CHAPTER – II

REVIEW OF RELATED LITERATURE

The review of related literature for relating to the problem has been presented in this Chapter. The working bibliography was collected from the libraries of the Annamalai University, Annamalai Nagar, Alagappa University, Karaikudi, Dr.Sivanthi Aditanar College of Physical Education, Tiruchendur and the Sports Authority of India, Nethaji Subash National Institute of Sports, Bangalore. The researcher also collected related information from the Internet Source.

Sundaramoorthy\textsuperscript{29} conducted a study to find out the effects of isolated and combined weight and plyometric training on selected strength parameters, speed and power. Forty five men students studying Master’s Degree in Physical Education at Dr.Sivanthi Aditanar College of Physical Education, Tiruchendur, were selected as subjects at random and were

divided into three groups consisting of 15 subjects each. Group-I underwent weight training, Group II underwent plyometric training, and Group III underwent combined weight and plyometric training. Arm strength, leg strength, explosive strength, strength endurance, speed and elastic power were selected as variables. The dip strength test, leg dynamometer test, vertical jump, sit-ups, 50 meters run and bunny hops were administered to test the aforesaid variables separately. The results of the study indicated that arm strength, leg strength, explosive strength, strength endurance, speed and elastic power were improved significantly by weight training, plyometric training and combined weight and plyometric training programmers. No significant difference existed among weight training, plyometric training and combined weight and plyometric training groups in improving the selected dependent variables. The trend was in favor of combined weight and plyometric training group for explosive strength, strength endurance, speed and elastic power whereas the trend was in favour of weight training group for arm strength and leg strength.
Wilson et al., \textsuperscript{30} assessed the performance of a group in an effort to gain greater insights into the adaptations invoked by plyometric and weight training. Forty-one previously trained males were randomly allocated to a control, plyometric, or weight-training group. The experimental groups trained for 8 weeks performing either heavy lifts or dynamic plyometric exercises. The following test items were performed prior to and at the completion of the training period: (a) vertical jump (b) a series of iso-inertial concentric and eccentric tests (c) push-up tests and (d) maximal bench press and squat lifts. Plyometric training significantly enhanced the rate of eccentric lower body force production. The weight-training group showed enhanced concentric function. These results were attributed to the specific stresses imposed by the differing forms of training and are discussed with reference to methods of enhancing training induced adaptations and the types of movements such training would tend to facilitate.

Iain M. Fletcher, et.al.,\textsuperscript{31} tried to determine the effect of combined weight and plyometric programmes on golf drive performance. Eleven male golfers were selected for this study. Full golf swing was analyzed for club head speed (CS) and driving distance (DD) before and after an 8-week training programme. The control group (n=5) continued their normal training, while the experimental group (n=6) performed 2 sessions per week of weight training and plyometrics. Control groups showed no significant (p \geq 0.05) changes, while the experimental subjects showed a significant increase (p \leq 0.05) in CS and DD. The changes in golf drive performance were attributed to an increase in muscular force and an improvement in the sequential acceleration of body parts contributing to a greater final velocity being applied to the ball. It was concluded that specific combined weights and plyometrics training can help to increase CS and DD in club golfers.

Wilson et.al\textsuperscript{32} determined as to which of three theoretically optimal resistance training modalities resulted in the greatest

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

Reddy\textsuperscript{33} conducted a study on the effects of plyometric and weight training followed by plyometric training on power, speed,

\begin{footnote}
\textsuperscript{33} Sathiyanarayana Reddy, “Relative Effects of Plyometric and Weight Training Followed by Plyometric Training on Power, Speed, Stride Length and
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stride length and stride frequency. Forty five (N=45) boys were selected at random and put into three groups (n=15). Group I underwent plyometric training, Group II underwent weight training followed by plyometric training and Group III acted as a control group. The subjects were tested for power, speed, stride length and stride frequency. Performance in power, speed, stride length and stride frequency improved significantly for both plyometric and weight training groups followed by plyometric training when compared with the control group and a non significant difference existed between the training groups.

