Chapter II

Review of Related Literature
CHAPTER - II

REVIEW OF LITERATURE

2.0 INTRODUCTION

Literature survey comprises locating, reading and evaluating reports of research as well as reports of casual observation and opinion that are related to the individual’s planned research report. A study of relevant literature is an essential step to get a full picture of what has been done with regard to the problem under study. The investigator has made an attempt to bring a brief review of research related to the present study to form the background for the present study and has presented the same with appropriate headings.

2.1 STUDIES ON CIRCUIT TRAINING

Mane et al. (2011) studied the Effects of Circuit Training for the Development of Vertical Jumping Ability, Endurance, Agility and Skill Ability in Football Players’ Boys Aged 10 To 12 Years. The main aim of this type of study was to investigate whether additional circuit training will be of any benefit in improving the performance of the students undergoing training in the following events Cardiovascular Endurance, Vertical Jumping Ability, Agility and Muscular Endurance. 40 students of N. L Dalmiya High School, Miraroad, and Mumbai were selected at random and were divided in two groups of 20 each by random allotment one of the groups was treated as control group. Circuit training was based on the assumption that could have developmental effect in Cardiovascular Endurance, Vertical Jumping Ability, Agility and Muscular Endurance. The criterion measures adopted for experimental group were Cardiovascular Endurance, Vertical Jumping Ability, Agility and Muscular Endurance. Initial readings were taken at the commencement of the training. Experimental group followed specifically prescribed circuit training scheduled three days a week for period of eight weeks. Final readings in the criterion measures were taken.
The improvement made in the test items by the two groups were tested for significance by the paired ‘t’test. The mean gain made by the Experimental Group over the Control Group in Each of the test item was also tested for significance using the ‘t’test.

Palanisamy et al. (2012) conducted study on effect of circuit training on aerobic, anaerobic capacity among kabaddi players the sample for the present study of thirty men kabaddi players from Arul Anandar College at Madurai. The subjects were selected using random sampling methods. Their age ranged from 18-23 years. There were divided into two equal groups namely circuit training group and control group. Vo₂ Max bench step test (Aerobic capacity) and 300 meters run (Anaerobic capacity) were administrated to them. Aerobic capacity considered as dependent variables and experimental group (Circuit training) and control group (No training) considered as independent variables. Circuit training group was given circuit training for the period of eight weeks three days per week for 1 hour in the morning on the playing ground. The training programmed was administrated for 45 minutes and the cool-down activates. The load was fixed based on the pilot study. The exercise was graduated from 1 week to 8 weeks by increasing the speed, resistance, duration and intensity. The intensity of each exercise started at 50% hear rate maximum and gradually increased to 90% before the end of the 8 weeks period. This is in accordance with the recommendation of the American College of Sports Medicine (1986) that recommended an exercise intensity of between 50-90% of maximal heart rate. Experimental group of the subject worked at each station and had 1 minutes of rest before changing the next station. The subject moved to the station in a clockwise direction as soon as the time allotted to each station was over, they were required to go through the 10 stations of the circuit three times. At the end of the circuit training programme, subjects were given cool down activities. The pre test and post test were taken before and after the training programme. Analysis of Covariance was used as a test of
significant. There was significant difference among circuit training group and control group on selected variables such as aerobic capacity among kabaddi players. There was significant difference among circuit training group and control group on selected variables such as anaerobic capacity among kabaddi players.

P.Karthikeyan et al. (2012) conducted study on the effects of circuit and moving circuit training on selected strength and power parameters such as leg strength and explosive power in terms of vertical distance. To achieve this purpose, forty five men studying in the Department of physical education and sports science, Annamalai university were selected as subjects at random and they were divided into three groups of fifteen subject each with age ranging from 18 to 24 years namely circuit group underwent their respectively trainings for three days per week for twelve weeks in which the control groups did not participate any special training programme apart from their regular physical education activities as per their curriculum .The following variables namely leg strength and explosive power in terms of vertical distance were selected as criterion variables. All the subject of three groups were tested on selected dependent variables at prior to and immediately after the training programme. The analysis of covariance was used to analyze the significant different, if any among the groups were compared, whenever the obtained ‘F’ ratio for adjusted post test was found to be significant, the Schefee’s post hoc test to find out the paired mean differences, if any. The 0.05 level of confidence was fixed as the level of significance to test the ‘F’ ratio obtained by the analysis of covariance, which was considered as an appropriate. There was significance different among circuit training group, moving circuit training group and control group on leg strength there was significance different among circuit training group, moving circuit training group and control group on explosive power in terms of vertical distance. There was a significance improvement on leg strength and explosive power in terms of vertical distance due to circuit training and moving circuit training.
Alagesan et al. (2012) conducted study on the effect of circuit resistance training on selected strength parameters. To achieve this purpose of the study, thirty men students studying bachelors degree at Annamalai Nagar, Tamil Nadu, India were selected as subject and they were divided into two equal groups of fifteen subject each, such as circuit resistance training group and control group I underwent circuit resistance programme for three day week for twelve weeks and Group II acted as control which did not participate in any special training programme apart from the regular physical education activities as per the curriculum. Among the strength parameters, the following variables namely leg strength and strength endurance were selected as criterion variables. And they were tested by using leg lift with dynamometer and bent knee sit ups respectively. All the subject of two groups were tested on selected dependent variables at prior to and immediately after the training programme. The analysis of covariance (ANCOVA) was used to analyze the significant different, if any, between the group. The .05 level of confidence was fixed to find out the level of signficance which was considered as an appropriate. The results of the study showed that there was a significant between circuit resistance training group and control group on leg strength and strength endurance. It was also found that there was a significant improvement on selected criterion variables namely leg strength and strength endurance due to circuit resistance training.

Taskin et al. (2009) studied the effect of circuit training on the sprint-agility and anaerobic endurance. The purpose of this study was to determine the effect of circuit training directed toward motion and action velocity over the sprint-agility and anaerobic endurance. A total of 32 healthy male physical education students with a mean age of 23.92 +/- 1.51 years were randomly allocated into a circuit training group (CTG; n = 16) and control group (CG; n = 16). A circuit training consisting of 8 stations was applied to the subjects 3 days a week for 10 weeks. Circuit training program was executed with 75% of maximal motion numbers in each station. The FIFA Medical Assessment and Research Centre (F-MARC) test
battery, which was designed by FIFA, was used for measuring sprint-agility and anaerobic endurance. Pre- and post training testing of participants included assessments of sprint-agility and anaerobic endurance. Following training, there was a significant ($p < 0.05$) difference in sprint-agility between pre- and post testing for the CTG (pre test = $14.76 +/ - 0.48$ seconds, post test = $14.47 +/ - 0.43$ seconds). Also, there was a significant ($p < 0.05$) difference in anaerobic endurance between pre- and post testing for the CG (pre test = $31.53 +/ - 0.48$ seconds, post test = $30.73 +/ - 0.50$ seconds). In conclusion, circuit training, which is designed to be performed 3 days a week during 10 weeks of training, improves sprint-agility and anaerobic endurance.

**Backham and Earnest et al. (2000)** conducted a study on metabolic cost of free weight circuit training. Free weight circuit training (CWT) classes are popular group exercise designed to improve aerobic capacity, body composition, and muscular strength and endurance. The purpose of this investigation was to determine the training intensity and caloric expenditure associated with free weight CWT. Twelve males and 18 females (age $25.1 +/ - 6.6$ years) participated in Bruce treadmill test to measure Vo2 max ($47.9 +/ - 10.6$ ml/kg min) subjects subsequently performed a learning trial, exiting to a $14$ min video- tagged free weight CWT sequence which included squats and weapon body exercise performed consecutively. All subjects them completed two randomly assigned video exercise bonds with light resistance ($-1.4$ kg for males & females) and moderate resistance (MR=$5.9$ kg for females and $10.5$ kg form), loads recommended by instruments for sedentary and fit individuals, respectively, statistical analysis by RM ANOVA ($P < 0.0036$) revealed significant increases in absolute and relative VO2 and caloric expenditure value at MK were $15.7 +/ - 2.3$ ml/kg min and $6.21 +/ - 0.01$ kcal/min for females. Associated HR response were $129.5 +/ - 18.4$ and $119.2 +/ - 19.4$ b pm for males and females. Respectively, the training stimulus was $<32\%$ VO2 max, significantly below ACSM recommendations (50% VO2 max) for improving cardio-vascular training stimulus. It was concluded HR should not be used to assess exercise intensity in these classes.
Thirumalaikumar et al. (2012) studied the effects of aerobic training and circuit resistance training on selected motor ability components among college men students. To achieve the purpose 45 college men students were selected randomly from college affiliated to Alagappa University. Their age was fixed in the range of 18 to 25 years. There were divided into three group experimental group. The data were collected before and after the training programme and statistically analyzed using analysis of covariance (ANCOVA). Significant results have been observed on speed and agility.

