CHAPTER – II

REVIEW OF RELATED LITERATURE
“The literature in any field forms the foundation upon which all future work will be built” (Aggarwal, 1975). The study of relevant literature is an essential step to get a clear idea of what has been done, with regard to the problem under study. Such a review brings about a deep and clear perspective of the overall field. A serious and scholarly attempt has been made by the scholar to go through the related literature and a brief review of the studies related to the present problem is described in this chapter. The reviews were collected from the libraries of Alagappa University, Karaikudi, Annamalai University, Chidambaram, Dr. Sivanthi Aditanar College of Physical Education, Tiruchendur, and through the Internet (Web Sources), journals and magazines etc.

The researcher finds out that some of the review of literature could be very supportive and strengthen this study. The reviews of the literature have been classified under the following headings:

1. Studies pertaining to plyometric training
2. Studies pertaining to resistance training

2.1. STUDIES PERTAINING TO PLYOMETRIC TRAINING

Aashish et al., (2015) investigated the effect of plyometric training programme on the agility performance among male basketball players. To achieve the purpose of this study a group of Thirty (N=30) male basketball players age ranged between 18 – 24 years, were selected from two basketball academies in Jaipur region- Ashta academy & Ryan school. The subjects were randomly assigned into two groups: experimental (n = 15) and control (n = 15) group. Experimental group was subjected to Millers plyometric
training twice per week for a period of 6-weeks. Control group underwent traditional
timeout academy coaching. The agility was measured by the help of T-test and Barrow’s ZigZag test. The paired t-test was used to assess the mean of Pre & post-test differences. Level of p≤0.05 was considered significant. The results from the study were very encouraging and demonstrated that the mean of agility test of Experimental Group was better than control group, Thus there was significant effect of the 6 week plyometric training programme on agility in young male basketball players. The plyometric training group reduced time on the ground while performing post-tests i.e- T-test as well as Barrow’s ZigZag test compared to the control group.

Nurper (2015) examined how speeding up, explosive strength, and kicking speed are affected by a 10-week plyometric training (PT) programme in elite female soccer players. Twenty adult players from Women First League (age=19.3±1.6 year, height=163.3±4.7 cm, body mass=56.6±6.1 kg) were divided into plyometric group (PG) and control group (CG). Both the groups performed technical and tactical training and matches together. PG performed PT 2 times per week for 10 weeks. No significant difference was found between the groups at pre-test variable (p>0.05). The significant improvement was found in the post-test of both groups (p<0.05), except for 10-20-m sprint test in the CG (p>0.05). Sprint, counter movement jump, standing broad jump, peak power and kicking speed test values were all significantly improved in the PG, as compared with the CG (p<0.05). The results indicated that safe and effective PT can be useful to conditioning coaches for explosive strength.

Saeed (2015) assessed the effects of short term plyometric training programme on sprint, strength, and power and agility performance in non-athletic men. In this research, 40 non-athletic men (year 18-23) participated. The participants were chosen
randomly and they participated in four tests strength (Swedish swimming, sit-ups),
power (vertical jumps, Horizontal jumps), agility (Illinois Agility Test, T Agility Test)
and 30 meters speed. The participants were divided into two groups, i.e. experimental
( plyometric training) and control group (did not perform PT training). They participated
in the training for 5 weeks and each week 1 session and each session 90 minutes. The
results of the study revealed that in experimental groups, significant increase observed in
Swedish swimming, horizontal jumps test and also significant decrease observed in 30
meters speed and test in comparison with control group (p-value of the respectively
0.001, 0.02, 0.00). The differences were significant and not observed of agility test in
comparison with control group. Conclusion: Therefore, it seems that plyometric training
have been effective on the physical preparation indices and can improve the non-
athletes’ performance.

Saez et al., (2015) determined the influence of a short-term combined plyometric
and sprint training (9 weeks) within regular soccer practice on explosive and technical
actions of pubertal soccer players during the in-season. Twenty-six players were
randomly assigned to 2 groups: control group (CG) (soccer training only) and combined
group (CombG) (plyometric + acceleration + dribbling + shooting). All players trained
soccer 4 times per week and the experimental groups supplemented the soccer training
with a proposed plyometric-sprint training programme for 40 minutes (2 days per week).
Ten-meter sprint, 10-m agility with and without ball, CMJ and Abalakov vertical jump,
ball-shooting speed, and Yo-Yo intermittent endurance test were measured before and
after training. The experimental group followed a 9-week plyometric and sprint
programme (i.e., jumping, hurdling, bouncing, skipping, and footwork) implemented
before the soccer training. Baseline-training results showed no significant differences
between the groups in any of the variables tested. No improvement was found in the CG; however, meaningful improvement was found in all variables in the experimental group: CMJ (effect size [ES] = 0.9), Abalakov vertical jump (ES = 1.3), 10-m sprint (ES = 0.7-0.9), 10-m agility (ES = 0.8-1.2), and ball-shooting speed (ES = 0.7-0.8). A specific combined plyometric and sprint training within regular soccer practice improved explosive actions compared with conventional soccer training only. Therefore, the short-term combined programme had a beneficial impact on explosive actions, such as sprinting, change of direction, jumping, and ball-shooting speed which are important determinants of match-winning actions in soccer performance. Therefore, we propose modifications to current training methodology for pubertal soccer players to include combined plyometric and speed training for athlete preparation in this sport.