Rubenstein\textsuperscript{34} compared the effects of a four-week, general resistance training programme(G) to a four-week combined plyometrics and general resistance training programme (GP) on shot speed on - goal (SS) in Division I Women’s Soccer players. Eight members of the Manhattan College Women’s Soccer Programme (19-22 yrs) were randomly assigned to either G (n=4) or GP (n=4). Prior to and subsequent to training, each subject was tested for SS using radar (Sports Radar 3500). Briefly,

subjects were asked to kick the ball (size 5, inflated to 6-1.01 atmospheres) maximally to a target 18ft away. Only trials that fell within 10-degree angle of trajectory relative to the device (visual inspection) were accepted as supported by the manufactures manual. All subjects took a running start (3-4 steps). Three trials were averaged for each subject and the means were compared using dependent ‘t’-tests. Neither group improved significantly (p>.05), however GP showed trends (p=.06) favouring increased SS (47.4 ± 2.0 mph PRE vs. 48.0 ± 2.0 mph POST) while G decreased slightly (50.2 ± 4.9 mph PRE vs. 49.8 ± 2.8 mph POST).

Fagan and Doyle\textsuperscript{35} investigated with nineteen males and fourteen females assigned to two training group the effect of maximum strength (85-90% 1 RM) and plyometrics, or maximum power (30% 1 RM jump squats) and plyometrics. Female competitive soccer players (N = 6) served as a control group. Training was given twice a week for 10 weeks. Both groups improved in lower body power and strength. Both forms of training were equally effective in increasing squat strength to perform plyometrics. However, sprint speed over distance of 5-40

meters did not change. Therefore, this form of training was very specific and did not carry-over to a useful athletic pursuit. Strength training only has specific effects on the trained exercisers.

*Lyttle et.al.*,\(^{36}\) examined the relative effectiveness of two leading forms of athletic training in enhancing dynamic performance in various tests. Thirty – three men who participated in various regional level sports, but who had no previously performed resistance training were randomly assigned to a maximal power training programme, a combined weight and plyometric programme or a non-training control group. The maximal power group performed weighted jump squats and bench press throws using a load that maximized the power output of the exercise. The combined group underwent traditional heavy weight training in the form of squats, and bench press and plyometric training in the form of depth jumps and medicine ball throws. The training consisted of two sessions a week for eight weeks. Both types of training were equally effective in enhancing a variety of performance measures such as jumping, cycling, throwing and lifting.

Maffiuletti et al.\textsuperscript{37} investigated the influence of a 4-week combined electromyo stimulation (EMS) and plyometric training programme on the vertical jump performance of 10 volleyball players. Training sessions were carried out three times weekly. Each session consisted of three main parts: EMS of the knee extensor muscles (48 contractions) EMS of the plantar flexor muscles (30 contractions), and 50 plyometric jumps. Subjects were tested before (week 0), during (week 2), and after the training programme (week 4), as well as once more after 2 week of normal volleyball training (week 6). Different vertical jumps were carried out, as well as maximal voluntary contraction (MVC) of the knee extensor and plantar flexor muscles. At week 2, MVC significantly increased (+20\% knee extensors, +13\% plantar flexors) as compared to baseline (P<0.05). After the 4-week training programme, the different vertical jumps considered were also significantly higher compared to pre training (< 0.001), and relative gains were between 8-10\% (spike counter movement jump) and 21\% (squat jump). The significant increases in maximal strength and explosive strength produced by the training programme were subsequently maintained after an additional 2

weeks of volleyball training. EMS combined with plyometric training has proven useful for the improvement of vertical jump ability in volleyball players. This combined training (approximately 2 weeks) modality produced rapid increases of the knee extensors and plantar flexors maximal strength. These adaptations were then followed by an improvement in general and specific jumping ability, likely to affect performance on the court. In conclusion, when EMS resistance training is proposed for vertical jump development, specific work out (e.g., plyometric) must complement EMS sessions to obtain beneficial effects.

