Chapter II

REVIEW OF RELATED LITERATURE

For any specific research project to occupy a place in the development of a discipline, the researcher must be thoroughly familiar with both previous theory and research. To assure this familiarity, every research project in the behavioral sciences has, as one of its early stage, a review of the theoretical and research literature.

The literature related to any problem helps the scholar to discover what is already known, which would enable the investigator to have a deep insight, clear perspective and a better understanding of the chosen problem and various factors connected with the study. So a number of books, journals, and websites were referred. In the following pages, an attempt has been made to present briefly a few important studies conducted abroad and in India, as they have significant bearing on the present study.

Maio Alves JM, Rebelo AN, Abrantes C, Sampaio J. (2010) analyzed the short-term effects of complex and contrast training (CCT) on vertical jump (squat and countermovement jump),
sprint (5 and 15 m), and agility (505 Agility Test) abilities in soccer players. Twenty-three young elite Portuguese soccer players (age 17.4 +/- 0.6 years) were divided into 2 experimental groups (G1, n = 9, and G2, n = 8) and 1 control group (G3, n = 6). Groups G1 and G2 have done their regular soccer training along with a 6-week strength training program of CCT, with 1 and 2 training sessions.wk, respectively. G3 has been kept to their regular soccer training program. Each training session from the CCT program was organized in 3 stations in which a general exercise, a multiform exercise, and a specific exercise were performed. The load was increased by 5% from 1 repetition maximum each 2 weeks. Obtained results allowed identifying (a) a reduction in sprint times over 5 and 15 m (9.2 and 6.2% for G1 and 7.0 and 3.1%, for G2; p < 0.05) and () an increase on squat and jump (12.6% for G1 and 9.6% for G2; p < 0.05). The results suggested that the CCT induced the performance increase in 5 and 15 m sprint and in squat jump. Vertical jump and sprint performances after CCT program were not influenced by the number of CCT sessions per week (1 or 2 sessions.wk). From the obtained results, it was suggested that the CCT is an adequate training strategy to develop soccer players’ muscle power and speed.
Tønnessen E, Shalfawi SA, Haugen T, Enoksen E. (2011). examined the effect of 10 weeks' 40-m repeated sprint training program that does not involve strength training on sprinting speed and repeated sprint speed on young elite soccer players. Twenty young well-trained elite male soccer players of age (±SD) 16.4 (±0.9) years, body mass 67.2 (±9.1) kg, and stature 176.3 (±7.4) cm volunteered to participate in this study. All participants were tested on 40-m running speed, 10 × 40-m repeated sprint speed, 20-m acceleration speed, 20-m top speed, countermovement jump (CMJ), and aerobic endurance (beep test). Participants were divided into training group (TG) (n = 10) and control group (CG) (n = 10). The study was conducted in the precompetition phase of the training program for the participants and ended 13 weeks before the start of the season; the duration of the precompetition period was 26 weeks. The TG followed a Periodized repeated sprint training program once a week. The training program consisted of running 40 m with different intensities and duration from week to week. Within-group results indicate that TG had a statistically marked improvement in their performance from pre to posttest in 40-m maximum sprint (-0.06 seconds), 10 × 40-m repeated sprint speed (-0.12 seconds), 20- to 40-m top speed (-0.05 seconds),
and CMJ (2.7 cm). The CG showed only a statistically notable improvement from pre to posttest in 10 × 40-m repeated sprint speed (-0.06 seconds). Between-group differences showed a statistically marked improvement for the TG over the CG in 10 × 40-m repeated sprint speed (-0.07 seconds) and 20- to 40-m top speed (-0.05 seconds), but the effect of the improvement was moderate. The results further indicate that a weekly training with repeated sprint gave a moderate but not statistically marked improvement in 40-m sprinting, CMJ, and beep test. The results of this study indicate that the repeated sprint program had a positive effect on several of the parameters tested. However, because the sample size in this study is 20 participants, the results are valid only for those who took part in this study. Therefore, we advice to use repeated sprint training similar to the one in this study only in periods where the players have no speed training included in their program. Furthermore, the participants in this study should probably trained strength, however, benefits were observed even without strength training is most likely to be caused by the training specificity.

Ronnestad BR, Kvamme NH, Sunde A, Raastad T. (2008). compared the effects of combined strength and plyometric training with strength training alone on power-related
measurements in professional soccer players. Subjects in the intervention team were randomly divided into 2 groups. Group ST (n = 6) performed heavy strength training twice a week for 7 weeks in addition to 6 to 8 soccer sessions a week. Group ST+P (n = 8) performed a plyometric training program in addition to the same training as the ST group. The control group (n = 7) performed 6 to 8 soccer sessions a week. Pretests and posttests were 1 repetition maximum (1RM) half squat, countermovement jump (CMJ), squat jump (SJ), 4-bounce test (4BT), peak power in half squat with 20 kg, 35 kg, and 50 kg (PP20, PP35, and PP50, respectively), sprint acceleration, peak sprint velocity, and total time on 40-m sprint. There were no significant differences between the ST+P group and ST group. Thus, the groups were pooled into 1 intervention group. The intervention group significantly improved in all measurements except CMJ, while the control group showed significant improvements only in PP20. There was a significant difference in relative improvement between the intervention group and control group in 1RM half squat, 4BT, and SJ. However, a significant difference between groups was not observed in PP20, PP35, sprint acceleration, peak sprinting velocity, and total time on 40-m sprint. The results suggest that there are no significant performance-
enhancing effects of combining strength and plyometric training in professional soccer players concurrently performing 6 to 8 soccer sessions a week compared to strength training alone. However, heavy strength training leads to significant gains in strength and power-related measurements in professional soccer players.

Polman R, Walsh D, Bloomfield J, Nesti M. (2004) compared 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.

