Chapter II

REVIEW OF RELATED LITERATURE

The investigator has gone through related literature available which is relevant to the present study. The relevant studies found in the various sources which the investigator has come across are enumerated below.

Christine\(^1\) et. al. conducted a study on body composition and aerobic requirement of male and female marathon runners (seven male and four female marathon runners). It was determined that experienced female runners as well as male runners were able to work at a high fraction of their aerobic capacity during actual marathon competition. And both the male and female marathon runners had more than lean body mass. Further no significant differences in these parameters were observed between the male and female runners studied.

\(^1\)W.L. Christine et. al. "Body Composition and Aerobic Requirements of Male and Female Marathon Runners," Abstract of Research paper AAHPER convention (1950), P.22.
Sackett\textsuperscript{2} selected forty six subjects who had failed the Washington State University physical fitness test, were given an additional test cardiovascular efficiency, vital capacity and resting pulse rate. They were divided into equal groups and were given separate interval and development training programs for 13 weeks and were then retested on the same variables. No significant differences were found between results of the two types of training. The 21 second /6 second endurance test was a poor measure of endurance wins. The test retest correlation was -12.

Banister\textsuperscript{3} compared a fitness training method in a school program. Four groups of 14 to 16 year old boys in a North Vancouver junior high school were closely matched on the basis of their scores on three indices. In one out of their four weekly physical education periods they took different training programmes:


\textsuperscript{3}E.W. Banister, "A Comparison of Fitness Training, Methods in a school Program." \textit{Research Quarterly} 36 (December 1965), P.387.
1) Interval Circuit training, emphasizing endurance and strength training,

2) Conventional Circuit training with endurance running,

3) Conventional circuit training with games activity,

4) Playing games only. The effect of introducing these different programmes in a typical weekly school program was studied. Gains were made by all groups in all the indices two months later. The largest gains were made by the interval circuit training group, particularly in the strength index.

Greenberg\(^4\) conducted a study to determine the effects of two interval training programmes on running ability. Two experimental groups of 30 subjects each and a control groups of 24 subjects were used in the training programme which was conducted 3 times weekly for 7 weeks. Both groups trained over distance of 110,

220 and 330 yards. In one group the speed of running was held constant while the number of repetitions of each distance was increased. The second group ran a fixed number of repetitions of each distance which was increased. The second group ran a fixed number of repetitions at a progressively faster speed. Both experimental groups improved significantly over the control group. However no significant difference in improvement of running ability over a 440 yard distance was found between the experimental group.

Davis\textsuperscript{5} studied the effects of two methods of training swimmers. Sixty four male college subjects while 25 others acted as a control group. Following a 7 weeks training programme, both experimental group made significant gains over the control groups. However neither increasing the pace nor increasing the number of repetition was better than the other for improving crawl stroke swimming speed for 90 yards.

\textsuperscript{5}Robert G. Davis "The Effect of Increasing Interval Training Pace or Distance Repetitions on Swimming Speed." Completed Research in Health, Physical Education and Recreation 8 (1966), P.82.
Glinski\textsuperscript{6} compared the effectiveness of fartlek, sprint and interval methods of training in developing selected physical fitness qualities of leg strength, speed in running and cardiovascular endurance. Sixty seven freshman male volunteers from the required physical education programme at state university college Oswego, New York were randomly assigned to three groups. These groups were assigned at random to the fartlek, sprint and interval method of training. Subjects participated in the various training programs for eight week period, meeting twice a week, for 40 minutes per session.

The Covariance technique was used to analyze the data to determine whether there were any significant differences among the training groups in the development of leg strength measured by the leg dynamometers speed in running measured by 60 yard dash and Cardiovascular endurance measured by the Harvard step test and 880 yard run. A single group analysis was performed to determine the improvement occurred on

the criterion within each experimental group over eight week period of training all analysis were evaluated at the 1 percent level of confidence.

