in all groups.A significant decrease in LDL-C and Total-Cholesterol levels was observed only when a LP diet was combined with a RT program, the RT being the most determining factor. Interestingly, an interaction between diet and exercise was found concerning LDL-C values. *Conclusion:* In this study, resistance training plays a key role in improving LDL-C and Total-Cholesterol; however, a lower protein intake (< 22% of daily energy intake as proteins) was found to achieve a significantly greater reduction in LDL-C.

Ossanloo, et al. (2012) determined the effects ofcombined Training (Aerobic Dance, Step Exercise and Resistance Training) on Body Fat Percents and Lipid Profiles in Sedentary Females of AL_ZAHRA University, The Effects of Combined Training (Aerobic Dance, Step Exercise and Resistance Training) on Body Fat Percents and Lipid Profiles in Sedentary Females of AL_ZAHRA University Exercise training and physical activity modified body fat percents and serum lipid profiles, but the influences of different types of exercises and combination of them on body fat percents and serum lipid profiles has rarely been investigated. The aim of this study was to investigate the effects of 12 weeks combination training included aerobic dance, step exercise and resistance training on body fat percents and serum lipid profiles in sedentary females. Eighty subjects randomly selected from 100 volunteered healthy sedentary females (25-45 years) based on American College of Sports Medicine and Physical Activity Rating Questionnaire in AL-ZAHRA University (Tehran, Iran). This subjects randomly divided in two groups such as, Exercise (n= 40) and Control groups (n= 40). Subjects in exercise group were training for 12 weeks, 3 sessions in week, and 60 minute in sessions with 60-80 percent of Heart Rates Reserve (HRR). Combination training program include aerobic dance, aerobic step exercise and resistance training was performed based on progressive overload training principal. Total Cholesterol (TC), Triglyceride (TG), Low Density Lipoprotein Cholesterol (LDL_C), High Density Lipoprotein Cholesterol (HDL_C) and Body Fat percents (% BF) has been measured before and after 12 weeks training program. Data compared with two tailed paired and independent sample t test ($p \leq 0.05$). The results showed that levels of HDL_C and % BF significantly modified after 12 weeks training ($p < 0.05$). There were no significant changes in TC, TG and LDL_C. These results indicated that moderate intensity combined training included aerobic dance, step exercises and resistance training have positive effect on some serum lipid profiles and body fat percents in sedentary females.

Chaudhary, et al. 2010) evaluated the effects ofaerobic and strength training on cardiac variables such as blood pressure, heart rate (HR), and metabolic parameters like cholesterol, high density lipoprotein (HDL), triglycerides and anthropometric parameters of obese women of Punjab. This study was performed as an experimental study, in which subjects were randomly selected. There were thirty obese women, aged between 35-45yrs with body mass index (BMI) of above 30. Subjects were grouped into control (n=10), aerobic training (n=10) and resistance training (n=10). Aerobic training was given for three days a week at 60-70% of maximum HR for 6 weeks. Resistance training (Delorme and Watkins Technique) was given for alternate days for 6 weeks. HR and blood pressure were measured before and after the exercise. Recovery HR was also measured.The findings of the study indicate statistically significant differences in recovery heart rate [Pre-exercise: 97.40± 5.378 (mean±standard deviation (SD)), post-exercise: 90.70±4.599, t=8.066, $P<0.001$] and in post-diastolic blood pressure [Pre-exercise: 85±3.265, post-exercise: 86.20±2.820, $P<0.001$] in aerobic training and in systolic blood pressure [Pre- and post-exercise] in both training groups ($P<0.001$). Significant differences were observed in very low-density lipoprotein [pre-exercise: 28.10±1.415, post-exercise: 26.86±0.760, t=5.378] and HDL [pre-exercise: 45.40±3.533, post-exercise: 53.60±3.134, t=6.318] levels in aerobic training group with $P<0.001$. BMI and body fat percentage showed significant improvements in both training groups. Aerobic training is more beneficial and can be used as a preventive measure in patients who are at risk of developing cardiovascular diseases due to obesity.

