Chapter II

REVIEW OF RELATED LITERATURE

A review of research reports related to the present study that the research scholar could gather, is presented in this chapter in order to provide the background material to evaluate the significance of this study as well as to interpret its findings.

Edward conducted a study on the effect of circuit training, weight lifting and interval training on circulo-respiratory endurance. Fifty-one college males from developmental physical education class at the University of New Mexico were randomly assigned to three exercise programmes. The subjects trained for a ten week period at their respective exercise programme. Pre-test and post-test measures of circulo-respiratory endurance were administered under some experimental conditions. The analysis of variance showed no significant differences between the three exercise programmes in the measures of circulo-respiratory endurance.

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Ferie\(^2\) selected 40 untrained male students to study the cardio-vascular response to exercise as influenced by training of various intensities. The heart rate intensities selected were 120-130, 140-150 and 160-170 beats per minute. The subjects were administered a pre and post treatment physical work capacity tests on bicycle ergometer. The experimental group trained five consecutive days per week for four weeks whereas, the control group played volleyball. An analysis of data revealed significant differences between the control and experimental groups trained with various intensities.

Stewart\(^3\) conducted a study to see the changes in physical work capacity as a result of physical training. He employed fifteen minutes of interval running, four times per week, for eight weeks. Physical work capacity was measured by the maximal oxygen uptake determined during treadmill exercise. Training had no significant effect on VO\(_{\text{max}}\). However, there was significant reduction in submaximal heart rate which was almost identical on the bicycle ergometer and

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treadmill. Thus it seemed that running training resulted in some changes which were not task specific. The improved cardio-vascular adaptation to submaximal exercise after training indicated a possible improvement in physical work capacity even though VO\textsubscript{2} max remained unchanged.

Burke\textsuperscript{4} conducted research on physiological effects of similar training programmes in males and females. Experimental groups trained three times weekly for eight weeks at a heart rate (HR) intensity between 75\% to 85\% of HR maximal with total distance run held equal between sexes. MANOVA revealed a significant difference between sexes in response to training. Univariate ANOVA revealed a significant training effect for VO\textsubscript{2} max expressed in ml/kg min\textsuperscript{-1} and 1 min\textsuperscript{-1}. VE\textsubscript{max} expressed in 1 min\textsuperscript{-1} and 1/kg min\textsuperscript{-1}. O\textsubscript{2} pulse at VO\textsubscript{2} max and body weight. Sex differences were found for VE\textsubscript{max} (1 min\textsuperscript{-1}) and weight. No significant training effect was found for HR max or VE at VO\textsubscript{2} max.

Henry\textsuperscript{5} found cardiovascular changes in 18 college athletes during training when compared with 15 control subjects who were physically active but did not engage in


a systematic regime. After training there were no significant differences in body weight or surface area but significant difference in heart rate occurred.

Toit\textsuperscript{6} administered a training programme to two groups employing weight training and progressive run, and noted that the running group showed a significant reduction in pulse rate, diastolic blood pressure and an increase in pulse pressure and basal oxygen consumption.

Halmgren\textsuperscript{7} studied intermittent long term training (gymnastic exercise or running once or twice a week for several weeks) and observed an increase in physical working capacity in a steady state, total haemoglobin, and blood volume. A decrease in pulse rate in the recumbent position was also observed.

Devies\textsuperscript{8} compared the effects of crest load training procedure, continuous running and high intensity on cardio-respiratory fitness. Researcher found that the three

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training groups showed significantly greater improvement in cardio-respiratory fitness than did the control group. However, no significant difference in VO capacity was demonstrated among the three training procedures.

