CHAPTER-II
REVIEW OF RELATED LITERATURE

The study related literature is an essential step to get a good comprehension of what has been done with regard to the problem under study such review is instrumental in the selection of topic, transaction of hypothesis and deductive reasoning leading to the problem. It will bring out a deep and clear perspective of overall field.

2.1 STUDIES ON CIRCUIT RESISTANCE TRAINING ON FOOTBALL

DeHoyo M et.al. (2015) Conducted a study on the effect of an eccentric-overload training program (i.e., half-squat and leg-curl exercises using flywheel ergometers) with individualized load on muscle-injury incidence and severity and performance in junior elite soccer players. Thirty-six young players (U-17 to U-19) were recruited and assigned to an experimental (EXP) or control group (CON). The training program consisted of 1 or 2 sessions/wk (3-6 sets with 6 repetitions) during 10 wk. The outcome measured included muscle injury (incidence per 1000 h of exposure and injury severity) and performance tests (countermovement jump [CMJ], 10-m and 20-m sprint test). Between-groups results showed a likely (ES: 0.94) lower number of days of absence per injury and a possible decrement of incidence per 1000 h of match play in EXP than in CON. Regarding muscle performance, a substantial better improvement (likely to very likely) was found in 20-m sprint time (ES: 0.37), 10-m flying-sprint time (ES: 0.77), and CMJ (ES: 0.79) for EXP than for CON. Within-group analysis showed an unclear effect in each variable in CON. Conversely, substantial improvements were obtained in CMJ (ES: 0.58), 20-m sprint time (ES: 0.32), 10-m flying-sprint time (ES: 0.95), and injury severity (ES: 0.59) in EXP. Furthermore, a possible decrement in total injury incidence
was also reported in EXP. The eccentric-based program led to a reduction in muscle-injury incidence and severity and showed improvements in commonsoccer tasks such as jumping ability and linear-sprinting speed.

González-Badillo JJ (2014) Conducted a study on analyze the effect of velocity based-resistance training (RT) with moderate load and few repetitions per set combined with jumps and sprints on physical performance in young soccer players of different ages. A total of 44 elite youth soccer players belonging to three teams participated in this study: an under-16 team (U16, n = 17) and an under-18 team (U18, n = 16) performed maximal velocity RT program for 26 weeks in addition to typical soccer training, whereas an under-21 team (U21, n = 11) did not perform RT. Before and after the training program all players performed: 20-m running sprint (T20); countermovement jump (CMJ); a progressive isoinertial loading test in squat to determine the load which players elicited \( \sim 1 \text{ m} \cdot \text{s} \) (V1LOAD); and an incremental field test to determine maximal aerobic speed (MAS). U16 showed significantly \( (P = .000) \) greater gains for V1LOAD than U18 and U21 (100/0/0%). Only U16 showed significantly \( (P = .01) \) greater gains than U21 (99/1/0%) for CMJ height. U18 obtained a likely better effect on CMJ performance than U21 (89/10/1%). The beneficial effects on T20 between groups were unclear. U16 showed a likely better effect on MAS than U21 (80/17/3%), whereas the rest of comparisons were unclear. The changes in CMJ correlated to the changes in T20 \( (r = -.49) \) and V1LOAD \( (r = .40) \). In conclusion, velocity-based RT with moderate load and few repetitions per set seems to be an adequate methodology to improve the physical performance in young soccer players.

Keiner M, Sander A, Wirth K, Schmidtbleicher D.(2014) Conducted a study on analyzes the possible correlations between the 1-Repetition Maximum/body mass (SREL)
in the front and back squats and COD. The subjects (n = 112) were at pretest between 13 and 18 years of age and were divided into 2 groups with 4 subgroups (A = under 19 years of age, B = under 17 years of age, and C = under 15 years of age). For approximately 2 years, 1 group (control group [CG]) only participated in routine soccer training, and the other group (strength training group [STG]) participated in an additional strength training program with the routine soccer training. Additionally, the performances in the COD of 34 professional soccer players of the first and second divisions in Germany were measured as a standard of high-level COD. For the analysis of the performance development within a group and pairwise comparisons between 2 groups, an analysis of variance with repeated measures was calculated with the factors group and time. Relationships between the COD and SREL were calculated for the normal distributed data using a plurality of bivariate correlations by Pearson. Our data show that additional strength training over a period of 2 years significantly affects the performance in the COD. The STG in all sub cohorts reached significantly (p < 0.05) faster times in the COD than did the CG. The STG amounted up to 5% to nearly 10% better improvements in the 10-m sprint times compared with that of the CG. Furthermore, our data show significant (p < 0.05) moderate to high correlations (r = -0.388 to -0.697) between the SREL and COD. Our data show that a long-term strength training improves the performance of the COD. Therefore, a long-term resistance training is recommended as early as in childhood and adolescence.

Melchiorri G et.al.,(2014) Conducted a study on verify the presence and eventually the magnitude of physiological cardio respiratory changes in young team sport players after a period of long-term detraining. Fourteen young soccer players (15 ± 1 year) were studied with two incremental tests at the end of the regular season and after a six-week total break period from training activities. Physiological variables were
evaluated: heart rate (HR), oxygen uptake (VO\textsubscript{2}), volume of ventilation (VE), aerobic (VA) and anaerobic (Van) running speed at thresholds and maximum effort were recorded. This study shows the magnitude of the physiological changes in young players after a period of long-term detraining. The results showed significant decreases at the end of the detraining period of VO\textsubscript{2} at VA of 22.7% (44.54 ± 4.56 vs. 34.41 ± 4.57 mL/kg/min, P<0.05), of 25.8% of VO\textsubscript{2} at VAn (54.60 ± 5.81 vs. 40.48 ± 5.07 mL/kg/min, P<0.05) and of 21.2% in VO\textsubscript{2} max (62.83 ± 5.77 vs. 49.46 ± 6.51 mL/kg/min, P<0.05). Speed at VA (11.5 ± 0.96 vs. 10.7 ± 0.97 km/h; P<0.05), speed at VAn (15.3 ± 1.05 vs. 14.2 ± 1.48 km/h; P<0.05), peak running speed (18.8 ± 1.20 vs. 17.2 ± 1.1 km/h; P<0.05). It is likely that alteration of metabolic parameters may significantly affect the range of physical condition and especially, aerobic-anaerobic resistance and maintenance training would be advisable in young athletes during the transition period. Given the relevance of worsening demonstrated by our data, coaches should avoid very long periods of complete rest (no more than 15 days) at the end of the season.

