CHAPTER-II
REVIEW OF RELATED LITERATURE

The review of related literature is a crucial aspect of planning a study, the object of which is to justify the rationale behind a study. It provides an overview of historical perspective, development, deviations and new departures of research in that area and also guides to identify the methods appropriate to the present problem under investigation. The review of related literature is instrumental in the selection of topic, formulation of hypothesis and detective reasoning leading to the problem. It helps to get a clear idea and supports the findings with regard to the problem under study.

2.1 STUDIES ON CIRCUIT TRAINING

Mayorga-Vega D, Viciana J, Cocca A. (2013) They conducted 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.

Romero-Arenas S, Blazevich AJ, et.al., (2013) conducted a study on effects of high-resistance circuit training in an elderly population. 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±5.3years) 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 12weeks. 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 significantly 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 and a decrease in fat mass.

Paoli A, et,al.,(2012) 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.We 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 secs rest, 2/3 repetitions with 2'30″ 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. We 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).Our data suggest that shorter HIRT sessions may increase REE after exercise to a greater extent than TT and may reduce RR hence improving fat oxidation. The shorter exercise time commitment may help to reduce one major barrier to exercise.

Bocalini DS, et,al.,(2012) The conducted study was to investigate the impact of circuit-based exercise on the body composition in obese older women by focusing on physical exercise and body weight (BW) gain control in older people. Seventy older women (>60 years old) voluntarily took part in the study. Participants were randomized

into six different groups according to body mass index (BMI): appropriate weight (AW) control (AWC) and trained (AWT) groups, overweight (OW) control (OWC) and trained (OWT) groups, and obesity (O) control (OC) and trained (OT) groups. The exercise program consisted of 50 minutes of exercise three times per week for 12 weeks. The exercises were alternated between upper and lower body using rest between sets for 40 seconds with intensity controlled by heart rate(70% of work). The contraction time established was 5 seconds to eccentric and concentric muscular action phase. The following anthropometric parameters were evaluated: height (m), body weight (BW, kg), body fat (BF, %), fat mass (FM, kg), lean mass (LM, kg), and BMI (kg/m(2)).The values (mean ± standard deviation [SD]) of relative changes to BW (-8.0% ± 0.8%), BF (-21.4% ± 2.1%), LM (3.0% ± 0.3%), and FM (-31.2% ± 3.0%) to the OT group were higher ($P < 0.05$) than in the AWT (BW: -2.0% ± 1.1%; BF: -4.6% ± 1.8%; FM: -7.0% ± 2.8%; LM: 0.2% ± 1.1%) and OWT (BW: -4.5% ± 1.0%; BF: -11.0% ± 2.2%; FM: -16.1% ± 3.2%; LM: -0.2% ± 1.0%) groups; additionally, no differences were found for C groups. While reduction ($P < 0.03$) in BMI according to absolute values was observed for all trained groups (AWT: 22 ± 1 versus 21 ± 1; OWT: 27 ± 1 versus 25 ± 1, OT: 34 ± 1 versus 30 ± 1) after training, no differences were found for C groups.In summary, circuit-based exercise is an effective method for promoting reduction in anthropometrics parameters in obese older women.

Mukaimoto T, Ohno M.(2012) conducted study on was to examine oxygen consumption (VO(2)) during and after a single bout of low-intensity resistance exercise with slow movement. Eleven healthy men performed the following three types of circuit resistance exercise on separate days: (1) low-intensity resistance exercise with slow movement: 50% of one-repetition maximum (1-RM) and 4 s each of lifting and lowering phases; (2) high-intensity resistance exercise with normal movement: 80% of 1-

RM and 1 s each of lifting and lowering phases; and (3) low-intensity resistance exercise with normal movement: 50% of 1-RM and 1 s each of lifting and lowering phases. These three resistance exercise trials were performed for three sets in a circuitpattern with four exercises, and the participants performed each set until exhaustion. Oxygen consumption was monitored continuously during exercise and for 180 min after exercise. Average VO(2) throughout the exercise session was significantly higher with high- and low-intensity resistance exercise with normal movement than with low-intensity resistance exercise with slow movement ($P < 0.05$); however, total VO(2) was significantly greater in low-intensity resistance exercise with slow movement than in the other trials. In contrast, there were no significant differences in the total excess post-exercise oxygen consumption among the three exercise trials. The results of this study suggest that low-intensity resistance exercise with slow movement induces much greater energy expenditure than resistance exercise with normal movement of high or low intensity, and is followed by the same total excess post-exercise oxygen consumption for 180 min after exercise.