Saratha et al. (2012) conducted study on effects of aerobic training and circuit training on selected motor components ability among school boys it was decided to select the untrained boy’s students who were not participating in any of the games or sports or in any special training or coaching programme. However, they were allowed to participate in their routine physical education classes in the school. Since, during the period of training the subjects were susceptible for changes due to growth it was decided to have one control group for the study. For this purpose, forty five boys students free from deformities and ailments were selected at random by lot from AMC School Bangalore, Karnataka. The age of the subject ranged from thirteen to fifteen. The subject were randomly assigned equally to one of the three groups in which group I acted as aerobic training (n=15) group II underwent circuit training (n=15) and group II underwent control group (n=15). Measurement for the motor ability components such as speed, leg explosive power and agility were recorded at the beginning (pre-test), after six weeks of the training. The selection of subject and assignment of treatment were at random. The subject were not equated in relation to the factor in which they have into account during the analysis of the post-test difference among the means. This was achieved by the application of analysis of covariance, where in the final mean were adjusted for the difference in the critical mean and the adjusted mean were tested for significance. From the analysis of data the following
conclusion were drawn. There was a significant difference among aerobic training and circuit training on selected motor ability components of school children. There was a significant improvement on speed due to circuit training and aerobic training programmes. However, the improvement on leg explosive power due to circuit training and aerobic training programmes. However the improvement was in favour of circuit training. There was a significant improvement on agility due to circuit training and aerobic training programmes. However, the improvement was in favour of circuit training.

Maniazhagu, et al. (2012) conducted study on effect of concurrent endurance training and circuit resistance training sequence on speed. The study was formulated as pre and post test random group design, in which fifty students were divided into five equal groups. The experimental group-I (n=10 CRT group) underwent circuit resistance training, the experimental group II (n=10 ET group) underwent endurance training, the experimental group –III (n=10 CRT before ET group) underwent circuit resistance training before endurance training, the experimental group- IV (n=10 CRT after ET group) underwent circuit resistance training after endurance training and control group – V (n=10, CG) did not undergo any specific training. Every training session lasted for 60 to 90 minutes. The training program was scheduled for the morning between 6.00 am to 8.00 am. The control group not exposed to any specific training. The subject underwent their respective programme under strict supervision prior to and during every session. Subject underwent a 10 minutes warm up cool down exercise that included jogging, stretching. It is of interest and benefit for competitive and recreational athletes to implement both strength and endurance training into their workout programs (Sale D.G 1987). Many perform these training programs concurrently in hopes of achieving the adaptations that are common to both form of exercise. However, these concurrent endurance training and circuit resistance training sequence involve different levels of training volume, intensity and duration. Strength training is defined
as a low number of repetitions performed on a load that is of high resistance, producing a maximal or near-maximal contraction. (Dudley et al., 1985, Sale et al., 1990) In contrast, endurance training is defined as repeated sub maximal contraction with load of low resistance. When performed independently, these four distinct forms of training induce for the most part, opposite physiological adaptation within the muscle. Therefore, the adaptation to training that the muscle endurance is specific to the training stimulus. The result of study showed that the concurrent endurance training and circuit resistance training sequence (circuit resistance training after endurance training group, circuit resistance training before endurance training group) significantly improved the speed and explosive power on the sample population.

George Abraham et al. (2012) conducted study on analyse the Impact of resistance circuit training on back strength among college foot ball players. Forty women student (n=40), studying in difference college, Mahatma Gandhi university, Kerala, were randomly selected as subjects and their age ranged from 17 to 23 years. The selected subjects were dividing into two groups of twenty subjects each. Group 1 considered as experiment that underwent resistance circuit training (RCTG) Three days for eight weeks, group II considered as control group (CG) that did not undergo any special training programme apart from their regular activates. All the subjects of the two groups were tested on selected criterion variable namely back strength. Analysis of covariance was used to analyse the data of pre and post test of resistance circuit training group and control group on confidence. The result revealed of significance of test “f” ratio obtained by the analysis of covariance was fixed at 0.05 level of confidence. The result reviled that the resistance circuit training group produced significant improvement (p≤0.05) on back strength when compared to control group.
Pushparajan et al. (2012), conducted study on effect of intra-session concurrent resistance circuit training and endurance training on physical fitness characteristic of male football players. The study was formulated as pre and post test random group design, in which sixty subjects were randomly divided into 4 equal groups. The experimental group: 1(n=15, RCT group) performed resistance circuit training, experimental group: 2(n=15; ET group) performed the endurance training, experimental group: (n=15, circuit group) performed a concurrent resistance circuit training and endurance training and control group (n=15 cg) did not undergo any specific training. Assessed for speed 50 yard dash, muscular strength programme. The Univariate analysis of variance showed that the training induced significant (p, 0.05) improvement in speed, muscular strength, aerobic capacity for three group. Speed 8.39% for RCT, 6.26% FOR ET, 9.31% for CRCTET, muscular strength 11.14% for RCT, 5.21% for ET, 16.96% CRCTET, Aerobic capacity 5.09% for RCT 7.61 for ET, 7.58 for CRCTET. Conclusion the finding indicates that concurrent resistance circuit training and endurance training programme can elicit improvements in physical fitness characteristics of male foot ball player.

Gettman LR et al. (1982) comparison of combined running and weight training with circuit weight training. The purpose of this study was to compare the physiologic effects of a program of combined running and weight training (RUN-CWT) with a program of circuit weight training (CWT). Thirty-six females (X age = 35.7 yr) and 41 males (X age = 36.1 yr) were randomly assigned to RUN-CWT, CWT, and control groups. The training groups participated in 12-wk programs, 3 d .wk-1. Three circuits of 10 weight-training exercises were completed with 12-15 repetitions performed in 30 s at 40% of one-repetition maximum at each station. The 30-min RUN-CWT program included 30 s of running on an indoor track following each CWT station, whereas the 22.5 min CWT program included a 15-s rest period between stations. The RUN-CWT groups had a significant (+ 17%) increase in VO2max (females 30.5-35.7 ml. kg-1. min-1 and males 39.7-46.3 ml. kg-1. min-1) and
strength (females + 24% and males +21%), and a significant decrease in body fat percentage (females -3.2% and males -4.1%). The CWT groups also increased significantly in VO2max (+12%) and strength (+17%) and decreased in body fat (-3.0%). The controls did not change significantly in any variable. Statistically, one training program was not shown to be superior to the other; thus, both programs of Arazi and Asadi et al. (2012) conducted a study on Effects of condensed versus circuit models on muscular strength, endurance and body composition. The purpose of this study was to examine the effects of condensed multiple-set resistance training and circuit multiple-set resistance training on muscular strength, endurance, body composition and arm and thigh circumference in healthy males. Twenty seven healthy males volunteered to participate in this study and assigned into three groups; according to; condensed multiple-set group (COM; n=9), circuit multiple-set group (CIM; n=8) and control group (CON; n=10). Subjects in the COM performed resistance training exercises for 3 sets continuously; whereas subjects in the CIM performed resistance training program for 1 set of each exercise and come back to the first exercise and this approach was performed 3 times each training session. Pre and post 8 weeks of training, one repetition maximum (1RM) and muscle endurance (60% of 1RM) for leg press and bench press, body weight, arm and thigh circumference and body composition were measured. No significant differences in body mass, arm and thigh circumference and muscular strength for the bench press exercise were observed for any group during the 8 weeks of training period (p > 0.05). A significant increase in muscular strength for the leg press exercise was observed for COM after 8 weeks of training (p < 0.05). Both the COM and CIM groups showed significant improvement compared with pre training and CON in muscular endurance for the bench press and leg press exercises (p < 0.05). In conclusion, it can be recommended that, COM is better for improving muscle strength and both training programs are proper for increasing muscular endurance.
Jabakumar et al. (2011) conducted a study on Impact of Circuit Training on Selected Motor Fitness and Kinaesthetic Sense among Hockey the purpose of the study was to analyse the effect of circuit training on college men Hockey players on selected biomotor variables and kinaesthetic sense. To achieve the purpose 40 men Hockey players were randomly selected from those who participated in the inter-collegiate level tournaments of University of Madras. Their age ranged from 18 and 24 years. The players were selected randomly and divided into two equal groups of 20 members each. Group one was treated as experimental group and the second group was control group. The experimental group was given circuit training for a period of six weeks and the control group was not given any treatment except of their routine. The data were collected from these two groups prior to and after the circuit training on selected bio-motor variables and kinaesthetic sense. The data collected were statistically examined by using paired ‘t’ test. The results of the study indicate that there was improvement in speed, agility, endurance and kinaesthetic sense after the stipulated period owing to 6 weeks circuit training. In case of explosive Power, there was no significant between the experimental and control group. Even though the circuit training was not given to control group, the previous experience of the players may influenced the performance of explosive power. So, the formulated hypothesis was partially accepted.