Miloski B et.al.,(2014) Conducted a study on verify whether aerobic fitness and ability to perform repeated high-intensity efforts influence the internal training load (ITL), which consists of the actual stress imposed in the athletes' organisms, in professional futsal players. Twelve high-level futsal players (age: 26.3±4.9 years, body mass: 73.5±7.5 kg) participated in the study. The investigated athletes took part in a 5-week pre-season period. The ITL was quantified by means of the session-Rating of Perceived Exertion method. The athletes performed the Yo-yo Intermittent Recovery Test level 2 (YYIR2) in order to assess the ability to perform repeated high-intensity actions, and the multistage shuttle-run test (MSRT) in order to evaluate aerobic fitness, before (T0) and after (T1) the pre-season period. Maximal oxygen uptake (VO2max.), oxygen uptake at Respiratory compensation point (VO2-RCP) and maximal aerobic speed (MAS)
obtained in MSRT were retained for analyses. The results from Pearson's correlation test showed significant and a very large correlation between ITL and YYIR2 performance (r=-0.75). Moreover, a significant and large correlation between ITL and VO2max. (r=-0.62), ITL and MAS (r=-0.67), and ITL and VO2-RCP (r=-0.58) were also observed. It can be concluded that aerobic fitness and ability to perform repeated high-intensity actions may influence ITL responses in professional futsal players.

Manolopoulos E, Katis A, Manolopoulos K, Kalapotharakos V, Kellis E.(2013) Conducted a study on the effects of a resistance exercise program on soccer kick biomechanics. Twenty male amateur soccer players were divided in the experimental group (EG) and the control group (CG), each consisting of 10 players. The EG followed a 10-week resistance exercise program mainly for the lower limb muscles. Maximal instep kicks kinematics, electromyography, and ground reaction forces (GRFs) as well as maximum isometric leg strength was recorded before and after training. A 2-way analysis of variance showed significantly higher ball speed values only for the EG (26.14 ± 1.17 m·s vs. 27.59 ± 1.49 m·s before and after training, respectively), whereas no significant differences were observed for the CG. The EG showed a decline in joint angular velocities and an increase in biceps femoris electromyography of the swinging leg during the backswing phase followed by a significant increase in segmental and joint velocities and muscle activation of the same leg during the forward swing phase (p < 0.05). The EG also showed significantly higher vertical GRFs and rectus femoris and gastronomies activation of the support leg (p < 0.05). Similarly, maximum and explosive isometric force significantly increased after training only for the EG (p < 0.05). These results suggest that increases in soccer kicking performance after a 10-week resistance training program were accompanied by increases in maximum strength and an
altered soccer kick movement pattern, characterized by a more explosive backward-forward swinging movement and higher muscle activation during the final kicking phase.

Sander A, Keiner M, Wirth K, Schmidtbleicher D. (2013) Conducted a study on the influence of periodised strength training for power performance more than 2 years. In this study, 134 elite youth soccer players were recruited from two youth training centers. The cohorts were arranged as follows: A (under 19 years), B (under 17 years) and C (under 15 years). The participants in each cohort were divided into two groups. One group (Strength training group [STG]) was subjected to regular soccer training in addition to strength training twice a week for 2 years. The other group (Control group [CG]) completed only the regular soccer training. The strength training was periodised with hypertrophy and intramuscular coordination blocks. For strength training, both the front squat and the back squat were performed once a week. The subjects were tested on the one-repetition maximum (1RM) of the front and back squat and a linear sprint over 30 m. There was significantly better performance from the STG on 1RM (p <0.001). In the sprint, the STG displayed significantly better improvements (p <0.05 to p <0.001) of up to 6%. The effects of strength training are reflected in the sprint performance. Therefore, it seems beneficial for youth to perform strength training to exploit the reserve capacity in sprint performances.

2.2 STUDIES ON CIRCUIT RESISTANCE TRAINING ON MOTOR FITNESS VARIABLES

Taipale RS et.al., (2014) Conducted a study on examined during an 8-week intervention preceded by an 8-week preparatory strength training period. Thirty-four subjects (21-45 years) were divided into experimental groups: men (M, n = 9), women (W, n = 9), and control groups: men (MC, n = 7), women (WC, n = 9). The experimental groups performed mixed maximal and explosive exercises, whereas control subjects
performed circuit training with body weight. Endurance training included running at an intensity below lactate threshold. Strength, power, endurance performance characteristics, and hormones were monitored throughout the study. Significance was set at $p \leq 0.05$. Increases were observed in both experimental groups that were more systematic than in the control groups in explosive strength (12 and 13% in men and women, respectively), muscle activation, maximal strength (6 and 13%), and peak running speed (14.9 ± 1.2 to 15.6 ± 1.2 and 12.9 ± 0.9 to 13.5 ± 0.8 km L h). The control groups showed significant improvements in maximal and explosive strength, but Speak increased only in MC. Sub maximal running characteristics (blood lactate and heart rate) improved in all groups. Serum hormones fluctuated significantly in men (testosterone) and in women (thyroid stimulating hormone) but returned to baseline by the end of the study. Mixed strength training combined with endurance training may be more effective than circuit training in recreational endurance runners to benefit overall fitness that may be important for other adaptive processes and larger training loads associated with, e.g., marathon training.

