

CHAPTER – II

REVIEW OF RELATED LITERATURE

A literature review is a body of text that aims to review the critical points of current knowledge including substantive findings as well as theoretical and methodological contributions to a particular topic. Its ultimate goal is to bring the reader up to date with current literature on a topic and forms the basis for another goal, such as future research that may be needed in the area. It gives an overview of what has been said, who the key writers are, what are the prevailing theories and hypotheses, what questions are being asked, & what methods and methodologies are appropriate and useful. As such, it is not in itself primary research, but rather it reports on other findings.

The present reviews are based upon the available literature in respect to the study under investigation and therefore confined to the studies in which the investigator has accessed. All the relevant literature thus obtained by the researcher has been presented in this chapter to furnish necessary background material to evaluate the significance of the study. The research scholar has made every possible effort to go through the literature related to the study of high intensity aerobic interval and concurrent low intensity aerobic and resistance interval training in the game of football wherever available. The scholar has gleaned through almost every source like research quarterly, journals of various kinds, periodicals, encyclopaedia,

relevant books and e-resources on football and other games to pick up related material.

While going through the various sources of literature, it has been observed that very limited work has been carried out in this field. Since this high intensity aerobic interval and concurrent low intensity aerobic and resistance interval training is recently emerging trend in the competitive sports arena and due to lack of literature available in the game of football the scholar has framed this section within its limit. However the scholar also gone through the literature of allied studies that are related to other games and sports to collect the necessary information for making a proper shape of the study.

2.1 STUDIES ON CONCURRENT TRAINING

Niara et al. (2015) aimed to evaluate anthropometric parameters, Insulin resistance (IR), and oxidative stress in obese individuals subjected to two types of concurrent training at the same intensity but differing in frequency. Accordingly, 25 individuals were divided into two groups: concurrent training 1 (CT1) (5 days a week) and concurrent training 2 (CT2) (3 days week), both with moderate intensity. Anthropometric parameters, IR, and oxidative stress were analyzed before and after 26 sessions of training. Both groups had reduced body weight and body mass index ($P < 0.05$), but only CT1 showed lower body fat percentage and increased basal metabolic rate ($P < 0.05$). Moreover, CT1 had increased HOMA-IR and decreased

protein damage (carbonyl level), and CT2 had decreased HOMA-IR and increased lipid peroxidation (TBARS level) ($P < 0.05$). It was concluded that both types of concurrent training could be an alternative for lowering body weight and BMI. It was also observed that concurrent training, depending on the frequency, can contribute to reducing body fat, oxidative damage (protein oxidation), and IR but can induce oxidative damage to lipids. More studies should be done to elucidate the mechanisms involved.

Maryam et al. (2013) found that the effects of resistance training (RT) and resistance plus endurance training (ERT) on respiratory system. The purpose of this research was to study single and concurrent effects of endurance and resistance training on pulmonary function. Thirty seven volunteer healthy inactive women were randomly divided into 4 groups: without training as control (C), Endurance Training (ET), RT, and ERT. The training was given for a period of eight weeks, three sessions a for ET was 20-26 min/session running with 60-80% maximum heart rate (HR max); for RT two circuits/session, 40-60s for each exercise with 60-80% one repetition maximum (1RM), and one and three minutes active rest between exercises and circuits respectively; and for ERT was in agreement with either ET or RT protocols, but the times of running and circuits were half of ET and RT. ANCOVA showed that ET and ERT increased significantly ($P < 0.05$) vital capacity (VC), forced vital capacity (FVC), and forced expiratory flows to 25%-75%; ET, RT and ERT increased

significantly ($P < 0.05$) maximum voluntary ventilation (MVV); and only ET increased significantly ($P < 0.05$) on forced expiratory volume in one second (FEV1) and FEV1/ FVC ratio. Conclusion: In conclusion, ET combined with RT (ERT) has greater effect on VC, FVC, FEF rating at 25%-75%, and also on PEF except MVV, rather than RT, and just ET has greater effect rather than ERT.

Sedano et al. (2013) investigated a study on combined aerobic and anaerobic training modalities. Eighteen well-trained male runners (age 23.7 ± 1.2 years) with a maximal oxygen consumption (Vo_{2max}) more than $65 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ were randomly assigned into 1 of the 3 groups: Endurance-only Group ($n = 6$), who continued their usual training, which included general strength training with Thera-band latex-free exercise bands and endurance training; Strength Group (SG; $n = 6$) who performed combined resistance and plyometric exercises and endurance training; Endurance-SG (ESG; $n = 6$) who performed endurance-strength training with loads of 40% and endurance training. The study comprised 12 weeks of training in which runners trained eight times a week (six endurance and two strength sessions) and five weeks of detraining. The subjects were tested on three different occasions. Findings revealed that the significant time with group interaction effects for almost all tests ($p < 0.05$). They concluded that concurrent training for both SG and ESG groups lead for improving maximal strength, RE, and PV with no

significant effects on the VO_2 kinetics pattern. The SG group was also seems to show improvements in 3-km time trial tests.

Andrea et al. (2012) observed that the study was to verify whether the order of execution of endurance and resistance exercises, in concurrent training, has different effects on the metabolic responses during recovery. Thirteen healthy women with age averaged 24.40 years, Mean (SD)] were investigated for energy expenditure (EE), oxygen consumption (VO_2), ventilation (V_e), respiratory frequency (RF), proportion of oxygen in expired air (FeO_2) and ratings of perceived exertion (RPE) both before and after three concurrent endurance and resistance trainings, carried out in different orders: endurance-resistance training (ERT), resistance-endurance training (RET) and alternating endurance resistance training (AERT). AERT elicited a significantly greater increase of EE, VO_2 , and V_e and a greater decrease of FeO_2 . ERT elicited a lower increase of RPE. Acute post-exercise physiological responses to concurrent endurance and resistance physical exercise seem to depend on the order of execution of the two parts: among the selected protocols, AERT seems to elicit the best responses.

Arazi et al. (2012) compared the effects of concurrent (resistance-aerobic) and aerobic training on lipid profile, blood glucose and blood pressure in middle-aged men at risk for cardiovascular disease. Twenty-nine untrained male volunteers 36-56 years old participated in this study. The subjects were randomly placed into one

of three groups (aerobic, concurrent (aerobic & resistant) and control). Body mass index, body fat percentage, glucose, blood pressure, and lipid profile were measured at baseline and after exercise training. Training program lasted for eight weeks and it was carried out 3 times per week. Statistical tests of paired t and ANOVA were used for data analysis. The results of Plasma TC, LDL, TG, glucose and HDL changed significantly with concurrent and aerobic training.

Aydin (2012) investigated that the effect of strength, endurance and concurrent training programs on strength gains (three days per week) of the upper and lower body in male university students for eight weeks. For this study thirty two active boys were randomly selected from university of mohaghegh ardabili to participate in this study. These subjects were randomly assigned to one of four groups: Strength training (S; N=8, 21.5 ±1.7 years), Endurance training (E; N=8, 20.7 ±1.8 years), Concurrent training (ES; N=8, 21.5 ±1.6 years), and Control group (C; N=8, 21.63 ±1.71 years). Pre-test and post-test data were collected for weight, fat percent, 1RM leg press, 1 RM shoulder press, 1 RM squat. Results showed Improvements in 1RM in all movements were significant in all training groups ($P \leq 0.05$) but were significantly greater in the S and ES groups as compared to the E group. There was no significant difference in the strength gains between S and ES groups ($P \leq 0.05$). In the present study strength gains on upper body in the S and ES groups showed little difference whereas discrepancy in strength gain in the lower body was higher in

the two groups. The C group showed decrease significantly in 1RM in all movements. The decrease strength in lower body was less than upper body in C group ($P \leq 0.05$). Conclusions: This finding indicated that no significant differences in strength gains on the upper and lower body between subjects performing concurrent endurance and strength training or strength training only.

Eduardo (2012) conducted a study on neuromuscular adaptations to strength training (ST) and concurrent training (CT) in elderly men. ST can produce increases in muscle strength, power, activation and mass. ST-induced strength gain may be explained by neural and morphological adaptations. The main neural adaptations to ST included increased recruitment of motor units and increased motor unit firing rate. Morphological adaptations included increases in the physiological cross-sectional area (CSA) of the muscle, in muscle thickness, in muscle fiber pennation angle, and changes in muscle myosin heavy-chain isoforms, resulting in the conversion of muscle fiber from sub types. The inclusion of moderate-to-high intensity (60-85% of maximum strength) ST in the routine of this population was recommended to improve neuromuscular function. CT promoted significant neuromuscular adaptations, but these gains may be of a lower magnitude than those obtained with ST. Although CT had an interference effect on neuromuscular adaptations, it also promotes improvement in cardiovascular function and was therefore

the most frequently recommended intervention for health promotion in the elderly.

Hosseini (2012) observed that the study was to compare the effect of endurance, resistance and concurrent training on the heart structure. Thirty-nine untrained female students (mean age 24 ± 2.58 yrs) were randomly divided into four groups: Control (C; $n=9$), Endurance (E; $n=10$), Strength (S; $n=10$) and Concurrent (SE; $n=10$). Endurance group training consisted of running at 65% of maximum heart rate (MHR) for 16 min per training unit during the first week, reaching 80% of MHR for 30 min during the 8th week. Strength group training consisted of performing four exercises namely leg press, bench press; pull down curls, and leg curls. During the first week, the training was performed at 50% of one repetition maximum (1RM) in 2 sets with 10 repetitions. The intensity of training increased to 80% 1RM in 3 sets and 6 repetitions during the 8th week. The SE training included the sum of the training performed by the E and S training groups. Left ventricular end diastolic and systolic diameters, post-wall thickness, left ventricular mass and mass index and septum wall thickness were measured by m-mode and 2-D echocardiography as the structural parameters. The end diastolic diameter in E and SE groups, the ventricular end systolic diameter, left ventricular mass and mass index of the SE group after the training increased ($P \leq 0.05$). In comparing the groups, only the increase of the end diastolic diameter in the SE group was significant ($P \leq 0.05$). The 8 weeks of

concurrent training compared with endurance or resistance training alone resulted in a significant increase in left ventricular end diastolic diameter. However, no significant differences were found for any other measured variables.