Ramirez et al., (2015) compared the effects of 6 weeks of vertical, horizontal, or combined vertical and horizontal plyometric training on muscle explosive, endurance, and balance performance. Forty young soccer players aged between 10 and 14 years were randomly divided into control (CG; n = 10), vertical plyometric group (VG; n = 10), horizontal plyometric group (HG; n = 10), and combined vertical and horizontal plyometric group (VHG; n = 10). Players performance in the vertical and horizontal countermovement jump with arms, 5 multiple bounds test (MB5), 20-cm drop jump reactive strength index (RSI20), maximal kicking velocity (MKV), sprint, change of direction speed (CODS), Yo-Yo intermittent recovery level 1 test (Yo-Yo IR1), and balance was measured. No significant or meaningful changes in the CG, apart from small change in the Yo-Yo IR1, were observed while all training programmes resulted in meaningful changes in explosive, endurance, and balance performance. However, only VHG showed a statistically significant (p ≤ 0.05) increase in all performance test and
most meaningful training effect difference with the CG across tests. Although no significant differences in performance changes were observed between experimental groups, the VHG programme was more effective compared with VG (i.e., jumps, MKV, sprint, CODS, and balance performance) and HG (i.e., sprint, CODS, and balance performance) to small effect. The study demonstrated that vertical, horizontal, and combined vertical and horizontal jumps induced meaningful improvement in explosive actions, balance, and intermittent endurance capacity. However, combining vertical and horizontal drills seems more advantageous to induce greater performance improvements.

**Michailidis (2015)** studied the effectiveness of plyometric training on performance of preadolescent soccer players. 21 players assigned to two groups: jumping-group (JG, n = 11) and control-group (CG, n = 10). Training programme was performed for 10 weeks. Anaerobic power performances were assessed by using standing long jump (SLJ), 10 m and 30 m sprint. In the JG the performance at the long jump was increased significantly (P = 0.031). Also the performance of JG increased at 30 m sprint running by 7.2 % (P < 0.001). None of the variables tested in the CG demonstrated difference between the pre-test and the post-test. Our results indicate that plyometric training can improve running performance at 30 m sprint and the performance at standing long jump in pre-adolescent soccer players.

**Anuranjan (2015)** bring out the effect of plyometric exercises on speed in Hockey players of L.N.I.P.E, Gwalior. For the purpose of study 40 male hockey players were selected from L.N.I.P.E, Gwalior. The experimental and the control group consisting of 20 players in each group. Training for eight weeks was given to the experimental group which consists of plyometric exercises on alternate days i.e. three sessions per week and controlled group were given general training. Fifty Metre Run
was used for Pre-Test and Post-test for both the experimental and controlled group to find out the effect of plyometric exercises for the development of Speed. Results of this study shows that due to the plyometric exercise the experimental group has shown vast improvement compare to the controlled group in Pre-test and Post-test results. It was concluded that plyometric training significantly improves the speed of Hockey players.

Aashish et al., (2015) investigated the effect of plyometric training programme on the agility performance among male basketball players. To achieve the purpose of this study a group of Thirty (N=30) male basketball players age ranged between 18 – 24 years, were selected from two basketball academies in Jaipur region- Ashta academy & Ryan school. The subjects were randomly assigned into two groups: experimental (n = 15) and control (n = 15) group. Experimental group was subjected to Millers plyometric training twice per week for a period of 6-weeks. Control group undergone traditional routine academy coaching. The agility was measured by the help of T-test and Barrow’s ZigZag test. The paired t-test was used to assess the mean of Pre & post-test differences. Level of \( p \leq 0.05 \) was considered significant. The results from the study were very encouraging and demonstrated that the mean of agility test of Experimental Group was better than control group, thus there was significant effect of the 6-week plyometric training programme on agility in the young male basketball players. The plyometric training group reduced time on the ground while performing post-tests i.e- T-test as well as Barrow’s ZigZag test compared to the control group.

Ramesh (2015) determined the effect of plyometric training on selected motor components among footballers. It was hypothesized that there would be significant differences on selected motor components due to the effect of plyometric training among college football players. For the present study the 30 male footballers from SBM College
of Engineering and Technology, Dindigul, Tamilnadu were selected at random and their age ranged from 18 to 25 years. For the present study pre-test and post-test random group design which consists of control group and experimental group was used. The subjects were randomly assigned to two equal groups of fifteen each and named as Group ‘A’ and Group ‘B’. Group ‘A’ underwent plyometric training and Group ‘B’ has not undergone any training. The data was collected before and after six weeks of training. The data was analyzed by applying dependent ‘t’ test. The level of significance was set at 0.05. The plyometric training had positive impact on speed, muscular endurance, agility and explosive power among footballers.

Harmandeep et al., (2015) reveal the six-week Plyometrics effect on vertical jumping ability of state level Volleyball players. Total twenty (n=20) Volleyball players of Amritsar district were selected. Vertical jumping ability was dependent variable and Plyometric training was independent variable. Two groups were formed by dividing subjects randomly, Experimental group (E; n =10) and Control group (C; n=10). Experimental group was given a six week plyometric training treatment while the control group was participated only their routine programme. For the data collection, Sargent jump test was used. Pre-test and post-test were taken. To analyze data, t-test was used to evaluate the effect of Plyometric treatment at 0.05 significance level. The outcomes of the study reveals that the difference was statistically significant between the experimental and control groups.