Giné-Garriga M, Guerra M, Pagès E, Manini TM, Jiménez R, Unnithan VB. (2010) Conducted a study on evaluate whether a 12-wk functional circuit-training program (FCT) could alter markers of physical frailty in a group of frail community-dwelling adults. Fifty-one individuals (31 women, 20 men), mean age (± SD) 84 (± 2.9) yr, met frailty criteria and were randomly assigned into groups (FCT = 26, control group [CG] = 25). FCT underwent a 12-wk exercise program. CG met once a week for health education meetings. Measures of physical frailty, function, strength, balance, and gait speed were assessed at Weeks 0, 12, and 36. Physical-frailty measures in FCT showed significant ($p < .05$) improvements relative to those in CG (Barthel Index at Weeks 0 and 36: 73.41 (± 2.35) and 77.0 (± 2.38) for the FCT and 70.79 (± 2.53) and
66.73 (± 2.73) for the CG. These data indicate that an FCT program is effective in improving measures of function and reducing physical frailty among frail older adults.

Marx J.O et.al., (2001) Conducted a study on determine the long-term training adaptations associated with low-volume circuit-type versus periodized high-volume resistance training programs in women. Thirty-four healthy, untrained women were randomly placed into one of the following groups: low-volume, single-set circuit (SSC; N = 12); periodized high-volume multiple-set (MS; N = 12); or non-exercising control (CON) group (N = 10). The SSC group performed one set of 8-12 repetitions to muscular failure 3 days per week. The MS group performed two to four sets of 3-15 repetitions with periodized volume and intensity 4 days per week. Muscular strength, power, speed, endurance, anthropometry, and resting hormonal concentrations were determined pre-training (T1), after 12 weeks (T2), and after 24 weeks of training (T3). 1-RM bench press and leg press, and upper and lower body local muscular endurance increased significantly (P < 0.05) at T2 for both groups, but only MS showed a significant increase at T3. Muscular power and speed increased significantly at T2 and T3 only for MS. Increases in testosterone were observed for both groups at T2 but only MS showed a significant increase at T3. Cortisol decreased from T1 to T2 and from T2 to T3 in MS. Insulin-like growth factor-1 increased significantly at T3 for SSC and at T2 and T3 for MS. No changes were observed for growth hormone in any of the training groups. Significant improvements in muscular performance may be attained with either a low-volume single-set program or a high-volume, periodized multiple-set program during the first 12 weeks of training in untrained women. However, dramatically different training adaptations are associated with specific domains of training program design which contrast in speed of movement, exercise choices and use of variation (periodization) in the intensity and volume of exercise.
Palmer CD, Sleivert GG.(2001) Conducted a study on determine whether a low-volume high-intensity resistance training session influenced running economy during a subsequent aerobic treadmill run. Nine well trained distance runners (mean +/- SD; VO2max, 66.6 +/- 10.2 ml x kg(-1) x min(-1); weight, 65.8 +/- 10.2 kg; height, 173.4 +/- 7.8 cm; age 20 +/- 1.1 years) with resistance training experience performed treadmill running at two different speeds (0.56 m x sec(-1) and 0.20 m x sec(-1) below speed corresponding to lactate equilibrium) either rested or 1, 8 or 24 hours after a 50-minute whole body resistance training session. Running economy was assessed using open circuit spirometry while heart rate was recorded telemetrically. The contractile properties of the quadriceps femoris were also determined following each resistance training session and prior to each treadmill run using percutaneous electrical stimulation. Sub maximal oxygen consumption was significantly increased one hour (2.6 +/- 2.3%, p=0.007), and eight hours (1.6 +/- 2.5%, p=0.032), but not 24 hours after resistance training. No significant differences were found in exercising heart rate, ventilation, respiratory exchange ratio, ratings of perceived exertion, or running mechanics. Peak twitch torque, time to peak torque, and half relaxation time of the quadriceps femoris were significantly reduced immediately following resistance training while peak twitch torque was also lower one hour following resistance training. Running economy following a resistance training session is impaired for up to 8 hours. This change was not paralleled by a concomitant change in exercising heart rate. The mechanism responsible for increased oxygen consumption following resistance training may be related to impairment of the force generating capacity of skeletal muscle, as there was a significant decrement in the contractile properties of the quadriceps femoris following resistance training.
Westcott WL et.al.,(2001) Conducted a study on assessed a way to increase the intensity and effectiveness of resistance training by comparing training with a slower repetition speed to training with a conventional repetition speed. Slower repetition speed may effectively increase intensity throughout the lifting phase while decreasing momentum. Two studies were done with untrained men (N=65) and women (N=82), (mean age=53.6) who trained two to three times per week for eight to 10 weeks on a 13 exercise Nautilus circuit performing one set of each exercise. Participants exclusively trained using regular speed repetitions for 8 to 12 repetitions per set at 7 sec each (2 sec lifting, 1 sec pause, 4 sec lowering) or a Super Slow training protocol where they completed 4 to 6 repetitions per set at 14 sec each (10 sec lifting, 4 sec lowering). All of the participants were tested for either the 10 repetition-maximum (RM) weight load (regular-speed group) or the 5-RM weight load (slow-speed group). In both studies, Super-Slow training resulted in about a 50% greater increase (p<0.001) in strength for both men and women than regular speed training. In Study 1, the Super-Slow training group showed a mean increase of 12.0 kg and the regular speed group showed an increase of 8.0 kg increase (p<0.001). In Study 2, the Super-Slow training group showed a 10.9 kg increase and the regular speed group showed an increase of 7.1 kg (p<0.001).Super-Slow training is an effective method for middle-aged and older adults to increase strength. Although studies still need to be done with at-risk populations, repetition speed should be considered when prescribing resistance training.

Kaikkonen H, Yrjämä M, Siljander E, Byman P, Laukkanen R. (2000) Conducted a study on the effects of a 12-week low resistance circuit weight training (CWT) on cardiovascular and muscular fitness were studied in 90 healthy sedentary adults. The subjects were randomized into three equally fit groups: CWT, Endurance (END) and Control (CON) according to their maximal aerobic power (VO2max).
Both training groups exercised for 12 weeks, 3 days a week in sessions of 40 min, with a heart rate (HR) level of 70-80% HRmax. The CWT group trained with air resistance machines. Heart rate was controlled by setting the speed of movement. The END group walked, jogged, cross-country skied or cycled. The net differences (between pre- and posttraining changes) between the CWT and CON groups was statistically significant for VO2max (2.45 ml x min\(^{-1}\) x kg\(^{-1}\), 95% CI 1.1; 3.8), for abdominal muscles (3.7 reps, CI 0.3; 7.1), for push-ups (1.1 reps, CI 0.2; 2.1), and for kneeling (2.25 reps, CI 0.01; 4.5). The net difference (between pre- and posttraining changes) in the END and CON groups was statistically significant for VO2max (2.75 ml(-1) x min(-1) x kg(-1), 95% CI 0.9; 4.6), and kneeling (3.0 reps, CI 0.7; 5.3). Low resistance CWT with moderately hard HR level has effects comparable to an equal amount of endurance training on the cardiovascular fitness of sedentary adults. The CWT model was beneficial also on muscular fitness. Based on the results, this type of exercise can be recommended for beginners because of its multilevel effects.