Elliott ,et al. (2002) studied the effects of eight weeks ofsupervised, low intensity resistance training (80% of 10 repetition maximum (10RM)) and eight weeks of detraining on muscle strength and blood lipid profiles in healthy, sedentary postmenopausal women. Fifteen postmenopausal women, aged 49–62 years, took part in the study. Subjects were assigned to either a control (n = 7) or training (n = 8) group. The training regimen consisted of three sets of eight repetitions of leg press, bench press, knee extension, knee flexion, and lat pull-down, three days a week at 80% of 10RM. Dynamic leg strength, 10RM, and blood lipid profiles (total cholesterol (TC), low and high density lipoprotein cholesterol (LDL-C, HDL-C), triglycerides, and very low density lipoprotein cholesterol (VLDL-C)) were measured at baseline, after eight weeks of training, and after a further eight weeks of detraining. Eight weeks of resistance training produced significant increases in knee extension ($F_{1,13} = 12.60$; $p<0.01$), bench press ($F_{1,13} = 13.79$; $p<0.01$), leg press ($F_{1,13} = 15.65$; $p<0.01$), and lat pull-down ($F_{1,13} = 16.60$; $p<0.005$) 10RM strength tests. Although 10RM strength decreased after eight weeks of detraining, the results remained significantly elevated from baseline measures. Eight weeks of training did not result in any significant alterations in blood lipid profiles, body composition, or dynamic isokinetic leg strength. There were no significant differences in any of the variables investigated over the 16 week period in the control group. These data suggest that a short, low intensity resistance training programme produces substantial improvements in muscle strength. Training of this intensity and duration was not sufficient to produce significant alterations in blood lipid concentrations.

Manna, et al. (2012) aimed at finding the effect oftraining on anthropometric, physiological and biochemical variables of Indian male Under 19 years volleyball players. A total of 30 Indian male volleyball players (age range: 16.00-18.99 yr; mean age: 17.7 ± 0.5 yr) regularly playing competitive volleyball volunteered for this study. The training sessions were divided into 2 phases (a) Preparatory Phase (PP, 8 weeks) and (b) Competitive Phase (CP, 4 weeks). The training programme consist of aerobic, anaerobic and skill development, and were completed 4 hrs/day; 5 days/week. Selected variables were measured at zero level (baseline data, BD) and at the end of PP and CP. A significant increase ($P<0.05$) in anaerobic power, back and grip strength, serum urea and HDL-C; and significant decrease ($P<0.05$) in body fat, recovery heart rate, hemoglobin, triglyceride and LDL-C were noted after training. No significant change was observed in stature, body mass, LBM, HRmax, VO_2max, uric acid and total cholesterol level of the players after the training. This would enable the coaches to assess the current status of an athlete and the degree of training adaptability and provide an opportunity to modify the training schedule accordingly to achieve the desired performance.

Kelley and Kelley (2009) did a meta analysis on impact ofprogressive resistance training on lipids and lipoproteins in adults. Randomized controlled trials > or =4 weeks dealing with the effects of PRT on lipids and lipoproteins in adult humans > or =18 years of age and published between January 1, 1955 and July 12, 2007 were included. Primary outcomes included total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), ratio of total cholesterol to high-density lipoprotein cholesterol (TC/HDL-C), non-high-density lipoprotein cholesterol (non-HDL-C), low-density lipoprotein cholesterol (LDL-C), and triglycerides (TG). A random-effects model was used for analysis with data reported as means and 95% confidence intervals. Twenty-nine studies representing 1329 men and women (676 exercise, 653 control) were included. Statistically significant improvements were found for TC (-5.5 mg/dl, -9.4 to -1.6), TC/HDL-C (-0.5, -0.9 to -0.2), non-HDL-C (-8.7 mg/dl, -14.1 to -3.3), LDL-C (-6.1 mg/dl, -11.2 to -1.0) and TG (-8.1 mg/dl, -14.5 to -1.8) but not HDL-C (0.7 mg/dl, -1.2 to 2.6). Changes were equivalent to -2.7%, 1.4%, -11.6%, -5.6%, -4.6%, and -6.4%, respectively, for TC, HDL-C, TC/HDL-C, non-HDL-C, LDL-C, and TG. Progressive resistance training reduces TC, TC/HDL-C, non-HDL-C, LDL-C and TG in adults.