Senthil (2015) trace the effects of 12 weeks of plyometric training programme on selected physical and physiological variables among high school boys. Plyometrics refers to exercise that enable muscles to reach maximal strength in as short a time as possible (power) by eliciting the stretch shortened cycle of a muscle fibre. To achieve
this purpose of the study, 40 boys have been selected randomly at Govt. Higher Secondary School, Gangavalli, Salem (Dt), TamilNadu, India in the age group between fourteen to sixteen. The selected subjects were divided into two equal groups of twenty each, namely plyometric training group and control group. The experimental group has undergone twelve weeks of plyometric training, whereas the control group maintained their daily routine activities but no special training was given. All the subjects of two groups were tested on selected criterion variables namely power, abdomen muscle strength, Cardio-respiratory endurance and Resting pulse rate using standardized tests, namely standing vertical jump, bent-knee sit-ups, Cooper’s 12-minute walk/run test and counting on radial artery/minute test prior to and immediately after the training period. The collected data were analyzed statistically through one way analysis of variance (ANOVA) to find out the significant difference, if any among the groups. .05 level of confidence was fixed to test the level of a significance which was considered appropriate. The results of the study showed that there was significant difference between plyometric training group and control group. Plyometric training group showed significant improvement on power, abdomen muscle strength, cardio-respiratory endurance and resting pulse rate compared to the control group.

Ramirez et al., (2014) investigated the efficiency of short-term vertical plyometric training program in soccer practice to improve both explosive actions and endurance among young soccer players. Seventy-six players were recruited and assigned either to a training group (TG; n = 38; 13.2 ± 1.8 years) or a control group (CG; n = 38; 13.2 ± 1.8 years) group. All players trained twice per week, but the TG followed a 7-week plyometric program implemented during soccer practice, whereas the CG followed regular practice. Twenty-meter sprint time (20-m), Illinois agility test time, counter-
movement jump (CMJ) height, 20- (RSI20) and 40cm-(RSI40) drop jump re-active strength index, multiple 5 bounds distance (MB5), maximal kicking test for distance (MKD), and 2.4-km time trial were measured before and after the 7-week period. Plyometric training induced significant ($p \leq 0.05$) and small to moderate standardized effect (SE) improvement in the CMJ (4.3%; SE = 0.20), RSI20 (22%; SE = 0.57), RSI40 (16%; SE = 0.37), MB5 (4.1%; SE = 0.28), Illinois agility test time (-3.5%, SE = -0.26), MKD (14%; SE = 0.53), 2.4-km time trial (-1.9%; SE = -0.27) performances but had a trivial and non-significant effect on 20-m sprint time (-0.4%; SE = -0.03). No significant improvement was found in the CG. An integrated vertical plyometric programme during the regular soccer practice can substitute soccer drills to improve most explosive actions and endurance, but horizontal exercises should also be included to enhance sprinting performance.

Gunnar (2014) examined the effect of a high-intensity sprint and plyometric training programme on 13-year-old male soccer players. A training group of 14 adolescent male soccer players, mean age ($\pm$SD) 13.5 years ($\pm$0.24) followed an eight-week intervention programme for one hour per week, and a group of 12 adolescent male soccer players of corresponding age, mean age 13.5 years ($\pm$0.23) served as control group. Pre- and post-tests assessed 10-m linear sprint, 20-m linear sprint and agility performance. Results showed a significant improvement in agility performance, pre 8.23 s ($\pm$0.34) to post 7.69 s ($\pm$ 0.34) ($p<0.01$), and a significant improvement in 0-20m linear sprint, pre 3.54s ($\pm$0.17) to post 3.42s ($\pm$0.18) ($p<0.05$). In 0-10m sprint the participants also showed an improvement, pre 2.02s ($\pm$0.11) to post 1.96s ($\pm$ 0.11), however this was not significant. The correlation between 10-m sprint and agility was $r = 0.53$ ($p<0.01$), and between 20-m linear sprint and agility performance, $r = 0.67$ ($p<0.01$). The major
finding in the study is the significant improvement in agility performance and in 0-20 m linear sprint in the intervention group. These findings suggest that organizing the training sessions with short-burst high-intensity sprint and plyometric exercises interspersed with adequate recovery time, may result in improvements in both agility and linear sprint performance in adolescent male soccer players. Another finding is the correlation between linear sprint and agility performance, indicating a difference when compared to adults.

**Frohlich et al., (2014)** brought to light the effects of an 8-week periodized PT programme on jumping high and power enhancement among male and female junior badminton players, using high-impact bilateral plyometric exercises. Starting and finishing with the bio-mechanical diagnostics of the squat jump (SJ), counter- movement jump (CMJ), and drop jump (DJ) on force plates, kinematic analysis of forehand overhead smashes, anthropometric data as well as force data for pre- and post-test were analyzed. Before and after the bio-mechanical diagnostics, the players (n=11) undergo an 8-week PT (2 units per week) with a total of 2286 jumps. 8 male and 3 female junior badminton players (age: 16.0±1.6 years, height: 175.5±9.9 cm, mass: 69.3±11.4 kg) were tested in jumping high and forehand overhead jump-smashes performance. Looking at the plyometric strength parameters of the squat jump (P<0.05; dz=0.8) and the floor reaction-time of the drop jump (P<0.05; dz=1.1), the positive effect of the 8-week PT among junior badminton players is significant. Consequently, this form of training is essential for the development of junior and top-level badminton players. Moreover, the study has shown that the contact of the overhead smash cannot be increased by improving plyometric strength training (P>0.05). Therefore, the focus must be on technical training. Consequently, it is considered to be important to include short-term
PT in in-season preparation in order to improve complex badminton-specific dynamic performance (smash-jumping).