Aidin et al. (2011) investigated that the effect of sequences of combined training on maximal strength and aerobic capacity after 8 weeks detraining. The twenty eight physically active male university students were randomly assigned to participate in one of following training group: group C (n=8) served as a control; ES (n=10) and SE (n=10) combined the two programs in different order during the same training session. The training groups performed concurrent training program with different sequence for 8 weeks (3 days per week). The following measurements were recorded on all subjects before and after 8 weeks of training and after 8 weeks detraining: weight; height; percent body fat; VO₂max (ml/kg/min); and one repetition maximum (1RM) leg press (LP); 1RM bench press (BP). Results showed significantly reduce in VO₂max and 1RM in movement bench press and leg press in the ES and SE groups after 8 weeks detraining ($P \leq 0/05$). No significant difference was observed in decrease maximal strength and VO₂ max between groups ES and SE after 8 weeks detraining.

Alireza et al. (2011) examined the effect of six weeks concurrent and circuit training on aerobic power in adolescent male soccer players. Twenty-four soccer players were randomly selected and

divided in to two training groups. Concurrent training (n=12) group performed two training programs: resistance training that involved 3sets of exercises in the first four weeks and 2sets of exercises in the last two weeks (%65 to %75 one RM;8 rep) and endurance training that included 3 repetitions run in the first four weeks and 2 repetitions run in the last two weeks(10 min ;%65 to %75 maximal HR).They performed training programs with an interrupt between two session; and in the last two weeks they did the both training in one session.2- Circuit training group (n=12) carried out the training in ten stations exercises(%70 to%80 maximal HR).All the subjects were evaluated before and after the training period using 1 mile test(aerobic power). For analysing the data they used t-test. Result of this study showed that aerobic power of the players within both groups after six weeks had significant improvement. Therefore; it was expected that both the circuit and concurrent training have greater influence on aerobic power of adolescent male soccer players.

Mahdi et al. (2011) conducted a study to compare the effect of two different methods of concurrent training (continuous & distinct) on body composition; aerobic power and muscle endurance in non-athlete male students. For this reason; 42 non-athlete students (age; 22.02 \pm 1.91 years; height; 175.83 \pm 5.88 cm; weight; 69.01 \pm 8.27 kg; BF; 13.71 \pm 3.33%) volunteered to participate. Subjects were randomly assigned to 3 groups: Distinct Resistance-Endurance (DRE) (n=14); Continuous Resistance-Endurance (CRE) (n=14); and Control

(C) (n=14). Subjects performed 2 sessions per week for 12 weeks. Strength training includes Bench press; Lateral pull down and cable triceps for upper body; squat; leg press and calf raise for lower body muscles that performed with 2-3 min rest interval between sets and exercises. These exercises were started with 2 sets; 10 repetitions and 60% 1RM in begin of program and reached to 3 sets; 4 repetitions and 90% 1RM in last week. Aerobic training involved 20 min interval running by 70% maximal heart rate in start and raised to 45 min running by 95% HR max in last week. DRE group performed aerobic training in one session and resistance training in other session in each week. In contrast; CRE group performed both aerobic and resistance training in each session together. Control group performed no regular exercise during this period. The findings showed BF% reduced significantly in both experimental groups compare to C group ($p<0.05$). Pull-ups and sit-ups records of DRE and CRE groups in post-test was higher than pre-test; but this improvement was significantly smaller in DRE group in sit-up test ($p<0.05$). $VO_2\text{max}$ increased significantly after training in both experimental and control groups but in DRE group it improved significantly higher than CRE group. They also concluded that concurrent training is more useful for the improvement of body composition and muscular strength.

Sajjad (2011) probed the effect of aquatic training, mental training and concurrent training (aquatic and mental training) on balance. For which 120 men were randomly selected as subjects and

divided in to four groups. They were aquatic, mental, concurrent and control groups and each group consisted of 30 subjects. For estimation of subjects' balance; Y-Test was used in three directions. Aquatic training group was given aquatic training to improve their balance for six weeks, three sessions a week, an hour a session. Mental training group was given six weeks of training, three sessions a week and 15 minutes a session. For concurrent group both aquatic and mental training did both the trainings for six weeks, three session a week, 90 minutes a session. Isaac & Mark imagination (1986) method which measured subjects' inside and outside mental imagination; was used in order to evaluate the ability of mental imagination. Descriptive statistic was used to describe the subjects' personal characteristics; and for determining the significant difference between the effects of three different exercise methods; ANOVA statistical test and Toki post hoc test ($p \leq 0/05$) were applied. Significant difference was observed in reaching distance of experimental groups after applying exercise programs. The result showed that there were significant differences among the training groups and concurrent training group had improved more balance than others. The result also suggested that designing fitness programs for seniors, special attention should be given to aquatic and mental training.

Sayed Javad et al. (2011) studied eight weeks concurrent training on blood lipid profile and body mass in young male wrestlers.

Twenty four young men wrestlers with the average age of 20.625 ± 1.135 years; height 172.710 ± 5.180 cm weight 65.442 ± 5.860 kg and BMI 22.928 ± 0.281 were selected voluntarily and divided randomly into 3 groups; endurance; strength and concurrent training (n=8). strength training (6 movements) and endurance training with the use of treadmill and concurrent training (the combination of both strength and endurance groups) were performed 3 times a week over a period of 8 weeks. Five cc blood was collected during 3 sets of measurement ; before training; at the end of 4th and 8th week at 8:00 o'clock and a significant level was considered ($p \leq 0.05$). Research findings showed %33.544 reduction of HDL-C in strength group during 3 level of measurements ($P=0.035$); while other variables blood and body mass did not show any significant changes in groups ($P > 0.05$). therefore; concurrent training can prevent the risk of strength training resulting from reduction in blood serum HDL-C in young male wrestlers; which can Causes cardiovascular diseases.

Mahmoud et al. (2011) investigated the effects of concurrent plyometric and endurance training on the physiological areas and soccer skills in male soccer players. Twenty nine male soccer players were randomly selected and divided in to three groups. They were endurance (n=10); plyometric (n=10) and concurrent (n=9) groups participated in this study. The endurance training consisted of 4×4 min interval running at 90-95% of maximal heart rate; with a 3 minutes jogging in between. The plyometric training consisted of 9

explosive jumping and throwing exercises in 3 sets with 10 repetitions which subjects have done with low to maximal intensity. The concurrent training consisted of both plyometric and endurance training at one session that plyometric training performed first. All the groups performed training program for 8 weeks and 3 times a week. The subjects performed Hoff- Helgerud football endurance; RAST; Vertical jump; Illinois; 30m sprint; body fat percentage and MorCherestian (for soccer skills) tests before and after training period. The analysis of data before and after training programs using t-test; ANOVA and LSD tests showed that in all the groups VO_{2max} increased significantly; but concurrent training was more than other training groups. In concurrent and plyometric training; anaerobic power; agility and 30m sprint increased significantly. No changes were found in this variable in endurance training. The research also showed no changes were found in dribbling and shooting skills in all of the groups after the training programs ($p < 0/05$). In this study utilizing concurrent training not only had no negative influence on soccer skills and physiological areas; but this can also with enhanced VO_{2max} improved soccer performance by increasing the distance covered; enhancing work intensity; and increasing the number of sprints and involvements with the ball during a match. It has been suggested that endurance training influenced the running economy (CR) and the oxygen uptake (VO_2) kinetics in heavy exercise by accelerating the primary phase and attenuating the VO_2 slow component. However, the effects of heavy weight training (HWT) in

combination with endurance training remain unclear. The purpose of this study was to examine the influence of a concurrent HWT+ endurance training on CR and the VO_2 kinetics in endurance athletes. Fifteen triathletes were assigned to endurance + strength (ES) or endurance-only (E) training for 14 wk. The training program was similar, except ES performed two HWT sessions a week. Before and after the training period, the subjects performed 1) an incremental field running test for determination of $\text{VO}_{2,\text{max}}$ and the velocity associated (VO_2) the second ventilatory threshold (VT2); 2) a 3000-m run at constant velocity, calculated to require 25% of the difference between VO_2 max and VT2 to determine CR and the characteristics of the VO_2 kinetics; 3) maximal hopping tests to determine maximal mechanical power and lower-limb stiffness; 4) maximal concentric lower-limb strength measurements. After the training period, maximal strength was increased ($P < 0.01$) in ES but remained unchanged in E. Hopping power was decreased in E ($P < 0.05$). After training, economy ($P < 0.05$) and hopping power ($P < 0.001$) was greater in ES than in E. VO_2 max, leg hopping stiffness and the VO_2 kinetics were not significantly affected by training either in ES or E. Additional HWT led to improved maximal strength and running economy with no significant effects on the VO_2 kinetics pattern in heavy exercise.

Ferrauti A et al. (2010) investigated the effect of concurrent strength and endurance training on running performance and running economy. Twenty two (8 women and 14 men) recreational

runners (mean \pm SD: age 40 ± 11.7 years; body mass index 22.6 ± 2.1 kg meter squares) were separated in two groups (n=11; combined endurance running and strength training programme (ES; 9 men 2 women and endurance running (E); 7 men and 4 women) both completed an 8 weeks intervention period that consisted of either endurance training (E: 276 ± 108 minute running per week) or a combined endurance and strength training programme (E S: 240 ± 121 – minute running plus two strength training sessions per week (120 minutes)). Strength training was focused on trunk (strength endurance programme) and leg muscles (high intensity programme). Before and after intervention, subjects completed an incremental treadmill run and maximal isometric strength tests. The initial values for VO_2 peak (ES: 52 ± 6.1 Vs E: 51.1 ± 7.5 ml. kg min) and anaerobic threshold (ES: $3.5 \pm .4$ Vs E: $3.5 \pm m.s^1$) were identical in both groups. A significant time X intervention effect was found for maximal isometric force off knee extension (ES: from 4.6 ± 1.4 – 6.2 ± 1 N.kg¹, $p < 0.01$), whereas no changes in body mass occurred. There was no significant difference between groups and no significant interactions (time X intervention) were found for VO_2 (obsolete and relative to vo_2 peak). Stride length and stride frequency also remained and changed the results suggested that no benefit of 8 weeks concurrent strength training for running economy and coordination of recreational marathon runner despite a clear improvement in leg strength, maybe because of an insufficient sample size or a short intervention period.