Chelly MS, Ghenem MA, Abid K, Hermassi S, Tabka Z, Shephard RJ. (2010) hypothesised that the addition of an 8-week lower limb plyometric training program (hurdle and depth
jumping) to normal in-season conditioning would enhance measures of competitive potential (peak power output [PP], jump force, jump height, and lower limb muscle volume) in junior soccer players. The subjects (23 men, age 19 ± 0.7 years, body mass 70.5 ± 4.7 kg, height 1.75 ± 0.06 m, body fat 14.7 ± 2.6%) were randomly assigned to a control (normal training) group (Gc; n = 11) and an experimental group (Gex, n = 12) that also performed biweekly plyometric training. A force-velocity ergometer test determined PP. Characteristics of the squat jump (SJ) and the countermovement jump (CMJ) (jump height, maximal force and velocity before take-off, and average power) were determined by force platform. Video-camera kinematic analyses over a 40-m sprint yielded running velocities for the first step (VS), the first 5 m (V5m) and between 35 and 40 m (Vmax). Leg muscle volume was estimated using a standard anthropometric kit. Gex showed gains relative to controls in PP (p < 0.01); SJ (height p < 0.01; velocity p < 0.001), CMJ (height p < 0.001; velocity p < 0.001, average power p < 0.01) and all sprint velocities (p < 0.001 for V5m and Vmax, p < 0.01 for VS). There was also a significant increase (p < 0.05) in thigh muscle volume, but leg muscle volume and mean thigh cross-sectional area remain unchanged. We conclude that biweekly plyometric
training of junior soccer players (including adapted hurdle and depth jumps) improved important components of athletic performance relative to standard in-season training. Accordingly, such exercises are highly recommended as part of an annual soccer training program.

Buchheit M, Mendez-Villanueva A, Delhomel G, Brughelli M, Ahmaidi S. (2010 Oct) compared 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.

Christou M, Smilios I, Sotiropoulos K, Volaklis K, Pilianidis T, Tokmakidis SP. (2006 Nov). examined 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.
Milanović Z, Sporiš G, Trajković N, James N, Samija K. (2013 Mar) determined the effects of a 12 week conditioning programme involving speed, agility and quickness (SAQ) training and its effect on agility performance in young soccer players. Soccer players were randomly assigned to two groups: experimental group (EG; n = 66, body mass: 71.3 ± 5.9 kg; body height: 1.77 ± 0.07 m) and control group (CG; n = 66, body mass: 70.6 ± 4.9 kg; body height: 1.76 ± 0.06 m). Agility performance was assessed using field tests: Slalom; Slalom with ball; Sprint with 90° turns; Sprint with 90° turns with ball; Sprint with 180° turns; Sprint with backward and forward running; Sprint 4 x 5 m. Statistically significant improvements (p < 0.05) between pre and post training were evident for almost all measures of agility, with and without the ball, with the exception being the Sprint with backward and forward running. This suggests that SAQ training is an effective way of improving agility, with and without the ball, for young soccer players and can be included in physical conditioning programmes. Key points SAQ training appears to be an effective way of improving agility with and without the ball in young soccer players Soccer coaches could use this training during pre-season and in-season training Compared with pre-training, there was a statistically
significant improvement in all but one measure of agility, both with and without the ball after SAQ training.

Markovic G, Jukic I, Milanovic D, Metikos D. (2007 May). evaluated the effects of sprint training on muscle function and dynamic athletic performance and to compare them with the training effects induced by standard plyometric training. Male physical education students were assigned randomly to 1 of 3 groups: sprint group (SG; n = 30), plyometric group (PG; n = 30), or control group (CG; n = 33). Maximal isometric squat strength, squat- and countermovement jump (SJ and CMJ) height and power, drop jump performance from 30-cm height, and 3 athletic performance tests (standing long jump, 20-m sprint, and 20-yard shuttle run) were measured prior to and after 10 weeks of training. Both experimental groups trained 3 days a week; SG performed maximal sprints over distances of 10-50 m, whereas PG performed bounce-type hurdle jumps and drop jumps. Participants in the CG group maintained their daily physical activities for the duration of the study. Both SG and PG significantly improved drop jump performance (15.6 and 14.2%), SJ and CMJ height (approximately 10 and 6%), and standing long jump distance (3.2 and 2.8%), whereas the respective effect sizes (ES) were moderate to high and ranged between 0.4 and
1.1. In addition, SG also improved isometric squat strength (10%; ES = 0.4) and SJ and CMJ power (4%; ES = 0.4, and 7%; ES = 0.4), as well as sprint (3.1%; ES = 0.9) and agility (4.3%; ES = 1.1) performance. We conclude that short-term sprint training produces similar or even greater training effects in muscle function and athletic performance than does conventional plyometric training. This study provides support for the use of sprint training as an applicable training method of improving explosive performance of athletes in general.

Cortis C, Tessitore A, Perroni F, Lupo C, Pesce C, Amendolia A, Capranica L. (2009 Dec). aimed at verifying whether chronic participation in soccer training has a beneficial effect (p < 0.05) on the improvement and the maintenance of interlimb coordination performance across the lifespan and whether coordination is moderated by strength and power performances. Forty young (12 +/- 1 yr), 42 adult (26 +/- 5 yr), and 32 older (59 +/- 11 yr) male soccer players and sedentary individuals were administered in-phase (IP) and antiphase (AP) synchronized (80, 120, and 180 bpm) hand and foot flexions and extensions, handgrip and countermovement jump (CMJ) tests. Regardless of age, soccer players always showed better performances (handgrip: 383 +/- 140 N; CMJ: 28.3 +/- 8.7 cm;
IP: 55.2 +/- 12.9 s; and AP: 31.8 +/- 25.0 s) than sedentary individuals (handgrip: 313 +/- 124 N; CMJ: 21.0 +/- 9.4 cm; IP: 46.7 +/- 20.2 s, and AP: 21.1 +/- 23.9 s). With respect to IP and AP performances, a hierarchical model (p < 0.0001) emerged for CMJ, explaining 30% and 26% of the variance for IP and AP, respectively. In contrast, handgrip did not provide increments in the explained variance. Results indicate that chronic soccer training is beneficial to develop strength, CMJ, and interlimb synchronization capabilities in children, to reach higher levels of proficiency in adults, and to maintain performance in older individuals. The predicted role of CMJ on interlimb coordination indicates that a fine neuromuscular activation timing is central for both jump and coordinative performances. In practice, to induce higher attentional control and executive function in open skill sport athletes and to better prepare players to cope with the demands of their match, coaches should modulate complex motor behaviors with increasing velocity of execution and are strongly recommended to make use of technical and tactical drills that focus on the player's agility under time pressure to induce higher attentional control and executive function.