Andzel and Busutti\(^9\) conducted a study on eight college women to determine selected metabolic and physiological responses to prior exercise, varied rest intervals and a strenuous endurance task. The criterion variables were measured during prior exercise (PE) and varied rest interval which preceded a strenuous endurance task. The subject performed PE on a treadmill at a workload designed to elevate the heart rate (HR) to approximately 140 beats per minute. This PE induced HR was maintained for two minutes. After the prior exercise, the subjects rested for either 30 or 90 seconds before starting a strenuous cardio-respiratory criterion task. The criterion task involved an all out run to exhaustion at a speed of five mph and a slope corresponding to 95-100\% of each subject's maximal oxygen consumption. Selected parameters, which included oxygen consumption, pulse and any oxygen deficit.

were statistically analysed during the prior exercise, rest interval and criterion following prior exercise for 90 seconds and prior exercise for 120 seconds. This analysis suggests that the mobilization effect of prior exercise is probably lost during the longer rest intervals.

Brar\textsuperscript{10} determined the effects of interval running with varying recovery types on cardio-respiratory endurance and selected physiological variables. The physiological variables were: blood pressure, pulse rate, recovery pulse rate, air flow rate, peak flow rate and physical work capacity. The subjects (high school boys) numbering eighty were equally divided into three experimental and one control group. The experimental groups were given interval training programme for a period of ten weeks, thrice a week. The interval training programme for three experimental groups was the same throughout the experimental period, the only differential factor being the mode of utilization of the relief interval. Experimental group I performed walking, experimental group II performed jogging and experimental group III performed walking and jogging combined during rest phase between spells of work. The fourth group served as control group. Analysis of the data revealed that interval

\textsuperscript{10}T.S. Brar, "Cardio-Respiratory and Physiological Changes Resulting from Interval Training with Varied Stimulus Density", (Unpublished Doctoral Dissertation, Jiwaji University, Gwalior, 1982).
running was an effective method in developing cardio-respiratory endurance, physical work capacity, airflow rate, resting blood pressure of the boys at school level, in the age group of 14 to 16 years. The group which performed jogging or a combination of walking and jogging produced better results when compared to the group which performed walking alone during the relief interval. Secondly, interval running method did not show any significant reduction in resting diastolic blood pressure and recovery pulse rates as a result of ten weeks of training. Finally, control group did not show any significant changes in cardio-respiratory and selected physiological variables.

Uppal\textsuperscript{11} conducted a study to determine the effects of interval training and two continuous load methods on cardio-respiratory and selected physiological parameters. Eighty untrained subjects were divided into three experimental groups and the control group. One group was given interval training, the second group Fartlek and the third group slow continuous running for a period of ten weeks. The load was progressively increased, after every two weeks. Researcher found that all the three groups had equal

\textsuperscript{11}Arun Kumar Uppal, "Comparative Effects of Two Duration Load Methods and Interval Running Method on Cardio-Respiratory Endurance and Selected Physiological Variables," (Unpublished Doctoral Dissertation, Jiwaji University, Gwalior, 1980).
training effects on maximal oxygen uptake, vital capacity, leg strength, breath holding time. Slow continuous and Fartlek method resulted in significantly higher improvements in cardio-respiratory endurance when compared to interval training. Slow continuous method and interval training were superior to Fartlek in reducing resting pulse rate. However, all the three training methods did not show any significant difference in diastolic blood pressure after exercise, blood haemoglobin content and red and white blood corpuscles.

Jossey studied the knowledge retained, cardiovascular fitness and skinfold measurement of college age females before and after a physical fitness course. 94 female college students were involved in physical education classes during the fall and winter quarters. 47 subjects served as control group enrolled in a physical education course other than physical fitness, and 47 subjects served as experimental group enrolled in a physical fitness course. Fitness knowledge, skinfold measurements, and cardiovascular fitness of each subject were measured at the beginning and end of the course. The data were subjected to an analysis of variance to determine if there were significant differences in mean gains between the experimental and control groups.

the winter and fall academic quarters, and morning and afternoon classes. Results revealed significance for knowledge gained for the fitness group, the afternoon group and the winter quarter group. Results also revealed no difference in skinfold measurements between any of the groups except the fall quarter group. There was also no difference between any of the groups in cardiovascular fitness. The .05 level was utilized to determine significance.