Riki et al. (2010) inquired the Concurrent improvements in aerobic capacity and muscle hypertrophies in response to a single mode of training have not been reported. The author examined the effects of low-intensity cycle exercise training with and without blood flow restriction (BFR) on muscle size and maximum oxygen uptake (VO_2max). A group of 19 young men (mean age \pm SD: 23.0 ± 1.7 years) were allocated randomly into either a BFR-training group ($n=9$, BFR-training) or a non-BFR control training group ($n=10$, CON-training), both of which trained three days/week for eight weeks. Training intensity and duration were 40% of VO_2 max and 15 min for the BFR-training group and 40% of VO_2 max and 45 min for the CON-training group. MRI-measured thigh and quadriceps muscle cross sectional area and muscle volume increased by 3.4–5.1% ($P < 0.01$) and isometric knee extension strength tended to increase by 7.7% ($p < 0.10$) in the BFR-training group. There was no change in muscle size ($\sim 0.6\%$) and strength ($\sim 1.4\%$) in the CON-training group. Significant improvements in VO_2 max (6.4%) and exercise time until exhaustion (15.4%) were observed in the BFR-training group ($p < 0.05$) but not in the CON training group (-0.1 and 3.9% , respectively). The results suggested that low-intensity; short-duration cycling exercise combined with BFR improved both muscle hypertrophy and aerobic capacity concurrently in young men.

Marcelo (2010) investigated a Concurrent training has been frequently used, although little is known about the effects of the

exercise sequence on physical fitness in elderly women. The objective of this study was to determine the effects of the sequence of aerobic and resistance exercise on physical fitness in women over 50 years old. The sample consisted of 26 women randomly divided into two groups: A1 (aerobic and resistance training) and M1 (resistance and aerobic training). Body weight, height, body mass index (BMI), sum of skinfolds, flexibility, and leg, back and hand grip strength were measured. Descriptive statistics and one-way ANOVA were used for data analysis, adopting a level of significance of 5%. The results showed significant changes in back strength ($p=0.01$) and leg strength ($p=0.0002$) after 12 weeks in group A1, and in leg strength ($p=0.02$) in group M1. Except for BMI ($p=0.05$), no differences in anthropometric measures, strength or flexibility were observed between groups after testing. In conclusion, improvement of strength and the lack of change in the other indices were observed in the women studied, irrespective of the sequence of concurrent training. This finding was important for older adults since it directly affects improvement in the quality of life and health of this population.

Stian Aspenes et al. (2009) conducted a study on combined strength and endurance training in competitive swimmers. The aim of this study was to investigate the impact of a combined intervention among competitive swimmers. 20 subjects assigned to a training intervention group ($n = 11$) or a control group ($n = 9$) from two different teams completed the study. Anthropometrical data, tethered

swimming force, land strength, performance in 50m, 100m and 400m, work economy, peak oxygen uptake, stroke length and stroke rate were investigated in all subjects at pre and post-test. A combined intervention of maximal strength and high aerobic intensity interval endurance training 2 sessions per week over 11 weeks in addition to regular training were used, while the control group continued regular practice with their respective teams. The intervention group improved land strength, tethered swimming force and 400m freestyle performance more than the control group. The improvement of the 400m was correlated with the improvement of tethered swimming force in the female part of the intervention group. No change occurred in stroke length, stroke rate, performance in 50m or 100m, swimming economy or peak oxygen uptake during swimming. Two weekly dry-land strength training sessions for 11 weeks increased tethered swimming force in competitive swimmers. This increment further improved middle distance swimming performance. 2 weekly sessions of high-intensity interval training did not improve peak oxygen uptake compared with other competitive swimmers.

Brandon (2008) observed that the impact of exercise training on health depends on the ability of exercise to promote a negative energy balance. Exercise's effect on promoting a negative energy balance is more likely to occur if exercise can induce a favorable dietary intake such as a reduced relative fat content in the diet. As such, the aim of this study was to evaluate and compare the effectiveness of aerobic

training, weight training and concurrent, aerobic and weight training on self-reported dietary intake. The effects of 16 weeks of aerobic (n = 12), weight (n = 13) and concurrent aerobic and weight training (n = 13) on self-reported dietary intakes were compared. Only the concurrent aerobic and weight training group showed significant ($p \leq 0.05$) reductions in total kilocalories, carbohydrates, proteins and fats consumed while the aerobic training group showed significant reductions in fat intake at the completion of the experimental period. However, no changes were observed in self-reported dietary intake in the weight training or non-exercising control groups. It was concluded that concurrent aerobic and weight training was the most effective mode of exercise at promoting a favorable improvement in self-reported dietary intake in the short term. These findings provided support for efforts to promote improvement in overall physical activity in an attempt to modify the patterns of dietary intake.

Ratamess et al. (2007) examined the combined effects of resistance and sprint/plyometric training with or without the Meridian Elite athletic shoe on muscular performance in women. Fourteen resistance-trained women were randomly assigned to one of 2 training groups: (a) an athletic shoe (N = 6) (AS) group or (b) the Meridian Elite (N = 8) (MS) group. Training was performed for 10 weeks and consisted of resistance training for 2 days per week and 2 days per week of sprint/plyometric training. Linear periodized resistance training consisted of 5 exercises per workout (4 lower body, 1 upper

body) for 3 sets of 3-12 repetition maximum (RM). Sprint/ plyometric training consisted of 5-7 exercises per workout (4-5 plyometric exercises, 40-yd and 60-yd sprints) for 3-6 sets with gradually increasing volume (8 weeks) followed by a 2-week taper phase. Assessments for 1RM squat and bench press, vertical jump, broad jump, sprint speed, and body composition were performed before and following the 10-week training period. Significant increases were observed in both AS and MS groups in 1RM squat (12.0 vs. 14.6 kg), bench press (6.8 vs. 7.4 kg), vertical jump height (3.3 vs. 2.3 cm), and broad jump (17.8 vs. 15.2 cm). Similar decreases in peak 20-m, 40-m, and 60-m sprint times were observed in both groups (20 m: 0.14 vs. 0.11 seconds; 40 m: 0.29 vs. 0.34 seconds; 60 m: 0.45 vs. 0.46 seconds in AS and MS groups, respectively). However, when sprint endurance (the difference between the fastest and slowest sprint trials) was analyzed, there was a significantly greater improvement at 60 m in the MS group. These results indicated that similar improvements in peak sprint speed and jumping ability were observed following 10 weeks of training with either shoe. However, high-intensity sprint endurance at 60 m increased to a greater extent during training with the Meridian Elite athletic shoe.

Nader (2006) studied that the strength and endurance training produce widely diversified adaptations, with little overlap between them. Strength training typically results in increases in muscle mass and muscle strength. In contrast, endurance training induces

increases in maximal oxygen uptake and metabolic adaptations that lead to an increased exercise capacity. In many sports, a combination of strength and endurance training is required to improve performance, but in some situations when strength and endurance training are performed simultaneously, a potential interference in strength development takes place, making such a combination seemingly incompatible. The phenomenon of concurrent training, or simultaneously training for strength and endurance, was first described in the scientific literature in 1980 by Robert C. Hickson, and although work that followed provided evidence for and against it, the interference effect seems to hold true in specific situations. At the molecular level, there seems to be an explanation for the interference of strength development during concurrent training; it is now clear that different forms of exercise induce antagonistic intracellular signaling mechanisms that, in turn, could have a negative impact on the muscle's adaptive response to this particular form of training. That is, activation of AMPK by endurance exercise may inhibit signaling to the protein-synthesis machinery by inhibiting the activity of mTOR and its downstream targets. The purpose of this review was to briefly describe the problem of concurrent strength and endurance training and to examine new data highlighting potential molecular mechanisms that may help explain the inhibition of strength development when strength and endurance training were performed simultaneously.

Tricoli et al. (2005) discussed the efficiency of training methods that improve lower-body power. Heavy resistance training combined with vertical jump (VJ) training was a well-established training method; however, there was a lack of information about its combination with Olympic weightlifting (WL) exercises. Therefore, the purpose of this study was to compare the short-term effects of heavy resistance training combined with either the VJ or WL programme. Thirty-two young men were assigned to 3 groups: WL = 12, VJ = 12, and control = 8. These 32 men participated in an 8-week training study. The WL training programme consisted of 3 x 6RM high pull, 4 x 4RM power clean, and 4 x 4RM clean and jerk. The VJ training program consisted of 6 x 4 double-leg hurdle hops, 4 x 4 alternated single-leg hurdle hops, 4 x 4 single-leg hurdle hops, and 4 x 4 40-cm drop jumps. Additionally, both groups performed 4 x 6 RM half-squat exercises. Training volume was increased after 4 weeks. Pretesting and post testing consisted of squat jump (SJ) and countermovement jump (CMJ) tests, 10 and 30 mtr. Sprint speeds, an agility test, a half-squat 1RM, and a clean-and-jerk 1RM (only for WL). The WL programme significantly increased the 10 mtr. Sprint speed ($p < 0.05$). Both groups, WL and VJ, increased CMJ ($p < 0.05$), but groups using the WL program increased more than those using the VJ programme. On the other hand, the group using the VJ programme increased its 1RM half-squat strength more than the WL group (47.8 and 43.7%, respectively). Only the WL group improved in the SJ (9.5%). There were no significant changes in the control group. In conclusion,

Olympic WL exercises seem to produce broader performance improvements than VJ exercises in physically active subjects.

Fletcher et al. (2004) determined the effect of combined weight and plyometric programs on golf drive performance. Eleven male golfer's full golf swing was analyzed for club head speed (CS) and driving distance (DD) before and after an 8-weeks training program. The control group (n=5) continued their normal training, while the experimental group (n=6) performed 2 sessions per week of weight training and plyometrics. Controls showed no significant ($p \geq 0.05$) changes, while the experimental subjects showed a significant increase ($p \leq 0.05$) in CS and DD. The changes in golf drive performance were attributed to an increase in muscular force and an improvement in the sequential acceleration of body parts contributing to a greater final velocity being applied to the ball. It was concluded that specific combined weights and plyometrics training can help to increase CS and DD in club golfers.