Ferrete C, Requena B, Suarez-Arrones L, de Villarreal ES.(2014) conducted a study on the effects of a 26-week on-field combined strength and high-intensity training on the physical performance capacity among prepubertal soccer players who were undertaking a competitive phase of training. Twenty-four prepubertal soccer players between the age of 8 and 9 years were randomly assigned to 2 groups: a control (C; n = 13) and an experimental group (S; n = 11). Both groups performed an identical soccer-training program, whereas the S group also performed combined strength and high-intensity training before the soccer-specific training. The 15-m sprint time (seconds), countermovement jump (CMJ) displacement, Yo-Yo intermittent endurance test (Yo-Yo IE), and Sit and Reach flexibility were each measured before (baseline) and after 9 (T2), 18 (T3), and 26 weeks
(posttest) of training. There were no significant differences between the groups in any of the variables tested at baseline. After 26 weeks, significant improvements were found in the CMJ (6.72%; effect size [ES] = 0.37), Yo-Yo IE (49.57%, ES = 1.39), and Flexibility (7.26%; ES = 0.37) variables for the S group. Conversely, significant decreases were noted for the CMJ (-10.82%; ES = 0.61) and flexibility (-13.09%; ES = 0.94) variables in the C group. A significant negative correlation was found between 15-m sprint time and CMJ (r = -0.77) and Yo-Yo IE (r = -0.77) in the S group. Specific combined strength and high-intensity training in prepubertal soccer players for 26 weeks produced a positive effect on performance qualities highly specific to soccer. Therefore, we propose modifications to current training methodology for prepubertal soccer players to include strength and high-intensity training for athlete preparation in this sport.

Randers MB et.al.,(2014) Conducted a study on investigate performance variables and indicators of cardiovascular health profile in elderly soccer players (SP, n = 11) compared to endurance-trained (ET, n = 8), strength-trained (ST, n = 7) and untrained (UT, n = 7) age-matched men. The 33 men aged 65-85 years underwent a testing protocol including measurements of cycle performance, maximal oxygen uptake (VO2max) and body composition, and muscle fibre types and capillarisation were determined from m. vastuslateralis biopsy. In SP, time to exhaustion was longer (16.3 ± 2.0 min; P < 0.01) than in UT (+48%) and ST (+41%), but similar to ET (+1%). Fat percentage was lower (P < 0.05) in SP (-6.5% points) than UT but not ET and ST. Heart rate reserve was higher (P < 0.05) in SP (104 ± 16 bpm) than UT (+21 bpm) and ST (+24 bpm), but similar to ET (+2 bpm), whereas VO2max was not significantly different in SP (30.2 ± 4.9 ml O2 · min(-1) · kg(-1)) compared to UT (+14%) and ST (+9%), but lower (P < 0.05) than ET (-22%). The number of capillaries per fibre was higher (P < 0.05) in SP than UT (53%) and ST (42%) but similar to ET. SP had less type IIxfibres than UT (-12% points). In
conclusion, the exercise performance and cardiovascular health profile are markedly better for lifelong trained SP than for age-matched UT controls. Incremental exercise capacity and muscle aerobic capacity of SP are also superior to lifelong ST athletes and comparable to endurance athletes.

Grieco CR, Cortes N, Greska EK, Lucci S, Onate JA. (2012) Conducted a study on the effect of a 10-week combined resistance-plyometric training program on the RE and V[Combining Dot Above]O2max in female soccer players. Fifteen Division 1A female soccer players (age 19.0 ± 0.7 years; height 1.67 ± 0.1 m; weight 61.7 ± 8.1 kg) performed a treadmill test for V[Combining Dot Above]O2max and RE at the end of a competitive season (PRE) and after a 10-week training program (POST). Isometric strength was measured in knee flexion and extension. Resistance training was conducted 2 d·wk on nonconsecutive days; plyometric training was conducted separately on different nonconsecutive days. Eleven subjects were included in the PRE-POST analysis (age 19.0 ± 0.8 years; height 1.67 ± 0.5 m; weight 59.9 ± 6.7 kg). Descriptive statistics were compared using analysis of variance with repeated measures with a Bonferroni adjustment, and significance was set at p < 0.05. A significant increase occurred after training in the V[Combining Dot Above]O2peak (10.5%; p = 0.008), time to fatigue (6.9%; p = 0.017), and interpolated maximal speed (3.6%; p = 0.016), despite there being a decrease in the maximal respiratory exchange ratio (2.9%; p = 0.001). There was no significant change in the RE at 9 km·h; however, there was a significant decrease in the percentage of the V[Combining Dot Above]O2peak at 9 km·h (-5.6%; p = 0.02). Maximal isometric strength of knee flexors and extensors did not change. The results suggest a plyometric-agility training program may increase the V[Combining Dot Above]O2peak in female soccer players; however, the effect on RE was equivocal.
Greska EK, Cortes N, Van Lunen BL, Oñate JA. (2012) Conducted a study on the effects of a 10-week off-season neuromuscular training program on lower extremity kinematics. Twelve Division I female soccer players (age: 19.2 ± 0.8 years, height: 1.67 ± 0.1 m, weight: 60.2 ± 6.5 kg) performed unanticipated dynamic trials of a running stop-jump task pertaining and post training. Data collection was performed using an 8-camera Vicon system (Los Angeles, CA, USA) and 2 Bertec (Columbus, OH, USA) force plates. The 10-week training program consisted of resistance training 2 times per week and field training, consisting of plyometric, agility, and speed drills, 2 times per week. Repeated measures analyses of variance (ANOVAs) were used to assess the differences between pre training and post training kinetics and kinematics of the hip, knee, and ankle at initial contact (IC), peak knee flexion (PKF), and peak stance. Repeated measures ANOVAs were also used to assess isometric strength differences pre training and post training. The alpha level was set at 0.05 a priori. The training program demonstrated significant increases in left hip extension, left and right hip flexion, and right hip adduction isometric strength. At IC, knee abduction angle moved from an abducted to an adducted position (-1.48 ± 3.65° to 1.46 ± 3.86°, p = 0.007), and hip abduction angle increased (-6.05 ± 4.63° to -10.34 ± 6.83°, p = 0.007). Hip abduction angle at PKF increased (-2.23 ± 3.40° to 6.01 ± 3.82°, p = 0.002). The maximum knee extension moment achieved at peak stance increased from pre training to post training (2.02 ± 0.32 to 2.38 ± 0.75 N·m·kg⁻¹, p = 0.027). The neuromuscular training program demonstrated a potential positive effect in altering mechanics that influence the risk of incurring an ACL injury.