Hsieh\textsuperscript{13} investigated the principle of Maximum Activity, that the working organs exhibit more uniform response than resting organs, by examining physiological variation in relation to measurement reliability during different intensities of exercise. Also, the relationship between error variance and the magnitude of the VO$_2$ max scores was examined. Twenty four male subjects were studied. Incremental VO$_2$ max tests were performed and lactate (LT) was determined by three investigators for each subject. The correlation coefficients ($r$) of VO$_2$ and LT among the three investigators ranged from $r = .94$ to $.96$. Two submaximal constant load exercise protocols were used to investigate Barcraft's principle: 40% above LT (aLT) and 40% below

LT (aLT). Intra class and Pearson's correlation coefficient were calculated and subsequently used to derive biological variance estimate for blood Lactic Acid (LA), haemoglobin (Hb), haematocrit (Het), oxygen consumption (VO$_2$), minute ventilation (VE), CO$_2$ production (VCO$_2$) and heart rate (HR). The blood parameters from the present study did not show that measurement variation was less during high intensity (aLT) exercise than the low intensity (bLT) exercise. Moreover, all of the VO$_2$ and related parameters show that within subject variation during aLT (.003 to 86.5) was greater than that of bLT exercise (.002 to 59.3). These findings disprove Barcraft's principle. The VO$_2$ max data of this study reveal that both high VO$_2$ max and medium VO$_2$ max subjects have larger day to day variance (11.27 and 10.89 respectively) than the low VO$_2$ max (40.1) subjects. This agrees with the data reported by Kroll (1970) on isometric strength. He concluded that the data of this study disprove Barcraft's Theory since blood and cardio respiratory responses are more uniform during low intensity exercise. Furthermore, the error variance of VO$_2$ max values was related to the magnitude of the VO$_2$ max scores.

Ward$^{14}$ determined the expected cardiovascular

$^{14}$Sue Davis Ward, "Cardiovascular Fitness Gains in Selected College Level Activities", Dissertation Abstracts International, 47 (January 1987) : 2504.
fitness gains in selected college level activities. The following activities were studied: aerobic dance, jazz dance, social dance and racketball, and represented students from all levels. Subjects were administered the Cooper Twelve-Minute Run-Walk Test as pre-test and post-test measures. In addition to MANOVA and F-ratio, Tukey test was utilized to determine significance in groups having different instructors. Results revealed significance in the female aerobic dance group for distance and fitness. No other group represented showed significance. No significance was found in groups having different instructors.

Jun\textsuperscript{15} determined the relative effectiveness of interval weight training on the development of dynamic muscular strength, power and cardio-respiratory function. Sixteen male students were randomly assigned to either the experimental group (interval weight training program) or the control group (circuit weight training program). Training was limited to sixty minutes twice a week and continued for six weeks. All subjects were pre-tested and post-tested for dynamic muscular strength, power and cardio respiratory function. The one way analysing covariance was used to determine significant difference between group means scores.

He concluded that six weeks of interval weight training produces significant increases in strength and power but does not produce a statistically significant improvement in cardio-respiratory function.

Kenney\textsuperscript{16} investigated changes in cardiovascular endurance, muscular strength and endurance, flexibility and body fat in males and females after three months of Circuit Weight-Training (CWT) and Variable Resistance Training (VRT). All subjects trained on the same equipment: Hip and Back, leg extension, leg Curl, Pullover, Lateral Raise, overhead Press, Arm cross, Decline Press (alternated with overhead press), Biceps and Triceps. Following a two week period to familiarize the subjects with the equipment, pre-testing was done for max \( VO_2 \) for arm ergometer cranking and treadmill run to exhaustion maximum lift (1-RM, on each Nautilus machine, muscular strength for leg extension and bench press at 600/second on the cybex II, muscular endurance for leg extension and bench press at 180°/second on the cybex II, flexibility for shoulder extension and trunk flexion and present body fat from sum of skinfolds. He concluded that high intensity training is better than low

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intensity training for improving max VO₂ on a treadmill; that males were significantly different from females for body fat reduction using Nautilus equipment; that males were significantly stronger than females on Hip & Back, leg extension, leg curl, arm cross, Decline Press, Cybex II leg press and Cybex II right arm press; that no differences existed between the CWT and VRT groups for muscular strength, muscular endurance, flexibility and body fat.