Rubenstein (2004) compared the effects of a four-week general resistance training program (G) to a four-week, combined plyometrics and general resistance training program (GP) on shot speed on - goal (SS) in Division I Women's Soccer players. Eight members of the Manhattan College Women's Soccer team (19-22 yrs) were randomly assigned to either G (n=4) or GP (n=4). Prior to and subsequent to training, each subject was tested for SS using radar (Sports Radar 3500). Briefly, subjects were asked to kick the ball (size 5, inflated to

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

Zacharogiannis et al. (2003) conducted that the effects of resistance training and short-duration interval training on rowing ergometer performance of college women rowers ($N = 24$) during the transition phase of training. That phase typically consists of low intensity and volume endurance exercise combined with strength training. Ss were subjected to heavy resistance training or high intensity ergometer interval training two days per week. Across time, both groups improved 500-m time, 1 RM bench press, and body mass. There was no change in 2000-m time, blood lactate, VO_2 max, Profile of Mood States, 1 RM squat, or injury frequency. The added training changed few variables, the primary performance factor being sprint or anaerobic work. Aerobic performance factors were not changed. So the added work did not interfere with the maintenance of that capacity. Sprint work or heavy resistance training improves short-duration

performances but does not affect longer-duration performances in the transition phase of training.

Hoff J et al. (2002) investigated that the professional soccer, a significant amount of exercise time is used to develop players' aerobic ability. Nevertheless, it was not known whether soccer specific training achieved the standard of effective endurance training to increase maximal oxygen uptake, specifically an exercise intensity of 90-95% of maximal heart rate in periods of three to eight minutes. For determining whether ball dribbling and small group play were suitable activities for interval training, and whether heart rate in soccer specific training was a valid measure of actual work intensity. Six well trained first division soccer players took part in the study. To test whether soccer specific training was effective interval training, players ran in a specially designed dribbling track, as well as participating in small group play (five a side). Laboratory tests were carried out to establish the relation between heart rate and oxygen uptake while running on a treadmill. Corresponding measurements were made on the soccer field using a portable system for measuring oxygen uptake. Exercise intensity during small group play was 91.3% of maximal heart rate or 84.5% of maximal oxygen uptake. Corresponding values using a dribbling track were 93.5% and 91.7%. No higher heart rate was observed during soccer training. Soccer specific exercise using ball dribbling or small group play may be performed as aerobic

interval training. Heart rate monitoring during soccer specific exercise was a valid indicator of actual exercise intensity.

Tumilty D (1993) studied the Physiological characteristics of elite soccer players. Soccer is one of the most popular sports in the world. There is still much uncertainty and debate surrounding its physiological requirements because emphasis is on skills to the neglect of fitness, conservative training methods and the difficulty of studying the sport scientifically. The frequently found values for total distance covered in a game of about 10 km and an above-average, though not outstanding, maximum oxygen uptake of 60 ml/kg/min suggested a moderate overall aerobic demand. A comparison of top teams and players with less abled participants indicated that the components of anaerobic fitness-speed, power, strength and the capacity of the lactic acid system differed better between the 2 groups. Generally, there was a reduction in the level of activity in the second half of games compared with the first. There was some evidence that increased aerobic fitness may help counteract this. Progressively lower muscle glycogen stores were one likely cause of reduction in activity, and nutrition also appeared as a key factor in minimizing performance deterioration, both in terms of overall diet and, more particularly, the ingestion of carbohydrates immediately before, during and after a game. There were evolutionary trends in the sport such as greater frequency of games, changes in the roles of players, and new strategies and tactics which were placing increasing demands on the

all-round fitness of players. Many studies indicated scope for improvement in player fitness. The challenges for coaches and players were to meet these fitness requirements without sacrificing the skill work which made the sport unique.

Rajasekaran (1999) examined the effects of maximum strength and speed training in series and parallel on elastic strength components such as speed, explosive power, leg strength, back strength, stride frequency and anaerobic capacity. For this purpose, forty five male students studying bachelor's degree in Physical Education and Sports, Department of Physical Education, Annamalai University, Annamalai Nagar, Tamil Nadu, India, were selected as subjects at random and they were divided into three groups of fifteen each, namely Group-I (series training), Group-II (parallel training) and Group-III (control group). The subjects of the experimental groups underwent their respective training programs four days per week for twelve weeks duration. All the subjects were tested prior to and immediately after the experimental period on the selected dependent variables. The results of the study indicated that all experimental groups were improved significantly the selected criterion variables. Leg strength and back strength showed no significant difference between series and parallel groups. However the increase of leg strength was in favor of parallel group.

Sebastian (1998) conducted a study on relative analysis of progressive training and alternate, high and low intensity training on

speed, flexibility and explosive power of boys. Sixty boys were selected at random from the subjects who had successfully completed minimum strength requirement test. The selected subjects put at random into one of the three groups, (n = 20). Group 1 underwent conventional progressive training, group 2 underwent alternate high and low intensity training and group 3 acted as control. The experimental groups were trained in their respective training programs five times a week for fourteen weeks. Prior to and after the training program, the subjects were tested for speed, flexibility and explosive power. The data were examined by analysis of covariance. Performance in speed, flexibility and explosive power improved significantly for both progressive and alternate high and low intensity training when compared to the control group, and no significant existed between the training groups.

2.2 STUDIES ON HIGH INTENSITY TRAINING

Hoffmann Jr. et al. (2014) conducted a study on Repeated Sprints, High-Intensity Interval Training, Small-Sided Games: Theory and Application to Field Sports. To analyze performance and fatigue effects of small-sided games (SSG) vs high-intensity interval training (HIIT) performed during a 4-wk in-season period in high-level youth football. Nineteen players from 4 youth teams (16.5 [SD 0.8] y, 1.79 [0.06] m, 70.7 [5.6] kg) of the 2 highest German divisions completed the study. Teams were randomly assigned to 1 of 2 training sequences (2 endurance sessions per wk): One training group started with SSG,

whereas the other group conducted HIIT during the first half of the competitive season. After the winter break, training programs were changed between groups. Before and after the training periods the following tests were completed: the Recovery-Stress Questionnaire for Athletes, creatine kinase and urea concentrations, vertical-jump height (countermovement jump [CMJ], drop jump), straight sprint, agility, and an incremental field test to determine individual anaerobic threshold (IAT). Significant time effects were observed for IAT (+1.3%, $\eta^2 = .31$), peak heart rate (-1.8%, $\eta^2 = .45$), and CMJ (-2.3%, $\eta^2 = .27$), with no significant interaction between groups ($P > .30$). Players with low baseline IAT values (+4.3%) showed greater improvements than those with high initial values ($\pm 0.0\%$). A significant decrease was found for total recovery (-5.0%, $\eta^2 = .29$), and an increase was found for urea concentration (+9.2%, $\eta^2 = .44$). Four weeks of in-season endurance training can lead to relevant improvements in endurance capacity. The decreases in CMJ height and total-recovery score together with the increase in urea concentration might be interpreted as early signs of fatigue. Thus, the danger of overtaxing players should be considered

Antonio P et al. (2012) conducted a study on the benefits of exercise are well established but one major barrier for many is time. It has been proposed that short period resistance training (RT) could play a role in weight control by increasing resting energy expenditure (REE) but the effects of different kinds of RT has not been widely

reported. Tested the acute effects of high-intensity interval resistance training (HIRT) vs. traditional resistance training (TT) on REE and respiratory ratio (RR) at 22 hours post-exercise. In two separate sessions, seventeen trained males carried out HIRT and TT protocols. The HIRT technique consists of: 6 repetitions, 20 seconds rest, 2/3 repetitions, 20 sec rest, 2/3 repetitions with 20 to 30 sec rest between sets, three exercises for a total of 7 sets. TT consisted of eight exercises of 4 sets of 8–12 repetitions with one/two minutes rest with a total amount of 32 sets. They measured basal REE and RR (TT0 and HIRT0) and 22 hours after the training session (TT22 and HIRT22). HIRT showed a greater significant increase ($p < 0.001$) in REE at 22 hours compared to TT (HIRT22 2362 ± 118 Kcal/d vs TT22 1999 ± 88 Kcal/d). RR at HIRT22 was significantly lower (0.798 ± 0.010) compared to both HIRT0 (0.827 ± 0.006) and TT22 (0.822 ± 0.008). Their data suggested that shorter HIRT sessions may increase REE after exercise to a greater extent than TT and reduced RR hence improving fat oxidation. The shorter exercise time commitment helped to reduce one major barrier to exercise.

Mahdi Bayati et al. (2011) studied that the technological advances in interval training for cyclists have led to the development of both heart rate (HR) monitors and power meters (PM). Despite the growing popularity of PM use, the superiority of PM-based training has not been established. The aim of this present study was to investigate the relative effectiveness of HR-based versus PM-based

interval training on 20 km time trial (20km TT), lactate threshold (LT) power, and peak aerobic capacity (VO₂max) in recreational cyclists. Participants (n =20; M age=33.9, SD =13) completed a baseline 20km TT to establish their VO₂max and LT and were then randomly assigned to either HR-determined or PM-determined training sessions. Over a period of up to 5 weeks participants completed 7.2 (± 1.1) interval training sessions at their specific LT for their respective interval training method. Repeated measures analysis of variances (ANOVAs) showed that both HR-based and PM-based training groups significantly improved their LT power ($F(1,16) = 28.$, $p < 0.01$, $\eta^2 = 0.63$) and 20km TT time ($F(1,16) = 4.92$, $p = 0.04$, $\eta^2 = 0.24$) at post-test, showing a 17 watt increase (9.8%) and a near 3-and-a-half minute improvement (7.8%) in 20km TT completion time. There were no significant group (HR vs. PM) x time (baseline vs. post-test) interactions for 20km TT completion time, LT power, or VO₂max ratings. Their results coincide with the literature supporting the effectiveness of interval training for endurance athletes. Furthermore, their findings indicated that there is no empirical evidence for the superiority of any single type of device in the implementation of interval training. Their study indicated that there were no noticeable advantages in using PM to increase performance in the average recreational cyclist, suggesting that low cost HR monitor was equally capable as training devices.

Sperlich et al. (2011) conducted a study on effects of 5 weeks of high-intensity interval training vs. volume training in 14-year-old soccer players. High-intensity interval training (HIIT) in junior and adult soccer has been shown to improve oxygen uptake (VO_2) and enhance soccer performance. The main purpose of this study was to examine the short term effects of a 5-week HIIT vs. high-volume training (HVT) program in 14-year-old soccer players regarding the effects on VO_2 max and 1,000-m time (T_{1000}) and on sprinting and jumping performances. In a 5-week period, 19 male soccer players with a mean (SD) age of 13.5 ± 0.4 years performed HIIT at close to ~90% of maximal heart rate. The HVT intensity was set at 60-75% of maximal heart rate. VO_2 max increased significantly (7.0%) from pre to post in HIIT but not after HVT. T_{1000} decreased significantly after HIIT (~-10 vs. ~-5 seconds in HVT). Sprint performance was increased significantly in both groups from pre to post testing without any changes in jumping performance.