Adams et al. conducted a study to investigate the effect of six weeks of squat, plyometric and squat plyometric training on power production. The purpose of this study was to compare the effectiveness of three training programmes Squat (S), Plyometric (P) and Squat-Plyometric (SP) in increasing hip and thigh power production as measured by vertical jump. Forty eight subjects were divided equally into 4 groups: ‘S’, ‘P’, ‘SP’ and control ‘C’. The subjects trained two days a week for a total of seven weeks which consisted of a week of technique learning period followed by six weeks of periodized ‘S’, ‘P’, or ‘SP’ training programmes. Hip

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and thigh power were tested before and after the training using the vertical jump test and the alpha level was set at .05 Statistical analysis of the data revealed a significant increase in hip and thigh power production, as measured by vertical jump in all three treatment groups. The ‘SP’ group achieved statistically greater improvement than the ‘S’ or ‘P’ groups. Examination of the mean scores shows that the ‘S’ group increased 3.30 centimeters in vertical jump the ‘P’ group increased 3.81 centimeters and the ‘SP’ group increased 10.67 centimeters. The results indicated that both the ‘S’ and ‘P’ training are necessary for improving hip and thigh power production as measured by vertical jumping ability.

**McBride et al.,**39 examined the effect of an 8-week training programme with heavy-versus light-load jump squats on various physical performance measures and electromyography (EMG). Twenty-six athletic men with varying levels of resistance training experience performed sessions of jump squats with either 30% (JS 30, n = 9) or 80% (JS 80, n = 10) of their one repetition maximum in the squat (1 RM) or served as a control (C, n = 7). An agility test, 20 metres sprint, and jump squats with 30% (30J), 50%  

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(55J), and 80% (80J) of their 1 RM were performed before and after training. Peak force, peak velocity (PV), peak power (PP), jump height, and average EMG (concentric phase) were calculated for the jumps. There were significant increases in PP and PV in the 30J, 55J, and 80J for the JS30 group (p< 0.05). The JS30 group also significantly improved in the 1 RM with a trend towards improved 20 metres sprint times. In contrast, the JS80 group significantly improved both PF and PP in the 55J and 80J and more significantly in the 1 RM but ran significantly slower in the 20-m sprint. In the 30J the JS30 group’s percentage increase in EMG activity was significantly different from that of the C group. In the 80J the J80 group’s percentage increase in EMG activity was significantly different from that of the C group. This investigation indicates that training with light-load jump squats results in increased movement velocity capabilities and that velocity-specific change in muscle activity may play a key role in this adaptation.

Kubachka and Stevens\textsuperscript{40} investigated the effects of plyometric, strength training, and body weight exercises on the power, strength and endurance capacities of the trunk muscles.

Training sessions were arranged twice a week for five weeks (a total of 10 training sessions). Ploymetrics significantly improved power (8.6%) and strength (45.9%). Strength training increased power by 7.3% and strength by 82.5%. Body weight increased strength only by 21.9%. Polymetrics and strength training were both equally effective.

_Fatouros, et.al_,\textsuperscript{41} conducted a study to investigate the effect of polymetric training and weight training on force-power parameters of vertical jumping. For this purpose, thirty one males (20.1 + / -1.4 yrs) were selected as subjects to determine if plyometric alone or in combination with weight training would increase force power parameters in vertical jump. Subjects were randomly assigned to either a plyometrics training (PT) (n=11), weight training (wt) (n=10), or combined plyometric and weight training (pwt) (n=10) group. Training involved progressive intensity (60-85% of 1RM) for three times a week for thirteen weeks. Dependent variables (Mean leg force, mean leg power and ground time) were compared prior to and after the training. All groups demonstrated significant changes as a result of the training. An ANCOVA was utilized since pre-training values were

not similar at the starting of the training programme. Mean leg force increased 373 N for the ‘PWT’ group, 237 N for the ‘PT’ group and 181 N for the ‘WT’ group. The increase ranged from 17.5–42.6% average power increased 17 W/KG (PWT), 11.9 W/KG(P) and 11.5 W/KG(WT) which represents improvement of 23–40%. average ground time decreased by 0.103 seconds, 0.067 seconds and 0.055 seconds for the ‘PWT’, ‘P’ and ‘WT’ groups respectively. ANCOVA revealed that ‘PWT’ training significantly increased force power parameters and decreased ground reaction time compared to both ‘WT’ and ‘P’. These results suggest that plyometrics in conjunction with weight training can produce greater gains in vertical jumping compared to plyometrics or weight training alone.