Norrell et al. (1986) conducted a study on, “The effect of an eleven week super circuit exercise programme on selected physiological and psychological measures of university of Alabama police officers. The health ad job performance of police officers could be enhanced by a time efficient exercise programme designed to meet their specific fitness requirements. The purpose of the study was to measure the effect of a “super circuit exercise programme on university of Alabama police officers. Nineteen male and three female officers participated in the 11 week programme. Preceding and following the training period a number of
health and occupational related fitness measures were taken on the participants. The programme consisted of nine resistance exercise stations. The resistance was provided by hydra fitness omnikineti exercise machines. After a short warm up consisting of stretching and mild calisthenics. The officers exercised continuously for 27 minutes, alternating 20 seconds at each resistance station with 40 seconds at each aerobic station for three complete circuits. The officers were instructed to try and make three exercise sessions per week with at least one day of recovery between the work outs. Despite some attendance problems, the training programme brought about many favourable changes in fitness. Multivariate analysis revealed significant gains in cardio vascular fitness as evidenced by a 15% increase in tred mill test performance. Benefits to cardio vascular in tred mill test performance. Benefits to cardio vascular fitness were also realized in a reduction of resting and exercise recovery heart rate (7% and 13% respectively). There were no significant increase in lower leg strength (7%), upper leg strength (15%), vertical jump (12.5%) and sit-ups (37%). Increase in the bench press strongly, state anxiety, blood pressure, or blood lipids. There were no favourable changes in body composition. It was concluded that “super circuit” exercise programme for eliciting and maintaining physical fitness among university of Alabama police officers. The programme was sufficient to bring about change in the majority of fitness variables tested, cardio vascular endurance, muscular strength and endurance and power.

Alcaraz et al. (2013) The aim of this study was to determine the efficacy of a program of high-resistance circuit (HRC) training, and to compare the effects of HRC to traditional heavy strength (TS) training on strength, muscle size, body composition and measures of cardiovascular fitness in a healthy elderly population. Thirty-seven healthy men and women (61.6±5.3 years) were randomly assigned to HRC (n=16), TS (n=14), or a control group (CG, n=7). Training consisted of weight lifting twice a week for 12 weeks. Before and after the training, isokinetic peak torque
in the upper and lower body, and body composition (dual X-ray absorptiometry) were determined. In addition, cardiovascular parameters were evaluated during an incremental treadmill test. Both HRC and TS groups showed significant increases in isokinetic strength (p<0.001), and the increase was significant greater in the experimental groups than in CG (p<0.03). There were significant increases in lean mass (HRC, p<0.001; TS, p=0.025) and bone mineral density (HRC, p=0.025; TS, p=0.018) in the experimental groups. Only HRC showed a significant decrease in fat mass (p=0.011); this decrease was significantly greater in HRC than in CG (p=0.039). There were significant improvements in walking economy in the HRC group (p=0.049), although there were no statistical differences between groups. There were no changes in any variables in CG. Hence, HRC training was as effective as TS for improving isokinetic strength, bone mineral density and lean mass. Only HRC training elicited adaptations in the cardiovascular system decrease in fat mass. The biological aging process is associated with a structural and functional deterioration in most physiological systems, including the neuromuscular and cardiovascular systems. These age-related changes affect a broad range of tissues, organ systems and functions which, cumulatively, can negatively impact activities of daily living in older adults (Chodzko-Zajko et al., 2009).

Changing body composition is a hallmark of the physiological aging process, which has Abbreviations: BMD, bone mineral density; CG, control group; DEXA, dual X-ray absorptiometry; ECG, electrocardiogram; EE, energy expenditure; GPAQ, global physical activity questionnaire; HRC, high-resistance circuit; LM, lean mass; RM, repetition maximum; TS, traditional heavy strength; VCO, carbon dioxide production; VE, ventilation; VO2

Maria Raj et al. (2013) analysed the Comparative effects of Plyometric, Circuit Training and Circuit Breaker Programmes on Selected Motor Components of School Level Basketball Players. The purpose of the study was to compare the effects of plyometrics, circuit training and circuit breaker programmes on selected
motor components of school level basketball players. For the purpose of the study; four groups: three experimental groups viz: plyometrics training group (A), circuit training group (B), and circuit breaker programme group (C) and the fourth group served as the control group. Random group design was employed. Reliability coefficients for the test- re-test scores on selected motor components: Cardio respiratory endurance (1.5 mile Run) 0.87, Hip and back flexibility (Sit and Reach Test) 0.97, Spine flexibility (Bridge Up Test) 0.94, Shoulder flexibility (Shoulder Rotation Test) 0.97, Static balance (Stork Stand Test) 0.97, Dynamic balance (Modified Bass Test) 0.97 were selected to collect the data. To find out the comparative effects of plyometric training, circuit training and circuit breaker programme on selected motor components of school level Basketball players, analysis of covariance was employed, the proposed hypothesis was tested at 0.05 level of confidence. The result revealed significant improvement in most of the selected motor components. All the three experimental groups were effective in improving the Cardio respiratory endurance (1.5 mile Run), Hip, back and spine flexibility and also balance (static and dynamic). The plyometric groups were comparatively better than the circuit training group and circuit breaker programme in improving the Cardio respiratory endurance of the subjects. In the case of shoulder flexibility all the three experimental groups did not show any significant improvement.

Chaouachi et al. (2008) examine the influence of the sequence order of high-intensity endurance training and circuit training on changes in muscular strength and anaerobic power. Forty-eight physical education students (ages, 21.4 ± 1.3 years) were assigned to 1 of 5 groups: no training controls (C, n = 9), endurance training (E, n = 10), circuit training (S, n = 9), endurance before circuit training in the same session, (E+S, n = 10), and circuit before endurance training in the same session (S+E, n = 10). Subjects performed 2 sessions per week for 12 weeks. Resistance-type circuit training targeted strength endurance (weeks 1-6) and explosive strength and power (weeks 7-12). Endurance training sessions included
5 repetitions run at the velocity associated with $V^{\prime}o_{2\text{max}}$ ($V^{\prime}o_{2\text{max}}$) for duration equal to 50\% of the time to exhaustion at $V^{\prime}o_{2\text{max}}$; recovery was for an equal period at 60\% $V^{\prime}o_{2\text{max}}$. Maximal strength in the half squat, strength endurance in the 1-leg half squat and hip extension, and explosive strength and power in a 5-jump test and countermovement jump were measured pre- and post-testing. No significant differences were shown following training between the S+E and E+S groups for all exercise tests. However, both S+E and E+S groups improved less than the S group in 1 repetition maximum ($p < 0.01$), right and left 1-leg half squat ($p < 0.02$), 5-jump test ($p < 0.01$), peak jumping force ($p < 0.05$), peak jumping power ($p < 0.02$), and peak jumping height ($p < 0.05$). The intra-session sequence did not influence the adaptive response of muscular strength and explosive strength and power. Circuit training alone induced strength and power improvements that were significantly greater than when resistance and endurance training were combined, irrespective of the intersession sequencing.

**Newton, and. Kraemer et al. (2001)** conducted a study on low-volume circuit versus high-volume periodized resistance training in women. The purpose of this investigation was to determine the long-term training adaptations associated with low-volume circuit-type versus periodized high volume resistance training programs in women. Methods: 34 healthy, untrained women were randomly placed into one of the following groups: low-volume, single-set circuit (SSC; N = 12); periodized high-volume multiple-set (MS; N = 12); or non exercising control (CON) group (N = 10). The SSC group performed one set of 8-12 repetitions to muscular failure 3 d·wk-1. The MS group performed two to four sets of 3-15 repetitions with periodized volume and intensity 4 d·wk-1. Muscular strength, power, speed, endurance, anthropometry, and resting hormonal concentrations were determined pertaining (T1), after 12 wk (T2), and after 24 wk of training (T3). Results: 1-RM bench press and leg press, and upper and lower body local muscular endurance increased significantly ($P < 0.05$) at T2 for both groups,
but only MS showed a significant increase at T3. Muscular power and speed increased significantly at T2 and T3 only for MS. Increases in testosterone were observed for both groups at T2 but only MS showed a significant increase at T3. Cortisol decreased from T1 to T2 and from T2 to T3 in MS. Insulin-like growth factor-1 increased significantly at T3 for SSC and at T2 and T3 for MS. No changes were observed for growth hormone in any of the training groups.

Conclusion: Significant improvements in muscular performance may be attained with either a low-volume single-set program or a high-volume, periodized multiple-set program during the first 12 wk of training in untrained women. However, dramatically different training adaptations are associated with specific domains of training program design which contrast in speed of movement, exercise choices and use of variation (periodization) in the intensity and volume of exercise.

**Muthusubramanian and Chittibabu et al. (2011)** conducted a study on effect of sports specific circuit training on aerobic capacity of high school male basketball players during competitive season. The aim of this study was to evaluate the effectiveness of a basketball specific endurance circuit on improving aspects of aerobic capacity of school basketball players. Thirty male high school aged basketball players volunteered to participate in this study. These subjects were classified into two groups namely experimental and control group. The experiment group underwent 6 weeks 2 sessions per week of basketball specific endurance training this war carried out on an outdoor courts. This training was carried out during the competitive phase of the high school basketball season. Pre and post aerobic capacity was measured on the field. There was a statistical significance from pre to post testing in the experimental group ($p < 0.005$) and no statistical significance on control ($p > 0.05$) group. The basketball specific endurance circuit showed modest effect in improving aerobic fitness during the competitive season.
Park et al. (2011) conducted a study on effects of 12-week circuit weight training and aerobic exercise on body composition, physical fitness, and pulse wave velocity in obese collegiate women. The purpose of this study was to study the effects of 12 weeks of circuit weight training and aerobic exercise on body composition, physical fitness, and pulse wave velocity in obese collegiate women.