Gallagher (2010) investigated that the effects of concurrent endurance and resistance training on 2,000-m rowing ergometer times in collegiate male rowers. This study evaluated if high rep, low rep, or no weight training at all would be best suited for decreasing 2,000-m rowing ergometer times in male varsity rowers. Subjects ($n = 18$) were rowers from Grand Valley State University who were randomly and equally assigned to 1 of 3 groups: control (CON), high-load low repetitions (HLLR), and low-load high repetitions (LLHR). The weight

training groups resistance trained and rowed twice a week, whereas the control group only rowed twice a week. Each group performed the training study workouts (weight training and rowing) along with their daily prescribed varsity practices. The subjects performed both pre and post 2,000-m ergometer tests on concept 2 indoor rowers to evaluate the effects of each training protocol. Paired t-tests revealed statistically significant decreases in 2,000-m times from pre to post testing for all groups ($p < 0.05$), whereas a 1-way analysis of variance with repeated measures did not reveal a statistically significant difference ($p = 0.96$) between the 3 groups (DCON: 22.8%, DLLHR: 23.1%, and DHLLR: 23.5%). However, a trend existed in the hypothesized direction, as the HLLR illustrated the greatest decrease in mean rowing time (CON: 11 seconds, LLHR: 12 seconds, and HLLR: 15 seconds). Overall, the current study demonstrates that although weight training does not create a statistically significant short-term training effect on rowing performance, the profound decreases in 2,000-m times seen in this study may be of practical significance for the oarsman.

Saskia Persoon et al. (2010) conducted a study on high-dose chemotherapy combined with autologous stem cell transplantation has improved the outcome of hematologic malignancies. Nevertheless, this treatment can cause persistent fatigue and a reduced global quality of life, role and physical function. Physical exercise interventions may be beneficial for physical fitness, fatigue and quality

of life. However, the trials conducted so far to test the effects of physical exercise interventions in this group of patients were of poor to moderate methodological quality and economic evaluations are lacking. Hence there was need for a rigorous, appropriately controlled assessment of the effectiveness of exercise programs in these patients. The aim of the present study was (1) to determine the effectiveness of individualized high intensity strength and interval training program with respect to physiological and psychological health status in patients with multiple myeloma or Hodgkin's lymphoma who have recently undergone high dose chemotherapy followed by autologous stem cell transplantation; and (2) evaluated the cost-effectiveness of this program. Methods: A multicentre, prospective, single blind randomized controlled trial was performed. They aimed to recruit 120 patients within an inclusion period of 2 years at 7 hospitals in the Netherlands. The patients were randomly assigned to one of two groups: (1) intervention plus usual care; or (2) usual care. The intervention consists of an 18-week individualized supervised high-intensity exercise program and counselling. The primary outcomes (cardiorespiratory fitness, muscle strength and fatigue) and secondary outcomes were assessed at baseline, at completion of the intervention and at 12 months follow-up.

Marcello et al. (2009) reviewed that the major physiological and performance effects of aerobic high intensity and speed-endurance running in football, and provides insight on implementation of

individual game-related physical training. Analysis and physiological measurements have revealed that modern football is highly energetically demanding, and the ability to perform repeated high-intensity work is of importance for the players. Furthermore, the most successful teams perform more high-intensity activities during a game when in possession of the ball. Hence, footballers need a high fitness level to cope with the physical demands of the game. Studies on football players have shown that 8 to 12 weeks of aerobic high-intensity running training (>85% HRmax) leads to VO₂max enhancement (5% to 11%), increased running economy (3% to 7%), and lower blood lactate accumulation during submaximal exercise, as well as improvements in the yo-yo intermittent recovery (YYIR) test performance (13%). Similar adaptations were observed when performing aerobic high-intensity training with small sided games. Speed-endurance training has a positive effect on football-specific endurance, as shown by the marked improvements in the YYIR test (22% to 28%) and the ability to perform repeated sprints (~2%). In conclusion, both aerobic and speed endurance training were used during the season to improve high-intensity intermittent exercise performances. The type and amount of training were game related and specific to the technical, tactical, and physical demands imposed on each player.

Bradley P et al. (2009) investigated a study was to determine the activity profiles of a large sample of English FA Premier League

soccer players and examine high-intensity running during elite-standard soccer matches for players in various playing positions. Twenty-eight English FA Premier League games were examined during the 2005–2006 competitive period ($n = 370$), using a multi-camera electronic tracking system. During a typical match, wide midfielders (3138 m, $s = 565$) covered a greater distance in high-intensity running than central midfielders (2825 m, $s = 473$, $P = 0.04$), full-backs (2605 m, $s = 387$, $P < 0.01$), attackers (2341 m, $s = 575$, $P < 0.01$), and central defenders (1834 m, $s = 256$, $P < 0.01$). In the last 15 min of a game, high-intensity running distance was ~20% less than in the first 15-min period for wide midfielders (467 m, $s = 104$ vs. 589 m, $s = 134$, $P < 0.01$), central midfielders (429 m, $s = 106$ vs. 534 m, $s = 99$, $P < 0.01$), full-backs (389 m, $s = 95$ vs. 481 m, $s = 114$, $P < 0.01$), attackers (348 m, $s = 105$ vs. 438 m, $s = 129$, $P < 0.01$), and central defenders (276 m, $s = 93$ vs. 344 m, $s = 80$, $P < 0.01$). There was a similar distance deficit for high-intensity running with (148 m, $s = 78$ vs. 193 m, $s = 96$, $P < 0.01$) and without ball possession (229 m, $s = 85$ vs. 278 m, $s = 97$, $P < 0.01$) between the last 15-min and first 15-min period of the game. Mean recovery time between very high-intensity running bouts was 72 s ($s = 28$), with a 28% longer recovery time during the last 15 min than the first 15 min of the game (83 s, $s = 26$ vs. 65 s, $s = 20$, $P < 0.01$). The decline in high-intensity running immediately after the most intense 5-min period was more evident in attackers (216 m, $s = 50$ vs. 113 m, $s = 47$, $P < 0.01$) and central defenders (182 m, $s = 26$ vs.

96 m, $s = 39$, $P < 0.01$). The results suggested that high-intensity running with and without ball possession is reduced during various phases of elite-standard soccer matches and the activity profiles and fatigue patterns vary among playing positions. The current findings provided valuable information about the high-intensity running patterns of a large sample of elite-standard soccer players, which could be useful in the development and prescription of specific training regimes.

Abbie (2009) probed that the intermittent bouts of high-intensity exercise result in diminished stores of energy substrates, followed by an accumulation of metabolites, promoting chronic physiological adaptations. In addition, β -alanine has been accepted as an effective physiological hydrogen ion (H^+) buffer. Concurrent high-intensity interval training (HIIT) and β -alanine supplementation may result in greater adaptations than HIIT alone. The purpose of this study was to evaluate the effects of combining β -alanine supplementation with high-intensity interval training (HIIT) on endurance performance and aerobic metabolism in recreationally active college men. Methods: Forty-six men (Age: 22.2 ± 2.7 yrs; Ht: 178.1 ± 7.4 cm; Wt: 78.7 ± 11.9 ; VO_{2peak} : 3.3 ± 0.59 $l \cdot min^{-1}$) were assessed for peak O_2 utilization (VO_{2peak}), time to fatigue (VO_2TTE), ventilatory threshold (VT), and total work done at 110% of pre-training VO_{2peak} (TWD). In a double-blind fashion, all subjects were randomly assigned into one either a placebo (PL – 16.5 g dextrose powder per packet; $n = 18$) or β -

alanine (BA – 1.5 g β -alanine plus 15 g dextrose powder per packet; n = 18) group. All subjects supplemented four times per day (total of 6 g/day) for the first 21-days, followed by two times per day (3 g/day) for the subsequent 21 days, and engaged in a total of six weeks of HIIT training consisting of 5–6 bouts of a 2:1 minute cycling work to rest ratio. Results: Significant improvements in VO_{2peak} , VO_{2TTE} , and TWD after three weeks of training were displayed ($p < 0.05$). Increases in VO_{2peak} , VO_{2TTE} , TWD and lean body mass were only significant for the BA group after the second three weeks of training. Conclusion: The uses of HIIT induced significant aerobic improvements and were effective and efficient. Chronic BA supplementation may further enhance HIIT, improving endurance performance and lean body mass.

Edge et al. (2005) compared the effects of high-intensity interval (HIT) and moderate-intensity continuous (MIT) training on changes in repeated-intensity ability (RSA) and muscle metabolism. Pre and post training, VO_{2peak} , lactate threshold (LT), and RSA (5 \times 6-s sprints, every 30s) were assessed in 20 females. Subjects were matched on RSA, randomly placed into the HIT (N = 10) or MIT (N = 10) group and performed 5 weeks (3 days per week) of cycle training, performing either HIT (6-10, 2-min at 80-95% LT). Both groups had significant improvements in VO_{2peak} and LT, with no significant differences between them. Both groups also had significant increases in RSA total work (kJ), with a significantly greater increase following HIT than MIT (13 vs 8.5%, respectively; $P < 0.05$). They concluded

that when total work is matched, high intensity interval training results in greater improvements in repeated sprint ability than moderate intensity continuous training.

Carl and Will (2004) conducted a study on the effects of high-intensity interval and resistance training on endurance performance and related physiological measures of competitive endurance athletes. There were 22 relevant training studies. Classified training as intervals (supramaximal, maximal, submaximal) and resistance (including explosive, plyometric, and weights). All effects on performance into percent changes in mean power and included effects on physiological measures that impact endurance performance. Endurance performance of the longest durations was enhanced. Interval training achieved its effects through improvements of maximum oxygen consumption, anaerobic threshold, and economy, whereas resistance training had benefits mainly on economy. Effects of some forms of high-intensity training on performance or physiology were unclear. Addition of explosive resistance and high-intensity interval training to a generally low-intensity training program produced substantial gains in performance. More research must be done to clarify the effects of the various forms of high-intensity training on endurance performance, to determine whether prescribing specific forms of resistance training can improve specific deficits of an endurance athlete's physiology, and to determine the effects of combining the various forms in periodized programs.