Priest¹⁷ studied the effects of aerobic training upon cardio-respiratory function, body composition and training indices, and relationship of these variables to 10000 meter run performance. Thirteen members of the East Texas State University Cross Country Team were pre-tested and post-tested for cardio-respiratory function and body composition. Running times for the fifteen meter, 600 meter, two-mile and 10,000 meter run were recorded. Significant improvements were identified between the following pre-test and post-test variables: maximum treadmill stress test, VO₂ max, oxygen pulse, fifteen meter run, 600 meter run, two mile run, 10,000 meter run, submaximal heart rate, resting

heart rate, and anaerobic capacity.

Wixson\textsuperscript{18} determined the effects of a season of intercollegiate basketball, swimming and volleyball on cardio-respiratory endurance, percentage of body fat, flexibility, and leg strength of female athletes. All the subjects were administered the following tests during pre-season and post-season testing sessions: Astrand-Rhyming Bicycle Ergometer Test for Cardio-respiratory endurance, Skinfold test for determining the percentage of body fat, a maximum leg strength test utilizing a load cell digital read out meter, and Leighton's flexometer tests for flexibility. The treatment intervention involved participation in one of the three sports programs which incorporated conditioning, training and seasonal competitive schedules. Analysis of data revealed that the basketball team decreased significantly in percentage of body fat and showed significant loss in left leg strength and left shoulder flexibility; that athletes participating on the swim team showed no significant gain or loss in any variable, that the volleyball team showed significant improvement in $\text{VO}_2\text{max}$, left leg strength, right and left

wrist flexibility and hip flexibility and a significant decrease in percentage of body fat, right and left shoulder flexibility, and left leg flexibility.

Boyd determined the physiological effect of two variable resistance weight training programs on males and females age 18-35 years, one group of each sex trained at 8-12 repetitions and other group of each sex trained at 18-22 repetitions for eight weeks. Testing included muscular strength, power and endurance (Cybex III), performance power (Margaria-Kalamen), body composition (under water), girth measurements, and cardiovascular fitness/Bulke treadmill test. All groups demonstrated significant increases in shoulder abduction (power endurance) while the female groups were the only groups to increase in strength. The female endurance group demonstrated significant increases in shoulder abduction (strength, power and endurance), while the other three groups showed no significant differences. Body composition results indicated significant increases for all groups in body density and lean body weight (except female strength). The male groups decreased more significantly than females in body fat and

body weight. Skinfold measurements showed a significant decrease in triceps (all groups) and biceps (all groups except male endurance measurements). Heart rate changes showed a significant increase for the strength groups (resting) and, a significant decrease for all groups (except the male strength group (maximum). Both pressure measurements indicated an increase in the female endurance group (resting diastolic). Measurements to 150 and 180 BPM showed significant increase for all groups (Systolic). Rate pressure product changes showed a significant increase while at rest (female strength) and at the end of exercise (female endurance and male strength).

Salih²⁰ identified the effects of a conditioning program on selected physiological variables of college women gymnasts. Ten women gymnasts at Oklahoma State University were tested prior to and following a three month conditioning program. Only six of the ten subjects were able to take the complete post-test. The other four took only the body composition post-test. The conditioning program consisted of running, warming up including stretching flexibility exercise, formal gymnastic training and strength

training. A modified Bulke treadmill Protocol was used to determine the anaerobic threshold and maximal oxygen uptake. Also measured were resting blood pressure, resting heart rate, per cent body fat by skinfold and underwater weighing, and strength. The results of this study revealed significant differences in trial effect indicating an increase or decrease from pre to post-test. Significant improvements were found in anaerobic threshold, heart rate, resting blood pressure in the standing position, per cent body fat from both skinfold and under water weighing and all strength measures except for right leg strength. No significant differences were found in the means of VO\(_2\) max (ml/kg/min), percentage of VO\(_2\) max at anaerobic threshold, supine resting blood pressure, resting heart rate and right leg strength.