Turner et.al,\textsuperscript{42} determined whether a 6-week regimen of plyometric training would improve running economy (i.e., the oxygen cost of sub maximal running). Eighteen regular but not highly trained distance runners (age = 29 ± 7 [means ± SD] years) were randomly assigned to experimental and control groups. All

subjects continued regular running training for 6 week. The experimental subjects did plyometric training. Dependent variables measured before and after the 6-week period were economy of running on a level treadmill at 3 velocities (women: 2.23, 2.68, and 3.13 m.s\(^{-1}\); men: 2.68, 3.13 and 3.58 m.s\(^{-1}\)), VO\(_2\)max, and indirect indicators of ability of muscles of lower limbs to store and return elastic energy. The plyometric training improved running economy (p<0.05). The VO\(_2\)max did not change with training. Plyometric training did not result in changes in jump height or efficiency variables that would have indicated improved ability to store and return elastic energy. He concluded that 6 weeks of plyometric training improves running economy in regular but not highly trained distance runners.

Masamoti et.al.,\(^{43}\) examined the acute effects of plyometric exercise on 1 repetition maximum (RM) squat performance in trained male athletes. Twelve men (mean age ±SD: 20.5± 1.4 years) volunteered to participate in 3 testing sessions separated by at least 6 days of rest. During each testing session the 1 RM was assessed on back squat exercise. Before all 3 trials, subjects warmed up on a stationary cycle for 5 minutes and performed

static stretching. Subjects then performed 5 sub maximal sets of 1-8 repetitions before attempting a 1 RM lift. Subjects rested for at least 4 minutes between 1 RM trials. During the first testing session (T1) subjects performed a series of sets with increasing load until their 1 RM was determined. During the second and third testing sessions subjects performed in counterbalanced order either 3 double-leg tuck jumps (TJ) or 2 depth jumps (DJ) 30 seconds before each 1 RM attempt. The average 1 RM lifts after T1 and testing sessions with TJ or DJ were 139.6 ± 29.3 kg., 140.5 ± 25.6 kg., and 144.5 ± 30.2 kg., respectively (T1<DJ; p<0.05). These data suggest that DJ performed before 1 RM testing may enhance squat performance in trained male athletes.

According to Jeffrey et.al., changes in muscle power output and fiber characteristics groups following, 8 week plyometric and aerobic exercise programme. Male subjects (n=19) were randomly assigned to either group 1 (plyometric training) or group 2 (plyometric training and aerobic exercise). The plyometric training consisted of vertical jumping, bounding, and depth jumping. Aerobic exercise (at 70% maximum heart rate) was formed for 20 minutes immediately following the plyometric

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workouts. Muscle biopsy specimens were collected from the muscles vastus lateralis before and after training. Type I and type II fibers were identified and cross-sectional areas calculated. Peak muscle power output, measured using a countermovement vertical jump, significantly increased from pre training to post training for group 1 (2.8%) and group 2 (2.5%). Each group demonstrated a significant increase in fiber area from pre training to post training for type 1 (group 1, 4.4%; group 2, 6.1%) and type II (group 1, 7.8%; group 2, 6.8%). Following plyometric training, there is an increased power output that may in part be related to muscle fiber size.

**Conroy**45 conducted a study to investigate plyometric training and its effects on speed, strength and power of intercollegiate athletes. Twenty-one female and thirty male track / field athletes at Ohio Northern University served as subjects. The subjects were divided by gender and track group (power or endurance) and randomly assigned to either an experimental group which participated in plyometric training or a control group which did not perform any of these drills. The experimental group trained three times per week with each session lasting 20-40

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minutes. Each subject was tested three times during the 14 week study. A repeated measures analysis of variance with three between factors and one within factors was used in comparing the variables among the groups for pre-test mid-test and post-testing periods. The between factors were gender (males/females) track group (power/endurance) and treatment group (control / experimental) and the within factor was the three test periods. A total of six assessment tests were administered. The skin fold measurement showed a four-way interaction between gender (males greater than females), between test periods (post test greater than pre-test) between track group (power greater than endurance) and between control and experimental groups. No other test demonstrated any significant differences between the groups. The 40 yard-dash showed a three-way interaction for the experimental group between gender and between track groups. The test for flexibility also showed a three-way interaction between test period between gender and between track groups. Iso-kinetic testing for power (180, 240 and 300 degrees) and the standing long jump showed a significant result for gender and track group. Iso-kinetic testing for strength (60 degrees) and the vertical jump test showed significant results for gender test period and track group. No other significant results were found.
Rimmer and Sleivert\textsuperscript{46} studied the effects of sprint-specific plyometric programme on sprint performance. Twenty six male subjects completed the training. A plyometrics group (N=10) performed sprint-specific plyometric exercises, while a sprint group (N=7) performed sprints. A control group (N=9) was included. The subjects performed sprints over 10 and 40 metres distances before (pre) and after (post) training. The magnitude of the improvements in the plyometric training group was not however significantly different from that of the sprint group. The control group showed no changes in sprint times. There were no significant changes in stride length or frequency, but ground contact time decreased at 37 metres by 4.4\% in the plyometrics group only. It is concluded that sprint specific plyometrics programme can improve 40 metres sprint performances to the same extent as standard sprint training, possibly shortening ground contact time.