maximal leg strength training on peak power output (Wpeak), vertical jump performance, and field performances in junior soccer players. Twenty-two male soccer players participated in this investigation and were divided into 2 groups: A resistance training group (RTG; age 17 +/- 0.3 years) and a control group (CG; age 17 +/- 0.5 years). Before and after the training sessions (twice a week for 2 months), Wpeak was determined by means of a cycling force-velocity test. Squat jump (SJ), countermovement jump (CMJ), and 5-jump test (5-JT) performances were assessed. Kinematics analyses were made using a video camera during a 40-m sprint running test and the following running velocities were calculated: The first step after the start (V(first step)), the first 5 m (V(first 5 meters)), and between the 35 m and 40 m (V(max)). Back half squat exercises were performed to determine 1-repetition maximum (1-RM). Leg and thigh muscle volume and mean thigh cross-sectional area (CSA) were assessed by anthropometry. The resistance training group showed improvement in Wpeak (p < 0.05), jump performances (SJ, p < 0.05 and 5-JT, p < 0.001), 1-RM (p < 0.001) and all sprint running calculated velocities (p < 0.05 for both V(first step) and V(first 5 meters), p < 0.01 for V(max)). Both typical force-velocity relationships and mechanical parabolic curves between power
and velocity increased after the strength training program. Leg and thigh muscle volume and CSA of RTG remained unchanged after strength training. Back half squat exercises, including adapted heavy loads and only 2 training sessions per week, improved athletic performance in junior soccer players. These specific dynamic constant external resistance exercises are highly recommended as part of an annual training program for junior soccer players.

Wong PL, Chamari K, Wisløff U. (2010 Mar). examined 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 submaximal 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.

Meckel Y, Gefen Y, Nemet D, Eliakim A. (2012 Jul). compared the effect of short-sprint repetition and long-sprint repetition training (SST, LST), matched for total distance, on selected fitness components in young soccer players. Thirty young (14-15 years) soccer players were randomly assigned to either the short-sprint training group or long-sprint training group and completed 2 similar sets of fitness tests before and after 7 weeks of training. The 2 training programs consisted of SST (4-6 sets of 4 × 50-m all-out sprint) and LST (4-6 sets of 200-m run at 85% of maximum speed), each performed 3 times a week. Before training, there were no baseline between-group differences in predicted VO2max, standing long jump, 30-m sprint time, 4 × 10-m shuttle running time, and 250-m running time. Both training programs led to a significant improvement in VO2max (predicted from the 20-m shuttle run, p < 0.01), with no
between-group difference (p = 0.14). Both training programs also led to a significant improvement in the anaerobic fitness variables of 30-m sprint time (p < 0.01), 4 × 10-m shuttle running time (p < 0.01), and 250-m running time (p < 0.01), with no between-group differences. Neither of the training programs had a significant effect on standing long jump (p = 0.21). The study showed that long, near-maximal sprints, and short, all-out sprint training, matched for total distance, are equally effective in enhancing both the aerobic and anaerobic fitness of young soccer players. Therefore, to maintain a player’s training interest and enthusiasm, coaches may alternate between these methods during the busy soccer season.

Sedano S, Matheu A, Redondo JC, Cuadrado G. (2011 Mar) determined the effects of a 10-week plyometric training program on explosive strength, acceleration capacity and kicking speed in young elite soccer players. Twenty-two players participated in the study: control group (CG), (N.=11; 18.2 ± 0.9 years) and treatment group (TG) (N.=11; 18.4 ± 1.1 years). Both groups performed technical and tactical training exercises and matches together. However, the CG players followed the regular physical conditioning program, which was replaced by a plyometric program for TG. Plyometric training took place three days a week
and included jumps over hurdles, horizontal jumps and lateral jumps over hurdles. Jumping ability, 10 m sprint and kicking speed were measured on five separate occasions. The main findings revealed that a 10-week plyometric program may be an effective training stimulus to improve explosive strength compared to a more conventional physical training program. The improvements in explosive strength can be transferred to acceleration capacity and kicking speed but players need time to transfer these increases.

Shalfawi SA, Haugen T, Jakobsen TA, Enoksen E, Tønnessen E. (2013 Nov) 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 the agility and repeated sprint training group or to the strength training group. All the participants were tested before and after a 10-week specific conditioning program. The pretest and posttest were conducted on 3 separate days with 1 day of low-intensity training in between. Test day 1 consisted of squat jump (SJ),
countermovement jump (CMJ), and RSA. Test day 2 consisted of a 40-m maximal linear sprint and an agility test, whereas a Beep test was conducted on test day 3 to assess aerobic capacity. The agility and repeated sprint training implemented in this study did not have a significant 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 significant (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 program of conditioning that does not result in a decreased performance of the players, the great importance of strength and conditioning specialist in implementing the training program, and the importance of choosing the time of the year to implement such
conditioning training programs. However, the fact that the present training program did not cause any decline in performance indicates that it is useful in maintaining the soccer players' physical performance during the competition period.

Hunter JR, O'Brien BJ, Mooney MG, Berry J, Young WB, Down N. (2011 May) compared the effect of 2 repeated sprint training interventions on an intermittent peak running speed (IPRS) test designed for Australian Rules football. The test required participants to perform 10 × 10-m maximal efforts on an 80-m course every 25 seconds, for each of which the mean peak speed (kilometers per hour) was recorded to determine IPRS. The training interventions were performed twice weekly for 4 weeks immediately before regular football training. In the constant volume intervention (CVol), sprint repetition number remained at 10 (n = 9), and in the linear increase in volume (LIVol) intervention, repetition number increased linearly each week by 2 repetitions (n = 12). Intermittent peak running speed, 300-m shuttle test performance, and peak running speed were assessed before and upon completion of training. All measures were compared to a control group (CON; n = 8) in which players completed regular football training exclusively. Intermittent peak running speed performance in CVol and LIVol improved
significantly (p < 0.01) by 5.2 and 3.8%, respectively, with no change in IPRS for CON. There were no differences in IPRS changes between CVol and LIVol. Additionally, peak running speed improved significantly (p < 0.01) by 5.1% for CVol, whereas 300-m shuttle performance improved significantly (p < 0.01) by 2.6% for LIVol only. Intermittent peak running speed, 300-m shuttle performance and peak running speed were improved after 4 weeks of training; however, progressively increasing sprint repetition number had no greater advantage on IPRS adaptation. Additionally, exclusive regular football training over a 4-week period is unlikely to improve IPRS, peak running speed, or 300-m shuttle performance.

Baker, D.G., Newton, R.U. (2008) described and compare the lower body strength, power, acceleration, maximal speed, agility, and sprint momentum of elite first-division national rugby league (NRL) players (n = 20) to second-division state league (SRL) players (n = 20) players from the same club. Strength and maximal power were the best discriminators of which players were in the NRL or SRL squads. None of the sprinting tests, such as acceleration (10-m sprint), maximal speed (40-m sprint), or a unique 40-m agility test, could distinguish between the NRL or SRL squads. However, sprint
momentum, which was a product of 10-m velocity and body mass, was better for discriminating between NRL and SRL players as heavier, faster players would possess better drive forward and conversely be better able to repel their opponents' drive forward. Strength and conditioning specialists should therefore pay particular attention to increasing lower body strength and power and total body mass through appropriate resistance training while maintaining or improving 10-m sprint speed to provide their players with the underlying performance characteristics of play at the elite level in rugby leagues.