It was concluded that 1) the fartlek, sprint and interval methods of training are equally effective in developing leg strength, speed in running and cardiovascular endurance. 2) The fartlek and interval methods of training are more effective than the sprint methods in developing cardiovascular endurance as measured by 880 yard run. 3) Progressive physical training of sixteen session over an eight week period is sufficient for improving the physical fitness items investigated in this study. The following recommendations are made for physical education teachers and coaches.

1) Short repetitive sprints should be utilized in improving performance on shot dashes.

2) More emphasis should be placed on the psychological aspects of training methods and careful consideration should be given to motivational techniques when using the interval and sprint methods of training to ensure peak physical performance.
3) Interval training should be utilized as a quick means of developing cardiovascular endurance.

Bentley determined the influence of several training programmes on speed, strength, power, general endurance and speed movement to male subjects aged 13 to 15 years at Hawkins junior high school were given training for 8 weeks for five days a week. Each group did the same work load each day but their training methods were different. Group A, the continual training ran 220 yards and jogged 220 yards for total of 440 yards. Group B one of the interval training group ran 110 yard for a total 440 yards. Group C ran course of 55 yard and jogged 55 yard for a total of 440 yards. Group D the control group participated in regular physical education class.

Pre and post test was administered before training. The strength was measured by a back leg dynamometer, power was measured by leap meter, general Endurance by a modified Harvard step test, 50 yards

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7 Eare Joines Bentley, "The Influence of Three Training Programmes on Strength, Speed, Power General Endurance and Speed of Movement." Dissertation Abstracts International 29 (November 1968), P.1436.
dash was given for speed test movement of speed was measured by extensors of the hip and flexors of the leg by an automatic timing device.

Analysis of variance revealed significant difference at .05 level of confidence in all variables except speed of movement. Significant gains were found between experimental group and control group. The Continual and interval training methods used in this study produced the same results. Product Moment Correlation technique was employed to determine the relationship between the variables, strength, power and speed appears to be the same continuum and one cannot be affected without having influence on the other.

Shermen investigated that superior endurance athletes posses an exceptionally high oxygen update (aerobic Capacity) under conditions of maximal muscular exertion, where as oxygen update capacity is not the sole determinant of prolonged and server physical work accomplishments. It does reflect the net oxygen transport ability of the cardiovascular system.

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Investigations on young adult and middle aged males have proved that physical training augments oxygen uptake capacity. However, there is scant information about whether such physiological adaptation occurs in the child whose aerobic mechanism is already quite adequate. A study was undertaken to substantiate whether maximal oxygen uptake of the junior high school boy could be elevated by an experimental physical activity program which stresses continues endurance running.

Fourteen healthy boys aged 12 to 15 years were evenly assigned to either an exercise group or a relatively sedentary control group. Prior to experiment and again after 5, 10, 15 weeks, subjects were assessed for maximal oxygen uptake elicited by an all out treadmill run (variables speed, 8.6 percent grade). Measurements were also made of selected cardiorespiratory, Physique and motor fitness attributes.

The experimental exercise program called "milathon training", was performed for 15 weeks, three times per week, each session lasting 30 minutes. Rate
of running was voluntarily and progressively increased as each trainee tried to accumulate greater distance during successive exercise exposures. Intensity of training was estimated at 575 Calories per hour.

On the average the seven exercised boys increased 5.43 ml/min/kg in aerobic capacity (10 percent) while the unexercised boys were not significantly affected, eighty percent of the resultant aerobic capacity gain (4.32 ml/min/kg) occurred during the first five weeks of training with relatively minor variations thereafter. Training produced significant improvements in all out treadmill runtime, two mile runtime, maximal oxygen pulse, maximal heart rate and rate of gross oxygen debt build up during the all out run. In absolute terms the latter two measures decreased and respectively were suggestive of greater cardiac output and aerobic adjustment during exhaustive work exercised subjects reduced body weight and fat while the less active subjects disprayed typical gains in both strength, agility, explosive leg power circulatory respiratory function in the quiet condition and oxygen debt tolerance did not respond to the training stimulus.
Despite a strong statistical association between 11 out treadmill run time and maximal oxygen uptake per kilogram of weight ($r = 0.84$) sequential increments in run duration did not uniformly reflect similar changes in aerobic capacity during training. Both estimates of physical fitness had distinctive profile patterns, the endurance trend linear and the aerobic capacity trend curvilinear. This suggested that oxygen uptake became relatively less decisive for successful endurance performance after an extensive physical training programme.