**Yahya et al., (2014)** studied the effects of plyometric exercises on physical fitness and motor skills indicators in Firoozabad city. Subjects were a group of 20 handball players from the city of Firoozabad. Plyometric exercises to train three days per week for eight weeks, were conducted. Participants were pre-and post-tested. Plyometric exercises with independent variables and change some changed parameters of physical fitness and fitness-related variables were investigated. The two methods for analyzing data, the descriptive statistics and inferential statistics were tested and the paired T alpha level was $\alpha = 5\%$. The results showed that plyometric exercises on muscular strength, agility and power had a positive effect. Also plyometric exercise on triple shooting and 3 steps shooting have a positive effect, but shooting on the move had negative effect. As regards to this matter that most of the handball techniques need to jump, use sudden shifts and explosive movements on hands and legs necessitates the implementation of plyometric exercises on handball athletes so as to strengthen some fitness factors like power agility and muscle power. Since most sport techniques need fitness factors we can conclude that plyometric exercise can increase some motion skills of handball players.

**Almoslim (2014)** compared the effect of combined plyometric and resistance training on sprinting performance on males with different body fat percent. Forty participants with BMI 18.5 to 24.9 kg/m2, aged between 18-22 years, according to body fat % two groups were formed, group I ($n=20$) consisted of 6 to 12% and group II ($n=20$) had 12.1 to 20% fat. Both groups were performed combined plyometric and resistance training 2 days per week, for 6 weeks with, 50 minutes of training per session. Pre and
post-test were performed on all the participants for measuring sprinting performance with regard to 30m, 40m and 50m. For analyzing the data, independent t-test and Paired t-test were utilized. The analysis of data revealed findings of both the groups i.e. participants had shown improved performance in 30m by 5.6% (4.77 ± 0.40 vs. 4.49 ± 0.38 sec; p = 0.000) for group I; and by 6.3% (4.92 ± 0.37 vs. 4.61 ± 0.35 sec; p = 0.000) for group II after the training programme. In 40m sprint the time of group I and II, resulted in significant decrease of 3.7% (5.80 ± 0.32 to 5.58 ± 0.35 sec; p < 0.001) and 5.1% (5.98 ± 0.43 to 5.66 ± 0.47 sec; p < 0.001) respectively. After training, there was significant decrease in 50m sprint time of 3.6% (7.06 ± 0.43 vs. 6.80 ± 0.47 sec; p = 0.000) in group I and 4.9% (7.28 ± 0.40 to 6.92 ± 0.46 sec; p = 0.000) in group II. However, there was no significant difference between groups for any of the speed distances. It was concluded that the effect of combined plyometric and resistance training programme showed improve performances in both fat groups with regard to 30m, 40m and 50m sprinting performance.

Ozbar et al., (2014) determined the effect of 8-week plyometric training (PT) on leg power, jump and sprint performance in female soccer players. Eighteen female soccer players from Women Second League (age = 18.2 ± 2.3 years, height = 161.3 ± 5.4 cm, body mass = 56.6 ± 7.2 kg) were randomly assigned to control (n = 9) and plyometric (n = 9) groups. Both groups continued together with regular technical and tactical soccer training for 4 days a week. Additionally, the plyometric group underwent PT for 8 weeks, 1 day per week, 60-minute session duration. During the 8-week period, the control group was not given any additional conditioning training. All players' jumps (triple hop, countermovement jump, and standing broad jump), running speed (20 m), and peak power were evaluated before and after 8 weeks. No significant difference was
found between the groups at pre-test variables (p > 0.05). Significant improvements were found in the post-test of both the groups (p ≤ 0.05), except for the 20-m sprint test in the control group (p > 0.05). Triple hop distance, counter-movement jump, standing broad jump, peak power, and 20-m sprint test values were all significantly improved in the plyometric group, compared with the control group (p ≤ 0.05). We concluded that short duration PT is an important improved component of athletic performance in female soccer players. The results indicate that safe, effective, and alternative PT can be useful to strength and conditioning coaches, especially during competition season where less time is available for training.

Gi Duck et al., (2014) examined the effect of low extremity plyometric training on back muscle power among high school throwing event athletes. The physical strength elements required for athletic throwing events include muscle strength, swiftness, agility, speed, flexibility, and physical balance. Although plyometric training and weight training are implemented as representative training methods for improving swiftness and agility, most studies of it have been conducted with players of other sports. The study subjects were 10 throwing event athletes attending K Physical Education High School. The subjects were randomly assigned to a control group of five subjects and an experimental group of five subjects. To analyze the body composition, an Inbody 3.0 instrument (Biospace, Korea) was used as experimental equipment to measure heights, weight, body fat percentages, and muscle masses and a Biodex system 4.0 (BIODEX, USA) was used to measure isokinetic muscle-joint and lumbar muscle strengths. The plyometric training consisted of 15 techniques out of the training methods introduced in the ‘Power up plyometric training’. The plyometric programme was implemented without any training load three times per week during daybreak exercises for the
experimental group. The number of times and the number of sets were changed over time as follows: three sets of 10 times in the 1st–4th weeks, three sets of 15 times in the 5th–8th weeks, and five sets of 15 times in the 9th–12th weeks. According to the ANCOVA results of lumbar extensor muscle strength at 60°/sec, the overall reliability of the model was notable. According to the ANCOVA results of lumbar flexor muscle strength at 60°/sec, the overall reliability of the model was significant. Plyometric training positively affected high school throwing event athletes. To summarize the study findings, the application of plyometric training with high intensity and loads improved the results of athletes who perform highly intensive exercises at normal times.