Bloomfield, J., Polman, R., O'Donoghue, P., & McNaughton, L. (2007) compared the effectiveness of 2 methodologies for speed and agility conditioning for random, intermittent, and dynamic activity sports (e.g., soccer, tennis, hockey, basketball, rugby, and netball) and the necessity for specialized coaching equipment. Two groups were delivered either a programmed method (PC) or a random method (RC) of conditioning with a third group receiving no conditioning (NC). PC participants used the speed, agility, quickness (SAQ) conditioning method, and RC participants played supervised small-sided soccer games. PC was also subdivided into 2 groups where participants either used specialized SAQ equipment or no
equipment. A total of 46 (25 males and 21 females) untrained participants received (mean +/- SD) 12.2 +/- 2.1 hours of physical conditioning over 6 weeks between a battery of speed and agility parameter field tests. Two-way analysis of variance results indicated that both conditioning groups showed a significant decrease in body mass and body mass index, although PC achieved significantly greater improvements on acceleration, deceleration, leg power, dynamic balance, and the overall summation of % increases when compared to RC and NC (p < 0.05). PC in the form of SAQ exercises appears to be a superior method for improving speed and agility parameters; however, this study found that specialized SAQ equipment was not a requirement to observe significant improvements. Further research is required to establish whether these benefits transfer to sport-specific tasks as well as to the underlying mechanisms resulting in improved performance.

Buchheit, M., Mendez-Villanueva, A., Delhomel, G., Brughelli, M., & Ahmaid, S. (2010) compared 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); ExpStraining 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.

Cochrane, Legg, and Hooker (2004) was investigated the effect short-term WBV training had on vertical jump, sprint, and agility performance in nonelite athletes. Twenty-four sport science students (16 men and 8 women) were randomly assigned to 2 groups: WBV training or control. Each group included 8 men and 4 women. Countermovement jump height, squat jump height, sprint speed over 5, 10, and 20 m, and agility (505, up and back) were performed by each participant before and after 9 days of either no training (control) or WBV training. Perceived discomfort of every participant was recorded after daily WBV exposure and nonexposure. There were no significant differences between WBV and control groups for CMJ, SJ, sprints, and agility. Perceived discomfort differed between the first and subsequent days of WBV training ($p < 0.05$); however, there was no difference between the WBV and control groups. It is concluded that short-term WBV training did not enhance performance in nonelite athletes.

Costello, K. E., Matrangola, S. L., & Madigan, M. L. (2012) investigated the independent effects of adding weight and
inertia on balance during quiet standing. Sixteen normal-weight young adult participants stood as still as possible on a custom-built backboard apparatus under four experimental conditions: baseline, added inertia only, added weight only, and added inertia and weight. Adding inertia by itself had no measurable effect on center of pressure movement or backboard movement. Adding weight by itself increased center of pressure movement (indicated greater effort by the postural control system to stand as still as possible) and backboard movement (indicating a poorer ability of the body to stand as still as possible). Adding inertia and weight at the same time increased center of pressure movement but did not increase backboard movement compared to the baseline condition. Adding inertia and adding weight had different effects on balance. Adding inertia by itself had no effect on balance. Adding weight by itself had a negative effect on balance. When adding inertia and weight at the same time, the added inertia appeared to lessen (but did not eliminate) the negative effect of adding weight on balance. These results improve our fundamental understanding of how added mass influences human balance.

Coutts, Murphy and Dascombe (2004) were examined the influence of direct supervision on muscular strength, power, and
running speed during 12 weeks of resistance training in young rugby league players. Two matched groups of young (16.7 +/- 1.1 years [mean +/- SD]), talented rugby league players completed the same periodized resistance-training program in either a supervised (SUP) (N = 21) or an unsupervised (UNSUP) (N = 21) environment. Measures of 3 repetition maximum (3RM) bench press, 3RM squat, maximal chin-ups, vertical jump, 10- and 20-m sprints, and body mass were completed pretest (week 0), midtest (week 6), and posttest (week 12) training program. Results show that 12 weeks of periodized resistance training resulted in an increased body mass, 3RM bench press, 3RM squat, maximum number of chin-ups, vertical jump height, and 10- and 20-m sprint performance in both groups (p < 0.05). The SUP group completed significantly more training sessions, which were significantly correlated to strength increases for 3RM bench press and squat (p < 0.05). Furthermore, the SUP group significantly increased 3RM squat strength (at 6 and 12 weeks) and 3RM bench press strength (12 weeks) when compared to the UNSUP group (p < 0.05). Finally, the percent increase in the 3RM bench press, 3RM squat, and chin-up(max) was also significantly greater in the SUP group than in the UNSUP group (p < 0.05). These findings show that the direct supervision of
resistance training in young athletes results in greater training adherence and increased strength gains than does unsupervised training.

Gabbett, T.J., Sheppard, J.M., Pritchard-Peschek, K.R., Leveritt, M.D., & Aldred, M.J. (2008) evaluated the efficacy of two different dynamic warm-up conditions, one that was inclusive of open skills (i.e., reactive movements) and one that included only preplanned dynamic activities (i.e., closed skills) on the performance of speed, change of direction speed, vertical jump, and reactive agility in team sport athletes. Fourteen (six male, eight female) junior (mean +/- SD age, 16.3 +/- 0.7 year) basketball players participated in this study. Testing was conducted on 2 separate days using a within-subjects cross-over study design. Each athlete performed a standardized 7-minute warm-up consisting of general dynamic movements and stretching. After the general warm-up, athletes were randomly allocated into one of two groups that performed a dynamic 15-minute warm-up consisting entirely of open or closed skills. Each of the warm-up conditions consisted of five activities of 3 minute duration. At the completion of the warm-up protocol, players completed assessments of reactive agility, speed (5-, 10-, and 20-m sprints), change of direction speed (T-test), and
vertical jump. No significant differences (p > 0.05) were detected among warm-up conditions for speed, vertical jump, change of direction speed, and reactive agility performances. The results of this study demonstrate that either open skill or closed skill warm-ups can be used effectively for team sport athletes without compromising performance on open skill and closed skill tasks.