Naclerio F, Faigenbaum AD, et,al., (2012) conducted a study on effects of different resistance training volumes on strength and power in team sport athletes: a pilot study. The aim of this study was to compare the effects of 3 different volume of resistance training (RT) on maximum strength and average power in college team sport athletes with no previous resistance training experience. 32 subjects (20 men and 12 women, age = 23.1± 1.57 yrs) were randomly divided into 4 groups: Low volume (n=8); 1 set per exercise and 3 sets per muscle group, moderate (n=8); 2 sets per exercise and 6 sets per muscle group, high (n=8); 3 sets per exercise and 9 sets per muscle group and a non RT-training control group (n=8). The 3 intervention groups trained for 6 weeks thrice weekly following a nonperiodized RT program differentiated only by the volume. Before

(T1) and after training (T2), 1RM and maximal average power (AP) produced on the bench press (BP), upright row (UR) and squat (SQ) were assessed by progressive resistance tests. 1RM-BP and 1RM-UR increased significantly in the three interventions groups ($p< 0.05$), while only the high volume group significantly improved 1RM-SQ ($p<0.01$). Moderate and high volume groups increased AP-BP ($p<0.05$) while only low volume improved AP-SQ ($p<0.01$). Moderate effect sizes (ES; $>0.20 < 0.60$) were observed for the 1RM-BP and 1RM-UR in the three training groups. High volume group showed the larger ES for 1RM-BP (0.45), 1RM UR (0.60) and 1RM SQ (0.47) whereas low volume group produced the higher ES for SQ-AP (0.53). During the initial adaptation period, a high volume RT program appears to be a better strategy for improving strength while during the season a low volume RT could be a reasonable option for maintaining strength and enhancing lower-body AP in team sport athletes.

Figueroa A, (2011) The conducted study on Menopause is associated with increased arterial stiffness and reduced muscle strength. Combined resistance (RE) and endurance (EE) exercise training can decrease brachial-ankle pulse wave velocity (baPWV), an index of arterial stiffness, in young men. We tested the hypothesis that combined circuit RE and EE training would improve baPWV, blood pressure (BP), and muscle strength in postmenopausal women.Twenty-four postmenopausal women (age 47-68 y) were randomly assigned to a "no exercise" control (n = 12) or to combined exercisetraining (EX; n = 12) group. The EX group performed concurrent circuit RE training followed by EE training at 60% of the predicted maximal heart rate (HR) 3 days per week. Brachial systolic BP, diastolic BP, mean arterial pressure, baPWV, HR, and dynamic and isometric muscle strength were measured before and after the 12-week study.Mean ± SE baPWV (-0.8 ± 0.2 meters/s), systolic BP (-6.0 ± 1.9 mm Hg), diastolic BP (-4.8 ± 1.7 mm Hg), HR (-4.0 ± 1.0 beats/min), and mean arterial pressure (-5.1 ± 1.6

mm Hg) decreased ($P < 0.05$), whereas dynamic leg strength (5.1 ± 1.0 vs 0.6 ± 1.0 kg for the EX and control groups, respectively) and isometric handgrip strength (2.8 ± 0.7 vs -0.6 ± 1.2 kg) increased ($P < 0.05$) in the EX group but not in the control group.Our findings indicate that a 12-week moderate-intensity combined circuit RE and EE training improves arterial stiffness, hemodynamics, and muscle strength in previously sedentary postmenopausal women. This study provides evidence that combined training may have important health implications for the prevention of hypertension and frailty in postmenopausal women.