Kraemer et.al.,\textsuperscript{47} examined the effects of sprint/ plyometric training with the Meridian Elite-style shoe on various


\textsuperscript{47} William J. Kraemer et.al. “The Effect of Meridian Shoe on Vertical Jump and Sprint Performances Following Short Term Combined Plyometric /
performance parameters. Seventeen healthy men were randomly assigned to either an athletic-shoe training group (AS) or a meridian elite-shoe training group (MS). Both the groups participated in an eight week training programme consisting of weight training and sprint/plyometric training. Anthorpometry, muscular strength, speed, power and rate of power development assessments were performed prior and after training. Both the groups demonstrated similar increases in 1RM squat and bench press, power output, and rate of force development during jumping. Both the group’s demonstrated similar improvement in 40-yard dash times, but the MS group showed greater improvement in 60-yards dash times. The MS group significantly increased their vertical jump height, whereas only a trend \( (p = 0.08) \) for improvement was observed in the AS group. Rate of sub maximal force development of the plantar flexor muscles in the dorsi flexed position improved to a greater extent in the MS group. Compared to two previous studies, this newly designed model of strength shoe showed a lower incidence of pain and injury. In conclusion, the results of the study indicated that the Meridian Elite shoes may have an ergogenic effect on performance when used during eight weeks of sprint / plyometric training.

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

Holcomb et al., studied the effectiveness of modified plyometric programmes on power and vertical jump. 51 college men were selected as subjects and they were put into modified plyometric depth jump programme (n=10), a counter movement jump programme (n=10), a weight training programme (n=12), and a conventional plyometric DJ programme (n=10) and a control group (n=9). Subjects underwent pre and post testing to determine power and VJ height. The test jumps were the counter


movement jump (CMJ) and static jump (SJ). The subjects trained 3 days a week for 8 weeks. All groups improved in both peak power and VJ, for CMJ; the peak power increased in all the training groups. No significant differences were found for power and VJ height among the training groups.

Stroupe et al.,\textsuperscript{50} investigated the effects of a jump-training involving instruction in jumping mechanics, plyometric training, and flexibility exercises and results were assessed on the jumping performance and mechanics of keen function in female (N=11) high school volleyball players. Training was performed three times a week for two hours per day over six weeks. A group of untrained males matched for physical structure served as a control group. Landing forces decreased, vertical jump increased, and knee mechanics improved after the training programme. There was no way of attributing these improvements to any one part of the complex training programme (technique, plyometrics, flexibility). Since a total of 18 sessions were experienced and yielded significant changes, it is likely that technique training (neurological reorganization) has a substantial effect on the athletes’ performances. Flexibility did not change through training.

Schwendel\textsuperscript{51} conducted a study on traditional baseball weight training versus power weight training effects on bat velocity. Subjects were sixty male and female college students, ranging in age from 18 to 28 years. The training programme exercises were the leg press, leg curl, leg extension, bench press, pull down, military press, bicep curl, and tricep extension, and performed on universal weight extension bench machines. Initial and final bat velocities were measured for all sixty subjects and subjects in the experimental groups were tested for a 1 RM in the training programme exercises. The traditional groups (3 x 10) performed each eccentric contraction in four seconds. The power groups executed each repetition in one second and trained according to the principles of periodisation. Both groups trained for seven weeks. The results suggest that power trained males made greater improvements in bat velocity than any other groups. Females made greater improvements in upper and lower body strength than males while traditional training and power training equally enhanced lower body strength.