Galpin, A.J., Li, Y., Lohnes, C.A., & Schilling, B.K. (2008) determined the reliability and effectiveness of a 4-week CAT training program on foot speed (FS) and choice reaction (REACT), and to assess whether training on the CAT would facilitate the improvement of a separate change-of-direction (COD) test in non-agility-trained, but active, men and women. Twenty-three participants (15 men, 8 women) pre- and posttested on FS, REACT, and COD drills. Eleven of those participants (7 men, 4 women) engaged in 4 weeks of training on the FS and REACT drills (EX). The remaining 12 (8 men, 4 women) did not participate in the training and served as controls (CON). Coefficients of variation indicate strong precision for FS (6.9%) and REACT (2.6%). Test-retest reliability, as analyzed by intraclass correlations (ICC), were high for both FS and REACT (0.89). Significant test-by-group interactions were observed for all three tests: FS (p = 0.004), REACT (p = 0.011), and COD (p =
Post hoc analysis indicated that EX increased foot contacts for the FS drill \( p = 0.006 \), whereas REACT and COD demonstrated decreases in time to completion \( p = 0.013 \) and \( p = 0.038 \), respectively. The CON group did not improve on any of the tests. This study indicates that the chosen CAT is an accurate and reliable tool for measuring foot speed and reaction time. These data justify the use of this CAT in analyzing foot speed and reaction time. Altogether, 4 weeks of foot speed and reaction training on the chosen CAT produced improvements in overall agility in non-agility-trained, but active, men and women. These data warrant the integration of such a device into the training program of untrained athletes attempting to improve agility.

Hao, W.Y., & Chen, Y. (2011) investigated the effects of BW on balance in boys. Sixteen healthy boys (age: \( 7.19 \pm 0.40 \) y) were randomly assigned to either an experimental or a control group. The experimental group participated in a BW training program (12-week, 2 times weekly, and 25-min each time) but not the control group. Both groups had five dynamic balance assessments with a Biodex Stability System (anterior/posterior, medial/lateral, and overall balance index) before, during and after the training (week- 0, 4, 8, 12, 24). Six
control and six experimental boys participated in a study comparing kinematics of lower limbs between FW and BW after the training (week-12). The balance of experimental group was better than that of control group after 8 weeks of training ($P < 0.01$), and was still better than that of control group ($P < 0.05$), when the BW training program had finished for 12 weeks. The kinematic analysis indicated that there was no difference between control and experimental groups in the kinematics of both FW and BW gaits after the BW training ($P > 0.05$). Compared to FW, the duration of stance phase of BW tended to be longer, while the swing phase, stride length, walking speed, and moving ranges of the thigh, calf and foot of BW decreased ($P < 0.01$). Backward walking training in school-aged boys can improve balance.

Harrison and Bourke (2009) were investigated whether an RS training intervention would enhance the running speed and dynamic strength measures in male rugby players. Fifteen male rugby players aged 20.5 (+/- 2.8) years who were proficient in resisted sledge training took part in the study. The subjects were randomly assigned to control or RS groups. The RS group performed two sessions per week of RS training for 6 weeks, and the control group did no RS training. Pre- and postintervention
tests were carried out for 30-m sprint, drop, squat, and rebound jumps on a force sledge system. A laser measurement device was used to obtain velocities and distance measures during all running trials. The results show a statistically significant decrease in time to 5 m for the 30-m sprint for the RS group (p = 0.02). The squat jump and drop jump variables also showed significant increases in starting strength (p = 0.004) and height jumped (p = 0.018) for the RS group from pre- to post-testing sessions. The results suggest that it may be beneficial to employ an RS training intervention with the aim of increasing initial acceleration from a static start for sprinting.

**Hoffman, J.R., et al., (2010)** examined the effect of acute and prolonged (4-weeks) ingestion of a supplement designed to improve reaction time and subjective measures of alertness, energy, fatigue, and focus compared to placebo. Nineteen physically-active subjects (17 men and 2 women) were randomly assigned to a group that either consumed a supplement (21.1 ± 0.6 years; body mass: 80.6 ± 9.4 kg) or placebo (21.3 ± 0.8 years; body mass: 83.4 ± 18.5 kg). During the initial testing session (T1), subjects were provided 1.5 g of the supplement (CRAM; α-glycerophosphocholine, choline bitartrate, phosphatidylserine, vitamins B3, B6, and B12, folic acid, L-tyrosine, anhydrous
caffeine, acetyl-L-carnitine, and naringin) or a placebo (PL), and rested quietly for 10-minutes before completing a questionnaire on subjective feelings of energy, fatigue, alertness and focus (PRE). Subjects then performed a 4-minute quickness and reaction test followed by a 10-min bout of exhaustive exercise. The questionnaire and reaction testing sequence was then repeated (POST). Subjects reported back to the lab (T2) following 4-weeks of supplementation and repeated the testing sequence. Reaction time significantly declined (p = 0.050) between PRE and POST at T1 in subjects consuming PL, while subjects under CRAM supplementation were able to maintain (p = 0.114) their performance. Significant performance declines were seen in both groups from PRE to POST at T2. Elevations in fatigue were seen for CRAM at both T1 and T2 (p = 0.001 and p = 0.000, respectively), but only at T2 for PL (p = 0.029). Subjects in CRAM maintained focus between PRE and POST during both T1 and T2 trials (p = 0.152 and p = 0.082, respectively), whereas significant declines in focus were observed between PRE and POST in PL at both trials (p = 0.037 and p = 0.014, respectively). No difference in alertness was seen at T1 between PRE and POST for CRAM (p = 0.083), but a significant decline was recorded at T2 (p = 0.005). Alertness was significantly lower at POST at both T1 and T2 for
PL (p = 0.040 and p = 0.33, respectively). No differences in any of these subjective measures were seen between the groups at any time point. Results indicate that acute ingestion of CRAM can maintain reaction time, and subjective feelings of focus and alertness to both visual and auditory stimuli in healthy college students following exhaustive exercise. However, some habituation may occur following 4-weeks of supplementation.