Alcaraz PE, Perez-Gomez J, et.al., (2011) conducted a study on Similarity in adaptations to high-resistance circuit vs. traditional strength training in resistance-trained men. To compare the effects of 8 weeks of high-resistance circuit (HRC) training (3-6 sets of 6 exercises, 6 repetition maximum [RM], ~35-second interset recovery) and traditional strength (TS) training (3-6 sets of 6 exercises, 6RM, 3-minute interset recovery) on physical performance parameters and body composition, 33 healthy men were randomly assigned to HRC, TS, or a control group. Training consisted of weight lifting 3 times a week for 8 weeks. Before and after the training, 1RM strength on bench press and half squat exercises, bench press peak power output, and body composition (dual x-ray absorptiometry) were determined. Shuttle run and 30-second Wingate tests were also completed. Upper limb (UL) and lower limb 1RM increased equally after both TS and HRC training. The UL peak power at various loads was significantly higher at posttraining for both groups ($p \leq 0.01$). Shuttle-run performance was significantly better after both HRC and TS training, however peak cycling power increased only in TS training ($p \leq 0.05$). Significant decreases were found in % body fat in the HRC group only; HRC and TS training both resulted in an increased lean but not bone mass. The HRC training was as effective as TS for improving weight lifting 1RM and peak power,

shuttle-run performance and lean mass. Thus, HRC training promoted a similar strength-mass adaptation as traditional training while using shorter training session duration.

Taşkin H. (2009) The conducted 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 posttraining 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 posttesting for the CTG (pretest = 14.76 +/- 0.48 seconds, posttest = 14.47 +/- 0.43 seconds). Also, there was a significant ($p < 0.05$) difference in anaerobic endurance between pre- and posttesting for the CG (pretest = 31.53 +/- 0.48 seconds, posttest = 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.

Duncan MJ, Al-Nakeeb Y, Nevill AM.(2009) The conducted study on Research examining the impact of physical activity on children's body image has been limited and equivocal. The current researchers examined the effect of 6-week circuit-based training on body esteem and body mass index (BMI) in 68 British children (34 boys and 34 girls, aged 10-11 years, 16% overweight, 7% obese). The Body Esteem Scale for Children (BES-C) was administered to both the intervention group and control group,

pre, post and 6 weeks post the intervention. BMI was directly assessed from height and body mass pre- and post-intervention. The results of this study revealed that, as compared to the control group, participation in 6-week circuit training significantly improved body esteem scores post-intervention. However, these scores were not sustained 6 weeks post-intervention. The improvement in body esteem scores from pre- to post-intervention was greater for girls as compared to boys. Additionally, BMI decreased significantly in the intervention group compared to the control group.

Alcaraz (2008) conducted study on Circuit training effectively reduces the time devoted to strength training while allowing an adequate training volume to be achieved. Nonetheless, circuit training has traditionally been performed using relatively low loads for a relatively high number of repetitions, which is not conducive to maximal muscle size and strength gain. This investigation compared physical performance parameters and cardiovascular load during heavy-resistance circuit (HRC) training to the responses during a traditional, passive rest strength training set (TS). Ten healthy subjects (age, 26 ± 1.6 years; weight, 80.2 ± 8.78 kg) with strength training experience volunteered for the study. Testing was performed once weekly for 3 weeks. On day 1, subjects were familiarized with the test and training exercises. On the subsequent 2 test days, subjects performed 1 of 2 strength training programs: HRC (5 sets × (bench press + leg extensions + ankle extensions); 35-second interset rest; 6 repetition maximum [6RM] loads) or TS (5 sets × bench press; 3-minute interset rest, 6RM loads). The data confirm that the maximum and average bar velocity and power and the number of repetitions performed of the bench press in the 2 conditions was the same; however, the average heart rate was significantly greater in the HRC compared to the TS condition (HRC = 129 ± 15.6 beats·min^{-1}, ~71% maximum heart rate (HRmax), TS = 113 ± 13.1 beats·min^{-1}, ~62% HRmax; $P < 0.05$). Thus, HRC sets are quantitatively similar to traditional strength

training sets, but the cardiovascular load is substantially greater. HRC may be an effective training strategy for the promotion of both strength and cardiovascular adaptations.