**Gonzalez et al., (2014)** examined the effects of a circuit training including plyometric jumps on cardio-respiratory fitness of children and adolescents with Down syndrome. Twenty-seven children and adolescent aged between 10 to 19 years with DS participated in this study and were divided in two groups: exercise (EXE, n=14) and control (CON, n=13). Work time, peak values of oxygen consumption, respiratory exchange ratio, heart rate and minute ventilation of the participants were measured pre- and post-training with a graded exercise treadmill test. The result of the study showed that EXE group increased all their cardio-respiratory parameters compared to baseline after 21 weeks of training (all $P<.05$). Additionally, and despite having similar pre-training values, the EXE group showed higher values than the CON group in all cardio-respiratory parameters after training (all $P<.05$). It may be concluded that youths with Down syndrome can achieve improvements in several cardio-respiratory parameters when performing 21 weeks of training including plyometric exercises.

**Shalfawi et al., (2013)** compared the effects of in-season combined resisted agility and repeated sprint training with strength training on soccer players' agility, linear
single sprint speed, vertical jump, repeated sprint ability (RSA), and aerobic capacity. Twenty well-trained elite female soccer players of age ± SD 19.4 ± 4.4 years volunteered to participate in this study. The participants were randomly assigned to either agility or repeated sprint training group or to the strength training group. All the participants were tested before and after a 10-week specific conditioning programme. Pre-test and post-test were conducted on 3 separate days with 1 day of low-intensity training in between. The agility and repeated sprint training implemented in this study did not have a prominent effect on agility, although there was a tendency for moderate improvements from 8.23 ± 0.32 to 8.06 ± 0.21 seconds (d = 0.8). There was a significant (p < 0.01) and moderate-positive effect on Beep-test performance from level 9.6 ± 1.4 to level 10.8 ± 1.0, and only a trivial, small effect on all other physical variables measured in this study. The strength training group had a positive, moderate, and considerable (p < 0.01) effect on Beep-test performance from level 9.7 ± 1.3 to level 10.9 ± 1.2 (d = 1.0) and a significant (p < 0.05) but small effect (d = 0.5) on SJ performance (25.9 ± 2.7 to 27.5 ± 4.1 cm). Furthermore, the strength training implemented in this study had a trivial and negative effect on agility performance (d = -0.1). No between-group differences were observed. The outcome of this study indicates the importance of a well-planned programme of conditioning results in an increased performance of the players. It also prove the great importance of strength and conditioning specialist in implementing the training programme, and the importance of choosing the time of the year to implement such conditioning training programmes. However, we also have to accept the fact that the present training programme did not cause any decline in performance and that it is useful in maintaining the soccer players' physical performance during the competition period.
2.2. STUDIES PERTAINING TO RESISTANCE TRAINING

Franco et al., (2015) determined the effects of combined resistance training and plyometrics on physical performance in under-15 soccer players. One team (n=20) followed a 6-week resistance training programme combined with plyometrics plus a soccer training programme (STG), whereas another team (n=18) followed only the soccer training (CG). Strength training consisted of full squats with low load (45-60% 1RM) and low-volume (2-3 sets and 4-8 repetitions per set) combined with jumps and sprints twice a week. Sprint time in 10 and 20 m (T10, T20, T10-20), CMJ height, estimated one-repetition maximum (1RMest), average velocity attained against all loads common to pre- and post-tests (AV) and velocity developed against different absolute loads (MPV20, 30, 40 and 50) in full squat were selected as testing variables to evaluate the effects of the training programme. STG experienced greater gains (P<0.05) in T20, CMJ, 1RMest, AV and MPV20, 30, 40 and 50 than CG. In addition, STG showed likely greater effects in T10 and T10-20 compared to CG. These results indicate that only 6 weeks of resistance training combined with plyometrics in addition to soccer training produced greater gains in physical performance than typical soccer training alone in young soccer players.

Tillman et al., (2015) evaluated the lower limb progressive resistance training which improves leg strength but not gait speed or balance in Parkinson's disease. The aim of the meta-analysis is to evaluate the evidence surrounding the use of PRT to improve gait and balance in people with PD. Five electronic databases, from inception to December 2014, were searched to identify the relevant studies. Data extraction was performed by two independent reviewers and methodological quality was assessed using the PEDro scale. Standardized mean differences (SMD) and 95% confidence intervals
(CIs) of fixed and random effects models were used to calculate the effect sizes between experimental and control groups and I (2) statistics were used to determine levels of heterogeneity. In total, seven studies were identified consisting of 172 participants (experimental n = 84; control n = 88). The pooled results showed a moderate but significant effect of PRT on leg strength (SMD 1.42, 95% CI 0.464-2.376); It may be suggested that PRT may be performed in conjunction with balance or task-specific functional training to elicit greater lower limb functional benefits in people with PD.