Hrysomallis, C. (2011) established the relationship between balance ability and sport injury risk in many cases, but the relationship between balance ability and athletic performance is less clear. This review compares the balance ability of athletes from different sports, determines if there is a difference in balance ability of athletes at different levels of competition within the same sport, determines the relationship of balance ability with performance measures and examines the influence of balance training on sport performance or motor skills. Based on the available data from cross-sectional studies, gymnasts tended to have the best balance ability, followed by soccer players, swimmers, active control subjects and then basketball players. Surprisingly, no studies were found that compared the balance ability of rifle shooters with other athletes. There were some sports, such as rifle shooting, soccer and golf,
where elite athletes were found to have superior balance ability compared with their less proficient counterparts, but this was not found to be the case for alpine skiing, surfing and judo. Balance ability was shown to be significantly related to rifle shooting accuracy, archery shooting accuracy, ice hockey maximum skating speed and simulated luge start speed, but not for baseball pitching accuracy or snowboarding ranking points. Prospective studies have shown that the addition of a balance training component to the activities of recreationally active subjects or physical education students has resulted in improvements in vertical jump, agility, shuttle run and downhill slalom skiing. A proposed mechanism for the enhancement in motor skills from balance training is an increase in the rate of force development. There are limited data on the influence of balance training on motor skills of elite athletes. When the effectiveness of balance training was compared with resistance training, it was found that resistance training produced superior performance results for jump height and sprint time. Balance ability was related to competition level for some sports, with the more proficient athletes displaying greater balance ability. There were significant relationships between balance ability and a number of performance measures. Evidence from prospective
studies supports the notion that balance training can be a worthwhile adjunct to the usual training of non-elite athletes to enhance certain motor skills, but not in place of other conditioning such as resistance training. More research is required to determine the influence of balance training on the motor skills of elite athletes.

Jakovljevic, S.T., Karalejic, M.S., Pajic, Z.B., Macura, M.M., & Erculj, F.F. (2011) investigated relations between speed and agility for both age groups of basketball players, in order to help coaches to improve their work. Sixty-four players aged 12 (M=11.98, SD=.311) and 54 players aged 14 (M=14.092, SD=.275) were tested. Three agility tests: agility T-test, zigzag agility drill and agility run 4×15 m and three speed tests: 20-m run, 30-m run, and 50-m run were applied. Fourteen year-old players achieved significantly better results in all speed and agility tests compared to 12-year-old players. The correlation coefficient (r=0.81, p=.001) showed that 12-year-old players have the same ability in 30- and 50-m runs. The other correlation coefficient (r=0.59, p=.001) indicated that 20-m and 30-m runs had inherently different qualities. The correlation coefficients between agility tests were lower than 0.71 and therefore each test in this group represents a specific task. In 14-year-old
players, the correlation coefficients between the speed test results were lower than 0.71. In contrast, the correlation coefficients between the agility tests were higher than 0.71, which means that all three tests represent the same quality. During the speed training of 12-year-old players, it is advisable to focus on shorter running distances, up to 30m. During the agility training of the same players, it is useful to apply exercises with various complexities. In speed training of the 14-year-old players, the 30- and 50-m runs should be applied, and agility training should include more specific basketball movements and activities.

**Jovanovic, M., Sporis, G., Omrcen, D., & Fiorentini, F. (2011)** evaluated the effects of the speed, agility, quickness (SAQ) training method on power performance in soccer players. Soccer players were assigned randomly to 2 groups: experimental group (EG; n = 50) and control group (n = 50). Power performance was assessed by a test of quickness—the 5-m sprint, a test of acceleration—the 10-m sprint, tests of maximal speed—the 20- and the 30-m sprint along with Bosco jump tests—squat jump, countermovement jump (CMJ), maximal CMJ, and continuous jumps performed with legs extended. The initial testing procedure took place at the beginning of the in-season
period. The 8-week specific SAQ training program was implemented after which final testing took place. The results of the 2-way analysis of variance indicated that the EG improved significantly (p < 0.05) in 5-m (1.43 vs. 1.39 seconds) and in 10-m (2.15 vs. 2.07 seconds) sprints, and they also improved their jumping performance in countermovement (44.04 vs. 4.48 cm) and continuous jumps (41.08 vs. 41.39 cm) performed with legs extended (p < 0.05). The SAQ training program appears to be an effective way of improving some segments of power performance in young soccer players during the in-season period. Soccer coaches could use this information in the process of planning in-season training. Without proper planning of the SAQ training, soccer players will most likely be confronted with decrease in power performance during in-season period.

Jullien, H., Bisch, C., Largouët, N., Manouvrier, C., Carling C.J., & Amiard, V. (2008) assessed the effects of specific leg strength training (as part of a broader exercise program) on running speed and agility in young professional soccer players. Twenty-six male players (ages 17 to 19 years) were divided into 3 groups. The reference group (Re) performed individual technical work only, the coordination group (Co) performed a circuit designed to promote agility, coordination, and balance control
(together with some technical work) and the Squat group (Sq) underwent 3 series of 3 squat repetitions (at 90% of the individual maximum value) and a sprint, before competition of the agility circuit and some technical work. These specific training programs were performed 5 times a week for 3 weeks. Before the experimental session and at the end of each week, all players were assessed using 4 types of tests, (agility, a shuttle test with changes of direction, and 2 sprints over 10 and 7.32 meters, respectively), with completion time being the only performance parameter recorded. Our results indicate that in the short sprints or shuttle sprint with changes in direction, lower limb strengthening did not improve performance. Performance improved in all 3 groups in the agility test but more so in the reference and coordination groups. It appears that soccer-specific training composed of exercise circuits specifically adapted to the different types of effort actually used in match play can enhance agility and coordination.

Kaplan, T., Erkmen, N., & Taskin, H. (2009) determined the running speed and agility performance by playing positions. The sample included 108 professional male soccer players at the national level and 79 amateur male soccer players at a regional level on teams from 10 clubs in Turkey. The study involved the
players being assessed by the 10- x 5-m shuttle run test (10 x 5 SRT) on a soccer field in a soccer season. The difference between the mean scores of the professional and amateur players is significant. Differences between mean scores according to playing positions of soccer players are not significant. In conclusion, professional soccer players' running speed and agility performances are higher than amateur soccer players. In addition, these results indicate that all soccer players have the same running speed and agility performance in accordance with their different playing positions. Coaches should consider individual training programs based on the positional role of soccer players.