Chtara M, (2008) conducted study on was to 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 trainingcontrols (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), andcircuit before endurance training in the same session (S+E, n = 10). Subjects performed 2 sessions per week for 12 weeks. Resistance-type circuittraining 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 Vo2max (Vo2max) for a duration equal to 50% of the time to exhaustion at Vo2max; recovery was for an equal period at 60% Vo2max. 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 trainingbetween 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 intrasession 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 intrasession sequencing.

BA Adeniji(2007) The conducted study on examined the Comparative Effects of Circuit Training Programme on Speed and Power of Pre- and Post-Menarcheal girls. A pre-test- posttest control group experimental design was used to carry out the study. A total of 80 Secondary School girlsfrom St. Peter's College, Olomore, Abeokuta, in Ogun State of Nigeria, ages 10-17 years took part in the study. The subjects were not involved in competitive school sports.Stratified random sampling technique was used to select 40 pre-menarceal and 40 postmenarcheal girls who were later randomly assigned to experimental and control groups. At the end of the training programme, 40 subjects completed the post training measurements, so there were 10 subjects in each of the four study groups (pre-menarcheal experimental, pre-menarcheal control, post-menarcheal control, post-menarcheal experimental, postmenarcheal control groups). The data collected were subjected to descriptive statistics of mean and standard deviation and inferential statistics of Analysis of Covariance (ANCOVA) (2-ways) using the difference score method to test the hypotheses for the study at 0.05 level of significance. Where there was any significant F, Scheffé post-hoc analysis was used for further analysis. The result showed that in general, maturation and training accounted for a lot of the differences in the performance of the study groups.There was no significant difference in power of pre- and post- menacheal girls as a result of 12-weeks circuit training programme. The findings also indicated that the main effects of factor A (Status: pre- and post- menarcheal girls) and factor B (Study Conditions:Experimental and Control) were statistically significant. The effects of the training on speed was significantly better for pre-menarcheal girls than for post-menarcheal girls (Post test 9.32; 9.56). Subjects in the experimental groups had better power than those in the control groups. The Implications of this study are that exercise training such as the circuit used in this study can make observable differences in speed and power of adolescents. Effective exercise training

programmes should therefore be considered as an integral and inevitable aspect of school curriculum.

Braun WA, Hawthorne WE, Markofski MM.(2005) The conducted study was to evaluate the effects of circuit training (CT) and treadmill exercise performed at matched rates of oxygen consumption and exercise duration on elevated post-exercise oxygen consumption (EPOC) in untrained women, while controlling for the menstrual cycle. Eight, untrained females (31.3 +/- 9.1 years; 2.04 +/- 0.26 l min(-1) estimated VO2max; BMI=24.6+/-3.9 kg/m2) volunteered to participate in the study. Testing was performed during the early follicular phase for each subject to minimize hormonal variability between tests. Subjects performed two exercise sessions approximately 28 days apart. Resting, supine energy expenditure was measured for 30 min preceding exercise and for 1 h after completion of exercise. Respiratory gas exchange data were collected continuously during rest and exercise periods via indirect calorimetry. CT consisted of three sets of eight common resistance exercises. Pre-exercise and exercise oxygen consumption was not different between testing days (P>0.05). Thus, exercise conditions were appropriately matched. Analysis of EPOC data revealed that CT resulted in a significantly higher (p<0.05) oxygen uptake during the first 30 min of recovery (0.27 +/- 0.01 l min(-1) vs 0.23+/-0.01 l min(-1)); though, at 60 min, treatment differences were not present. Mean VO2 remained significantly higher (0.231 +/- 0.01 l min(-1)) than pre-exercise measures (0.193 +/- 0.01 l min(-1)) throughout the 60-min EPOC period (p<0.05). Heart rate, RPE, V(E) and RER were all significantly greater during CT (p<0.05). When exercise VO2 and exercise duration were matched, CT was associated with a greater metabolic disturbance and cost during the early phases of EPOC.