Beurskens et al., (2015) investigated effects of resistance vs. balance training on MIF and BLD of the leg extensors in old adults. Subjects were randomly assigned to resistance training (n = 19), balance training (n = 14), or a control group (n = 20). Bilateral heavy-resistance training for the lower extremities was performed for 13 weeks (3 × / week) at 80% with a maximum of one repetition. Balance training was conducted using predominately unilateral exercises on wobble boards, soft mats, and uneven surfaces for the same duration. Pre- and post-tests included uni- and bilateral measurements of maximal isometric leg extension force. At baseline, young subjects outperformed older adults in uni- and bilateral MIF (all p < .001; d = 2.61-3.37) and also in measures of BLD (p < .001; d = 2.04). We also found considerable increases in uni- and bilateral MIF after resistance training (all p < .001, d = 1.8-5.7) and balance training (all p < .05, d = 1.3-3.2). In addition, BLD decreased following resistance (p < .001, d = 3.4) and balance training (p < .001, d = 2.6). It can be concluded that both training regimens resulted in increased maximal isometric force (MIF) and decreased bilateral deficit (BLD) of the leg extensors (HRT-group more than BAL-group), almost reaching the levels of young adults.
Schoenfeld et al., (2015) conducted the effect of repetition duration during resistance training on muscle hypertrophy. Studies were deemed eligible for inclusion if they met the following criteria: (1) were an experimental trial published in an English-language referral journal; (2) directly compared different training tempos in dynamic exercise using both concentric and eccentric repetitions; (3) measured morphologic changes via biopsy, imaging, and/or densitometry; (4) had a minimum duration of 6 weeks; (5) carried out training on muscle failure, defined as the inability to complete another concentric repetition while maintaining proper form; and (6) used human subjects who did not have a chronic disease or injury. A total of eight studies were identified that investigated repetition duration in accordance with the criteria outlined. Results indicate that hypertrophic outcomes are similar when training with repetition durations ranging from 0.5 to 8 s. From a practical standpoint it would seem that a fairly wide range of repetition durations can be employed if the primary goal is to maximize muscle growth. Findings suggest that training volitionally at very slow durations is inferior from a hypertrophy standpoint, although a lack of controlled studies on the topic makes it difficult to draw definite conclusions.

Saleem and Jince (2015) determined the effects of eight weeks of resistance training programme on selected physiological variables such as, anaerobic capacity, aerobic capacity, and resting pulse rate of college men. The subjects of the study were 50 college men from Kerala state. The subjects were randomly assigned into two groups namely an experimental group (N=25) and a control group (N=25). The experimental group participated in resistance training programme three days in a week for a period of eight weeks. The control group did not participate in any training except their day to day activities. All the subjects were tested in the selected physiological variables such as
aerobic capacity, anaerobic capacity, and resting pulse rate before and after eight weeks of resistance training programme. Aerobic capacity measured with Forestry step test and the pulse counted was taken for 15 seconds, after 15 seconds of the completion of test. It was tabulated with norms and expressed as VO₂ Max (ml Kg⁻¹ min⁻¹). Anaerobic capacity measured with Sargent vertical jump test was taken and expressed in kgm/s. The number of inches between the reach and jump measured to the nearest inch further converted into centimeters and derived in kgm/s⁻¹ from the equation [p=2.21 wt D]. Resting pulse rate was taken at the radial artery and the pulse counted for one minute was recorded in the number of beats per minute. The data pertaining to selected physiological variables were analysed by paired ‘t’ test to determine the difference between initial and final mean for experimental and control group. Significant difference was found to exist at 0.05 level (0.05 = 2.064) in experimental group following eight weeks of resistance training in anaerobic capacity, aerobic capacity, and resting pulse rate. In the case of control group there were no changes in any of the selected variables.

Ramakrishnan and Gopinath (2014) examined the effect of weight training and circuit weight training on strength and physiological variables among male players of various games and sports. For this purpose, forty-five male players studying in various colleges around Thiruvallur, Tamilnadu, were selected as subjects. The age of the subjects ranged from 18 to 23 years. They were divided into three equal groups, each group consisted of fifteen subjects, in which experimental group - I underwent weight training, experimental group - II underwent circuit weight training and group - III acted as control not participating in any special activities apart from their regular activities. The training period for the present study was three days (alternative days) in a week for twelve weeks. Prior to and after the experimental period, the subjects were tested on leg
strength, strength endurance and vital capacity. Leg strength was assessed by administering dynamometer in kilograms, strength endurance was assessed by administering sit-ups test in numbers per minute and vital capacity was analysed by using wet spirometer in litres. The Analysis of Covariance (ANCOVA) was applied to find out any significant difference between the experimental groups and control group on selected criterion variables. Whenever the adjusted post-test mean was found to be significant, the Scheffé S was used as post-hoc test. The result of the study shows that the weight training and circuit weight training groups had increased the leg strength, strength endurance and vital capacity significantly.

Subramanian (2014) studied the effect of eight weeks of supervised core strength training on selected physical and physiological parameters such as muscular strength, back strength, flexibility, mean arterial pressure, vital capacity, and resting pulse rate of cricket players. For these purpose 30 male cricket players, aged 18 to 22 years took part in the study. Selected subjects were randomly assigned to either core strength training (n=15) or control (n=15) group. The training regimen lasted for eight weeks. The selected dependent variables were assessed using standard tests and procedures, before and after the training regimen. Analysis of covariance was used to determine the significant difference existing between pre-test and post-test on selected dependent variables. The analysis of data revealed that eight weeks of core strength training had striking impact on selected physical and physiological parameters.

Soto-Rey et al., (2014) analyzed the differences in manual reaction time (RT) to visual stimuli in two samples of physically active persons: a group of athletes without hearing impairment (n = 79; M age = 22.6 yr., SD = 3.7) and a group of athletes with hearing impairment (n = 44, M age = 25.6 yr., SD = 5.0). Reaction time (RT) was
measured and then differences between both groups were assessed by sex, type of sport (individual vs team sports), and competition level. RT to visual stimuli was significantly shorter for athletes with hearing impairment than for those without hearing impairment, with a significant sex difference (shorter RT for males), but no differences regarding type of sport or competition level. Suggestions for further research and sport applications are provided.