It was concluded that maximal oxygen intake of adolescent males attained under the specific working conditions employed was an alterable physiological response which could be improved by milathon training. Aerobic capacity could be significantly modified in five to ten weeks while improvement in endurance running performance and changes in body composition require a more prolonged period of physical training.

Weber and Knowlton⁹ compared the cardiorespiratory

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and anthropometric assessment made on 95 randomly selected young college males enrolled in three physical fitness sections and one tennis course, each lasting eight weeks. Laboratory and field measures were utilised to report and evaluate changes in functional fitness and physique variables including nine selected fat and girth measurements, height and weight timed vital capacity, Harvard step test, grip strength, mile run time and vertical jump. Analysis of the data yielded the following conclusions: a) Eight weeks of physical fitness training can produce significant improvement in physique and cardiorespiratory characteristics.; b) a skill oriented tennis class demonstrated no significant physical improvement.; c) Body weight can be increased while body fat is lost.; d) Vital capacity has little value in reflecting levels of physical performance. Specificity of a physical fitness program will influence its outcome.

Adams and Bernauer\textsuperscript{10} investigated the efforts of selected pace variations on the oxygen requirement of

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\textsuperscript{10}William C Adams and Edmund M. Bernauer, "The Effects of Selected Pace Variations on The Oxygen Requirements of Running a 4:37 Mile." \textit{Research Quarterly} 39 (December 1968), P. 837.
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running a 4.37 mile. Nine experienced middle distance runners completed three experimental runs of equal distance and duration on a motor driven treadmill. Each run varied according to pace (steady, fast-slow fast and slowfast), with the individual order to runs rotated to prevent bias in this respect. Heart rate and oxygen consumption measures were taken during rest, exercise and a 30 minute recovery period. Oxygen Consumption values for the 30-90 minute recovery period were extrapolated from earlier measured recovery values.

Analysis of data indicated that there was no significant differences among the three pace plans in net oxygen intake during the runs. However the total oxygen debt value for the steady pace was lower than that for either the fast slowfast or the slow fast paces. The total net oxygen requirement for the steady pace was found to be significantly less than that for the other two paces with no significant, difference between the fast slowfast and slow fast paces. It was concluded that a steady pace is most efficient for achieving best time in the mile run. Several reasons for individual differences in the oxygen requirement for running a specified effort were discussed.
Harpper selected and placed 25 college men into three matched groups on the basis of maximum oxygen consumption. One group participated in a modified army conditioning program of calisthenics and marching (N=8) while the second group participated in a program of interval training involving running (N=9). The third group (control) participated in recreational activities (N=8). The group met 5 days per week for 7 weeks. Pre and post conditioning maximum oxygen consumption and Harvard step test indexes were recorded to evaluate differences. The results showed that the interval training group improved significantly on the two fitness test. The army trained group showed no significant improvement in maximum oxygen consumption but did have significant improvement for the Harvard step test. The control group did not improve significantly.