Gotshalk, Lincoln A.; Berger, Richard A.; Kraemer, William j.(2004) conducted study on this investigation was to determine the level of cardiovascular stress elicited by continuous and prolonged circuit resistance training (CRT). Each of the 11 men who volunteered as a subject were tested to determine oxygen consumption and heart rate responses to a submaximal and maximal treadmill protocol and a CRT session consisting of 10 exercises and 10 repetitions at 40% of 1 repetition maximum (1RM) for each station with 4.6 circuits performed. The physiological stress of the CRT in this study was evident by the sustained heart rate of more than 70% of maximum for 16.6 minutes, with the last 12 minutes at more than 80%. Despite the large anaerobic component in CRT, VO2 was sustained at 50% or more of maximum for the final 12 minutes. Treadmill running, involving large muscle groups, increased VO2 more rapidly than CRT, where alternating larger and smaller muscle groups were used. In addition, at the same VO2 heart rate differed significantly between the 2 modes of activity. Heart rate in CRT was higher (at 165) than the heart rate of 150 found during treadmill running at the same 50% VO2. Such workouts may be used in a training cycle in classical linear periodization or in a nonlinear program day targeting local muscular endurance under intense cardiorespiratory conditions, which may help individuals develop enhanced toleration of physiological environments where high cardiovascular demands and higher lactate concentrations are present.

Haltom RW (1999) conducted study on There is a paucity of research concerning energy expenditure during and after circuit weight training (CWT). There is evidence that duration of rest between sets affects metabolic responses to resistive exercise. The purpose of the study was to determine the effect of rest-interval duration upon the magnitude of 1 h of excess postexercise oxygen consumption (EPOC).Seven healthy men completed two randomized circuit weight training sessions using 20-s and 60-

s rest intervals (20 RI, 60 RI). Sessions included two circuits of eight upper and lower body resistive exercises in which 20 repetitions were performed at 75% of a previously determined 20 repetition maximum.The 1 h EPOC of 10.3 +/- 0.57 L for the 20 RI session was significantly higher than 7.40 +/- 0.39 L for the 60 RI session. The net caloric expenditure during 1 h of recovery from the 20 RI session was significantly higher than that of the 60 RI session (51.51 +/- 2.84 vs 37.00 +/- 1.97 kcal); however, total gross energy expenditure (exercise + 1 h recovery) was significantly greater for the 60 RI protocol (277.23 kcal) than the 20 RI protocol (242.21 kcal).Data demonstrate that shortening the rest interval duration will increase the magnitude of 1 h EPOC from CWT; however, the exercise + recovery caloric costs from CWT are slightly greater for a longer rest interval duration protocol. These data suggest that total caloric cost be taken into account for CWT.

Pichon,(1996) conducted study compared metabolic cost and cost:work ratio to blood pressure and heart rate response between circuit and traditional weight training. Subjects (5 M, 3 F) completed one traditional and one circuit weight training workout. [latin capital V with dot above]O2 was measured during workout and recovery. Total work was calculated by summing the vertical work on the weights and limbs. Heart rate was continuously monitored. SBP and DBP were measured during the last 10 set of each leg exercise and once a minute during recovery. Cost:work ratios were significantly higher for traditional weight training ($p = 0.003$). However, due to the greater total workload, total metabolic cost was higher for circuit weight training ($p = 0.032$). Exercise and recovery rate-pressure product (RPP) were calculated. Exercise heart rate was significantly higher during circuit weight training. No differences were found in BP response. Exercising RPP was significantly higher during circuit weight training,

indicating a higher workload on the heart. This may be an important consideration when recommending weight training programs for persons with cardiovascular complications.

Mosher (1994) conducted 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 calisthenic 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 [latin capital V with dot above]O2 max test. Data were analyzed using a repeated measures ANOVA with significance established at $p < 0.05$. The exercise group had significant increases in [latin capital V with dot above]O2 max, upper body strength, and lower body strength, and significant decreases in skinfold 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.