Mosher\(^{21}\) examined the relationship of selected body measures to exercise energy cost in women and developed a regression equation to predict energy expenditure during submaximal exercise. 100 volunteers who served as subjects were of age 18 to 41. The body measures recorded were age, height, weight, and body composition (using hydrostatic weighing technique). The submaximal exercise task was treadmill jogging at a predetermined target heart rate. Oxygen consumption was assessed by the open circuit method.

During the submaximal treadmill exercise task to target heart rate, the mean values for oxygen consumption were 1.34912/min and 22.1088 ml/kg min. A significant relationship was found between heart rate, body composition, and weight with exercise oxygen consumption in women. Stepwise multiple regression analysis yielded a formula for submaximal exercise energy cost using heart rate and body composition as predictors.

Testerman\textsuperscript{22} examined training and detraining effects on selected physiological measures of fitness in adult black women. Pre, post and detraining post measurements were made on body weight, heart rate, blood pressure, sum of skinfolds (triceps, supra illiac and thigh), and predicted max VO\textsubscript{2}. The study was conducted in four stages: Two training stages and two detraining stages. Training was either by walking/jogging or aerobic dancing 3 times per week over 11 to 12 weeks at 70-75\% of age adjusted max HR. One detraining period was for 10 weeks, a second for 15 weeks. Data was analyzed by factorial ANOVA. Predicted max VO\textsubscript{2} was significantly increased after training and was either maintained or reduced back to pretraining level through detraining. Skinfold thicknesses were significantly reduced

\textsuperscript{22}Edwyna Pace Testerman, "Training and Detraining Effects on Selected Physiological Measures of Fitness in Adult Black Women", Dissertation Abstracts International, 46 (December 1985) : 1556.
following training and after detraining either stabilized or returned to pretraining levels. Body weight, heart rate, and systolic and diastolic blood pressure underwent almost no change from training through the detraining period.

Mayfield\textsuperscript{23} determined the effects of aerobic dancing on the cardio-respiratory system, body composition and self-actualization in 17 females subjects engaged in this activity for 10 weeks, three times per week, as measured by the Astrand-Rhyming Bicycle Ergometer Test. Pre and Post-test measurements were administered for these variables. On the basis of two-way ANCOVA the following conclusions were made: (1) Individuals participating in the aerobic dance program achieved significantly higher levels of cardio-respiratory fitness than the individuals in the control group. (2) Individuals participating in aerobic dance program lost a significantly greater amount of body fat than those in the control group. (3) There was no significant difference in degree of self-actualization in both groups.

Zwiren\textsuperscript{24} compared 36 conditioned runners and


swimmers - 18 males and 18 females - in control circulatory responses to submaximal and near maximal exercise. Metabolic and cardio-respiratory responses to maximal bicycle ergometer exercise, fat free weight and haemoglobin concentration were determined in all subjects. Central circulatory responses (cardiac output (A-V)O₂ difference, heart rate and stroke volume) to bicycle ergometer exercise were measured at 70, 80, and 90 per cent of VO₂ max. Cardiac output was determined by the CO₂ rebreathing method. The findings and conclusions of this study were: (1) There was no significant sex difference for cardiac output and (A-V)O₂ difference at an uptake of 15.1 min⁻¹. (2) Men had significantly lower heart rate and higher stroke volume compared to women at an oxygen uptake of 15.1 min⁺. (3) At various percentages of VO₂ max during submaximal and near maximal exercise, men had significantly higher cardiac output, (A-V)O₂ different, and stroke volume and non significantly difference heart rate compared to women. (4) Differences between men and women in fat free weight and haemoglobin concentration were found to account for almost all (85-99%) of the sex related varimax in central circulatory responses to exercise. Since these two factors consistently differ between the sexes, the differences between men and women observed in this study in circulatory responses to exercise should be considered truly sex linked. (5) Fat free weight was found to be slightly more
important than haemoglobin concentration in accounting for each of the observed sex differences in central circulatory responses to exercise.