Pollock, et al studied the effects of walking on

11 Donald D. Harpper, Charles E. Billings and Donald K. Mathews, "Comparative Effects of Two Physical Conditioning Programs on Cardiovascular Fitness in Man." Research Quarterly 40 (May 1969), P.293.

body composition and cardiovascular functions of middle aged men. Sixteen sedentary men 48.9 years of age volunteered to train 40 min, 4 times/week, for 20 weeks. Eight controls of similar qualification were also evaluated. Training progressed from 2.5 miles during week 1 to 3.25 miles during weeks 16-20. The experimental group increased significantly in oxygen intake capacity from 2.30 to 2.941/min (+28%). Pulmonary Ventilation from 86.9 to 102.61/min (STPD : +15%) and oxygen pulse from, resting heart rate and systolic blood pressure did not change. Resting diastolic blood pressure reduced significantly from 77.7 to 74.9 mm Hg. Heart rate reductions from a standard treadmill walk ranged from 4 to 17 beats/min during exercise and from 16 to 20 beats/min during recovery. Body composition showed reductions in total body weight (-1.3 kg) and percent fat (-1.1%). The control group remained constant in most cardiovascular functions and body composition measures. Vigorous walking training had a significant effects on cardiovascular functions and body composition of adult men.
Johnson\textsuperscript{13} compared the effectiveness of slow continuous running, interval training and pace training methods of improving running performance. 120 college freshmen enrolled in body mechanics and conditioning classes at the university of South Alabama Mobile, Alabama were the subjects of the study. The subjects were tested initially for maximum performance on three tests 1) a maximum time run on a motor driven treadmill running at a speed of 10 miles per hour at zero percent incline 2) a maximum time run on a motor driven treadmill at eight and one half mile per hour and zero percent incline 3) a mile run. The two treadmill tests were utilized to approximate a relatively, good one mile for run for an untrained college freshman, and a good two mile run for the same subjects.

The subjects were placed into one of the three training groups according to his physical education class period. Group I the slow continuous running group trained at relatively slow continuous running pace Group I began training by running twenty minutes each

session and progressed to thirty minutes each training session. Group II, the interval training group trained by intermittently running a certain distance and resting for a scheduled period of time. Group II utilizes both fast and slow interval training on alternate days. Fast interval training was confined to distance of either 60 or 220 yard dashes and slow interval training involved running a set number of either 440 or 880 yard dashes. Group III the pace group trained at a predetermined study pace for a mile run. Each subject would train at this prescribed pace for as long as he could maintain the pace or complete a mile. Each subject ran only once at each training session and as soon as each individual finished one mile at the set pace he would begin training at a faster pace. The subject trained once a day three times a week for eight weeks. Any subject who did not attend all twenty four training sessions was dropped from the study.

All subjects were retested on the identical tests at the end of the training period. The mean gains between initial and final scores for each test were analyzed for each group by the difference method a 't'
test for significance of the differences between correlated means. Analysis of covariance was utilized to compute any differences which existed among the groups on each test. Orthogonal comparisons were then used to calculate the nature of these differences. The main findings of the study were:

1) All three training groups showed significantly improved performance on all three running tests.

2) The slow continuous training group was significantly better in improving performance on the treadmill run at eight and a half mile per hour than the combined effects of the interval and pace training groups.

3) Slow continuous running is better than interval and pace training.

4) Pace training is a very effective method of training to specifically train a runner for a particular pace and is highly effective from the standpoint of time and from the psychological point of view.

Crews\textsuperscript{14} investigated the inter-action of frequency and intensity of training as they affect physical work

\textsuperscript{14} Thaddens Reed Crews, "Interaction of Frequency and Intensity of Training on Physical Work Capacity." Dissertation Abstract International 34 (July 1973), P.III15
capacity, cardiovascular function and body composition of adult males. Forty six sedentary male members of the teaching and research faculty and staff of the University of Missouri - Columbia were pretested on the following variables. Physical work capacity, exercise and recovery heart rate, oxygen consumption, oxygen debt respiratory quotient ventilation equivalent and percent body fat. Participants were randomly assigned to one of six training groups after an initial blocking on pretest physical work capacity scores. At the conclusion of the pretesting the subjects trained for seven weeks as member of the six groups representing all possible combinations of three levels of frequency of training (five, three or one day per week), and two levels of intensity of training (exercise heart rate of 150 or 120 beats per minute). All participants exercised 50 minutes per week and thus the duration of a training session was dependent on the frequency of training. Those subjects who were members of a group exercising five days per week performed ten minutes a day at either a heart rate of 150 or 120 beats per minute. Members of group exercising three days per week performed 17, 17 and 16 minutes were their respective sessions at one of the prescribed heart rate. The
subjects exercising only one day per week completed their entire 50 minutes workouts, at the desired heart rate in one conditioning session. It was not necessary that the walk and/or jogging be performed continuously. At the end of the training the subjects were posttested in a manner identical to that of the pretest.