Murphy, Emmett; Schwarzkopf, Robert(1992) conducted study was to compare the effects of standard set weight training (SWT) and circuit weight training (CWT) on excess post-exercise oxygen consumption (EPOC). The type and order of exercises were the same for both programs. The programs differed in three respects: a circuit approach as opposed to three sets of the same exercise; the percent of maximum weight used was 80 percent in SWT and 50 percent CWT; and rest periods were shorter for CWT (30 seconds) than SWT (120 seconds). This longer rest period resulted in a longer SWT

program (50 minutes) than the CWT program (19 minutes). Ten untrained college men performed both weight-training programs. Resting metabolic rate (RMR) was determined before each weight program, followed by a determination of EPOC.The magnitude and duration of EPOC produced by CWT were significantly ($p < 0.01$) greater than those produced by SWT. The EPOC produced by CWT was 20 minutes in duration with a net caloric cost estimated at 24.9 kilocalories, while that produced by SWT was 15 minutes in duration with an estimated net caloric cost of 13.5 kilocalories. The intensity of CWT (289 kilograms per minute) was also greater than that of SWT (106 kilograms per minute).It was concluded that the magnitude and duration of EPOC is greater for CWT in comparison to SWT and the EPOC produced by weight training is somewhat less than that found for aerobic exercise.

Haennel R, Teo KK, Quinney A, Kappagoda T.(1989) The conducted study on effect of hydraulic circuit training (HCT) on cardiovascular (CV) function was assessed in 32 healthy middle-aged males (X age = 42.2 +/- 2.1 yr). Maximal aerobic power (VO2max), with simultaneous measurement of stroke volume (SV) and cardiac output (CO), by impedance cardiography, was assessed pre- and post-training. Subjects were randomly assigned to a nonexercising control group, a cycle training group (cycle), or one of the two HCT groups. Training groups participated in a 9 wk program, 3 d.wk-1. Subjects assigned to HCT exercised on a 9 station circuit, completing 3 circuits.d-1. Each circuit consisted of three 20 s work intervals at each station with a 1:1 work:rest ratio. One HCT group (HCTmax) completed the maximal repetitions possible (RM) during each work interval. The other HCT group (HCTsub) exercised at 70-85% of RM. Following training VO2max (ml.kg-1 min-1) was significantly increased in all training groups (18.0, 12.5, and 11.3% for cycle, HCTsub, and HCTmax groups, respectively; P less than 0.05). The increase in VO2max observed in the cycle group was

significantly greater than that recorded by the two HCT groups (P less than 0.05). For all three training groups, the increase in VO2max was associated with increases in SVmax and COmax (P less than 0.05 for both). These findings suggest that both maximal and submaximal HCT programs can elicit improvements in cardiovascular fitness.

Petersen SR, Miller GD, Quinney HA, Wenger HA.(1988) conducted study on This work was supported by the Natural Sciences and Engineering Research Council. This study was designed to investigate the influence of high-velocity resistance circuit training on maximal aerobic power. Twenty-seven trained males participated either as training (N = 16) or control (N = 11) subjects. The training group exercised for two 20 sec sets at each of six stations of hydraulic, variable resistance apparatus over two or three circuits maintaining an exercise:relief ratio of 1:2 during each circuit. Subjects trained four times weekly over 5 weeks. The resistance at each station was adjusted as necessary to maintain consistent angular limb velocities of approximately 3.2 rad/sec. The VO2max for the training group was increased ($p < 0.001$) by 9.5% when expressed in either absolute or relative terms. No changes were observed for control subjects. Oxygen consumption responses measured over two circuits for six training group subjects averaged 61 and 57% of VO2max for exercise and relief intervals, respectively. It is therefore suggested that the hydraulic circuit resistance program described will elicit a metabolic intensity sufficient to improve aerobic power, even in previously trained subjects.

Gettman LR, Ward P, Hagan RD.(1982) conducted study on 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 RUN-CWT and CWT were effective in improving measures of physical fitness.