Ibis et al. (2010) determined and evaluated chroniceffects of plyometric training on haematological parameters of the Turkish National Alpine Ski Team athletes during 12-week preparation period. In the study, 12 sportsmen volunteers participated whose mean age was 17.50 years. Participants performed 12-week plyometric training protocol. The training programme was applied for 12 weeks and 5 days a week in total 60 training unit. As the programme proceeded, the intensity and content of training increased. Blood samples were taken before and after the training programme. The red blood cell (RBC), white blood cell (WBC), granulocyte (GR), haematocrit (HCT), hemoglobin (HGB), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC) measurement were analysed on blood samples with automatic haematologicalanalyser (Toshiba Accute PPS TBA-40FR). Wilcoxon signed rank test was used in order to compare statistical values of before and after exercise and significance level α was set at 0.05. Before and after training programme, values were compared for RBC, WBC, GR, MCV, MCH, MCHC and no significant changes have been observed for these values. However, there was significant ($p>0.05$) increase in HCT and HGB values. We concluded that as a result of the study, 12-week plyometric training programme increased the RBCs and HGB levels and as a result improved oxygen carriage capacity of the Turkish National Alpine Ski Team athletes.

Heinicke et al. (2001) determined whether athletes from differentdisciplines are characterized by different blood volumes and secondly to what extent the blood volume can possibly limit endurance performance within a particular discipline. We investigated 94 male elite athletes subdivided into the following 6 groups: downhill skiing (DHS), swimming (S), running (R), triathlon (TA), cycling junior (CJ) and cycling professional (CP). Two groups of untrained subjects (UT) and leisure sportsmen (LS) served as controls. Total hemoglobin (tHb) and blood volume (BV) were measured by the CO-rebreathing method. In comparison to UT (mean +/- SD: tHb 11.0 +/- 1.1 g/kg, BV 78.3 +/- 7.9 ml/kg) tHb and BV were about 35 - 40 % higher in the endurance groups R, TA, CJ, and CP (e. g. in CP: tHb 15.3 +/- 1.3 g/kg, BV 107.1 +/- 7.0 ml/kg). Within the endurance groups we found no significant differences. The anaerobic discipline DHS was characterized by very low BV (87.6 +/- 3.1 ml/kg). S had an intermediate position (BV 97.4 +/-6.1 ml/kg), probably because of the immersion effects during training in the water. VO(2)max was significantly related to tHb and BV not only in the whole group but also in all endurance disciplines. The reasons for the different BVs are an increased adaptation to training stimuli and probably also individual predisposing genetic factors.

2.5 EFFECTS OF TRAINING ON MOTOR FITNES VARIABLES

Thomas (2009) was compared the effects of two plyometric training techniques on power and agility in youth soccer players. Twelve males from a semiprofessional football club's academy (age = 17.3 +/- 0.4 years, stature = 177.9 +/- 5.1 cm, mass = 68.7 +/- 5.6 kg) were randomly assigned to 6 weeks of depth jump (DJ) or countermovement jump (CMJ) training twice weekly. Participants in the DJ group performed drop jumps with instructions to minimize ground-contact time while maximizing height. Participants in the CMJ group performed jumps from a standing start position with instructions to gain maximum jump height. Posttraining, 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 treatment groups ($p > 0.05$). The study concludes that both DJ and CMJ plyometrics are worthwhile training activities for improving power and agility in youth soccer players.

Campo et al. (2009) examined how explosive strength, kickingspeed, 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 time 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.

Ebben et al. (2010) evaluated the effectiveness of a periodizedplyometric training program and the impact of the duration of the post-training recovery period on countermovement jump performance. Fourteen women subjects participated in a 6-week periodized plyometric training program. Ten women subjects served as non-training controls. All subjects' countermovement jump height, peak power, and body mass were assessed before and 2, 4, 6, 8, and 10 days after training. Kinetic data were obtained via a force platform using the average of 3 repetitions of the countermovement jump for each testing session. Jump height was 25.0% greater ($p \leq 0.05$) after training with no difference ($p > 0.05$) between recovery periods of 2, 4, 6, 8, or 10 days, for the training group. Peak power was 11.6-14.3% ($p \leq 0.001$) greater after training for the training group with no difference ($p > 0.05$) between recovery periods of 2, 4, 6, 8, or 10 days. Analysis revealed no significant difference ($p > 0.05$) for jump height or peak power from pre- to posttest for the control group. Practitioners should prescribe periodized plyometric programs with decreasing volume and increasing intensity to improve jump performance without a need for a post-training recovery period.