Simao et al., (2012) investigated the effects of non-linear periodized (NLP) and linear periodized (LP) resistance training (RT) on muscle thickness (MT) and strength, measured by an ultrasound technique and one repetition maximum (1RM), respectively. Thirty untrained men were randomly assigned into 3 groups: The right biceps and triceps MT and 1RM strength for the exercises bench press (BP), lat-pull down, triceps extension, and biceps curl (BC) were assessed before and after 12 weeks of training. The NLP programme varied training bi-weekly during weeks 1-6 and on a daily basis during weeks 7-12. The LP programme followed a pattern of intensity and volume changes every 4 weeks. The CG did not engage in any RT. Post training, both trained groups presented significant 1RM strength gains in all exercises (with the exception of the BP in LP). The 1RM of the NLP group was greatly higher than LP for BP and BC post training. There were no significant differences in biceps and triceps MT between baseline and post-training for any group; however, after training, there were significant differences in biceps and triceps MT between NLP and the CG. The effect sizes were higher in NLP for the majority of observed variables. In conclusion, both LP and NLP are effective, but NLP may lead to greater gains in 1RM and MT over a 12-week training period.
Zavanela et al., (2012) examined the health and fitness benefits of a resistance training intervention performed at a workplace. The subjects (untrained men bus drivers) were recruited from a bus company and divided into a training (n = 48) and control (n = 48) groups after initial pre-screening. The training group performed a 24-week resistance training programme, whereas the control group maintained their normal daily activities. Each group’s health and fitness were assessed before and after the 24-week training period. The study concluded that a periodized resistance training intervention performed within the workplace improved different aspects of health and fitness in untrained men, thereby potentially providing other work-related benefits.

Geirsdottir et al., (2012) investigated the physical function predicted improvement in the quality of life in the elderly Icelanders after 12 weeks of resistance exercise. Subjects (N = 237) female participated in a 12-week resistance exercise programme (3 times/week; 3 sets, 6-8 repetitions at 75-80% of the 1-repetition maximum) designed to increase strength and muscle mass of major muscle groups. Body composition, quadriceps- and grip strength, timed up and go test (TUG), six minute walk for distance (6MW) and HRQL were measured at baseline and endpoint. They concluded that the increase in lean mass was small (+0.8 kg), quadriceps strength (+53.5 N), grip strength (+3.0 lb), TUG (-0.6 sec), 6MW (+33.6 m) and HRQL (+1.2 t-score) improved significantly. Changes in 6MW predicted improvement in HRQL after 12 weeks.

Sherk et al., (2012) conducted a study on the effects of resistance training duration on muscular strength retention 6-month post training in older men and women. Twenty five men and 44 women (aged 55–75 years) who returned for testing 6 months after training, 38 had continued to exercise on their own (Ex) and 31 stopped training (NoEx). This represents 40.8% of the original 169 participants who were contacted.
Individual measures of strength were averaged to represent a measure of mean upper body or lower body strength. Changes in mean 1RM (one repetition maximum) strength and percent changes in strength were analyzed for pre (pre training), post (post training), and 6MP (6 months post) time points by mixed-factor ANOVAs (analyses of variance). The results showed that the upper and lower body strengths were still significantly higher than baseline values, 6MP training for both groups. However, the longer-duration (80 week) training programme provided a greater, although non–statistically significant, ability to maintain strength at higher levels at 6MP training compared to the strength values obtained at the end of the two different training periods. In addition, lower body strength was better maintained than measures of upper body strength independent of initial training duration. Supervised strength training represents an efficacious intervention for improving strength in older adults with residual benefits lasting longer than previously expected.

Scholtes et al., (2012) evaluated the effectiveness of functional progressive resistance exercise (PRE) training on walking ability in children with cerebral palsy (CP). Fifty-one ambulant children with spastic CP (mean age 10 years 5 months, 29 boys) were randomized to an intervention (n=26) or control group (n=25, receiving usual care). The intervention consisted of 12 weeks functional PRE circuit training, for 3 times a week. Main outcome measures were walking ability and participation. Secondary outcomes were muscle strength and anaerobic muscle power. Possible adverse outcomes were spasticity and passive range of motion (ROM). Muscle strength increased remarkably in the training group compared to the control group, but walking ability, participation and anaerobic muscle power did not change. Spasticity and ROM remained unchanged, except for a considerable decrease in rectus femoris length in the
intervention group. It is concluded that twelve weeks of functional PRE-training does not improve walking ability, despite improved muscle strength.

**Ignjatovic et al., (2011)** investigate the influence of additional resistance training on cardio-respiratory endurance in young (15.8 ± 0.8 yrs) male basketball players. Experimental group subjects (n=23) trained twice per week for 12 weeks using a variety of general free-weight and machine exercises designed for strength acquisition, beside on-going regular basketball training programme. Control group subject (n=23) participated only in the basketball training programme. Oxygen uptake (VO$_2$max) and related gas exchange measures were determined continuously during maximal exercise test using an automated cardio-pulmonary exercise system. Muscle power of the extensors and flexors was measured by a specific computerized tensiometer. Results from the experimental group (VO$_2$max) 51.6 ± 5.7 ml. min$^{-1}$.kg$^{-1}$ pre vs. 50.9 ± 5.4 ml.min$^{-1}$.kg$^{-1}$ post-resistance training showed no change (p>0.05) in cardio-respiratory endurance, while muscle strength and power of main muscle groups increased prominently. These data demonstrate no negative cardio-respiratory performance effects on adding resistance training to ongoing regular training programme in young athletes.