Statistical analysis of the data consisted of the examination of the mean gain scores between and within exercise groups for each dependent variable. A two way analysis of variance with blocking was computed to test the significance of pretest and posttest mean differences among groups for each dependent variable. The Wilcoxon Signed Ranks test was utilized to test the significance of the differences between pretest and posttest scores within each group for all dependent variables.

Supplementary data analysis included the utilization of the person product-moment correlation coefficient to determine the relationship among three methods of predicting percent body fat.

The result of the statistical analysis reveal no significant interaction effects for any of the dependent variable. Examination of the main effects
discloses significant F-ratio for intensity of training for the dependent variable. Physical work capacity recovery heart rate at one three and five minutes following a standard treadmill test and percent body fat.

Inspection of the pretest and posttest means for these variables indicates a greater training effect for the 150 intensity level with respect to physical work capacity and recovery heart rate. The 120 intensity level produced a significantly greater decrease in percent fat than the 150 heart rate group.

The only significant F value for the main effect, frequency of training was found for physical work capacity through the use of a multiple comparison test. It was shown that both the five and three day a week groups had significant greater improvement than the one day per week group. There was no significant difference between the five and three day groups.

The within groups analysis yielded significant gains by all groups for the dependent variable physical work capacity and exercise heart rate at three minutes of a standard treadmill test. In addition examination
of the pretest and posttest mean indicates training effects by all groups for the dependent variable exercise heart rate at one minute of a standard treadmill test, and recovery heart rates at one, three and five minutes after a standard treadmill run.

Jr. Davies\textsuperscript{15} compared the effects of the crest load training procedures, continuous running, and high intensity on controlled sprinting or cardiorespiratory fitness as determined by $v_{o2}$. During the investigation data were also compiled pertaining to the effects of these training programmes on body weight and resting pulse rate. 118 students attending Utah State University were assigned to one of the three experimental procedures or the control group. The running programme consisted of eight weeks of experimentation consist of one week of pretesting, one week of post testing and an intervening six week training programme. During the treatment period each group met three times a week and followed a prescribed workout procedures for thirty minutes each session.

The three training groups showed significantly greater improvement in cardiorespiratory fitness than did the control group. However, no significant difference in VO₂ capacity was demonstrated among the three training procedures. The data based on resting pulse rate supported the VO₂ findings that the three training groups experienced a significant improvement in the cardiorespiratory efficiency not evidenced by control group. However, these data allowed further differentiation regarding the fitness achieved among the training procedure. Reduction in resting pulse rate indicates the continuous running to be superior to the crest load training procedure.

A significant reduction in total body weight was experienced by all four treatment groups with no significant difference recorded between groups. This general weight loss was attributed to variable interaction.

The Balke fifteen minutes Run was demonstrated to be a very consistent measure of cardiorespiratory fitness. The correlation between the pre and posttest means and among the three pretests and post test were high enough to meet research standards. It was
concluded that a) when an individual stresses himself at or above crest load intensity, 140 to 150 beats per minute and if he works diligently throughout each training session, any training programme based on running should provide approximately the same results.