Sixty-two women were randomly chosen by Chambers\textsuperscript{25} from sessions of modern dance, ballet, and jazz to participate in pre and post task of four parameters. The 12 week treatment was attendance in their respective dance class two days a week, 40-45 minutes per session. A control group also participated in pre and post-tests. They were women selected from a health class and had virtually no physical activity for the treatment period. The gain scores between pre and post-tests were significant for all parameters tested. Per cent body fat was the most significant at .001 level. The data indicated that the beginning level dance class can contribute significantly towards specific fitness parameters. Advanced women dancers and varsity women athletes had no significant differences in fitness components.

Palgi\textsuperscript{26} investigated the extent to which VO\textsubscript{2} max and three additional independent variables - anaerobic


threshold (AT), anaerobic capacity (ANC) and per cent body fat - can account for variance in endurance performance. Additionally, comparisons were made between boys and girls on physiological, morphological and performance measures. Thirty girls and 28 boys, 10-14 years of age underwent a multi stage treadmill test for assessment for VO₂ max (ml/kg/min) and AT. ANC/CPM/kg/min) was determined in 30 seconds cycling task. A regression equation was used to estimate per cent body fat from skinfold measurements. A two kilometer run was selected as the endurance performance task. Results indicated that in 10-14 year old children, there is a substantial relationship between measures of anaerobic and aerobic function, although to some extent each provides independent information about endurance performance. While VO₂ max is an important determinant of endurance performance, ANC was found to be as important, rejecting the contention that individual differences in distance running abilities of elementary school children predominately reflect variations in aerobic power. The sub-maximal measure of AT (VO₂ at AT) is just as effective as VO₂ max in accounting for variance in endurance performance. When girls and boys were compared, no reliable differences were found for run time and ANC and in per cent body fat.
Beaudet compared physiological parameters involved in oxygen transport in men and women of similar aerobic capacities as assessed by maximum oxygen uptake. The parameters of cardiac output, cardiac output divided by body weight, haemoglobin concentration, and per cent body fat were examined to detect differences that might exist due to sex or fitness level. The statistical analysis indicated that cardiac output increased with fitness level increases and was greater in men. Cardiac output divided by body weight increased with increases in fitness level but showed no difference due to sex. Haemoglobin concentration was greater in men but did not vary due to fitness level. Percent body fat was greater in women and decreased with increases in fitness level.

Singler selected 51 college men to study the effect of vigorous exercise programme on skinfold thickness. The subjects were divided into two groups. The experimental group participated in the prescribed programme for eight weeks, while the remaining subjects did not participate in

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vigorously. It was observed that there was no significant change in the skinfold measurements.

Trahan selected forty female subjects to determine and compare the effects of two kinds of conditioning programmes on nine fat deposit sites, i.e., biceps, triceps, forearm, scapula, fifth rib, waist, abdomen, inner thigh and knee. A randomization procedure was employed to assign the subjects to one of the two experimental conditions - the strength exercise programme or endurance exercise programme. The subjects participated in the exercise programme three times per week for seven weeks. Endurance oriented exercise programme resulted in greater subcutaneous fat loss than the strength oriented exercise programme.

Boilean and Associates formed two groups from sedentary college men as subjects on the basis of their relative fatness. All subjects walked or ran on a motor driven treadmill, 60 minutes per day, five days a week for nine weeks. The approximate energy expenditure prescribed

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was 600 kilo calories per day of physical conditioning. As a result of physical conditioning programme, significant decrease occurred in the sum of 10 skinfold measurements.