Carl et al. (2004) conducted a study on the effects of high-intensity interval and resistance training on endurance performance and related physiological measures of competitive endurance athletes. There were 22 relevant training studies. Classified training as intervals (supramaximal, maximal, submaximal) and resistance (including explosive, plyometrics, and weights). All effects on performance into percent changes in mean power and included effects on physiological measures that impact endurance performance. Endurance performance of the longest durations was enhanced. Interval training achieved its effects through improvements of maximum oxygen consumption, anaerobic threshold, and economy, whereas resistance training had benefits mainly on economy. Effects of some forms of high-intensity training on performance or physiology were unclear. Addition of explosive resistance and high-intensity interval training to a generally low-intensity training program produced substantial gains in performance. More research should be done to clarify the effects of the various forms of high-intensity training on endurance performance, to determine whether prescribing specific forms of resistance training can improve specific deficits of an endurance athlete's physiology, and to determine the effects of combining the various forms in periodized programs.

Dupont et al. (2004) investigated the effects of in-season, high intensity interval training on professional male soccer player's running performances. Twenty-two subjects participated in 2 consecutive training periods of 10 weeks. The first period was considered as a

control period and was compared with a period where 2 high-intensity interval training exercises were included in the usual training program. Intermittent runs consisted of 12-15 runs lasting 15 seconds of rest. Sprint repetitions consisted of 12-15 all-out 40-m runs alternated with 30 seconds of rest. Results from the high-intensity interval training have shown that maximal aerobic speed was improved and that the time of the 40-m sprint was decreased, whereas no change in either parameter was observed during the control period. This study showed that improvements in physical were made during the in-season period.

Seiler et al. (2002) measured that the physiological responses to varied intensity interval training. Runners (M = 9; F = 3), after initial testing, performed four interval training conditions of 24 x 1, 12 x 2, 6 x 4, or 4 x 6 minute bouts with equal work and rest durations, resulting in a total of 48 minutes of involvement for each condition. Average running velocity decreased with increase in interval duration. Peak VO_2 was significantly higher for 6 minute intervals (~92% VO_{2max}) than for 1 minute intervals (~82% VO_{2max}). Blood lactates and RPE were similar across all conditions, both increasing as each exercise bout progressed. The greatest physiological load was experienced in the 4-min intervals. Physiological loading in interval training is greatest when work intervals are four minutes. The shorter the interval, the less demanding is the work, but the greater is the potential volume of a particular work quality.

Helgerud et al. (2001) found that the VO_2 max improved 10.7% and lactate threshold by 15.9%. Running economy improved by 6.7%; distance covered in a match increased by 20%; and work level (measured by HR) increased by 3.5%. The introduction of interval training in a season of endurance-based sport increased the performance characteristics of athletes in competitions.

Thomas et al. (1984) studied that the interval training and continuous running were compared for effects on physiological adaptations. Untrained men and women were randomly assigned to four groups: 1) running continuously at 75% HRmax for four miles; 2) running continuously at 75% HRmax for two miles; 3) eventually running eight one minute intervals at 90% HR max with three minute recovery intervals; and 4) no exercise control. Males (N = 24) and females (N = 35) completed. Training sessions were conducted three times a week for 12 weeks. Only the interval training group improved significantly more than the control group in VO_2 max. The effect of training was similar between genders, although values differed between them. There were no differences in percentage of body fat changes, triglycerides, cholesterol, and high density lipoproteins. Interval training benefits aerobic capacity more than continuous training. Elite junior male soccer players were divided into an experimental group (N = 9) that experienced additional interval training as a stimulus for improving aerobic function for eight weeks, and a control group that trained normally. The interval training

consisted of running 4 x 4-min at 90-95% HR max with a 3-min group between-repetition recovery and jog. The interval group was the only group that improved aerobic function.

2.3 STUDIES ON FOOTBALL

Macpherson Tom W. and Matthew Weston (2015) conducted a study on Effect of Low-Volume Sprint Interval Training on the Development and Subsequent Maintenance of Aerobic Fitness in Soccer Players. To examine the effects of low-volume sprint interval training (SIT) on the development (part 1) and subsequent maintenance (part 2) of aerobic fitness in soccer players. In part 1, 23 players from the same semi-professional team participated in a 2-wk SIT intervention (SIT, $n = 14$, age 25 ± 4 y, weight 77 ± 8 kg; control, $n = 9$, age 27 ± 6 y, weight 72 ± 10 kg). The SIT group performed 6 training sessions of 4–6 maximal 30-s sprints, in replacement of regular aerobic training. The control group continued with their regular training. After this 2-wk intervention, the SIT group was allocated to either intervention ($n = 7$, 1 SIT session/wk as replacement of regular aerobic training) or control ($n = 7$, regular aerobic training with no SIT sessions) for a 5-wk period (part 2). Pre and post measures were the YoYo Intermittent Recovery Test Level 1 (YYIRL1) and maximal oxygen uptake (VO_{2max}). In part 1, the 2-week SIT intervention had a small beneficial effect on YYIRL1 (17%; 90% confidence limits $\pm 11\%$), and VO_{2max} (3.1%; $\pm 5.0\%$) compared with control. In part 2, 1 SIT session/wk for 5 wk had a small beneficial

effect on VO_{2max} (4.2%; $\pm 3.0\%$), with an unclear effect on YYIRL1 (8%; $\pm 16\%$). Two weeks of SIT elicits small improvements in soccer players' high-intensity intermittent-running performance and VO_{2max} , therefore representing a worthwhile replacement of regular aerobic training. The effectiveness of SIT for maintaining SIT-induced improvements in high-intensity intermittent running requires further research

Faude Oliver et al. (2014) conducted a study on the Effect of Short-Term Interval Training During the Competitive Season on Physical Fitness and Signs of Fatigue: A Crossover Trial in High-Level Youth Football Players. To analyze performance and fatigue effects of small-sided games (SSG) vs high-intensity interval training (HIIT) performed during a 4-wk in-season period in high-level youth football. Methods: Nineteen players from 4 youth teams (16.5 [SD 0.8] y, 1.79 [0.06] m, 70.7 [5.6] kg) of the 2 highest German divisions completed the study. Teams were randomly assigned to 1 of 2 training sequences (2 endurance sessions per wk): One training group started with SSG, whereas the other group conducted HIIT during the first half of the competitive season. After the winter break, training programs were changed between groups. Before and after the training periods the following tests were completed: the Recovery-Stress Questionnaire for Athletes, creatine kinase and urea concentrations, vertical-jump height (countermovement jump [CMJ], drop jump), straight sprint, agility, and an incremental field test to determine individual anaerobic threshold (IAT). Results: Significant time effects were observed for IAT

(+1.3%, $\eta p2 = .31$), peak heart rate (-1.8%, $\eta p2 = .45$), and CMJ (-2.3%, $\eta p2 = .27$), with no significant interaction between groups ($P > .30$). Players with low baseline IAT values (+4.3%) showed greater improvements than those with high initial values ($\pm 0.0\%$). A significant decrease was found for total recovery (-5.0%, $\eta p2 = .29$), and an increase was found for urea concentration (+9.2%, $\eta p2 = .44$). Conclusion: Four weeks of in-season endurance training can lead to relevant improvements in endurance capacity. The decreases in CMJ height and total-recovery score together with the increase in urea concentration might be interpreted as early signs of fatigue. Thus, the danger of overtaxing players should be considered.

Singh A (2014) investigated to compare the effects of combined strength and plyometric training with soccer training alone on strength and power-related measurements in professional soccer players. Subjects were randomly divided into two groups: group EG ($n = 14$) performed heavy resistance and plyometric training thrice a week during 6 weeks training period in addition to 6-8 soccer sessions per week; group CG ($n = 14$) performed 6-8 soccer sessions a week. EG significantly increased ($p < 0.05$) ball shooting speed and agility but showed no changes in body mass. Within-subject improvement was significantly higher ($p < 0.01$) in the EG compared with the CG for vertical jump height, 10 and 30 m sprint times, distances covered in the Yo-Yo intermittent recovery test. Plyometric can be concurrently

performed with high load muscular strength training to enhance soccer players' explosive performances

Freitas Camila G. (2014) investigated the Psychophysiological Responses to Overloading and Tapering Phases in Elite Young Soccer Players. This study investigated the effect of a 2-week overloading training phase followed by a 2-week tapering phase on internal training load (ITL), salivary cortisol, stress tolerance, and upper respiratory tract infections symptoms (URTI) in 11 male young soccer players (16.0 ± 0.5 yrs). Ratings of perceived exertion (session- RPE) were taken after each training session ($N = 194$) to determine ITL. Saliva sampling was conducted at the end of each week and cortisol concentration assessed by ELISA. DALDA and WURSS-21 questionnaires were administered every week to evaluate stress tolerance and severity of URTI respectively. The number of athletes reporting URTI symptoms was recorded. The overloading phase promoted greater ITL and a higher resting cortisol concentration than the tapering phase ($P < .05$). While no significant changes in stress tolerance or URTI severity were observed, the number of athletes reporting URTI symptoms was higher during the overloading phase. A significant correlation was observed between symptoms of stress and severity of URTI ($r_s = -.71$; $P = .01$). The results indicate that an integrated approach using psychological measures (session-RPE and DALDA), self-reports of URTI symptoms, and endocrine responses (cortisol) to training are pertinent for monitoring young soccer players.

Kamenetz et al. (2013) analyzed the structure and content of the competition period in mini-football. It was determined that the structure of the competition period consists of 4 competitive mesocycles. In each mesocycle includes various types of micro-cycles (competitive, cross-game and rehabilitation). Reflects the ratio of specific and non-specific (general preparations) means training work. So in the competitive period for competitive mesocycles general preparations exercises ranged from 38.3 to 42.4%, special-preparation - from 29.9 to 32.6%, competitive - from 20.9 to 23.3%. The intensity of the training load in intergame micro cycles less than competitive. This corresponds to the strategy of building the training process in the competitive period. During the competition period the ratio of the training load was: aerobic focus - 49.2%, mixed - 46.1%, anaerobic alactate - 2.4%, anaerobic glycolytic - 2.3%. Defines the scope and focus of the training load: longer the aerobic work, then - mixed, anaerobic- alactate and anaerobic-glycolytic. The comparative characteristics of the intensity of the training load in competitive and inter - game micro cycles.