b) a significant reduction in resting pulse rate will result from regular running programme equal to or above crest load intensity. c) Physical fitness is a prime objective of physical education and cardiorespiratory endurance is by far the most significant quality that comprises the individuals total physical fitness. In order to make a positive contribution to cardiorespiratory endurance. Physical education curriculums should include many different types of sports and activities that require student to surpass crest load intensity regularly and preferably on several different occasions, during each class sessions furthermore the skill needed in the performanance of endurance type activities having the potential for above crest load intensity should constitute a large portion of the physical education curriculum. The development of wholesome concepts in relation to cardiorespiratory endurance should also be of major concern to curriculum specialists in physical education.
Kasch et al.\textsuperscript{16} compared the cardiovascular changes in middle aged men for two years of training. Fifteen sedentary middle aged men (39-60 years mean 47) were divided into exercise (n=9) and non-exercise (n=6) group. Exercise consisted of 60 min session, principally running, three times per week. Evaluation were made at 6 months intervals. Mean maximum aerobic capacity improved 17% over the 2 years period from 2.589 to 3.0361\textsuperscript{1}/min in the trained group. Maximum pulmonary ventilation increased 7% from 115 to 123 l/min, BTPS. Maximum heart rate decreased 6 beats to 174.1 O\textsubscript{2} pulse improved 21% from 14.4 to 17.4 ml/beat. Post exercise lactate dropped slightly from 99 to 91 mg/100 ml. Essentially no change occurred in the non exercising; control group.

Mckibben\textsuperscript{17} compared the effects of three different work loads of varying intensity and distance on cardiovascular endurance. Group I trained at a heart

\textsuperscript{16} F.W. Kasch, et. al. "Cardiovascular Changes in Middle Aged Men During Two Years of Training." Journal of Applied Physiology 34 (1973), P.53.

\textsuperscript{17} Stephen Allan Mckibben, "A Comparison of Three Work Loads of Varying Intensity and Distance on Cardiovascular Endurance." Dissertation Abstracts International 34 (May 1974), P. 7029
rate of 150 beats per minute for fifteen minutes, Group II trained at a rate ranging from 120 to 180 beats per minute for fifteen minutes and Group III trained at a rate of 150 beats per minute over the distance run by group II. Subjects were trained five days a week on the treadmill for seven weeks. Pre and post tests were administered for the following criteria maximum Oxygen update ml/kg/min; maximum Oxygen update, l/min, resting heart rate, maximum heart rate, mile run percent body fat.

An analysis of variance on the pre and post tests and gain, correlation coefficient analysis, and Tukey's Range Test were used to test for significant results, leading to the following conclusions:

a) Running for fifteen minutes a day at a heart rate of 150 beats per minute for seven weeks will produce cardiovascular improvement.

b) When spending equal amounts of energy during a given time, there is no difference in continuous running and interval running in the development of cardiovascular endurance.
Brent selected eighty eight male college students enrolled in a conditioning class at Western Illinois University. He studied the effects of three different training treatments upon performance and physiological changes. A treatment was assigned randomly as follows. Treatment 1) control group had no organised training during the experiment Treatment 2) Continuous Running Training individuals assigned to this group run two miles, three times per week at a pace determined by themselves. Treatment 3) Interval Running Training these subjects ran two miles, three times per week on an interval schedule. The pace of the intervals was determined for each individual on the basis of two miles pretest for time. Improvement in the interval group was accomplished by increasing the length of the interval and keeping the pace same. Treatment 4) Continuous Pace Running Training : The subjects in this group ran two miles, three times per week, trying to improve the total time each day. A goal was established based upon the pretest time for the two mile run. If the goal was achieved on a given day as new goal was established for the next day.

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18SwedBurg Randy Brent, "A Comparison of Three Methods of Pace Training for Distance Running," Dissertation Abstract International 35 (February 1975), P.5101
Pre and post test was given to all subjects in the following areas: i) Laboratory Test- blood pressure, Brozekkeys test of body composition, three second timed vital capacity and Astrand-Rhyming test of predicted maximal Oxygen uptake ii) Field Test- Cooper's Twelve minute run and two mile run for time.