Twelve obese collegiate women were randomly assigned either to an exercise training group (TG) or control group (CG). The main exercise program was composed of an approximately 40–65 min session of circuit weight training (resistance training and aerobic exercise) as well as jogging at an intensity of 50–70% of the age-predicted heart rate reserve. The circuit weight training program was made by Korean Institute of Sport Science and was modified as needed for obese collegiate women. All analyses were performed using SPSS and all data was reported as mean ± standard deviation (SD). Significant differences between groups were determined using a two-way repeated measures analysis of variance (ANOVA) with a post hoc test (Turkey method). Statistical significance was accepted for all tests at a value of p < 0.05. The results indicated that after the 12-week intervention, there were no significant changes in body weight, % body fat, or WC in either group. There was a significant interaction of time by group with respect to body weight (p < 0.05), Department of Computer Software, Soon Chunyang University, Asan, South of Korea % body fat (p < 0.01), and WC (p < 0.01) and there was a significant change in back strength between the TG before beginning the program and the TG after having completed the program (p < 0.01). There was also a significant interaction of time by group with respect to back strength (p < 0.01), grip strength (p < 0.05), sit and reach (p < 0.01), sergeant-jump (p < 0.01), and the one leg balance with eyes closed (p < 0.01); however, these differences were not statistically significant between groups. Further, there was a significant interaction of time by group with respect to the 1,200 m run for cardiopulmonary endurance (p < 0.01); however, this difference was not statistically significant between the TG pre and TG post. In addition, there was a significant in sit-ups
(p \textless 0.01) and the 1,200 m run (p \textless 0.01) between the TG and CG. There was no significant difference in side-steps between the TG and CG. Further, there were no significant differences in the pulse wave velocity, RPP, SBP, DBP, and MAP between the TG and CG. In conclusion, circuit weight training and aerobic exercise had favourable effects on the occurrence of obesity and physical fitness in obese collegiate women.

Brentano et al. (2008) conducted a study on strength training (ST; high intensity/low volume/long rest) has been used in several populations, including children, young adults, and older adults. However, there is no information about circuit weight training (CWT; low intensity/high volume/short rest) in apparently healthy postmenopausal women. The purpose of the present study was to analyze the effects of high-intensity ST and circuit training on isometric strength (IS), upper limb dynamic strength (ULS) and lower limb dynamic strength (LLS), muscle activation of quadriceps (EMG quad), maximal oxygen uptake (V \( \text{\textemdash}_{\text{\textsuperscript{\textmax}}} \)), time to exhaustion (TE), and bone mineral density (BMD). Twenty-eight postmenopausal women were divided into 3 groups: 1) ST group (STG, n = 9, 45-80\% 1 repetition maximum (1RM), 2-4 sets, 20-6 reps), 2) circuit training group (CTG, n = 10, 45-60\% 1RM, 2-3 sets, 20-10 reps), and 3) a control group (CON, n = 9, no exercise). Significance level was defined as \( p \textless 0.05 \) for all analyses. After 24 weeks of training, increases were observed in STG and CTG. However, whereas in the STG, the IS (32.7\%), ULS (28.7\%), LLS (39.4\%), EMG quad (50.7\%), V \( \text{\textemdash}_{\text{\textsuperscript{\textmax}}} \) (22\%), and TE (19.3\%) increased, CTG showed changes only in IS (17.7\%), ULS (26.4\%), LLS (42.2\%), V \( \text{\textemdash}_{\text{\textsuperscript{\textmax}}} \) (18.6\%), and TE (16.8\%). BMD did not change in any experimental group. In the CON, there were no changes in the variables analyzed. Our results suggest that ST and circuit training positively affect postmenopausal women's muscular strength, muscular activation, and cardio respiratory fitness, with no changes in BMD.
Vega and Viciana et al. (2013) conducted a study on effects of a Circuit Training Program on Muscular and Cardiovascular Endurance and their Maintenance in Schoolchildren. The purpose of this study was to evaluate the effects of a circuit training program along with a maintenance program on muscular and cardiovascular endurance in children in a physical education setting. Seventy two children 10-12 years old from four different classes were randomly grouped into either an experimental group (n = 35) or a control group (n = 37) (two classes for each group). After an eight-week development program carried out twice a week and a four-week detraining period, the experimental group performed a four-week maintenance program once a week. The program included one circuit of eight stations of 15/45 to 35/25 seconds of work/rest performed twice. Abdominal muscular endurance (sit-ups in 30 seconds test), upper-limbs muscular endurance (bent arm hang test), and cardiovascular endurance (20-m endurance shuttle run test) were measured at the beginning and at the end of the development program, and at the end of the maintenance program. After the development program, muscular and cardiovascular endurance increased significantly in the experimental group (p < 0.05). The gains obtained remained after the maintenance program. The respective values did not change in the control group (p > 0.05). The results showed that the circuit training program was effective to increase and maintain both muscular and cardiovascular endurance among schoolchildren. This could help physical education teachers design programs that permit students to maintain fit muscular and cardiovascular endurance levels.

Babalola et al. (2011) conducted a study on effects of 8-weeks Circuit Training Programme on Physiological and Performance Characteristics of University Racket Game Players. The attainment and sustenance of excellent performance in any rating engagement via the adoptions of specific training method alone may be in doubt without special emphasizes on general fitness training methods. This study was carried out to examine the responses exhibited
by University of Ibadan racket game athletes concerning their physiological and performance characteristics following an 8-week circuit training programme. Multistage sampling technique was used to select 32 participants. The subjects were randomly selected (male and female) from four strata that made-up racket games in the University. These are: Badminton, Table tennis, Tennis and Squash. The subjects underwent training twice a week, for eight consecutive weeks. A single group quasi experimental design, otherwise known as repeated measure design was used for the study. Data collected were analyzed using descriptive statistics of mean, range and standard deviation for interpretations of research questions, while inferential statistics of paired t-test was adopted to confirm the significance of the stated hypotheses at the 0.05 level of significance. The results show that there was significant difference in the pretest-posttest responses of physiological variables measured (Resting diastolic and systolic blood pressure RDBP & RSBP, resting heart rate RHR and Body Mass Index BMI). The differences recorded for the performance characteristics of speed and agility was not significant. However, measurements of cardio respiratory endurance, general muscular endurance, arm muscular strength and flexibility showed statistically significant differences. It was recommended that racket games coaches and players should adopt regimental field training programme and engage in strenuous physical training to achieve better body compositions suitable for competitive engagement in their various sports.

**Olesen et al. (1981)** studied the effect of a set of circuit training programme on strength and muscular endurance of college age men (N = 42) enrolled in weight training classes, Pre and post- test for 1RM straight absolute muscular endurance and relative muscular endurance were given of two workout session per week of seven weeks. In each session students were requested to complete two set of ten exercises. Both sets of an exercise were completed a student moved to the next activity. A work result ratio of 20 sec/10 sec was used. The test/ retest procedure and pre and post test means changes were analysed.
using person's 'r' and dependent 't' analysis. Men changes between pre and post tests for 1 RM strength in the bench press and by press, and relative muscular endurance in the bench press were significant (p < 0.05) no significant change in relative muscular endurance in the leg press (p < 0.05).

Simmons et al. (1967) studied the effect of circuit training upon cardiovascular condition and motor performance. Fifteen male students physical education course were the subjects. The training was done twice in 9 week in thirty minutes of period for value weeks. The results of this study showed statistically significant mean improvement in nine to fourteen cardiovascular variables and in all thirteen motor fitness variables. Highest mean improvement observed in dynamometrical leg strength, dips and shoulder extension and flexibility.

Miller et al. (1969) investigated the effectiveness of circuit training and weight training on upper body strength in ninth grade boys (N=50). The boys were administrated the Oregon simplification of Rogers's physical fitness index to assess the development of the upper body strength. After a six week training programme both weight training and circuit training programs produced significant gains in upper body with circuit gain being greater.

Randal R. Kirk et al. (1969) in his study effects of circuit training on running half a mile for mid three groups, the first group (N=30) used interval training in the second had (N=30) circuit training addition to interval training and the third group (N=20) acted as the control group. The interval running programme was identified for both the experimental groups and was progressive included a battery of eight exercise with the objective of completing a circuit (consisting of three complete sets of exercise) in less time during each training session. The control group had instruction in Badminton. The experiment was conducted on alternate days, over an eight weeks period. The results showed that the interval training and the circuit training groups were significantly faster than the control group. No significant differences were found between the interval running group and the circuit training group.
Naghibzadesh et al. (1987) investigated a study to determine if circuit training could be an effective method to improve aerobic capacity as well as strength. 47 female volunteers were assigned to circuit training, jogging and control group. Each subject was tested prior and at the end of eight weeks training period on vo2 max and 1rm bench press and leg press. Based on result of this investigation there was a 12% and 9.6% increase in vo2 max for the circuit training and jogging group respectively. The circuit training group improved 28.1% in leg press and 20.1% in bench press. There was no significant increase for the jogging group in strength parameters however there was a positive changes in leg press. The control group did not change significantly in any variable.