Tufts\textsuperscript{31} investigated the effect of diet and physical activity upon obese college women enrolled in a weight control class, which met for 35 minutes three times a week for a semester. The diet applied was the "1000 calorie Exchange Plan" established by the American Dietetic Association. The physical activities varied from day to day but consisted of calisthenics, rhythmics, folk dances, badminton, basketball, hiking, jogging, bicycling and circuit training. Body weight and eleven skinfold measurements were taken to evaluate body composition. Analysis of data showed significant reduction in skinfold measurements.

Priest\textsuperscript{32} determined whether or not significant changes occur in flexibility, heart rate, body weight, selected anthropometric measurements, body fat and general physical condition as a result of participation in Aerobic


\textsuperscript{32}\textsuperscript{32}Nita Nelson Priest, "Comparative Effects of Two Programs of Aerobic Dance on the Flexibility, Body Composition and General Physical condition of Selected College Women", Dissertation Abstracts International, 44 (January 1984) : 2086.
Dancing and/or Aerobics Ninety-two female volunteers participated in the following pretest and post-test procedures: Twelve minutes run, skinfold measurements, anthropometric measurements, sit and reach test, and resting heart rate. Class/sections randomly assigned to one of the training regimens, exercised for fifty minutes, three times a week, for a period of six weeks. A third group participated as the control group. The following significant changes were recorded: The resting heart rate of the Aerobics group was significantly lower on the post-test. Flexibility of the Aerobics group improved significantly. The Aerobic group gained on the abdominal measurement and the Aerobic Dancing group gained in the gluteal and lost in both thighs. The Aerobic Dancing group lost body fat. Both dance groups showed a significant gain in distance covered in the twelve minute run.

Wilmore and Associates\textsuperscript{33} in their study showed changes in physique for men aged 17 to 59 years who jogged 3 days a week for 10 weeks. The average distance run by the end of 10 weeks was 84.4 km or about 2.8 km a day. Body composition changes did occur but they were relatively small. Because lean body weight did not change, the decrease

in body weight was due to a reduction in percentage body fat from pretest (18.9%) to post-test (17.8%) values, which represented a fat loss of 1.07 kg. The reduction in individual skinfold values paralleled the decrease in body fat.

Quirk and Sinning\textsuperscript{34} conducted a study on six male and six female subjects who performed maximal bicycle ergometer work and skipped rope at selected rates. Measures included oxygen uptake, oxygen debt, blood lactate and heart rate. No significant differences were found between treatment for females for any measure. Rope skipping placed high demands on both aerobic (females 92% VO\textsubscript{2} max, males 76.88%) and anaerobic capacities (Females 100-106% lactate values after maximum bicycle exercise; males, 58-72%). In males, who did not reach VO\textsubscript{2} max during rope skipping it was verified that the VO\textsubscript{2} requirements do not increase with skipping rate over a relatively wide range, but that extremely high rates do require more energy from both aerobic and anaerobic sources. Differences in tolerance of males and females to rope skipping were attributed to the lower aerobic power and higher body fat of females.

Calemen et al.\(^{35}\) studied nine college Basketball athletes to determine the effects of a season of competition on the aerobic and anaerobic energy sources. Pre and post season variable of resting and recovery heart rates, performances of the treadmill test (time), maximal oxygen intake (M/kg.min) and the scores of Margaria anaerobic capacity test (vertical velocity) were studied. Analysis of data yielded non-significant decrease in recovery heart rate, treadmill performance time, and VO\(_2\) max, a non-significant increase in resting heart rate and anaerobic power and a significant increase in vertical velocity from pre to post-test. The results of this investigation suggest that the training regime in basketball was of sufficient intensity to maintain cardio-respiratory function and improve anaerobic performance.

Tanaka\(^{36}\) investigated the relative effects on spot reduction of two types of exercise, one representing the anaerobic (Abdominal exercises) or spot reduction model, and the other representing the aerobic (Jogging/running) model.