Field\textsuperscript{52} conducted a study to compare the effects of power development of plyometric versus weight training. For this, the author selected male and female basketball and volleyball players. Among the subjects, group-I was trained with box jumping and group-II with weight training. For assessing power, vertical jump test was conducted. All the subjects were pre tested 2 days prior to beginning of a week training programme and post tested 3 days after completion of the programme. Results were presented in the form of improvement over the weight training regime, deemed not statistically significant.

\textit{Blattner and Nobles}\textsuperscript{53} conducted a study on 48 volunteer male subjects to find out the effects of Isokinetic and Plyometric training on vertical jumping performance. The subjects were randomly assigned to one of the three groups (n=16), Group I was trained with isokinetic exercise, Group II was trained with plyometric exercise and Group III was the control. Subjects in the training group were trained three time a week for eight weeks. Covariance analysis was used to compare post-test scores with the effect of pre-test differences. Results showed both training

\textsuperscript{52} Field “Comparing the Effects of Power Development of Plyometric Versus Weight Training”, \textit{Coaching Volleyball}, (June/July, 1989), 4-5.

\textsuperscript{53} Blattner and Noble “Relative Effects of Isokinetic and Plyometric Training on Vertical Jumping Performance” \textit{Track and Field Quarterly Review}, p.583-588.
groups improved significantly the vertical jump capacity. However, no significant difference existed among the training groups.

Gemar\textsuperscript{54} studied the effects of weight training and plyometric training on vertical jump, standing long jump and forty meters sprint. The training consists of plyometric drills twice a week or weight training exercises three times a week for an eight-week period. The gain achieved by both treatment groups was significantly ($p < 0.5$) greater than those experienced by control group; but no significant difference existed between the gains attained by the two treatment groups. It is concluded that under the delimitation of this, there is no significant difference between the performances in improving leg power.

Ford \textit{et.al}\textsuperscript{55}, examined the effects of three combinations of plyometric and weight training programmes on physical fitness test items. For this purpose, 50 high school boys participated for 10 weeks in one of the three programmes. They found that

\textsuperscript{54} J.A. Gemar, “The Effects of Weight Training and Plyometric Training and Plyometric Training on Vertical Jumps, Standing Long Jump and Forty Meter Print”, \textit{College Of Human Development and Perform Anu, University Of Oregon}, 1, 1988

\textsuperscript{55} H.T. Ford, etal., “Effects of Three Combination of Plyometric and Weight Training Programmes on Selected on Physical Fitness Test Items”, \textit{Perceptual and Motor Skills}, 56, (June, 1983), 919-922.
training in combination with other activities can be useful as a physical fitness training procedure.

Jeyaseelan\textsuperscript{56} compared the effects of plyometric training on Arm strength, Arm endurance and Arm explosive power of high school boys. For this purpose, 30 boys were selected at random as subjects. Their age ranged from 13 to 15 years. The subjects of experimental group underwent the prescribed plyometric training programme three days per week for eight weeks whereas the control group did not involve in any specific training programme. The data collected from the two groups prior to and after the experimentation were statistically analyzed for significant difference by applying the count of the analysis of covariance (ANCOVA). Finally, it was concluded that all the selected variables were significantly improved due to training when compared to the control group.

Adams \textit{et al.},\textsuperscript{57} investigated the effects of four weeks of plyometric vs weighted plyometric training on vertical jump in


strength – trained females. The subjects (N=14) were formed in two groups. The plyometric group performed depth jumps, split squats, and double – leg hops with body weight as resistance twice a week. The weighted – plyometric group performed the same exercises with the addition of a weight equivalent to 20% of one repetition maximum in the second week, and 40% of one repetition maximum in the fourth week. Both groups performed 3x6 squats one day per week after plyometric training. Both groups improved vertical jump with no difference between them.

Durham et.al., 58 studied the effects of plyometric and weighted – plyometric training on lower body anaerobic power. Strength – trained females (n=14) performed four weeks of training after being divided into two groups. The weighted group increased added resistance from 20% to 40% of one repetition maximum over the four weeks. Depth jumps, split squats, and double – leg hops were performed. Both groups increased number of jumps, average jump height, and peak jump height. Power output and fatigue index did not change. There was no significant difference in any variables between the two groups.