Gettman LR, Ayres JJ, Pollock ML, Durstine JL, Grantham W.(1979) conducted study on was to determine the effects of 8 weeks of circuit strength training (CST) followed by 8 weeks of jogging and then 8 weeks, of CST or jogging. During the final 8 weeks, the subjects were randomly assigned to either CST or jogging groups. The subjects (n=16, x age = 29 yrs) exercised 3 days/week. The strength training involved 2 circuits of reciprocal exercises using isokinetic devices with 10 to 15 repetitions/set and 30 seconds of rest between sets. The subjects jogged 3 miles/day during the jogging program. After the initial 8 weeks of CST, significant changes were found in treadmill performance time, maximum oxygen uptake (VO2max), maximum pulmonary ventilation (VEmax), body fat, total skinfold fat, fat weight, lean weight, isotonic bench and leg press, and isokinetic slow speed, fast speed, and power endurance measures. The jogging program elicited significantly greater changes in treadmill performance time and VO2max. Further reductions were found in total skinfolds and waist girth during the

jogging program. Leg strength was maintained during jogging but upper body strength was reduced significantly. Physiologic levels were maintained during the final 8 weeks and showed no differences between the CST and jogging groups.

2.2 STUDIES ON YOGIC PRACTICES

Tracy BL, Hart CE. (2013) conducted a study on the effects of yoga on general physical fitness, despite the widespread participation in this form of exercise. Twenty one young healthy adults were selected as subjects with the age group of 29 ± 6 years.. Yoga subjects exhibited increased strength, increased shoulder flexibility when compared with control group. There were no changes in handgrip strength or maximal aerobic fitness. In summary, this short-term yoga training protocol produced beneficial changes in musculoskeletal fitness that was specific to the training stimulus.

Sultana.D. (2011), conducted a study on the effect of twelve weeks yogic practices on selected physiological variables on female students in Pondicherry university. For the concerned study, a total of 30 subjects were selected and they were divided into two groups, viz experimental (N-15) and control group (N-15). The experimental group practiced selected yoga asana, suryanamaskar, meditation and pranayama. It was concluded that there are significant changes in the four selected variables due to yoga practice.

Bharatha priya and Gopinath(2011) conducted a study on the effect of yogic practice on flexibility among school boys. Forty subjects were selected from A.R.R Matriculation Higher Secondary School and their age ranged from 15 to17 years. The subjects were divided into two groups namely the control and the experimental group. The experimental group underwent selected ‘asanas’ and ‘pranayama’ for five days per

week for twelve weeks. Finding of flexibility shows significant improvement due to the twelve weeks yogic practice when compared to the control group.

Komathi and Kalimuthu (2011) conducted a study on the effect of yogic practices on abdominal strength among school boys. Forty subjects were selected from A.R.R Matriculation Higher Secondary School and their age ranged from 15 to17years. The subjects were divided into two groups namely the control and the experimental group. The experimental group underwent selected asanas and pranayama for five days per week for twelve weeks. Finding of abdominal strength shows a significant improvement due to the twelve weeks yogic practice when compared to the control group.

Manimakalai and Chitra (2011) conducted a study on the effect of yogasana practice on flexibility among Annamalai University Women Students. Thirty healthy, untrained female subjects were selected from Annamalai University in various departments and their age ranged from 18 to 25 years. The subjects were divided into two groups namely the control and the experimental group. The experimental group underwent selected asanas for five days per week for eight weeks. Finding of flexibility shows significant improvement due to the eight weeks yogic practice when compared to the control group.

Sekar babu and Kulothugan(2011) conducted a study on the effect of yogic practices on selected physiological variables of men hockey players. Thirty hockey men players were selected from Annamalai University, Chidambaram and their age ranged from 18 to 25 years. The subjects were divided into two groups namely the control and the experimental group. The experimental group underwent forty five minutes selected asanas and pranayama practice five classes per week for eight weeks. The study showed

yogic practices group significantly improved, breath holding time and significantly decreased resting pulse rate when compared to the control group.

Neethi and Chidambara Raja(2011) conducted a study on the effect of yogic practices and physical exercises on muscular strength self - concept and blood pressure. Forty five healthy, untrained female subjects were selected from various Departments of Annamalai University and their age ranged from 18 to 25 years. The selected subjects were equally divided into three groups. Group I underwent yoga practices, group II underwent physical exercises and group III acted as a control group. The experimental groups underwent their training programme for five days per week for eight weeks. The yogic practices group and physical exercises group on muscular strength, significantly improved when compared with the control group.