Oberacker LM, Davis SE, Haff GG, Witmer CA, Moir GL. (2012) conducted a study on the effects of resistance training performed on either a stable or unstable surface on performance tests in female soccer players. Nineteen National Collegiate Athletic
Association Division II female soccer players were assigned to either an unstable training group (UST: 19.0 ± 0.47 years; 1.69 ± 6.4 m; 67.8 ± 7.7 kg) or a stable training group (ST: 19.6 ± 0.49 years; 1.64 ± 3.2 m; 62.7 ± 6.27 kg). Player positions were distributed evenly between the groups. Both the groups followed a 5-week periodized resistance training program designed to develop maximum muscular strength. The groups performed the same exercises during each workout, with the UST performing 2 of the exercises in each session on an unstable surface. Pre training and post training measures of straight-line sprint speed, planned and reactive agility, aerobic capacity, and countermovement vertical jump (CMJ) were taken. Significant main effects for time were reported for straight-line sprint speed, planned agility, and reactive agility with both groups demonstrating improvements during the post training testing session. The ST demonstrated a significant increase in CMJ during the post training session (change in mean: 0.04 m) in contrast to the decline demonstrated by the UST (change in mean: -0.01 m). Performing resistance training exercises on an unstable surface confers no advantage over traditional resistance training exercises for improving the speed, agility, and aerobic capacity of female soccer players. Furthermore, the use of an unstable surface may inhibit the effects of resistance training on vertical jump height, an important variable in soccer performance.

Buchheit M, Mendez-Villanueva A, Delhomel G, Brughelli M, Ahmaidi S.(2010) Conducted a study on the effects of explosive strength (ExpS) vs. repeated shuttle sprint (RS) training on repeated sprint ability (RSA) in young elite soccer players, 15 elite male adolescents (14.5 ± 0.5 years) performed, in addition to their soccer training program, RS (n = 7) or ExpS (n = 8) training once a week for a total of 10 weeks. RS training consisted of 2-3 sets of 5-6 × 15- to 20-m repeated shuttle sprints interspersed with 14 seconds of passive or 23 seconds of active recovery (≈2 m·s⁻¹); ExpS training consisted of 4-6 series
of 4-6 exercises (e.g., maximal unilateral countermovement jumps (CMJs), calf and squat plyometric jumps, and short sprints). Before and after training, performance was assessed by 10 and 30 m (10 and 30 m) sprint times, best (RSAbest) and mean (RSAmean) times on a repeated shuttle sprint ability test, a CMJ, and a hopping (Hop) test. After training, except for 10 m (p = 0.22), all performances were significantly improved in both groups (all p's < 0.05). Relative changes in 30 m (-2.1 ± 2.0%) were similar for both groups (p = 0.45). RS training induced greater improvement in RSAbest (-2.90 ± 2.1 vs. -0.08 ± 3.3%, p = 0.04) and tended to enhance RSAmean more (-2.61 ± 2.8 vs. -0.75 ± 2.5%, p = 0.10, effect size [ES] = 0.70) than ExpS. In contrast, ExpS tended to induce greater improvements in CMJ (14.8 ± 7.7 vs. 6.8 ± 3.7%, p = 0.02) and Hop height (27.5 ± 19.2 vs. 13.5 ± 13.2%, p = 0.08, ES = 0.9) compared with RS. Improvements in the repeated shuttle sprint test were only observed after RS training, whereas CMJ height was only increased after ExpS. Because RS and ExpS were equally efficient at enhancing maximal sprinting speed, RS training-induced improvements in RSA were likely more related to progresses in the ability to change direction.

López-Segovia M, Palao Andrés JM, González-Badillo JJ. (2010) Conducted a study on the effect of the training executed by 2 under-19 teams from the first Spanish division on aerobic power, strength, and acceleration capacity. Two under-19 soccer teams that competed in the same league were evaluated on 2 occasions. The first evaluation (E1) was done at the beginning of the competitive period, and the second evaluation (E2) was done 16 weeks later, coinciding with the end of the first half of the regular season. The following were evaluated: lower-body strength through jump height with countermovement with and without load (CMJ/CMJ20), speed of the Smith machine bar movement in a progressive load test of full squats (FSL), acceleration capacity in 10, 20, and 30 m (T10, T20, T30, T10–20, T10–30, T20–30), and maximal aerobic speed (MAS).
Team A executed complementary strength training, and training loads were determined with regard to the speed with which each player moved the bar in FSL. Between the evaluations, the training sessions of each team were recorded to assess their influence on the changes in E2. Team A significantly improved its MAS (p < 0.01) and its application of strength in the CMJ\textsubscript{20} (p < 0.05) and FS\textsubscript{20-30} (p < 0.01), while significantly worsening their acceleration capacity in all the splits (p < 0.01). Team B slightly worsened its MAS and significantly improved its application of strength in the CMJ\textsubscript{20} (p < 0.01) and FS\textsubscript{50-60} (p < 0.05). Its acceleration capacity improved insignificantly except for in the 20- to 30-m interval/T\textsubscript{20-30} (p < 0.05). The present study demonstrates that the use of loads as a function of the speed of movement, without the need to determine maximum repetitions is a methodology that is adequate for the improvement of the application of strength in under-19 soccer players.