**Cowley et al., (2011)** examined the effect of progressive resistance training on leg strength, aerobic capacity and functional tasks of daily living in persons with Down syndrome. Thirty persons with DS (age 28 SD 8 years) were assigned to an intervention or control group. The intervention group performed resistance training 2 days per week for 10 weeks. Participants performed tests to measure isometric and isokinetic knee extensor and flexor peak torque, peak aerobic capacity and timed performance on chair rise, walking and stair ascent and descent. The results showed that persons with DS
receiving the intervention significantly increased their isokinetic knee extensor and flexor peak torque [Absolute change (post minus pre-value) was 17.0 SD 29.6 and 12.6 SD 18.9 N m, respectively] and isometric knee extensor peak torque at angles of 45° (2.9 SD 23.2 N m), 60° (3.0 SD 22.9 N m) and 75° (14.2 SD 30.0 N m). These changes were significantly greater than in the control group. In addition, the time to ascend (-0.3 SD 0.8 s) and descend (-0.6 SD 0.9 s) stairs significantly decreased in the intervention group compared to the control group. These findings show that progressive resistance training is an effective intervention for persons with DS to improve leg strength and stair-climbing ability.

Miranda et al., (2011) investigated the effects of linear vs. daily undulatory periodized resistance training on maximal and sub maximal strength gains. Twenty resistance trained men were randomly assigned to 2 training groups: linear periodization (LP) group and daily undulating periodization (DUP) group. The subjects were tested at baseline after 12 weeks for 1RM and 8RM loads in leg press (LEG) and bench press (BP) exercises. The training programme was performed in alternated sessions for upper (session A: chest, shoulder and triceps) and lower body (session B: leg, back and biceps). The 12-week periodized training was applied only in the tested exercises, and in the other exercises, 3 sets of 6-8RM were performed. Both groups exhibited significant increases in 1RM loads on LEG and BP, but no statistically significant difference between groups was observed. The same occurred in 8RM loads on LEG and BP. However, DUP group presented superior effect size (ES) in 1RM and 8RM loads for LEG and BP exercises when compared to the LP group. In conclusion, periodized RT can be an efficient method for increasing the strength and muscular endurance in trained individuals. Although there was no statistically significant difference between
periodization models, DUP promoted superior ES gains in muscular maximal and submaximal strength.

**Alcaraz et al., (2011)** compared the effects of 8 weeks of high-resistance circuit (HRC) training (3-6 sets of 6 exercises, 6 repetition maximum [RM], 35-second inter set recovery) and traditional strength (TS) training (3-6 sets of 6 exercises, 6RM, 3-minute inter set recovery) on physical performance parameters and body composition with 33 healthy men randomly assigned to HRC, TS, or a control group. Training consisted of weight lifting 3 times a week for 8 weeks. Before and after the training, 1RM strength on bench press and half squat exercises, bench press peak power output, and body composition (dual x-ray absorptiometry) were determined. Shuttle run and 30-second Wingate tests were also completed. Upper limb (UL) and lower limb 1RM increased equally after both TS and HRC training. The UL peak power at various loads was significantly higher at post training for both groups (p < 0.01). Shuttle-run performance was significantly better after both HRC and TS training, however peak cycling power increased only in TS training (p < 0.05). Significant decreases were found in the percentage of body fat in the HRC group only; HRC and TS training both resulted in an increased lean but not in bone mass. The HRC training was as effective as TS for improving weight lifting 1RM and peak power, shuttle-run performance and lean mass. Thus, HRC training promoted a similar strength-mass adaptation as traditional training while using shorter training session duration.

**Brandon and Ina Shaw (2005)** determined whether resistance training could alter cardio-respiratory endurance (VO$_2$ max), and reduce CAD risk. A quantitative, experimental, comparative research design incorporating a pre-test, a treatment period and a post-test was used. Twenty-eight untrained male volunteers were age matched
(mean age: 28 years and seven months) and randomly assigned to either a non exercising control group (n = 15) or a resistance-training group (n = 13). The study demonstrated no statistically significant change in VO$_2$ max for the control group from their pre-test (25.097 ml/kg/min) to their post-test (23.778 ml/kg/min) ($p = 0.201$). However, resistance training significantly ($p \leq 0.01$) increased the VO$_2$ max from 26.674 ml/kg/min to 30.981 ml/kg/min ($p = 0.004$). Additionally, the difference between the pre- and post-test of the control and training group, respectively, demonstrated that the control group's mean VO$_2$ max was significantly lower than that of the resistance-training group ($p = 0.001$). Although not all studies have demonstrated significant increases in VO$_2$ max following resistance training, the results of this study showed that eight weeks of resistance training were sufficient to result in a significant improvement in VO$_2$ max. This suggests that an exercise programme that includes resistance training results in a composite of physical and physiological improvements necessary to impact favourably on risk for Coronary artery disease (CAD).

2.3. SUMMARY OF THE LITERATURES

In this chapter, the researcher had given thirty-eight research abstracts, which had been conducted recently and published through magazines, journals and periodicals pertaining to the topic considered in this study. These reviews of related literature helped the researcher to understand of the problem and to interpret the result better.