Lehnert et al. (2009) attempted to validateplyometric training program and the evaluation of the changes in monitored speed and explosive power predispositions during and after the end of the training program. The program was applied to a group of female youth volleyball players (n = 11) twice a week during an eight week period. Their actual level of explosive power and locomotor speed was evaluated before, during and after the intervention was completed. The levels were determined with the following tests: the standing vertical jump, the vertical jump with an approach and the shuttle run for 6 × 6 m. There were positive changes in the average values of test scores during the period of testing, but the dynamics of the changes in the explosive power and the speed were different. Other increases in all the characteristics were noticeable when the final measurements were made six weeks after the completion of the training program. Examination of the differences in the test scores by the follow up group, before the beginning and six weeks after finishing the intervention, was centred on objectively and statistically important changes in the volleyball players'motor predispositions ($p < .05$). The results of the program support the opinion that plyometric exercises are effective tools in the development of explosive power and speed in young athletes.

Elvis et al. (2009) determined the effect of 12 weeks of high versusmoderate intensity resistance training of equal work output on body composition in overweight women (BMI=25–29.9kg/m2). A total of twenty (20) sedentary women were randomized into two equal groups (n= 10). Thus, the moderate intensity exercise (MI:5sets*, 6reps,60%IRM–1repetition maximum and high intensity exercise (HI: 5 sets* 6 reps, 85% IRM) were conducted. Therefore, the F-value of lean body weight, percent body fat and body density were 8.87, 5.23, 9.33 compared to a critical value of 3.24 respectively. Thus, Tukey's honesty significant difference test was used as the post–hoc analysis to identify the source of the significant difference. Therefore, as a result of the follow-up verification, the Tukey's HSD – values for lean body weight (4.20*); percent body fat (4.07*); and body density (4.12*) compared to critical value of 4.05 respectively. Thus, after participation in a 12-week resistance training programme, it is concluded that 12 weeks of high intensity resistance training may be more effective in improving body composition than moderate intensity resistance training. It is therefore, recommended that women should participate in high intensity resistance training to achieve optimal gains in muscle size, strength, fitness and performance.

Burnham et al. (2010) compared chain training totraditional training for the bench press. Women collegiate athletes in volleyball and basketball (N = 19) participated in a 16-session bench press program. They were matched into either a Traditional or a Chain training group by 1-repetition maximum (1RM). The Traditional group performed the bench press with conventional equipment, while the Chain group trained with attached chains (5% of weight). Analysis showed a significant increase in 1RM for both groups over 16 sessions, Traditional +11.8% and Chain +17.4%. The difference between the groups was not statistically significant, but suggests the women who trained with attached chains improved their bench press more than the Traditional group.

Chaudhary and Jhajharia (2010) attempted to find out the effectsof plyometric exercises on selected motor abilities of university level female basketball players. The subjects, 20 female basketball players of Lakshmibai National Institute of Physical Education, Gwalior, were randomly divided in two groups, that is, experimental and control group. The age of subjects varied between 18 and 22 years. The criterion measures vertical jump, 20-m dash, movement speed, flexibility and agility in the beginning and at the end of the experimental period of 6 weeks for both the groups. In order to study the effect of plyometric exercises on selected motor abilities, the analysis of co-variance is used at the 0.05 level of significance. It was concluded that the plyometric training is an effective means for improving the following variables: agility, flexibility vertical jump and movement speed. On the other hand, plyometric training is not an effective means for improving the variable, that is, speed of movement (20-m dash). There was no significant improvement in case of control group.

Ebben (2004) had examined various variables including plyometrics. This study describes the results of a survey of the practices of National Hockey League strength and conditioning (NHL S&C) coaches. The response rate was 76.6% (23 of 30). This survey examines (a) background information, (b) physical testing, (c) flexibility development, (d) speed development, (e) plyometrics, (f) strength/power development, (g) unique aspects, and (h) comments. Results indicate, in part, that coaches assess an average of 7.2 parameters of fitness, with tests of strength and power being the most common. All coaches used a variety of flexibility-development strategies. Results reveal that 21 of 23 (91.3%) of NHL S&C coaches follow a periodization model (PM). Of the coaches who follow a PM, 21 of 21 (100%) indicated that their athletes used Olympic-style lifts, and 21 of 21 coaches (100%) trained athletes with plyometric exercises. For those who used plyometrics with their athletes, 17 of 21 (80.1%) reported no plyometric-related injuries in the past year. Coaches who report they did not follow a PM also did not use Olympic-style lifts, plyometrics, or speed development strategies, such as assisted, resisted, or interval training, with their athletes. Finally, coaches reported that the squat and their variations, as well at the Olympic-style lifts and its variations, were most frequently used with their athletes. The survey serves as a review, as well as a source of applied information and new ideas.