Wong PL, Chamari K, Wisløff U.(2010) Conducted a study on the effects of on-field combined strength and power training (CSPT) on physical performance among U-14 young soccer players. Players were assigned to experimental (EG, n = 28) and control groups (CG, n = 23). Both groups underwent preseason soccer training for 12 weeks. EG performed CSPT twice a week, which consisted of strength and power exercises that trained the major muscles of the core, upper, and lower body. CSPT significantly (p < 0.05) improved vertical jump height, ball-shooting speed, 10 m and 30 m sprint times, Yo-Yo intermittent endurance run (YYIER), and reduced sub maximal running cost (RC). CSPT had moderate effect on vertical jump, ball-shooting, 30 m sprint, and YYIER, small effect on 10 m sprint, RC, and maximal oxygen uptake. YYIER had significant (p < 0.05) correlations with 10 m (r = -0.47) and 30 m (r = -0.43) sprint times, ball-shooting speed (r = 0.51), and vertical jump (r = 0.34). The CSPT can be performed together with soccer training with no concomitant interference on aerobic capacity and
with improved explosive performances. In addition, it is suggested that CSPT be performed during the preseason period rather than in-season to avoid insufficient recovery/rest or overtraining.

Wong PL, Chaouachi A, Chamari K, Dellal A, Wisloff U.(2010) Conducted a study on the effect of concurrent muscular strength and high-intensity running interval training on professional soccer players' explosive performances and aerobic endurance. Thirty-nine players participated in the study, where both the experimental group (EG, n = 20) and control group (CG, n = 19) participated in 8 weeks of regular soccer training, with the EG receiving additional muscular strength and high-intensity interval training twice per week throughout. Muscular strength training consisted of 4 sets of 6RM (repetition maximum) of high-pull, jump squat, bench press, back half squat, and chin-up exercises. The high-intensity interval training consisted of 16 intervals each of 15-second sprints at 120% of individual maximal aerobic speed interspersed with 15 seconds of rest. EG significantly increased (p < or = 0.05) 1RM back half squat and bench press but showed no changes in body mass. Within-subject improvement was significantly higher (p < or = 0.01) in the EG compared with the CG for vertical jump height, 10-m and 30-m sprint times, distances covered in the Yo-Yo Intermittent Recovery Test and maximal aerobic speed test, and maximal aerobic speed. High-intensity interval running can be concurrently performed with high load muscular strength training to enhance soccer players' explosive performances and aerobic endurance.

Mujika I, Santisteban J, Castagna C.(2009) Conducted a study on the effects of 2 in-season short-term sprint and power training protocols on vertical countermovement jump height (with or without arms), sprint (Sprint-15m) speed, and agility (Agility-
15m) speed in male elite junior soccer players. Twenty highly trained soccer players (age 18.3 +/- 0.6 years, height 177 +/- 4 cm, body mass 71.4 +/- 6.9 kg, sum skin folds 48.1 +/- 11.4 mm), members of a professional soccer academy, were randomly allocated to either a CONTRAST (n = 10) or SPRINT (n = 10) group. The training intervention consisted of 6 supervised training sessions over 7 weeks, targeting the improvement of the players' speed and power. CONTRAST protocol consisted of alternating heavy-light resistance (15-50% body mass) with soccer-specific drills (small-sided games or technical skills). SPRINT training protocol used line 30-m sprints (2-4 sets of 4 x 30 m with 180 and 90 seconds of recovery, respectively). At baseline no difference between physical test performances was evident between the 2 groups (p > 0.05). No time x training group effect was found for any of the vertical jump and Agility-15m variables (p > 0.05). A time x training group effect was found for Sprint-15m performance with the CONTRAST group showing significantly better scores than the SPRINT group (7.23 +/- 0.18 vs. 7.09 +/- 0.20 m.s, p < 0.01). In light of these findings CONTRAST training should be preferred to line sprint training in the short term in young elite soccer players when the aim is to improve soccer-specific sprint performance (15 m) during the competitive season.

Chatzopoulos DE et.al.,(2007) Conducted a study on the post activation potentiating effect after a heavy resistance stimulus (HRS) on running speed (RS). Fifteen amateur team game players (basketball, volleyball, handball, and soccer players), ages 18-23 years running the 30-m dash and the intermediate phase of 0-10 and 0-30 m sprints, were used to evaluate RS. Resistance training consisted of 10 single repetitions at 90% of 1 repetition maximum. The running tests were performed 3 times--(a) 3 minutes prior the HRS, (b) 3 minutes after the HRS, and (c) 5 minutes after the HRS--in separated training sessions. Results showed that RS was not affected 3 minutes after
the resistance training, but it increased for both selected running phases (0-10 and 0-30 m) 5 minutes after the HRS (p < 0.05). These findings indicate that heavy resistance exercise improves 10- and 30-m sprint performance when performed 5 minutes after the exercise bout.

Malina RM, Ribeiro B, Aroso J, Cumming SP. (2007) Conducted a study on evaluate the growth, maturity status and functional capacity of youth soccer players grouped by level of skill. The sample included 69 male players aged 13.2-15.1 years from clubs that competed in the highest division for their age group. Height and body mass of players were measured and stage of pubic hair (PH) was assessed at clinical examination. Years of experience in football were obtained at interview. Three tests of functional capacity were administered: dash, vertical jump and endurance shuttle run. Performances on six soccer-specific tests were converted to a composite score which was used to classify players into quintiles of skill. Multiple analysis of covariance, controlling for age, was used to test differences among skill groups in experience, growth status and functional capacity, whereas multiple linear regression analysis was used to estimate the relative contributions of age, years of training in soccer, stage of PH, height, body mass, the height x weight interaction and functional capacities to the composite skill score. The skill groups differed significantly in the intermittent endurance run (p<0.05) but not in the other variables. Only the difference between the highest and lowest skill groups in the endurance shuttle run was significant. Most players in the highest (12 of 14) and high (11 of 14) skill groups were in stages PH 4 and PH 5. Pubertal status and height accounted for 21% of the variance in the skill score; adding aerobic resistance to the regression increased the variance in skill accounted for to 29%. In both regressions, the coefficient for height was negative. Adolescent soccer players aged 13-15 years classified by skill do not differ in age,
experience, body size, speed and power, but differ in aerobic endurance, specifically at the extremes of skill. Stage of puberty and aerobic resistance (positive coefficients) and height (negative coefficient) are significant predictors of soccer skill (29% of the total explained variance), highlighting the inter-relationship of growth, maturity and functional characteristics of youth soccer players.