Dealy et al. (1960) studied two groups of children and administered the five items of Washington state elementary school physical education test, before and after an eight week programmed. Both the groups had regular physical education class four days a week for twenty minutes spent the remaining six minutes in either equal exercise or circuit training. The squad exercise showed improved in only one item, but the circuit training group improved in all item and their total physical fitness improvement was significant at the 0.01 level of confidence. In the university of Massachusetts, men college student between 21 and 234 randomly assigned into three group s and were given training programme thrice a week experimental group was given five minutes circuit exercise and twenty five minutes games. Experimental group 2 was given ten minutes circuit exercise and fifteen minutes game. The circuit consisted of bench steps, Pushups, leg changes, Squat thrust, sit ups and pull ups. The games were basket ball, soccer, touch football, tough rugby and volley ball. The results showed experimental group 1 had obtained better but lower performance on beach steps when compared with experimental group 2.
Gettman & Pollock, et al. (1980-81) have conducted an extensive review of the research that has been conducted in the area of circuit training and derived the advantages (a) It is an activity that attends to the major components of athletic fitness, (b) It can be conducted in a very small area (small room with a multi station weight training machine); and (c) the complete workout (3sets) can be completed in less than 30 minutes. Further, the work out can be highly motivating.

Allen et al (1976) investigated a new concept in training that has a great deal of application for off-season conditioning. Thus emerged the circuit training concept with traditional weight training into a form of training, now referred circuit weight training.

Hamrick et al. (1968) made a comparative analysis of the three days a week and two days a week schedules of circuit training. Two groups of male college freshmen (N = 22) were formed and they participated in an eight weeks circuit training programme which consisted of three hours of conditioning per week using an analysis of variance. It was found that the Monday - Wednesday Friday group, was significantly better, to the Tuesday - Thursday group. However, the data revealed no significant difference in improvement by either group in any other component of fitness. The 'F' ratio obtained for difference in pre and post test measures revealed significant improvement for both group in recovery pulse, agility, flexibility, arm strength, leg strength and abdominal strength. The Monday Wednesday and Friday group was also successful in improving terminal pulse.

2.2 STUDIES ON AEROBIC TRAINING

Hoff et al. (2002) to examine the effects of maximal strength training with emphasis on neural adaptations on strength- and endurance-performance for endurance trained athletes. Nineteen male cross-country skiers about 19.7 ± 4.0 years of age and a maximal uptake VO2 max) of 69.4 ± 2.2 ml x kg−1 x min−1 were randomly assigned to a training group (n =9) or a control group (n = 10).
Strength training was performed, three times a week for 8 weeks, using a cable pulley simulating the movements in double poling in cross-country skiing, and consisted of three sets of six repetitions at a workload of 85% of one repetition maximum emphasizing maximal mobilization of force in the concentric movement. One repetition maximum improved significantly from $40.3 \pm 4.5$ to $44.3 \pm 4.9$ kg. Time to peak force (TPF) was reduced by 50 and 60% on two different sub maximal workloads. Endurance performance measured as time to exhaustion (TTE) on a double poling ski ergo meter at maximum aerobic velocity, improved from 6.49 to 10.18 min; 20.5% over the control group. Work economy changed significantly from $1.02 \pm 0.14$ to $0.74 \pm 0.10$ ml x kg$^{0.67}$ x min$^{-1}$

Maximal strength training with emphasis on neural adaptations improves strength, particularly rate of force development, and improves aerobic endurance performance by improved work economy.

Gamelin et al. (2009) conducted a study was designed to examine peak Vo$_2$ responses of prepubescent children following a 7-week aerobic training. Twenty-three boys and thirty girls (9.7 ± 0.8 years) were divided into a high intensity experimental group (HIEG: 20 girls and 13 boys) and a control group (CG: 10 girls and 10 boys). A graded 20-m shuttle run with measurement of gas exchange values was performed prior to and after the 7-week training program. The test consisted of a 3-min run at 7 km x h$^{-1}$ to determine energy cost of running, immediately followed by a 20-meter shuttle run test. HIEG had two 30 min-sessions of short intermittent aerobic training per week at velocities ranging from 100 up to 130 % of the maximal aerobic speed. For HIEG, absolute peak Vo$_2$ (9.1 %) and relative to body mass peak Vo$_2$ (8.2 %) increased significantly ($p < 0.001$); it was unchanged in the CG. Similarly, maximal shuttle run improved significantly in HIEG (5.1 %, $p < 0.001$). In contrast, there was no significant change for CG. For both groups energy cost of running remained unchanged. These findings show that prepubescent children could significantly increase their peak Vo$_2$ and maximal shuttle velocity with high intensity short intermittent aerobic exercises.
Isler and Kosar et.al (2006) studied the effect of step aerobics training on anaerobic performance of men and women. The purpose of this study was to investigate the effects of 10 weeks of step aerobics training on anaerobic performance of men and women. College-age volunteers (64 women and 54 men) were divided into step aerobics (33 women, 27 men) and control (31 women, 27 men) groups. Before and after the 10-week period, the subjects' body composition, muscular strength, Wingate anaerobic performance, and vertical jump anaerobic performances were determined. The step aerobics group participated in step aerobics sessions of 50 minutes per day, 3 days per week for 10 weeks, at 60–80% of their heart rate reserve. Results of $2 \times 2$ analysis of covariance with repeated measures indicated significant sex differences in percentage body fat, lean body mass, muscular strength, and in all of the measured indices of the Wingate Anaerobic Test. The step aerobics group showed significant improvement only in mean power relative to body weight compared with the control group and women showed significant improvement only in anaerobic power of vertical jump when compared with men. It can be concluded that 10 weeks of step aerobics was not effective in improving all of the measured anaerobic indices in men and women.

Soh et.al (2012) analysed the impact of an eight-week aerobic and strength-training programme on agility and leg power of Malaysian netball players. The purposes of the study were: (1) to determine the agility and leg power among Malaysian national junior netball players and (2) to determine the impact of eight-week aerobic and strength-training programme on these two variables. A total of 21 netball players from Bukit Jalil Sport School were selected as the subjects in this study. The SEMO Agility Run test was used to determine the agility level while leg power was measured using the Vertical Jump test. Pre-test and post-test results showed no significant differences in the agility and leg power level among the netball players. The mean values for the agility and leg
power post-test were 12.59 (SD = 0.56) seconds and 50.24 (SD = 4.90) cm respectively. The pre-test and post-test results for different playing positions recorded the highest improvement in agility and leg power among attacker, followed by centre, and defender. Thus, the training conducted in this study was found to have improved agility and leg power marginally, especially among attacker and centre netball players. (JUMMEC 2007; 10(1): 25-28)

Rachel and Steve et.al (2010) investigate the effect of sequence of resistance and aerobic training on energy consumption on sedentary overweight females. Participants were 15 sedentary overweight females (age = 28.6 ±12 yrs; BMI = 28.1±7.8) Subjects did a counterbalanced intervention: resistance training (circuit training) first (intervention RT) or aerobic exercise first (intervention AT), while oxygen consumption was continuously measured for 80 min. Subjects performed a warm-up on the treadmill at 40% of their heart rate reserve for 5 minutes, then for 30 minutes did continuous walking or jogging on the treadmill at ~67% of their predicted maximum heart rate reserve. Immediately following treadmill exercise, subjects performed 25 minutes of resistance exercises including 2 sets of 12 reps at 67% of their 1RM of each exercise. Cool down consisted of five minutes on the treadmill with a gradual decline in speed. The energy used during the AT intervention was 431.2 ± 90.9 kcals compared to the RT intervention 398.3 ± 93.9 kcals. The mean difference was significant, (p=0.003). Based on the results of this study, aerobic exercise preceding resistance training has a greater impact on total energy consumption in females versus the reverse order.

Paavolainen et.al (1999) investigated the effects of simultaneous explosive strength and endurance training on physical performance characteristics of 10 experimental (E) and 8 control (C) endurance athletes who trained for 9 weeks. The total training volume was kept the same in both groups, but 32 % of training in E and 3 % in C were replaced by explosive type strength training. A 5 km time trial (5k) running economy (RE), maximal 20 m speed (VO₂ max) and 5 jump (5J)
tests were measured on a track. Maximal anaerobic (MART) and aerobic treadmill running tests were used to determine maximal velocity in the MART (VMART) and maximal oxygen uptake (O₂ max). The 5K time, RE and VMART improved (P < 0.005) in E, but no changes were observed in C. VO₂ max and 5J increased in E (P < 0.01) and decreased in C (P < 0.001). O₂ max increased in C (P<0.05), but no changes were observed in E. In the pooled data, the changes in the 5K velocity during 9 week of training correlated (P<0.05) with the changes in RE (O₂ up take (r = 0.54) and VMART (r = 0.55). In conclusion the present simultaneous explosive strength and endurance training improved the 5K time in well – trained endurance athletes without changes in their O₂ max. This improvement was due to improved neuro muscular characteristics that were transferred into improved VMART and running economy.