Sukhdev Singh, Vishaw Gaurav and Ved Parkash (2011) conducted a study on the effects of 6-weeks nadi-shodhana pranayama training on cardio-pulmonary parameters. A group of 30 male healthy subjects were selected from the Department of Physical Education (T), Guru Nanak Dev University, Amritsar (Punjab, India); subjects aged 18 – 24 years, volunteered to participate in the study. The subjects were divided into two groups, one control and experimental group. The experimental groups were subjected to 'Nadi-shodhana' pranayama programme for 6 weeks which consisted of daily sessions, lasting for 30 min. The result reveals there was significant difference among the two groups. 'Nadi-Shodhana' pranayama training programme was recommended to improve vital capacity and control heart rate which contributed to enhance health status.

Punithavathi (2010) conducted a study on the effects of aerobic exercises and yogic practices on selected physical, physiological and biochemical variables among school girls. 45 girls were selected from St. Joseph's of Cluny Higher Secondary School,

Pondicherry. The age group of the subjects ranged between 14 to 18 years. The subjects were divided into three groups and each group consisted of fifteen subjects. The two experimental groups underwent two different training programmes namely aerobic exercises and yogic practice. Findings show that all these variables have significantly improved among experimental group than the control group.

Saroja M (2010) conducted a study on the effect of yogic practice and walking on selected physical, physiological and biochemical variables among aged people. For this study 30 men students were selected from Vallal Alagappar Walker Club, Karaikudi, and their age ranged from 45-55 years. They were divided into three equal groups namely yogic practice group, walking group and control group. The study showed that there was a significant effect in weight, resting pulse rate and cholesterol level due to the influence of yoga practice and walking among aged people. When compared there was a significant improvement through the yoga practice.

Vaz W.L (2010) conducted a study on the effect of nostril dominance Yogic exercise programme on different cardio respiratory variables. Twenty one athletes of L.N.C.P.E Gwalior were selected and divided randomly into four groups namely right nostril dominance group, left nostril dominance group, both nostril dominance group and control group. Further they were evaluated after six weeks of training on selected cardio respiratory endurance, heart rate and respiratory rate by applying t-test at 0.05 level of significance. The findings show yogic breathing training is a potential tool that significantly affects cardio respiratory parameters mentioned above. The study will be useful future researchers too since it has come up with primary quantitative data to support its objectives.

Shenbagavalli (2010) conducted a study on the effects of Gymnastics Exercises and Yoga Exercises on College students on selected physical performance, physiological and Bio-chemical variables in this study. The subjects selected for this study was 90 women college students divided into three groups, control group, yoga exercise group and gymnastic exercise group. The age group of the subject was 18 to 21 years to assess the effects of 12 weeks training for gymnastics and Yogic exercise programme. The result showed that the gymnastic exercise and yogic exercise brought significant improvement among the women college students on all variables except in diastolic blood pressure.

Kasundra (2010) conducted a study on the impact of pranayama training on selected components of blood. For the present study, Subjects selected were B.A Students studying in Mahadev Desai Grem Seva Mahavidyalaya. Randomly 30 students were selected for the study and then they were divided into two equal groups randomly which consists of 15 subjects each belonging to one experimental and one control group. A Group was exposed to pranayama and group B was control group. Experimental group participated in pranayama training for eight weeks. The variables and test items selected for the present study were cholesterol Blood glucose hemoglobin, WBC, RBC and Platelets. This study revealed a significant difference in pre test and post test of experimental groups of selected blood components of i.e. cholesterol, Blood glucose, Hemoglobin, WBC, RBC and Platelets. The study showed that Pranayama training has an impact on select components of blood.

Chidambara Raja (2010) conducted a study on the effect of yogic practice and physical fitness on flexibility, anxiety and blood pressure. Forty five subjects, working women in various Faculties of Annamalai University in the age group of 35 to 40 years were selected. They was divided into three equal groups each group consisted of fifteen subjects. Group I underwent yoga practice, group II underwent physical exercises and group III acted as control group. The training period for this study was five days a week for eight weeks. After training flexibility, anxiety and blood pressure have significantly improved among experimental group than the control group.