**Meylan, C., & Malatesta, D. (2009)** determined the influence of a short-term plyometric training within regular soccer practice on explosive actions of early pubertal soccer players during the in-season. Fourteen children (13.3 +/- 0.6 years) were selected as the training group (TG) and 11 children (13.1 +/- 0.6 years) were defined as the control group (CG). All children were playing in the same league and trained twice per week for 90 minutes with the same soccer drills. The TG followed an 8-week plyometric program (i.e., jumping, hurdling, bouncing, skipping, and footwork) implemented as a substitute
for some soccer drills to obtain the same session duration as CG. At baseline and after training, explosive actions were assessed with the following 6 tests: 10-meter sprint, agility test, 3 vertical jump tests (squat jump [SJ], countermovement jump [CMJ], contact test [CT] and multiple 5 bounds test [MB5]). Plyometric training was associated with significant decreases in 10-m sprint time (-2.1%) and agility test time (-9.6%) and significant increases in jump height for the CMJ (+7.9%) and CT (+10.9%). No significant changes in explosive actions after the 8-week period were recorded for the CG. The current study demonstrated that a plyometric program within regular soccer practice improved explosive actions of young players compared to conventional soccer training only. Therefore, the short-term plyometric program had a beneficial impact on explosive actions, such as sprinting, change of direction, and jumping, which are important determinants of match-winning actions in soccer performance.

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

Mujika, I., Santisteban, J., & Castagna, C. (2009) examined 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 skinfolds 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 performance 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.

Oxyzoglou, N., Kanioglou, A., & Ore G. (2009) was examined the performance on velocity, agility, and flexibility after six months of specific handball training or a mainstream physical education program in participants (handball, n = 51; physical education, n = 70) who engaged in 3 sessions per week (60 min./session) including ball-handling exercises, horizontal and vertical jump shots, fast breaks, and several defensive skills. Statistically significant differences were observed between the two groups on velocity, agility, and flexibility with differences favouring the handball group. Handball training could significantly improve preadolescents' physical performance.

Pasanen, K., Parkkari, J., Pasanen, M., Kannus, P. (2009) investigated whether a 6-month neuromuscular warm-up programme could improve muscle power, balance, speed and agility. Cluster randomised controlled study. 27 top level female floorball teams in Finland. 222 players (mean age 24 years); 119 in the intervention group and 103 in the control group were followed-up for one league season (6 months). A neuromuscular warm-up programme included sports-specific running technique, balance, jumping and strengthening exercises. The
teams were advised to use the programme 1-3 times per week through the league season. One training session took approximately 25 min. Performance tests were assessed before and after the 6-month intervention and included static jump, countermovement jump, jumping over a bar, standing on a bar and figure-of-eight running. At 6 months, significant between-group differences were found in two outcome measures: jumping over a bar (number of jumps in 15 s) and standing on a bar (number of balance losses in 60 s). These differences were 2.3 jumps (95% CI 0.8 to 3.8, p = 0.003), favouring the intervention group, and -0.4 balance losses (95% CI -0.8 to 0.0, p = 0.050), again in favour of the intervention group. A neuromuscular warm-up programme improved the floorball players' sideways jumping speed and static balance. The exercises were also safe to perform and can thus be recommended for weekly training of floorball players.

Polman, R., Bloomfield, J., & Edwards, A. (2009) investigated the efficacy of both programmed (speed, agility, and quickness; SAQ) and random (small-sided games; SSG) conditioning methods on selected neuromuscular and physical performance variables. Twenty volunteers (21.1 +/- 4.0 y, 1.71 +/- 0.09 m, 66.7 +/- 9.9 kg; mean +/- SD) completed the study.
The study design used two physically challenging periodized experimental conditions (SAQ and SSG conditions) and a nonexercise control condition (CON). Participants engaged in 12.2 +/- 2.1 h of directed physical conditioning. All participants had at least 24 h of recovery between conditioning sessions, and each 1-h session included 15 min of general warm-up and a 45-min exercise session. Participants completed a battery of tests (15-m sprint, isokinetic flexion/extension, depth jump) before and following the training program. There was a 6.9% (95% CI: -4.4 to 18.3) greater improvement in 5-m acceleration time and 4.3% (95% CI: -0.9 to 9.5) in 15-m mean running velocity time for the SAQ group compared with the SSG group. In addition, increases in maximal isokinetic concentric strength for both the flexor and extensor muscles, with the exception of 180 degrees/s flexion, were greater in the SAQ than SSG condition. The SAQ group also showed 19.5% (95% CI: -11.2 to 50.2) greater gain in reactive strength (contact time depth jump) and 53.8% (95% CI: 11.2 to 98.6) in mean gastrocnemius medialis activity in comparison with SSG. SAQ training should benefit the physical conditioning programs of novice players performing invasion games.
Salonikidis and Zafeiridis (2008) were diagnosed the presence of laterality in tennis lateral movements and to compare the effects of plyometric training (PT), tennis-specific drills training (TDT), and combined training (CT) on performance in tennis-specific movements and power/strength of lower limbs. Sixty-four novice tennis players (21.1 +/- 1.3 years) were equally (n = 16) assigned to a control (C), PT, TDT, or CT. Training was performed 3 times/week for 9 weeks. Testing was conducted before and after training for the evaluation of reaction time (single lateral step), 4-m lateral and forward sprints, 12-m forward sprints with and without turn, reactive ability, power, and strength. Power and strength improved in most tests after PT and CT. Lateral and forward sprints were correlated (r = -0.50 to -0.75; P < 0.05) with power/strength. In conclusion, PT improved fitness characteristics that rely more on reactive strength and powerful push-off of legs such as, lateral reaction time, 4-m lateral and forward sprints, drop jump and maximal force. TDT improved all 4-m and 12-m sprint performances, whereas CT appeared to incorporate the advantage of both programs and improved most tests items. Tennis coaches should be aware that each training regimen may induce more favorable changes to different aspects of fitness.
Salonikidis, K., & Zafeiridis, A. (2008). studied: (i) to diagnose the presence of laterality in tennis lateral movements and (ii) to compare the effects of plyometric training (PT), tennis-specific drills training (TDT), and combined training (CT) on performance in tennis-specific movements and power/strength of lower limbs. Sixty-four novice tennis players (21.1 +/- 1.3 years) were equally (n = 16) assigned to a control (C), PT, TDT, or CT. Training was performed 3 times/week for 9 weeks. Testing was conducted before and after training for the evaluation of reaction time (single lateral step), 4-m lateral and forward sprints, 12-m forward sprints with and without turn, reactive ability, power, and strength. There was a significant difference in lateral speed (side-steps) between the 2 sides (P < 0.05). PT, TDT, or CT improved the 4-m lateral and forward sprints (P < 0.05). PT and CT improved also the reaction time of the "slow" side (P < 0.05), whereas TDT and CT improved the 12-m sprint performances with and without turn (P < 0.05). Power and strength improved in most tests after PT and CT. Lateral and forward sprints were correlated (r = -0.50 to -0.75; P < 0.05) with power/strength. In conclusion, PT improved fitness characteristics that rely more on reactive strength and powerful push-off of legs such as, lateral reaction time, 4-m lateral and
forward sprints, drop jump and maximal force. TDT improved all 4-m and 12-m sprint performances, whereas CT appeared to incorporate the advantage of both programs and improved most tests items. Tennis coaches should be aware that each training regimen may induce more favorable changes to different aspects of fitness.