Christou M et al., (2006) Conducted a study on the effects of a progressive resistance training program in addition to soccer training on the physical capacities of male adolescents. Eighteen soccer players (age: 12-15 years) were separated in a soccer (SOC; n = 9) and a strength-soccer (STR; n = 9) training group and 8 subjects of similar age constituted a control group. All players followed a soccer training program 5 times a week for the development of technical and tactical skills. In addition, the STR group followed a strength training program twice a week for 16 weeks. The program included 10 exercises, and at each exercise, 2-3 sets of 8-15 repetitions with a load 55-80% of 1 repetition maximum (1RM). Maximum strength ([1RM] leg press, bench-press), jumping ability (squat jump [SJ], countermovement jump [CMJ], repeated jumps for 30 seconds) running speed (30 m, 10 x 5-m shuttle run), flexibility (seat and reach), and soccer technique were measured at the beginning, after 8 weeks, and at the end of the training period. After 16 weeks of training, 1RM leg press, 10 x 5-m shuttle run speed, and performance in soccer technique were higher (p < 0.05) for the STR and the SOC groups than for the control group. One repetition maximum bench press and leg press, SJ and CMJ height, and 30-m speed were higher (p < 0.05) for the STR group compared with SOC and control groups. The above data show that soccer training alone improves more than normal growth maximum strength of the lower limbs and agility. The addition of resistance training, however, improves more maximal strength of the upper and the lower body, vertical jump height, and 30-m speed. Thus, the combination
of soccer and resistance training could be used for an overall development of the physical capacities of young boys.

Malina RM, Eisenmann JC, Cumming SP, Ribeiro B, Aroso J.(2004) estimate the contribution of experience, body size and maturity status to variation in the functional capacities of adolescent football (soccer) players. The sample included 69 players 13.2-15.1 years of age from three clubs which competed in the highest division for their age group in the first Portuguese national division. Height and weight were measured and stage of pubic hair development was assessed at clinical examination. The number of years of experience in football was obtained at interview. Three tests of functional capacity were administered: 30-m dash (running speed), vertical jump (explosive power) and a yo-yo intermittent endurance test (aerobic resistance). Multiple linear regression analysis was used to estimate the relative contributions of age, stage of sexual maturity, height, weight and years of formal training in football to the three indicators of functional capacity. Stage of puberty, body size and years of training accounted for 21% to 50% of the variance in the three tasks. Sexual maturity status was the primary contributor to the variance in the intermittent shuttle run, whereas weight and height were the primary contributors to the explained variance in the 30-m dash and vertical jump, respectively. In conclusion, biological maturity status significantly influences the functional capacity of adolescent football players 13-15 years of age. Training is a significant contributor to aerobic resistance, whereas weight and height are significant contributors to the sprint and vertical jump, respectively.

Polman R, Walsh D, Bloomfield J, Nesti M.(2004) Conducted a study on the efficacy of three physical conditioning programmes provided over a 12 week period (24 h in total) on selected anthropometric and physical fitness parameters in
female soccer players. Two of the groups received physical conditioning training in accordance with speed, agility and quickness (SAQ); one group used specialized resistance and speed development SAQ equipment (equipment group; n = 12), while the other group used traditional soccer coaching equipment (non-equipment group; n = 12). A third group received their regular fitness sessions (active control group; n = 12). All three interventions decreased (P < 0.001) the participants’ body mass index (-3.7%) and fat percentage (-1.7%), and increased their flexibility (+14.7%) and maximal aerobic capacity (VO2max) (+18.4%). The participants in the equipment and non-equipment conditioning groups showed significantly (P < 0.005) greater benefits from their training programme than those in the active control group by performing significantly better on the sprint to fatigue (-11.6% for both the equipment and non-equipment groups versus -6.2% for the active control group), 25 m sprint (-4.4% vs -0.7%), left (-4.5% vs -1.0%) and right (-4.0% vs -1.4%) side agility, and vertical (+18.5% vs +4.8%) and horizontal (+7.7% vs +1.6%) power tests. Some of these differences in improvements in physical fitness between the equipment and non-equipment conditioning groups on the one hand and the active control group on the other hand were probably due to the specificity of the training programmes. It was concluded that SAQ training principles appear to be effective in the physical conditioning of female soccer players. Moreover, these principles can be implemented during whole team training sessions without the need for specialized SAQ equipment. Finally, more research is required to establish the relationship between physical fitness and soccer performance as well as the principles underlying the improvements seen through the implementation of SAQ training programmes.
2.3 STUDIES ON SUPER CIRCUIT RESISTANCE TRAINING