Fatouros and Kambas\textsuperscript{59} analysed strength, anaerobic power and mobility of older men subjected to a 24 week strength training protocol followed by prolonged detraining. Fifty two healthy but inactive older men were assigned to a control group, low intensity training group and high intensity training group. They carried out a 24 week, whole body strength training programme followed by a 48 week detraining period. Upper and lower body strength, anaerobic power (Wingate testing), and mobility (timed up and go, walking, climbing stairs) were measured at baseline and immediately after training and during detraining. Although low intensity training improved (p<0.05) strength (42.66\%), anaerobic power (10\%), and mobility (5.7\%), high intensity training elicited greater (p<0.05) gains (63.91\% in strength, 17.25\% in anaerobic power, 9.14\% in mobility). All training induced gains in the LIST group had been abolished after four to eight months of detraining, whereas in the HIST group strength and mobility gains were maintained throughout detraining. However, anaerobic power had returned to baseline levels after four months of detraining in both groups. Higher intensity training protocols induce greater gains in strength,\footnote{Fatouros IG, Kambas A “Strength training and detraining effects on muscular strength, anaerobic power, and mobility of inactive older men are intensity dependent”. \textit{Britain Journal of Sports Medicine}, 2005 Oct;39(10):776-80.}
anaerobic power, and whole body physical function of older men. Moreover, higher intensity training may maintain the gains for more prolonged periods after training ceases.

Elliot and Sale\textsuperscript{60} studied the effects of eight weeks of supervised 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 and after eight weeks of training, and after a further eight weeks of detraining. Eight weeks of resistance training produced significant increases (p<0.01), leg press. 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.

Maximal force production per unit of muscle mass (muscle quality, or MQ) has been used to describe the relative contribution of non-muscle-mass components to the changes in strength with age and strength training (ST). To compare the influence of age and gender on MQ response to ST and detraining, 11 young men (20-30 years), nine young women (20-30 years), 11 older men (65-75 years), and 11 older women (65-75 years), were assessed for quadriceps MQ at baseline, after 9 weeks of ST, and after 31 weeks of detraining. MQ was calculated by dividing quadriceps one repetition maximum (IRM) strength by quadriceps muscle volume determined by magnetic resonance imaging. All groups demonstrated significant increases in IRM strength and muscle
volume after training \( (p < .05) \). All groups also increased their MQ with training \( (p < .01) \), but the gain in MQ was significantly greater in young women than in the other three groups \( (p < .05) \). After 31 weeks of detraining, MQ values remained significantly elevated above baseline levels in all groups \( (p < .05) \), except the older women. These results indicate that factors other than muscle mass contribute to strength gains with ST in young and older men and women, but those other factors may account for a higher portion of the strength gains in young women. These factors continue to maintain strength levels above baseline for up to 31 weeks after cessation of training in young men and women, and in older men\(^{61}\).

The purpose of this study was to examine the effects of age and gender on the strength response to strength training (ST) and detraining. Eighteen young (20-30 yr) and 23 older (65-75 yr) men and women had their one-repetition maximum (1 RM) and isokinetic strength measured before and after 9 wk of unilateral knee extension ST (3 d x wk(-1)) and 31 wk of detraining. The young subjects demonstrated a significantly greater \( (P < 0.05) \) increase in 1 RM strength \( (34+/−3\% ; 73+/−5 \text{ vs } 97+/−6 \text{ kg}) ; P < \)

0.01) than the older subjects (28+/−3%; 60+/−4 vs 76+/−5 kg, P < 0.01). There were no significant differences in strength gains between men and women in either age group with 9 wk of ST or in strength losses with 31 wk of detraining. Young men and women experienced an 8+/−2% decline in 1 RM strength after 31 wk of detraining (97+/−6 vs 89+/−6 kg, P < 0.05). This decline was significantly less than the 14+/−2% decline in the older men and women (76+/−5 vs 65+/−4 kg, P < 0.05). This strength loss occurred primarily between 12 and 31 wk of detraining with a 6+/−2% and 13+/−2% decrease in the young and older subjects, respectively, during this period. These results demonstrate that changes in 1 RM strength in response to both ST and detraining are affected by age. However, ST-induced increases in muscular strength appear to be maintained equally well in young and older men and women during 12 wk of detraining and are maintained above baseline levels even after 31 wk of detraining in young men, young women, and older men\(^{62}\).