Each of the subjects in the three training programmes participated for eight weeks and only those who were regular participants were used for the final data analysis. A 't' test for correlated means was used to determine if the gains between the pre and post test were significant. If a significant "t" was found, a one way fixed effect analysis of covariance was used to compare the mean gains of the control, continuous running, interval and continuous pace training groups. Where a significant "F" value was found the Tukey follow up test was used to determine where there were differences. As a result of the statistical analysis the following findings were taken:

1) The body composition test showed a .05 significance change in the continuous pace training group, but this change was not statistically different from the other three groups.
2) Timed vital capacity showed no statistically significant changes in any of the groups.

3) The continuous running, interval and continuous pace training groups, all gained oxygen consumption in litres at the .01 level of significance.

4) The oxygen consumption in millilitre per Kilogram was significant at .01 level for the interval and continuous pace groups.

5) The gains for all groups were significant on the Cooper's twelve minute run. The mean gain for the control group was at the .05 level and the other three groups showed significant gains at the .01 level.

6) The three experimental groups improved at the .01 level on the two mile run for time.

7) The oxygen uptake of the continuous pace training group was significantly improved when compared to the control group.

8) The interval and continuous pace training group showed significant gains in Cooper's twelve minute test when compared to control group.
9) The three experimental groups improved significantly in performance on the two mile run for time when compared with the control group.

10) The interval training group showed significant performance gains on the two mile run for time over the continuous running group.

The effect of a moderate exercise programme on the sum of 12 skinfold measurements of 11 obese college women was reported by Moody, Kollias and Bushkirk\textsuperscript{19}. Five walk-jog patterns were formulated, each equalling 500 kcal expenditure, ranging from 50\% of the distance walked at three mph and 50\% jogged at five mph, to 100\% jogged at five mph. The actual selection of the run walk combination each day was left to the participant. The training programme was conducted six days per week for eight weeks. Over a period of eight weeks, sum of 12 skinfolds decreased significantly.

Wallace took thirty one college women (age 17 to 42) and divided them in four age groups to observe the effects of four months of cardiovascular training on the composition of body fat. Training was 3 days/week for an average of 15 minutes each session, at 80% of physical work capacity. Measurement of percent body fat, weight and girth were taken before and after four months of training. Daily caloric needs and daily caloric intake were measured along with the caloric expenditure of each workout. Each group decreased in percent body fat, and one group decreased significantly. This significant decrease was found in the group that was extremely above the optional fat ranges. The remaining groups were within the optional fat ranges. Weight changes did not reflect fat loss due to lean body mass development. Daily caloric needs were equal to daily caloric intake which would indicate fat maintenance. All fat lost was therefore due to the caloric expenditure of the training. Overfat individuals can reduce body fat significantly with simple cardiovascular training of walking and running.

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20 Janet P. Wallace, "Responses of The Composition of Body Fat to Cardiovascular Training in College Women." *Research Quarterly* 46 (October 1975), P. 317
Individuals within the optional ranges can maintain body composition with simple cardiovascular training of walking and running. Further fat loss can be done by increasing the intensity, duration and frequency of exercise.

Eugene[^21] conducted a study of sixty three college age females between seventeen and twenty one years of age. The subjects were randomly assigned to one of the four running regimens described as: 1) Interval running two times weekly (Group-I), 2) Long slow distance endurance running twice weekly (Group-II), 3) Interval running three sessions weekly (Group-III), and 4) Long slow distance endurance running three times weekly (Group-IV). Before and after ten weeks of experimental conditioning, data was collected and analysed using a two way analysis of variance for height, weight, nine circumferential assays, seven skinfolds, four body composition components responses, five selected blood chemistry and volume variables and twelve cardiovascular parameters.

The number of students who hoped to matriculate and the low incidence of absenteeism throughout verified the interest that college aged females have in improving their well being. Data analysis revealed significant pre/post F ratios for the following variables. 1) Elevated cholesterol Group II, 2) invated triglyceride values, Group II, III and IV, 3) Increased serum lactate dehydrogenase in all four groups, 4) Increased calf girth for groups I and III 5) decreased suprailiac skinfold for group I, II and III, while group II and III also decreased in sub-scapular skinfold, 6) lowered resting heart rate for group I, II 7) increased post exercise systolic blood pressure for groups II and III, 8) reduced diastolic blood pressure for groups III and IV 9) improved duration of effort on the Modified Balke Treadmill Test for group I, III and IV, 10) improved distance covered on the Cooper's Twelve Minute Run-Walk test for women in all groups and 11) increased maximal aerobic power for group III & IV.