**Van Zant and Bouillon et.al (2007)** investigated the effects on muscular strength and aerobic conditioning. The strength cycle ergo meter has been proposed as a method of simultaneously increasing aerobic conditioning and muscular strength, because of its unique capacity of disengaging the pedal crank, thus allowing for concurrent single-leg cycling. The purpose of this study was to assess the aerobic and muscular strength effects of strength cycle training (SCT), comparing it to similar standard cycle training. A total of 28 recreationally trained adult subjects (9 men, 19 women) were paired for VO₂peak and randomly assigned to either SCT or Monark cycle training (MCT). Subjects trained 3 days per week following a progressive interval protocol for 9 weeks under supervised conditions. Training intervals (5 minutes' duration) consisted of 3 minutes of standard cycling at an intensity of 60–85% of maximum heart rate (HR max), and 2 minutes of either the disengaged cycling mode (SCT) or standard cycling plus 30 W (MCT). Subjects began training for a total of 25 minutes per session, progressing to 45 minutes per session by study's end. Prior to and following training, subjects were measured for VO₂peak; sub maximal VO₂, heart rate (HR),
RPE, power output, and knee and ankle isokinetic strength. Training resulted in significant ($p < 0.05$) increases in $\dot{V}O_2$peak (14.5%) and sub maximal power output (11%), and significant reductions in sub maximal $\dot{V}O_2$, HR, and RPE in both groups. Significant increases in bilateral isokinetic knee extension (4–6%) and left ankle plantar flexion (10.5%) was noted following training in both groups. No group differences were detected in any variable. Although the strength cycle effectively increased aerobic function and resulted in modest selected increases in lower-extremity muscular strength, these changes were not different from those seen using a similar standard cycling protocol.

Patricia CH Wong et al. (2008) studied the effects of a 12-week twice weekly additional exercise training, which comprised a combination of circuit-based resistance training and aerobic exercises, in additional to typical physical education sessions, on aerobic fitness, body composition and serum C-reactive protein (CRP) and lipids were analysed in 13- to 14-year-old obese boys contrasted with a control group. Both the exercise group (EG, n = 12) and control group (CG, n = 12) participated in the typical 2 sessions of 40-minute physical education (PE) per week in schools, but only EG participated in additional 2 sessions per week of 45 to 60 minutes per session of exercise training, which comprised a combination of circuit-based resistance training and aerobic exercises maintained at 65% to 85% maximum heart rate (HR max = $220 - \text{age}$). Body composition was measured using dual energy X-ray absorptiometry (DEXA). Fasting serum CRP and blood lipids were analyzed pre- and post exercise programme. Aerobic fitness was measured by an objective laboratory sub maximal exercise test, PWC170 (Predicted Work Capacity at HR 170 bpm). Exercise training significantly improved lean muscle mass, body mass index, fitness, resting HR, systolic blood pressure and triglycerides in EG. Serum CRP concentrations were elevated at baseline in both groups, but training did not result in a change in CRP levels. In the CG, body weight increased significantly at the
end of the 12-week period. This study supports the value of an additional exercise training programme, beyond the typical twice weekly physical education classes, to produce physiological benefits in the management of obesity in adolescents, including prevention of weight gain.

Knuttgen et al (2007) conducted a study on strength training and aerobic exercise: comparison and contrast. Most exercise programs for conditioning and rehabilitation are oriented to strength development, aerobic (cardiovascular) fitness, or a combination of the 2. Because the 2 types of exercise are located at the opposite extremes of a muscular power continuum, the design of a program must be highly specific with regard to the exercise to be undertaken, as well as the intensity, duration, and frequency, in order to attain optimal results. Strength exercise programs involve weight training or the use of high-resistance machines with exercise that is limited to a few repetitions (generally less than 20) before exhaustion. Aerobic exercise involves exercise performed for extended periods (e.g., 10–40 minutes) with large muscle activity involving hundreds of consecutive repetitions that challenge the delivery of oxygen to the active muscles. The chronic physiological adaptations and the variables in program design are highly specific to the type of exercise performed.

Glaister and Moir et.al (2006) examine the aerobic and anaerobic correlates of multiple sprints cycling performance. The aims of this study were to examine (a) the relationship between maximal oxygen uptake (\( \dot{V}O_2\max \)) and several performance indices of multiple sprint cycling; (b) the relationship between maximal accumulated oxygen deficit (MAOD) and those same performance indices; and (c) the influence of recovery duration on the magnitude of those relationships. Twenty-five physically active men completed a \( \dot{V}O_2\max \) test, a MAOD test, and 2 maximal intermittent (20 × 5 seconds) sprint cycling tests with contrasting recovery periods (10 seconds or 30 seconds). Mean ± SD for age, height, and body mass were 20.6 ± 1.5 years, 177.2 ± 5.4 cm, and 78.2 ± 8.2 kg, respectively. All tests were conducted on a friction-braked cycle ergometer with
subsequent data normalized for body mass. Moderate \(0.3 \leq r < 0.5\) positive correlations were observed between power output data and MAOD (range, 0.31–0.46; 95% confidence limits, −0.10 to 0.72). Moderate to large positive correlations also were observed between power output data and \(\dot{V}O_2\text{max}\), the magnitude of which increased as values were averaged across all sprints (range, 0.45–0.67; 95% confidence limits 0.07–0.84). Correlations between fatigue and \(\dot{V}O_2\text{max}\) were greater in the intermittent protocol with 30-second recovery periods \(r = −0.34\); 95% confidence limits, 0.06 to −0.65). The results of this study reflect the complex energetic associated with multiple sprint work. Though the findings add support to the idea that multiple sprint sports demand a combination of speed and endurance, further longitudinal research is required to confirm the relative importance of these parameters.

**Drummond et.al (2005)** conducted a study on aerobic and resistance exercise sequence affects excess post exercise oxygen consumption. Excess post exercise oxygen consumption (EPOC) may describe the impact of previous exercise on energy metabolism. Ten males completed Resistance Only, Run Only, Resistance-Run, and Run-Resistance experimental conditions. Resistance exercise consisted of 7 lifts. Running consisted of 25 minutes of treadmill exercise. \(\dot{V}O_2\) was determined during treadmill exercise and after each exercise treatment. Our findings indicated that treadmill exercise \(\dot{V}O_2\) was significantly higher for Resistance-Run compared with Run-Resistance and Resistance only at all time intervals. At 10 minutes post exercise, \(\dot{V}O_2\) was greater for Resistance Only and Run-Resistance than for Resistance-Run. At 20 and 30 minutes, \(\dot{V}O_2\) following Resistance Only was significantly greater than following Run Only. In conclusion, EPOC is greatest following Run-Resistance; however, treadmill exercise is more physiologically difficult following resistance exercise. Furthermore, the sequence of resistance and treadmill exercise influences EPOC, primarily because of the effects of resistance exercise rather than the exercise combination. We recommend performing aerobic exercise before resistance exercise when combining them into 1 exercise session.
Kosar et al. (2006) conducted a study on effect of step aerobics training on anaerobic performance of men and women. The purpose of this study was to investigate the effects of 10 weeks of step aerobics training on anaerobic performance of men and women. College-age volunteers (64 women and 54 men) were divided into step aerobics (33 women, 27 men) and control (31 women, 27 men) groups. Before and after the 10-week period, the subjects' body composition, muscular strength, Wingate anaerobic performance, and vertical jump anaerobic performances were determined. The step aerobics group participated in step aerobics sessions of 50 minutes per day, 3 days per week for 10 weeks, at 60–80% of their heart rate reserve. Results of 2 × 2 analysis of covariance with repeated measures indicated significant sex differences in percentage body fat, lean body mass, muscular strength, and in all of the measured indices of the Wingate Anaerobic Test. The step aerobics group showed significant improvement only in mean power relative to body weight compared with the control group and women showed significant improvement only in anaerobic power of vertical jump when compared with men. It can be concluded that 10 weeks of step aerobics was not effective in improving all of the measured anaerobic indices in men and women. Aerobic exercise is to a healthy cardiovascular system. Aerobic exercise is an activity can be sustained for an extended period of time without building an oxygen department in the muscle. It is a type of exercise that over the heart and lungs causes them to work harder than them do when person is a rest, Charles (1983).