Fifty four male volunteer subjects, ranging in ages from 17 to 56, from a Northern California Community College were stratified into three fitness levels. All subjects were then pretested on the hydrostatic and anthropometric measures. The population was then randomly assigned to either order 1(12 sessions of anaerobic followed by 12 sessions of aerobic) or order 2(12 sessions of aerobic followed by 12 sessions of anaerobic). After each of the 12 exercise sessions, all subjects were tested on the hydrostatic and anthropometric measures. The analysis involved two pairs of ANCOVAs, one for each dependent variable. The first ANCOVA analysed aerobic vs anaerobic effects by three levels of fitness and age as the covarite. After only 12, 25 minute exercise cycles, aerobic exercise resulted in a 4% decrease in the per cent of body fat and approximately a one inch loss in waist girth for the Joggers/runners. Anaerobic treatment showed no effects. The mean percentage change of the low fitness group exceeded that of the high fitness group under aerobic condition when measured hydrostatically, but not anthropometrically because of the unexpected lower pretreatment girth measures among the least fit. The results of the findings of this investigation confirm the efficiency of the aerobic exercise in reducing the percentage of body fat and waist girth measurement. The findings support previous research results on the lack of evidence to support the anaerobic or spot reduction model.
Naghibzadeh\textsuperscript{37} examined if circuit weight training could be an effective model to improve aerobic capacity as well as strength. The 47 female volunteers, with a range of 17 to 36 years of age, were assigned to circuit weight training, jogging, and control groups. Each subject was tested prior to and at the end of the 8 week training period on VO\textsubscript{2} max and 1 RM bench press and leg press. The data were analysed by use of multivariate ANCOVA. According to the results of this investigation, there was a 12\% and 96\% increase in VO\textsubscript{2} max for the circuit weight training and jogging groups respectively. The circuit weight 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 change in the leg press. The control group did not change significantly in any variable. He concluded that continuous circuit weight training is an excellent modality to develop aerobic fitness as well as strength.

Cisar\textsuperscript{38} investigated the physiological determinants of distance running performance across adolescent age


\textsuperscript{38} Craig James Cisar, "Physiological Determinants of Distance Running Performance Across Adolescent Age Groups", Dissertation Abstracts International, 47 (December 1986) : 2075.
groups. Based on logistic growth curves, 106 highly active males aged 8 to 21 years, were divided into sub groups aged 8 to 11 yr (N=23), 12 to 14 yr (N=29), 15 to 17 yr (N=29), and 18 to 21 yr (N=25). Measurements taken included leg strength, anaerobic power, anaerobic capacity (AC), fatigue index (FI), body weight (BW), height, leg length, biacromial diameter (BIAD), bi-iliac diameter, leg volume, relative fat (RF), fat weight, lean body weight, running economy (RE), anaerobic threshold (AnT), maximal oxygen uptake (VO₂ max), and 2-m run time. In the overall group of subjects, factor analysis of the physiological variables identified three distinct common factors underlying the highly inter correlated physiological determinants of distance running performance: physical development, body fat, and muscular power. The results indicated that different physiological variables were important to distance running performance at various adolescent stages of growth and development.

Gibbons³⁹ investigated the effects of three selected training intensity levels on anaerobic threshold, aerobic power, and aerobic capacity of young females. Anaerobic threshold (AT), aerobic capacity (max VO₂) and aerobic power (AP) were determined on young females (N=29)

during a maximum oxygen consumption test on motorized treadmill using modified Bulke protocol. The subjects were then randomly assigned to one of the three training groups as follows: (1) 40% above AT, (2) at AT, and (3) 40% below AT. All subjects trained on motorized treadmills at individual training heart rates (+ 5 beats per minute) four times per week for a total of eight weeks. Post-test was administered after training. It was concluded that aerobic capacity and aerobic power can be increased in females through training, that aerobic capacity and aerobic power can be improved in females by training at 40% above anaerobic threshold, at anaerobic threshold and at 40% below anaerobic threshold.

Schreiber studied the effect of participation in university athletics on anaerobic fitness and the relationship of somato type to the development of anaerobic capacity. She concluded that all somato types improved in anaerobic capacity as a result of training. High intensity work of a low duration made the greatest intra-group improvement in anaerobic capacity following participation in their sports.