Simeonov, P., Hsiao, H., Powers, J., Kim, I.J., Kau, T.Y. and Weaver, D. (2013) suggested the ladder positioning method or procedure could reduce the risk of ladder stability failure and the related fall injury. The objective of the study was to comparatively evaluate the effectiveness of a multimodal angle indicator with other existing methods for extension ladder angular positioning. Twenty experienced and 20 inexperienced ladder users participated in the study. Four ladder positioning methods were tested in a controlled laboratory environment with 4.88 m (16 ft) and 7.32 m (24 ft) ladders in extended and retracted positions. The positioning methods included a no-instruction method, the current standard anthropometric method, and two instrumental methods - a bubble level indicator, and a multimodal indicator providing direct feedback with visual and sound signals. Performance measures included positioning angle and time. The results indicated that the
anthropometric method was effective in improving the extension ladder positioning angle ($p < 0.001$); however, it was associated with considerable variability and required 50% more time than no-instruction. The bubble level indicator was an accurate positioning method (with very low variability), but required more than double the time of the no-instruction method ($p < 0.001$). The multimodal indicator improved the ladder angle setting as compared to the no-instruction and anthropometry methods ($p < 0.001$) and required the least time for ladder positioning among the tested methods ($p < 0.001$). An indicator with direct multimodal feedback is a viable approach for quick and accurate ladder positioning. The main advantage of the new multimodal method is that it provides continuous feedback on the angle of the device and hence does not require repositioning of the ladder. Furthermore, this indicator can be a valuable tool for training ladder users to correctly apply the current ANSI A14 standard anthropometric method in ladder angular positioning. The multimodal indicator concept has been further developed to become a hand-held tool in the form of a smart phone application.

Taşkin, H. (2009) determined the effect of circuit training directed toward motion and action velocity over the sprint-agility
and anaerobic endurance. A total of 32 healthy male physical education students with a mean age of 23.92 +/- 1.51 years were randomly allocated into a circuit training group (CTG; n = 16) and control group (CG; n = 16). A circuit training consisting of 8 stations was applied to the subjects 3 days a week for 10 weeks. Circuit training program was executed with 75% of maximal motion numbers in each station. Circuit training, which is designed to be performed 3 days a week during 10 weeks of training, improves sprint-agility and anaerobic endurance, through to adulthood. Previous school-based physical activity interventions have demonstrated modest improvements to cardiovascular disease risk factors by implementing extra-curricular activities or improving current physical education curriculum.

Thomas, French, and Hayes (2009) was compared the effects of two plyometric training techniques on power and agility in youth soccer players. Twelve males from a semiprofessional football club's academy were randomly assigned to 6 weeks of depth jump (DJ) or countermovement jump (CMJ) training twice weekly. Participants in the DJ group performed drop jumps with instructions to minimize ground-contact time while maximizing height. Participants in the CMJ group performed jumps from a
standing start position with instructions to gain maximum jump height. The study concludes that both DJ and CMJ plyometrics are worthwhile training activities for improving power and agility in youth soccer players.

Walklate, B.M., O'Brien, B.J., Paton, C.D., & Young, W. (2009) investigated whether supplementing regular group training with short sessions of badminton-specific agility-sprint training conferred any greater changes in performance than regular training alone. Twelve national level badminton players completed a set of performance tests in the week before and after a 4-week training period. Performance tests consisted of 10- and 20-meter sprints, a multistage fitness test, a 300-meter shuttle run, and a novel badminton sprint protocol. After pretesting, pair-matched participants were randomly assigned into regular or supplementary training groups. Both groups undertook regular national squad training consisting of 4 2-hour sessions per week. In addition, the supplementary group completed a high-intensity sprint-training regime consisting of 7 to 15 repeats of badminton-specific sprints twice per week. Relative to control, the supplementary training group reported improvements (mean +/- 90% confidence limits) in the 300-meter shuttle run (2.4% +/- 2.7%) and badminton sprint
protocol (3.6% +/- 2.6%). However, there were no substantial difference in either the 10-meter (-0.3% +/- 2.1%) or 20-meter (-0.6% +/- 1.8%) sprint or the multistage fitness test (0.0% +/- 2.7%). Supplementing regular training with sessions of short-duration sprint training appears to lead to worthwhile increases in repeated-agility sprint performance with national level badminton players.

Ya^gie, J.A., and B.M. Campbell. (2006) determined the effect of a 4-week balance training program on specified functional tasks. Thirty-six subjects age - 22.7 ± 2.10 years; height = 168.30 ±9.55 cm; weight = 71.15 ± 16.40 kg) were randomly placed into control IC; n = 19) and experimental groups (Tx; i = 17). The Tx group trained using a commercially available balance training device (BOSU). Postural limits (displacement and sway) and functional task (time on ball, shuttle run, and vertical jump) were assessed during a pretest (T1), a posttest (T2), and 2 weeks posttraining (T3). Multivariate repeated measures analysis (* =0.05) revealed significant differences in time on ball, shuttle run, total sway, and fore/aft displacement after the exercise intervention (T2). T3 assessment revealed that total sway and time on ball remained controlled; however, no other measures were retained. Balance training
improved performance of selected sport-related activities and postural control measures, although it is unclear whether the effect of training would transfer to general functional enhancement.

**Summary of Literature**

The review of literature helped the investigator to spot out relevant topics and variables. Further the literature helped the investigator to frame the suitable hypothesis leading to the problems. The latest literature also helped the investigator to support her findings with regard to the problem. Further the literature collected in the study will also help the research scholar understanding in the similar areas.

The research studies were presented in two sections. The first section carries effect of theraband training. Here the reviews were collected from the year 1990 to till date. The second section carries effect of medicine ball training. All the research studies were presented in the section proves that there is a significant improvement on all selected variables due to training. The strong evidence shown in the literature is that the positive association between the two training programmes and improvements of all selected parameters.
The review of literature helped the researcher from the methodological point of view too. It was learnt that most of the research studies cited in this chapter on content analysis and experimental design as the appropriate methods for finding out the lapses and remediation.