Theophilos (2013) evaluated the effects of the short-term and extremely short-term interval training protocols on the aerobic performance in young soccer players. Thirty six (n=36) amateur players aged 16.2 ± 1.1 yrs participated in this study. After the baseline laboratory evaluation (VO_{2max} , vVO_{2max} , RE, vAT), the subjects were further divided into 3 groups: the short-term group A (15s:15s)], the

extremely short-term group B (6s:30s)] and the control group (C). After the completion of the 10-week research protocols, the players' aerobic performance was re-evaluated. The repeated measures analysis of variance (ANOVA) was applied in order to evaluate the interactions of the 10-week interval training protocols on the players' aerobic capacity. The results showed that the training groups presented a significant improvement in the VO_{2max} (9.63% & 7.4%) and the vVO_{2max} (5.8% & 5.35%) while the control group did not improve. In addition, the running economy (RE) did not improve significantly in the players of the interval training groups while the analysis of variance revealed that the intervention protocols did not affect the players' velocity in the anaerobic threshold (vat). Conclusively, the interval training protocols of 15s:15s and 6s:30s which were applied in a time period of 10 weeks contributed to the increase of both the VO_{2max} and the VO_{2max} in young soccer players.

Guillen F (2013) this study focused on the higher-order structure of mental toughness and to examine differences in mental toughness between athletes and non-athletes. Participants of this study – 927 athletes and 931 non-athletes – completed a battery of questionnaires designed to assess four characteristics of mental toughness: hope, optimism, perseverance and resilience. The higher-order structure of mental toughness was found to be the same for both athletes and non-athletes. The latent mean differences analyses showed that athletes scored higher in mental toughness when

compared to non-athletes. Taken together, these findings support the theoretical assumption that mental toughness is a higher-order construct encompassing different characteristics and that sport participation is associated with higher mental toughness.

Gyambrah et al. (2013) conducted a study to assess the mental toughness of senior high school football players in the Greater Accra Region of Ghana. Descriptive survey design was employed and thirty male student football players sampled from a twelve weeks football training program was studied using convenience and purposive sampling techniques. Their psychological factors of mental toughness were tested by Loehr's (1986) mental toughness test. The factors recorded for mental toughness indicated controlled attitude, self-confidence, positive energy, motivational level, attention control, visualization and imagery. Players tested average in all the factors with controlled attitude being the highest and control of attention their lowest. From the findings it was recommended that, high school football players should be trained to enhance all the seven factors for mental toughness. Again an examination of differences among players at all levels in a variety of sporting and physical activities and noting changes across different situations would promote understanding of mental toughness, quality of psychomotor intelligence and cognitive processes in schools.

Sevel and Karthikeyan (2011) conducted a study to find out the effect of aerobic interval training on selected endurance parameters

such as strength endurance and cardio respiratory endurance. The selected criterion variable at prior to and immediately after the training program by using bend knee sit ups and cooper's 12 min run/walk test. The results of the study revealed that there was a significant difference between aerobic interval running group and control group on selected endurance parameter. A significant improvement on selected criterion endurance variable was also noticed due to aerobic interval running program.

Bupesh et al. (2011) determined the effect of aerobic training on performance related variables of footballers. The criterion variables selected for the study were kicking for the distance and dribbling. The result of the study showed that there was a significant difference among the experimental and the control group before and after the training period on kicking for the distance and dribbling.

Manoj Kumar and Thirumalai Kumar (2011) studied the effect of specified football drills with and without relaxation technique on selected 40 game skill variables among school level football players. The dribbling ability Morgan Christian soccer ability test was used, it was measured in seconds and it was a standardized test. The result of the study revealed that both the experimental training namely specified football drills with relaxation technique and specified football drills without relaxation technique had significant improvement on selected skill variables namely passing, shooting and dribbling among the school level football players. There is no significant difference on

the improvement of selected skill variables between both the experimental groups among the school level football players.

Wong (2010) studied that the effect of concurrent muscular strength and high-intensity running interval training on professional soccer players' explosive performances and aerobic endurance. Thirty-nine players were 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 ($p \leq 0.05$) 1RM back half squat and bench press but showed no changes in body mass. Within-subject improvement was significantly higher ($p \leq 0.01$) 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.

Crocce Peter et al. (2010) conducted a study on Psychology Cognitive-Affective Stress Management Training with High Performance Youth Volleyball Players: Effects on Affect, Cognition, and Performance. Cognitive-Affective Stress Management Training (SMT) is a coping skills training program designed to help athletes control dysfunctional stress processes (Smith, 1980). The present quasi-experimental study investigated the effects of SMT on affect, cognition, and performance in high performance youth volleyball players. Members of Alberta's Canada Games men's and women's (under 19 years of age) volleyball teams were assigned to either an experimental treatment group or a waiting-list control group. The treatment program consisted of eight modules, approximately 1 week apart, that allowed subjects to learn and apply somatic and cognitive coping skills. The results indicated that the treatment group emitted fewer negative thoughts in response to videotaped stressors and had superior service reception performance in a controlled practice compared to the control group. There were no interpretable differences between groups for either state anxiety (CSAI-2) or trait anxiety (SCAT). The cognitive and performance measures provided converging support for Smith's program. The results are discussed in terms of coping skills training, theoretical issues regarding the measurement of anxiety, and possible affect-cognition system independence.

Andreas Ivarsson et al. (2009) reported that between 65–91% of elite soccer players in Sweden have at least one injury per year.

Several studies define different physiological and psychological factors affecting athletic injury-risk. A number of models contain proposals that specify relationships between psychological factors and an increased athletic injury-risk. Examples include Williams and Andersen's stress-injury model and Johnson and Ivarsson's empirical model of injury risk factors which proposes that factors such as trait anxiety and ineffective coping skills are influential. The purpose of this study was to examine the relationship between (a) personality factors, b) coping variables, and (c) stress and injury risk. Participants were 48 male soccer players from 3 Swedish teams ranging age from 16 to 36 years ($M = 22$ years). Participants completed 5 questionnaires: Football Worry Scale, Swedish universities Scales of Personality, Life Events Survey for Collegiate Athletes, Daily Hassle Scale and Brief COPE. Information on injuries was collected by athletic trainers of the teams over 3-months. Results suggest injury was significantly predicted by 4 personality trait predictors: somatic trait anxiety, psychic trait anxiety, stress susceptibility, and trait irritability. Collectively, the predictors self-blame and acceptance could explain 14.6% of injury occurrence. More injuries were reported among players who score high in daily hassles. These results support previous findings. Recommendations are given for both the athletes and the trainers on working to prevent sport injuries.

Gucciardi D (2009) evaluated the effectiveness of two different psychological skills training (PST) packages in enhancing mental

toughness among three youth-aged (under 15 years old) Australian football teams. We compared a program targeting the keys to mental toughness identified previously (Gucciardi, Gordon, & Dimmock, 2008) with a more traditional PST program targeting self-regulation, arousal regulation, mental rehearsal, attentional control, self-efficacy, and ideal performance state as well as a control group. Overall, both intervention groups reported more positive changes in subjective ratings of mental toughness, resilience, and flow than the control group. Similar ratings for mental toughness were reported by the parents and coaches. Both PST packages appeared to be equally effective in enhancing mental toughness.

Mujika Inigo et al. (2007) investigated the Individualized Aerobic-Power Training in an Underperforming Youth Elite Association Football Player. A 7-week, 10-session individual training program was implemented with a youth elite football (soccer) player who had been underperforming because of poor aerobic fitness. The intervention focused on developing aerobic power and high lactate production and contributed to a 32.3% improvement in a football-specific performance test. The player was able to return to play and exceed expected performance levels during competitive match play.

Impellizzeri et al. (2006) compared the effects of specific (small-sided games) vs. generic (running) aerobic interval training on physical fitness and objective measures of match performance in soccer. Forty junior players were randomly assigned to either generic (n=20) or

specific (n=20) interval training consisting of 4 bouts of 4 min at 90-95 % of maximum heart rate with 3 min active rest periods, completed twice a week. The following outcomes were measured at baseline (Pre), after 4 weeks of pre-season training (Mid), and after a further 8 weeks of training during the regular season (Post): maximum oxygen uptake, lactate threshold (Tlac), running economy at Tlac, a soccer-specific endurance test (Ekblom's circuit), and indices of physical performance during soccer matches (total distance and time spent standing, walking, and at low- and high-intensity running speed). Training load, as quantified by heart rate and rating of perceived exertion, was recorded during all training sessions and was similar between groups. There were significant improvements in aerobic fitness and match performance in both groups of soccer players, especially in response to the first 4 weeks of pre-season training. However, no significant differences between specific and generic aerobic interval training were found in any of the measured variables including soccer specific tests. The results of this study showed that both small-sided games and running are equally effective modes of aerobic interval training in junior soccer players.

Chamari *et al.* (2005) studied the aerobic capacity of soccer players substantially influences their technical performance and tactical choices. Thus, the assessment of soccer players' aerobic performance should be of interest for soccer coaches in order to evaluate and improve their endurance training sessions. In this study, they presented a new test to assess aerobic performance in soccer by

means of a specific dribbling track: the Hoff test. They further determined whether improvement in maximal oxygen uptake was reflected in increased distance covered in the Hoff test. We tested 18 male soccer players (14 years old) both in the laboratory and using the Hoff test before and after 8 weeks of soccer training. The distance covered in the Hoff test correlated significantly with maximum oxygen uptake, and improved by 9.6% during the 8 weeks training period, while maximum oxygen uptake and running economy improved by 12 and 10%, respectively. Backward multiple regression showed maximum oxygen uptake was the main explanatory variable for the distance covered in the Hoff test. The study demonstrated a significant correlation between laboratory testing of VO_2 max and performance in the Hoff test. Furthermore, training induced improvements in VO_2 were reflected in improved performance in the Hoff test. They suggested that it should be a goal for active U-15 soccer players to cover more than 2100 metres in the Hoff test, as this required a VO_2 max of above 200 ml/kg (0.75)/min, which should serve as a minimum in modern soccer.