Martel, et al., **(2005)** examined the trends in plyometric training. Numerous studies have reported that land-based plyometrics can improve muscular strength, joint stability, and vertical jump (VJ) in athletes; however, due to the intense nature of plyometric training, the potential for acute muscle soreness or even musculoskeletal injury exists. Performance of aquatic plyometric training (APT) could lead to similar benefits, but with reduced risks due to the buoyancy of water. Unfortunately, there is little information regarding the efficacy of APT. Thus, the purpose of this study was to examine the effects of APT on VJ and muscular strength in volleyball players. Nineteen female volleyball players (aged 15 +/- 1 yr) were randomly assigned to perform 6 wk of APT or flexibility exercises (CON) twice weekly, both in addition to traditional preseason volleyball training. Testing of leg strength was performed at baseline and after 6 wk, and VJ was measured at baseline and after 2, 4, and 6 wk. Similar increases in VJ were observed in both groups after 4 wk (APT = 3.1%, CON = 4.9%; both $P < 0.05$); however, the APT group improved by an additional 8% ($P < 0.05$) from week 4 to week 6, whereas there was no further improvement in the CON group (-0.9%; P = NS). After 6 wk, both groups displayed significant improvements in concentric peak torque during knee extension and flexion at 60 and 180 degrees x s(-1) (all $P < 0.05$). The combination of APT and volleyball training resulted in larger improvements in VJ than in the CON group. Thus, given the likely reduction in muscle soreness with APT versus land-based plyometrics, APT appears to be a promising training option.

Luebbers, et al., **(2003)** had examined the effects of two plyometric training programs, equalized for training volume, followed by a 4-week recovery period of no plyometric training on anaerobic power and vertical jump performance. Physically active, college-aged men were randomly assigned to either a 4-week (n = 19, weight = 73.4 +/- 7.5 kg) or a 7-week (n = 19, weight = 80.1 +/- 12.5 kg) program. Vertical jump height, vertical jump power, and anaerobic power via the Margaria staircase test were measured pretraining (PRE), immediately posttraining (POST), and 4 weeks posttraining (POST-4). Vertical jump height decreased in the 4-week group PRE (67.8 +/- 7.9 cm) to POST (65.4 +/- 7.8 cm). Vertical jump height increased from PRE to POST-4 in 4-week (67.8 +/- 7.9 to 69.7 +/- 7.6 cm) and 7-week (64.6 +/- 6.2 to 67.2 +/- 7.6 cm) training programs. Vertical jump power decreased in the 4-week group from PRE (8,660.0 +/- 546.5 W) to POST (8,541.6 +/- 557.4 W) with no change in the 7-week group. Vertical jump power increased PRE to POST-4 in 4-week (8,660.0 +/- 546.5 W to 8,793.6 +/- 541.4 W) and 7-week (8,702.8 +/- 527.4 W to 8,931.5 +/- 537.6 W) training programs. Anaerobic power improved in the 7-week group from PRE (1,121.9 +/- 174.7 W) to POST (1,192.2 +/- 189.1 W) but not the 4-week group. Anaerobic power significantly improved PRE to POST-4 in both groups. There were no significant differences between the 2 training groups. Four-week and 7-week plyometric programs are equally effective for improving vertical jump height, vertical jump power, and anaerobic power when followed by a 4-week recovery period. However, a 4-week program may not be as effective as a 7-week program if the recovery period is not employed.

2.6 SUMMARY OF RELATED STUDIES

In this chapter, studies pertaining to effects of plyometric training, effects of resistance training, effects of combined training, effects of different trainings on biochemical variables and effects of motor fitness variables were reviewed. The review of related studies proved that though there were studies pertaining isolated treatment of plyometrics and resistance trainings were done among different groups of people and different combination of trainings were undertaken, there was further scope for research to find out the effect of plyometric, resistance and combined training on selected biochemical variables and motor fitness variables among college women. Hence, this research was attempted.

Based on the experience gained through this study, suitable methodology was formulated which is presented in Chapter III.