Myers TR, Schneider MG, Schmale MS, Hazell TJ. (2014) Conducted a study on determine if a time-effective whole-body aerobic resistance-training circuit using only body-weight exercises is as effective in improving aerobic and anaerobic fitness, as well as muscular strength and endurance as a traditional concurrent style training combining resistance and endurance training. Thirty-four sedentary females (20.9±3.2 y; 167.6±6.4 cm; 65.0±15.2 kg) were assigned to either: 1) a combined resistance and aerobic exercise group (COMBINED; n=17); or 2) a circuit-based whole-body aerobic resistance-training circuit group (CIRCUIT; n=17). Training was 3 days per week for 5 weeks. Pre- and post-training measures included a VO2peak test, anaerobic Wingate cycling test, and muscular strength and endurance tests. Following training, VO2peak improved with CIRCUIT by 11% (p=0.015), with no change for COMBINED (p=0.375). Both relative peak power output and relative average power output improved with CIRCUIT by 5% (p=0.027) and 3.2% (p=0.006) respectively and with COMBINED by 5.3% (p=0.025) and 5.1% (p=0.003). Chest and hamstrings 1-RM improved with CIRCUIT by 20.6% (p=0.011) and 8.3% (p=0.022) and with COMBINED by 35.6% (p<0.001) and 10.2% (p=0.004) respectively. Only the COMBINED group improved back (11.7%; p=0.017) and quadriceps (9.6%; p=0.006) 1-RM. The COMBINED group performed more repetitions at 60% of their pre-training 1-RM for back (10.0%; p=0.006) and hamstring (23.3%; P=0.056) vs CIRCUIT. Our results suggest that a circuit-based, whole-body aerobic resistance-training program can elicit a greater cardio respiratory response and similar muscular strength gains with less time commitment, compared to a traditional resistance training program combined with aerobic exercise.
Angioi M, Metsios G, Twitchett EA, Koutedakis Y, Wyon M. (2012) Conducted a study on 24 females engaged in contemporary dance (age 27 ± 5.9 yrs; height 165.3 ± 4.8 cm; weight 59.2 ± 7.6 kg) were recruited and randomly assigned to either an exercise (n = 12) or a control group (n = 12). Three dancers withdrew during the study. The intervention group completed a 6-week conditioning programme comprising two 1-hr sessions of circuit and vibration training per week. The circuit training focused on local muscular endurance and aerobic conditioning and vibration training protocol concentrated on power. Repeated measures ANOVA revealed significant increases for the conditioning group in lower body muscular power (11%), upper body muscular endurance (22%), aerobic fitness (11%), and aesthetic competence (12%) (p< 0.05). The control group reported decreases in all the fitness parameters with the exception of aerobic fitness as well as a decrease in aesthetic competence (7%). A 6-week circuit and vibration training programme, which supplemented normal dance commitments, revealed significant increases in selected fitness components and a concomitant increase in aesthetic competence in contemporary professional and student dancers.

Westcott WL et.al., (2001) Conducted a study on the intensity and effectiveness of resistance training by comparing training with a slower repetition speed to training with a conventional repetition speed. Slower repetition speed may effectively increase intensity throughout the lifting phase while decreasing momentum. Two studies were done with untrained men (N=65) and women (N=82), (mean age=53.6) who trained two to three times per week for eight to 10 weeks on a 13 exercise Nautilus circuit performing one set of each exercise. Participants exclusively trained using regular speed repetitions for 8 to 12 repetitions per set at 7 sec each (2 sec lifting, 1 sec pause, 4 sec lowering) or a Super Slow training protocol where they completed 4 to 6 repetitions per set at 14 sec
each (10 sec lifting, 4 sec lowering). All of the participants were tested for either the 10 repetition-maximum (RM) weight load (regular-speed group) or the 5-RM weight load (slow-speed group). In both studies, Super-Slow training resulted in about a 50% greater increase (p<0.001) in strength for both men and women than regular speed training. In Study 1, the Super-Slow training group showed a mean increase of 12.0 kg and the regular speed group showed an increase of 8.0 kg increase (p<0.001). In Study 2, the Super-Slow training group showed a 10.9 kg increase and the regular speed group showed an increase of 7.1 kg (p<0.001). Super-Slow training is an effective method for middle-aged and older adults to increase strength. Although studies still need to be done with at-risk populations, repetition speed should be considered when prescribing resistance training.

BeckhamSG, Earnest CP. (2000) Conducted a study on determine the training intensity and caloric expenditure associated with free weight CWT. Twelve males and eighteen females (age 25.1+/-6.6 years) participated in a Bruce treadmill test to measure VO2max (47.9+/-10.6 ml/kg min). Subjects subsequently performed a learning trial, exercising to a 14 minute video-taped free weight CWT sequence which included squats and upper body exercises performed consecutively. All subjects then completed two randomly assigned video exercise bouts with light resistance (LR = 1.4 kg for males and females) and moderate resistance (MR = 5.9 kg for females and 10.5 kg for males), loads recommended by instructors for sedentary and fit individuals, respectively. Statistical analysis by RM ANOVA (p<0.0036) revealed significant increases in absolute and relative VO2, HR, and energy expenditure at MR as compared to LR for males and females. Mean VO2 and caloric expenditure values at MR were 15.7+/-2.3 ml/kg min and 6.21+/-1.01 kcal/min for males and 13.5+/-1.4 ml/kg min and 4.04+/-1.45 kcal/min for females. Associated HR responses were 129.5+/-18.4 and 119.2+/-19.4 bpm for males.
and females, respectively. The training stimulus was <32% VO2max, significantly below ACSM recommendations (50% VO2max) for improving cardiovascular fitness; HR criteria (60% HRmax), however were met. Free weight CWT performed with loads < or =10.5 kg may not provide a sufficient cardiovascular training stimulus.HR should not be used to assess exercise intensity in these classes.

Maiorana A et.al.,(2000) Conducted a study on the effect of a novel circuit weight training (CWT) program on cardio respiratory fitness, muscular strength, and body composition in 13 patients with chronic heart failure (CHF), using a prospective randomized crossover protocol. Peak exercise oxygen uptake (VO (2 peak)) increased after the 8-wk CWT program (19. 5 +/- 1.2 vs. 22.0 +/- 1.5 ml. kg(-1). min(-1), P < 0.01), as did exercise test duration (15.2 +/- 0.9 vs. 18.0 +/- 1.1 min, P < 0. 001). Sub maximal exercise heart rate was lower after training at 60 and 80 W (121 +/- 3 vs. 134 +/- 5 beats/min, P < 0.01) as was rate pressure product, whereas ventilatory threshold increased, from 52 +/- 3 to 58 +/- 3% of VO(2 peak) (P < 0.05). CWT also increased maximal isotonic voluntary contractile strength for seven different muscle groups, from 392 to 462 kg (P = 0.001). CWT, an exercise prescription specifically targeting peripheral abnormalities in CHF, improves functional capacity and muscular strength in these patients.