Bloomer et al. (2005) conducted a study on energy cost of moderate-duration resistance and aerobic exercise. The purpose of this study was to compare energy expenditure of resistance and aerobic exercise matched for total time and relative intensity. Ten trained men (24.3 ± 3.8 years) performed 30 minutes of intermittent free-weight squatting at 70% of 1 repetition maximum and continuous cycling at 70% of VO2max, in a crossover design. VO2, kilocalories (kcal), work, respiratory
exchange ratio (RER), $V_E$, heart rate (HR), and rating of perceived exertion (RPE) data were recorded. Cycling resulted in greater total $\text{VO}_2$ (87 ± 3 vs. 53 ± 3 L, mean ± $SEM$), kcal expenditure (441 ± 17 vs. 269 ± 13), and work (335 ± 11 vs. 128 ± 11 kJ) than squatting did. The mean RER was greater during squatting (1.03 ± 0.01 vs. 0.94 ± 0.01), and the $V_E$ values were greater during cycling (82 ± 3 vs. 70 ± 3 L·min$^{-1}$). The HR response was nearly identical between exercise modes (160 ± 5 vs. 160 ± 4 bpm), whereas the RPE was greater during squatting (16.96 ± 0.41 vs. 14.88 ± 0.42). These data suggest that although lower than similarly matched aerobic exercise, resistance exercise resulted in an energy cost that would meet the recommendations for kcal expenditure as suggested by the American College of Sports Medicine, if performed 4–5 days per week. These findings should be considered by coaches and trainers working with individuals mutually interested in muscular development and weight management, because programs of structured resistance exercise may assist with both.

**J. Helgerud, et.al.2001** The aim of the present study was to study 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 after training. In the training group: a) maximal oxygen uptake ($\text{Vo}_2\text{max}$) 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 < .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 +/- .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.

**Alpert et al. (1990)** Investigated effects of aerobic exercise on 24 3–5 yr olds. 30 min of aerobic exercises were provided daily for 8 wks for 12 Ss, while the remaining 12 Ss engaged in free play on the school playground. Ss were given pre- and post-test on a sub maximal exercise test on a paediatric bicycle (baseline and 3 workloads), an agility test, a health knowledge test, a self-esteem scale, and an observational measure of their gross-motor activity. Despite comparability on pre-test, the aerobic exercise group showed significant decreases in heart rate at all 3 workloads as well as increases in agility and self-esteem following the exercise program.

### 2.3 STUDIES ON CARDIO AEROBIC CIRCUIT TRAINING

**Patricia et al. (1994)** studied the effects of 12 Weeks of Aerobic Circuit Training on Aerobic Capacity, Muscular Strength, and Body Composition in College-Age Women-This study determined the effects of a combined aerobic and circuit weight-training program on maximal oxygen consumption, body composition, and muscular strength of college-age women. Of the 33 who volunteered to participate, 17 were randomly assigned to the exercise program while the remaining 16 served as controls. The training involved a 45-min circuit of 30 activities including five 3-min aerobic exercises and 25 30-sec weight training or callisthenic exercises. The subjects exercised at 40 to 50% of their 1-RM for each weight station. Workloads for the aerobic stations were assigned
based on the workload needed to elicit 75 to 85% of the maximal heart rate reached during the VO$_2$ max test. Data were analyzed using repeated measures ANOVA with significance established at $p < 0.05$. The exercise group had significant increases in VO$_2$ max, upper body strength, and lower body strength, and significant decreases in skin fold sum and percent body fat. This indicates that an aerobic circuit weight-training program is an effective way to improve cardiovascular fitness, body composition, and muscular strength in college-age women.

**Jurimae et al. (2000)** conducted a study to compare circulatory responses to circuit weight (CWT) and aerobic walking training sessions of similar energy cost in 33 middle-aged pre-menopausal overweight females participated in the experiment. Individual physical working capacity (PWC) was measured using cycle ergo meter test. A circuit weight training session consisted of leg extension, bench press, sit-ups, and leg-press exercise. The subject performed four circuits at the maximal possible speed, using a work to rest period between the exercise and the heart rate was recorded continuously. During the walking fast as possible on the indoor track. The total energy cost of the waking training session was the same as during CWT session, approximately 270 kcal, and accelerometer, heart rate and blood pressure were measured every 5 min during the walking training session. The PWC index was significantly ($P<0.05$) higher in the overweight group comparison with the control females (215.4 +/- 76.1 and 187.9 +/- 42.4 w, respectively). The resting blood pressure was normal in both groups ($< 140/90$mm Hg). Heart rate was between 120 and 140 beats min$^{-1}$ during CWT and weight training session were acceptable forms of physical activity to increase cardiovascular fitness in middle-aged overweight and normal body weight females.

**Marcinik et al. (1987)** conducted a comparative study on Aerobic/calisthenics and aerobic/circuit weight training program for navy men: study I, participants were 43 navy men (mean age =32.1 years) assigned to one of three exercise training protocol: Aerobic/CWT performed at either 40% or 60% of
determined one reputation maximum strength or Aerobic/ calthenics training. During the 10 week study, each exercise group participated in three training session per week performed on alternate days. The result of this study indicates that dynamic strength (both upper and lower) increased for the Aerobic/CWT group but not for the Aerobic/calthenics group. With exception of bench press endurance for the Aerobic/calthenics group, all groups should significance increased in muscular endurance and stamina. No significant changes were seen in static strength or flexibility in any of the group. Study II subject were 87 male navy personal (mean age = 19.8 years) receiving basic training at the recruit training command, san Diego, CA, one company of recruits(N=41) participated in an experimental Aerobic/CWT program at &0% of determined one reputation maximum. A second company (N=46) received the standard navy recruits physical training program (Aerobic/calthenics training). During the eight-week study both group participated in an identical running performed 3 times per week on alternate days. Additionally, Aerobic/CWT participants completed 2 circuits (1 circuit =15 exercises) three times per week on alternate days to running. Study finding show the experimental Aerobic/CWT program produced significantly greater dynamic strength and muscular endurance changes than the standard Aerobic/calthenics program.

**Moir et al (2006)** conducted a study on aerobic and anaerobic correlates of multiple sprints cycling performance. The aims of this study were to examine (a) the relationship between maximal oxygen uptake ($\dot{V}O_2$$_{max}$) and several performance indices of multiple sprint cycling; (b) the relationship between maximal accumulated oxygen deficit (MAOD) and those same performance indices; and (c) the influence of recovery duration on the magnitude of those relationships. Twenty-five physically active men completed a $\dot{V}O_2$$_{max}$ test, a MAOD test, and 2 maximal intermittent (20 × 5 seconds) sprint cycling tests with contrasting recovery periods (10 seconds or 30 seconds). Mean ± SD for age, height, and body mass were 20.6 ± 1.5 years, 177.2 ± 5.4 cm, and 78.2 ± 8.2 kg, respectively.
All tests were conducted on a friction-braked cycle ergometer with subsequent data normalized for body mass. Moderate \(0.3 \leq r < 0.5\) positive correlations were observed between power output data and MAOD (range, 0.31–0.46; 95% confidence limits, −0.10 to 0.72). Moderate to large positive correlations also were observed between power output data and \(\dot{V}O_2\)max, the magnitude of which increased as values were averaged across all sprints (range, 0.45–0.67; 95% confidence limits 0.07–0.84). Correlations between fatigue and \(\dot{V}O_2\)max were greater in the intermittent protocol with 30-second recovery periods \((r = −0.34; 95\% \text{ confidence limits, } 0.06 \text{ to } −0.65)\). The results of this study reflect the complex energetic associated with multiple sprint work. Though the findings add support to the idea that multiple sprint sports demand a combination of speed and endurance, further longitudinal research is required to confirm the relative importance of these parameters.

**Benerakis et al. (1983)** examine the training affect of an upper body circuit training programme on heart rate and oxygen uptake conducted a study on the training affect of an upper body circuit training programme on heart rate and oxygen uptake training programme extended to eight weeks. Subjects included 8 college students (5 men, 3 women) with a control group of 4 men and 4 women. Training consisted of 8 exercises one circuit a day. Subjects exercises at a percentage of their weight for a specific number of repetition as developed by **vitace (1973)**. Control and experimental group was pre and post test using physical work capacity test on bicycle ergometer. Result showed that following the training period, the experimental group showed no significant decrease in resting heart rate but significant increase was in \(\text{vo2 max}\) of the group.

**Foley et al. (1986)** investigate the effect of aerobic circuit training programme on predicted oxygen uptake of pubescent children Conducted a study on the effect of aerobic circuit training programme on predicted oxygen uptake of pubesont children. A conducted sub max bicycle ergometer test for prediction of
maximal oxygen uptake was used to determine the effect of 8 weeks of training on 15 volunteer’s student’s age 10-11 years. Subjects for the study were randomly programme school v grade class. The experimental group trained three times per week for 8 weeks in a circuit training programme at a target rate of 70% of age predicted vo2 max for 30 minutes per section acting as control group, 12 students participated in organized game and sport activities for equivalent periods o time. a pre test and post test design utilizing ANCOVA revealed no significant difference at the 0.05 level between group.