Gorostiaga et al. (2005) determined the effects of simultaneous explosive strength and soccer training in young men, 8 experimental (S) and 11 control (C) players, aged 17.2 (0.6) years, were tested before and after an 11-week training period with respect to the load-vertical jumping curve [loads of 0-70 kg (counter-movement jump CMJ0-70)], 5- and 15-m sprint performances, submaximal running endurance

and basal serum concentrations of testosterone, free testosterone and cortisone. In the S group, the 11-week training resulted in significant increases in the low-force portion of the load-vertical jumping curve (5-14% in CMJ0-30, $p < 0.01$) and in resting serum total testosterone concentrations (7.5%, $p < 0.05$), whereas no changes were observed in sprint running performance, blood lactate during submaximal running, resting serum cortisone and resting serum free testosterone concentrations. In the C group, no changes were observed during the experimental period. In the S group, the changes in CMJ0 correlated ($p < 0.05-0.01$) with the changes in the 5-m ($r = 0.86$) and 15-m ($r = 0.92$) sprints, whereas the changes in CMJ40 correlated negatively with the changes in the testosterone: cortisol ratio ($r = -0.84, -0.92$, respectively, $p < 0.05$). These data indicated that young trained soccer players with low initial strength levels can increase explosive strength by adding low-frequency, low-intensity explosive-type strength training. The inverse correlations observed between changes in CMJ40 and changes in the testosterone: cortisol ratio suggest that a transient drop in this ratio below 45% cannot always be interpreted as a sign of overstrain or neuroendocrine dysfunction.

Lenamar et al. (2005) investigated the developmental trajectory of the Brazilian Rhythmic Gymnastics Youth Team, focusing on the identification of competitive factors (motivator and stressful) that occurs in different sport's career phases. The sample was composed ten athletes. As measuring instruments the Frester's Test Psychic

Load and a semi-structured interview were used. The data were analyzed through the descriptive statistics and categorical type of content's analysis. The results demonstrated that in the rhythmic gymnastics the process of the athletes' motor specialization begins at 12 years; the motivator factors evidenced were fun for sport and being the favorite; the stressful factors were being harmed by the judges and not time for fun. Concluding in a general analysis the athletes perceived the competitive sporting context as more stressful than motivator; this affirmation increased starting from the motor's practice phase where the competitive stress was intensified.

Dupont G et al. (2004) has conducted a study on effect of in-season, high – intensity interval training in soccer players. The effects of in-season, high-intensity interval training on professional male soccer players' running performances were investigated. Twenty-two subjects participated in 2 consecutive training periods of 10 weeks. The first period was considered a control period and was compared with a period where 2 high-intensity interval training exercises were included in the usual training program. Intermittent runs consisted of 12-15 runs lasting 15 seconds at 120% of maximal aerobic speed alternated with 15 seconds of rest. Sprint repetitions consisted of 12-15 all-out 40-m runs alternated with 30 seconds of rest. Results from the high-intensity interval training have shown that maximal aerobic speed was improved (+8.1 +/- 3.1%; $p < 0.001$) and that the time of the 40-m sprint was decreased (-3.5 +/- 1.5%; $p < 0.001$), whereas no

change in either parameters were observed during the control period. This study showed that improvements in physical qualities can be made during the in-season period.

Hoff et al. (2004) evaluated the effect of endurance interval training using an intensity at 90-95% of maximal heart rate in 3- to 8-minute bouts have proved to be effective in the development of endurance, and for performance improvements in soccer play. Strength training using high loads, few repetitions and maximal mobilization of force in the concentric mode have proved to be effective in the development of strength and related parameters.

Golby, J., & Sheard, M. (2003) examined the relations between demographic characteristics of rugby players and selected aspects of psychological performance in rugby league football. Mental toughness was assessed using Psychological Performance Inventory and Hardiness on the Personal Views Survey 111-R. Participants (N = 70) were international rugby league footballers representing four teams (Wales, France, Ireland, England) in the 2000 Rugby League World Cup. Participants completed the questionnaires in training camp. Welsh-nationality players had a significantly higher mean score on two of the hardiness subscales. Hardiness measures displayed the greatest and most frequently statistically significant differences. The findings concur with previous work indicating superior hardiness is related to improved performance in sports.

Hughes et al. (2003) found that recreationally trained Ss (M = 6; F = 2) performed SIT (6 bouts of 4-8 Wingate 30-s tests with 4-min recovery between tests) six times with 1-2 days of rest between sessions over two weeks. Performance was measured by a ride to exhaustion at ~80% VO₂ peak. Physiological measures were taken. VO₂ peak was unchanged over the training period. Maximum anaerobic work increased by 14% and cycle time to exhaustion increased ~101%. Lactate measures were unchanged as a result of the training. Judiciously applied sprint interval training and recovery resulted in improved intense aerobic work and to a lesser extent, anaerobic work. Active men and women were assigned to three training or a control group: continuous training (N = 10; 70% VO₂max for 30-50 minutes), interval training (N = 10; 85-100% VO₂max 16-35 minutes), speed training (N = 10; 100% maximal speed in 20-50 m intervals for 300-400 m total distance per session), and control (N = 8). Training was for three days per week and lasted for eight weeks. Only speed training increased MAOD. It remained unchanged in the other two forms of training. Moderate interval intensity training and continuous training mainly change aerobic power in exercise. Only supra maximal sprint training stimulates improvement in MAOD.

Gorostiaga *et al.* (2002) examined the soccer players in two groups which performed soccer and explosive-strength training (N = 10) or soccer training alone (control; N = 11) for 11 weeks. It was found that the explosive-strength group significantly improved the low

portion of the load-vertical jumping curve, the amount of serum testosterone, and in the first four weeks, 5-m sprint training. Endurance adaptation was not compromised.

Helgerud (2001) studied the effects of aerobic training on performance during soccer match and soccer specific tests. Nineteen male elite junior soccer players, age 18.1 +/- 0.8 yr, randomly assigned to the training group (N = 9) and the control group (N = 10) participated in the study. The specific aerobic training consisted of interval training, four times 4 min at 90-95% of maximal heart rate, with a 3-min jog in between; twice per week for 8 wk. Players were monitored by video during two matches, one before and one after training. In the training group: a) maximal oxygen uptake (VO₂max) increased from 58.1 +/- 4.5 mL × kg⁻¹ × min⁻¹ to 64.3 +/- 3.9 mL × kg⁻¹ × min⁻¹ (P < 0.01); b) lactate threshold improved from 47.8 +/- 5.3 mL × kg⁻¹ × min⁻¹ to 55.4 +/- 4.1 mL × kg⁻¹ × min⁻¹ (P < 0.01); c) running economy was also improved by 6.7% (P < 0.05); d) distance covered during a match increased by 20% in the training group (P < 0.01); e) number of sprints increased by 100% (P < 0.01); f) number of involvements with the ball increased by 24% (P < 0.05); g) the average work intensity during a soccer match, measured as percent of maximal heart rate, was enhanced from 82.7 +/- 3.4% to 85.6 +/- 3.1% (P < 0.05); and h) no changes were found in maximal vertical jumping height, strength, speed, kicking velocity, kicking precision, or quality of passes after the training period. The control group showed no changes in any of the

tested parameters. Enhanced aerobic endurance in soccer players improved soccer performance by increasing the distance covered, enhancing work intensity, and increasing the number of sprints and involvements with the ball during a match.

Kubitz Karla A. ,and Daniel M. Landers (1993) investigated the Effects of Aerobic Training on Cardiovascular Responses to Mental Stress. This study aimed to quantify the hemolytic responses of elite female football (soccer) players during a typical weekly training session. Ten elite female football players (7 field players [FPs] and 3 goalkeepers [GKs]) were recruited from the Australian National Women's Premier League and asked to provide a venous blood sample 30 min before and at the immediate conclusion of a typical weekly training session. During this training session, the players' movement patterns were monitored via a 5-Hz global positioning system. The blood samples collected during the training session were analyzed for iron status via serum ferritin (SF) analysis, and the hemolytic response to training, via serum free hemoglobin (Hb) and haptoglobin (Hp) measurement. 50% of the participants screened were found to have a compromised iron stores (SF $P = .011$), and the serum Hp levels were significantly decreased ($P = .005$), with no significant differences recorded between the FPs and GKs. However, the overall distance covered and the movement speed were significantly greater in the FPs. The increases in free Hb and decreases in Hp levels provide evidence that a typical team-sport training session may result in

significant hemolysis. This hemolysis may primarily be a result of running-based movements in FPs and/or the plyometric movements in GKs, such as diving and tackling.

Shields *et al.* (1984) conducted a study with the likely hypothesis that the degree to which a football player was physically suited to his position determined his value as a player, they attempted to describe the characteristics of a given player and position and, from that, to determine the characteristics that make up a first class player in that position. Over a 4-year period 167 football players were examined at the National Athletic Health Institute, Inglewood, California, and grouped according to playing position and class. Position groups were: 1, linemen; 2, linebackers and tight ends; 3, running backs, quarterbacks and kickers; and 4, wide receivers and defensive backs. Classes were: I, rookies (nonstarters); II, veterans (nonstarters); and III, starters (veterans and an occasional rookie). Testing was in two phases, body characteristics and direct measurement of body function. All testing was done in connection with the preseason physical exam. Significant differences were found when data were analyzed by position. Position 1 players were taller, heavier, and had a higher percentage of body fat than players at other positions. These values decreased from Position 1 to Position 4. In terms of cardiovascular fitness the opposite trend was seen. Strength measures were also specific to given position groups. While few differences were seen when data were analyzed by class, one

interesting finding was that Class III players (starters) were not only the oldest, but also had the highest level of cardiovascular fitness. Their conclusion was that while size, strength, and endurance are obvious advantages for the successful regular player, there was an unmeasurable quality reflected in the playing ability of the veteran player that was not easily identified in the beginning player.

2.4. SUMMARY OF REVIEW OF LITERATURE

The research studies conducted in this area had been reviewed. To have a clear, comprehensive picture of high intensity aerobic interval training and concurrent low intensity aerobic and resistance interval training. The investigator had given seventy three research studies, which have been conducted in the area of sports training, appeared in various periodicals, journals, e-searching, abstract-cum-souvenirs and a variety of relevant books and master, doctoral thesis in physical education and sports sciences. The reviews summarize the influence of low and high intensity aerobic and resistance interval training in developing the motor fitness, physiological, psychological and skill performance variables of college level male football players. Hence, the investigator made an attempt to study the effect of high intensity aerobic interval training and concurrent low intensity aerobic interval and resistance training.