**Gotshalk et al. (2004)** conducted a study on cardiovascular responses to a high-volume continuous circuit resistance training protocol. The treadmill maximal test provides important maximal VO2 and HR data from which the physiological measures during the circuit performance can be evaluated. It is consequential to note that all subjects followed the same circuit sequence, but started the circuit at different points. This scientific control helped to better substantiate the physiological results. Inspecting Figure 1, it is clear that the %maximum heart rate was much higher than the %maximum VO2 response. Although this study did not investigate physiological mechanisms of HR to VO2 responses to exercise, it should be noted that previous research has demonstrated that the use of arm variations (overhead, in front, and to side as with the exercises used in the circuit) often leads to a differential increase in exercise HR as compared to VO2. The important practical implication is that HR alone may be an inaccurate indicator of the actually oxygen consumption (and thus caloric expenditure) of a circuit training protocol.

**Marchini et al. (2009)** studied the circuit weight training jogging in metabolic risk factors of overweight / obese women. Resisted and aerobic exercises are recommended to reduce weight and improve health, but which exercise modality offers the best results is still unclear. The aims of this study were to compare circuit weight training (CWT) with jogging (JOGG) on multiple
cardiovascular disease (CVD), metabolic risk factors and fitness of overweight and obese women (body composition, lipid profile, uric acid, glucose, metabolic equivalent (MET), heart rate, blood pressure, flexibility, resting energy expenditure (REE) and nitrogen balance (NB)). Fifty women were randomly divided in two groups, but only 26 finished it: CWT (n=14; 36+/− 12 years old; body mass index, BMI=32+/− 7 kg/m(2)) and JOGG (n=12; 37+/− 9; BMI=29+/− 2). The first month of training consisted of 60 min x 03 days/week and the second month of training consisted of 04 days/week for both protocols and a dietary reduction. Both groups reduced total body mass, fat body mass, BMI, plasma uric acid and increase in MET (p<0.05); there was no change in lean body mass, REE and resting heart rate. CWT reduced total cholesterol, plasma triglycerides, NB and increased flexibility; JOGG reduced waist/hip ratio, glucose, systolic blood pressure, high-density lipoprotein cholesterol, and increased the total cholesterol/high-density lipoprotein cholesterol ratio (p<0.05). Both protocols improved CVD and metabolic risk factors. The CWT presented favourable changes regarding lipid profile and flexibility; JOGG on glucose, waist/hip ratio and blood pressure. These results suggest that resisted exercise combined with aerobics should be considered for obese people. Nevertheless, regarding some basal differences between the groups, it was not possible to conclude that changes were due to exercise type or intra-group variability.

**Petersen SR et.al (1989)** studied the influence of high-velocity circuit resistance training on VO2max and cardiac output. In order to investigate the influence of high-velocity circuit resistance training on maximal aerobic power, maximal stroke volume and cardiac output, and blood lactate removal during recovery, 16 habitually active males were blocked on initial VO2max into either training or control groups. The training group completed two (weeks 1 and 2) or three (weeks 3-6) circuits of 10 variable-resistance hydraulic exercise stations at an exercise: relief ratio of 1:2 on alternate days over six weeks. Angular velocities
of movement were maintained at approximately 3.1 rad.s\(^{-1}\). Following training, the VO\(_{2}\)max was increased (p less than .01) from 4.32 to 4.68 l.min\(^{-1}\). Maximal stroke volume was increased (p less than .05) from 120 to 129 ml and heart rate response to an absolute sub maximal exercise load was decreased (p less than 0.05) from 153 to 146 beats.min\(^{-1}\). As well, enhanced (p less than .01) removal of lactate from the blood was observed during recovery from exhausting exercise. No changes were observed for control subjects. These results indicate that positive alterations in aerobic and cardiovascular function may be achieved consequent to high-velocity circuit resistance training.

**Bhambhani Y et al. (2005)** analyzed the effects of circuit training on body composition and peak cardio respiratory responses in patients with moderate to severe traumatic brain injury. To examine the time course of the changes in body composition and peak cardio respiratory fitness resulting from routine brain injury rehabilitation program (BIRP) activities and circuit training in patients with moderate to severe traumatic brain injury (TBI). Time-series design spanning 18 weeks. Trials T1 and T2 were completed in weeks 1 and 2, respectively, to establish reliability of the measurements, followed by trial 3 (T3) 4 weeks later to evaluate changes resulting from the BIRP. BIRP in a community rehabilitation hospital. Fourteen in patients with moderate to severe acquired TBI (Glasgow Coma Scale score, 4.6+/−1.4; time since injury, 17.2+/− 17 mos). Twelve-week circuit-training program designed to enhance muscular strength and endurance and aerobic fitness. Subjects were tested midway (T4) through the program and at the end (T5) of 12 weeks. The patients completed an average of 32 supervised sessions, each lasting 1 hour. Changes in body composition and peak cardio respiratory responses no significant changes were observed in the body mass or percentage body fat during the study. The peak values of power output, oxygen uptake, and ventilation rate increased significantly as a result of training, with no concomitant increases in peak heart rate or blood lactate (T5>T3, T2, T1; P <.05).
No significant changes were evident midway through training. In a heterogeneous sample of patients with moderate to severe TBI, (1) body composition and peak cardio respiratory responses remained fairly stable during 6 weeks of BIRP activities, (2) improvements in peak cardio respiratory fitness required more than 6 weeks of circuit training, and (3) a 12-week course of circuit training without controlling caloric intake was not effective in reducing body weight or percentage body fat.

**Edward et al. (1970)** conducted a study on the effect of circuit training weight lifting and interval training on cardio-respiratory endurance. Fifty one college males from developmental physical education classes at the university, of New Mexico were randomly assigned to one of the three-exercise programme. The subjects trained for ten weeks period at their respective exercise programme. Pre-test post-test measures of cardio-respiratory endurance were administered under same experimental condition. The ANOVA showed no significant differences between the three exercise programmes in the measures of cardio-respiratory endurance.

**Michael et al. (2006)** examine the effect of aerobic and interval circuit training on fitness and body image among women. Seventy-two college females were assessed for physical fitness and nine body image components defined in the Body Self-Image Questionnaire (BSIQ). Participants were non-randomly assigned, using intact groups, to one of three exercise programs (i.e., experimental conditions), aerobic exercise training (n = 23), interval circuit training (n = 28), or no vigorous exercise (control; n = 21) programs, completed over 12 weeks. A 3 (groups) x 2 (time) repeated measures MANOVA with follow-up Univariate ANOVAs were computed to determine the extent to which the exercise intervention influenced body image. Results indicated significantly improved fitness scores for the aerobics/strength circuit training group. For the body image dependent variables, the interval circuit training group experienced the greatest improvement, specifically in overall appearance evaluation, health/fitness evaluation, health/fitness influence,
and reduced negative effect. It was concluded that an interval program of aerobic, anaerobic, and strength training is more beneficial in improving body image than either aerobic exercise alone or no exercise.

Gettman et al. (1978) studied the effect of circuit weight training on strength, cardio respiratory functions, and body composition of adult men. The purpose of this study was to determine the changes elicited by circuit weight training (CWT) and running (RN) programs conducted 3 days/week for 20 weeks. Subjects were randomly assigned to one of three groups: CWT (n = 11); RN (n = 16); and control (n = 14). CWT consisted of 10 exercises performed in 2 sets of 15 reps with 20 to 25 sec rest between exercises. CWT workout time decreased from 30 min to 23 min; exercise heart rate (HR) increased from 79% to 84% max; average weight increased from 42% to 56% of max 1 RM strength and total weight increased 81% (1506 to 2720 lbs/workout). The RN group exercised at 85% max HR for 23 to 27 min/workout. Multivariate and step-down analyses showed the CWT group to be significantly different from the control group at the end of 20 weeks in leg press strength, fat weight, and Vo2 max (1/min). The RN group was significantly different from the CWT group in Vo2 max and treadmill time. Univariate analyses revealed no differences between the CWT and control groups in Vo2 max expressed as ml/kg LBW.min but did show a significant superiority of the RN group over the other two groups in this variable. It was concluded that the CWT program was most specific in improving strength and changing body composition and produced only a small aerobic effect as measured on the treadmill running test.

isoinertial resistance exercises on a multi-station gym and high-speed, low-resistance arm ergometry. Peak arm ergometry tests, upper extremity isoinertial strength testing, and testing of upper extremity isokinetic strength were all performed before and after training. None of the subjects suffered injury from exercise training. Significant increases were observed in peak oxygen consumption (29.7%, $P < 0.01$), time to fatigue ($P < 0.01$), and peak power output during arm testing ($P < 0.05$). Significant increases in isoinertial strength for the training manoeuvres ranged from 11.9% to 30% ($Ps < 0.01$). Significant increases in isokinetic strength were experienced for shoulder joint internal rotation, extension, abduction, adduction, and horizontal adduction ($Ps < 0.05$). Chronic survivors of paraplegia safely improve their upper extremity cardio respiratory endurance and muscle strength when undergoing a short-term circuit resistance training program. Gains in fitness and strength exceeded those usually reported after either arm endurance exercise conditioning or strength training in this subject population.