Stewart and Gutin\textsuperscript{22} studied the changes in sub

\textsuperscript{22}Kerry J. Steward and Bernard Gutin, "Effects of Physical Training on Cardiorespiratory Fitness in Children." \textit{Research Quarterly} 47 (March 1976), P.110.
maximal and maximal HR and Vo₂ as a result of 8 weeks interval training in boys aged 10-12 years 13 boys trained while 11 acted as controls. Training HR's averaged approximately 9% of the mean maximal HR. Vo₂max did not change significantly with training, the apparently high threshold for a training effect on Vo₂ max in children is probably related to their naturally active lives. The stresses induced by short term training are probably small as compared to the overall activities of children. On the other hand sub maximal heart rate during bicycle and treadmill exercise decreased significantly with training. The O₂ cost of these submaximal tasks remained unchanged. The findings suggest that the use of Vo₂ max as the only training criterion for cardiorespiratory fitness may be misleading. Since most work tasks proceed at a submaximal rate, and training induced improvement in submaximal response was demonstrated without improvement at maximal effort. Perhaps submaximal Physiological and performance measures are more important than maximal ones in the assessment of cardiorespiratory fitness.
Frank conducted the study to investigate if there were changes in various physiological components of college age men after participating in four different physical conditioning programmes for ten weeks. The physiological components measured were body weight, skinfold, resting blood pressure, exercise blood pressure, serum cholesterol and serum triglyceride, cardiovascular fitness was measured by using Harvard step test, the twelve-minute walk/run and three minute shuttle run and one-minute lateral jump.

The subjects were seventy six men from junior college in Rhode Island. They were divided into four different groups; three participated in a different physical conditioning programme and one was a control group which had no formal physical conditioning programme. The different conditioning groups were (1) Cooper's Aerobic programme (2) Interval conditioning programme (3) Regular physical education programme and (4) Control group. All subjects were pre and post tested on twelve variables.

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Through the use of analysis of covariance each of the twelve variables were analysed. Nine variables were found to be significant beyond the 5% level of confidence. Significant differences were found favouring the Aerobic, Interval and Physical Education groups when comparing the variables of these groups with those of control group. Intercorrelations were performed on all subjects in all four groups.

It was concluded that: Among the four groups Interval conditioning, Aerobic conditioning and Regular Physical Education group were significant in reducing serum cholesterol and triglyceride in comparison to the control group. The Aerobic conditioning, Interval conditioning and Regular Physical groups improved significantly in cardiovascular fitness than that of control group. The Interval conditioning group showed that resting systolic blood pressure and exercise systolic blood pressure was significantly lower than that of control group.

The Interval conditioning group and control group showed significantly more recovery heart rates following maximal work on the Harvard step test than
did either Aerobic conditioning or the Regular Physical Education group.

Serum cholesterol and serum triglyceride's concentration is significantly reduced by engaging in Physical Conditioning Programme.

The control group showed significant increase in serum cholesterol and triglycerides. The control group did not improve in its cardiovascular fitness.

Shire\textsuperscript{24} at. el. studied the effect of high resistance slow rate (HR-SR) and low resistance fast rate (LR-FR) training on cardiorespiratory function and body composition. 34 college women (age 17 to 22 years) were randomly assigned to one of the three groups: HR-SR (n=13); LR-FR (n=11); or C (control, n=10). Assessment of cardiorespiratory function (using a progressive load bicycle ergometer test to maximal exertion) and body composition (anthropometric and underwater weighing) were made before and after ten

weeks physical training programme. The experimental subjects trained on a bicycle ergometer three days per week, with the time per training session progressively increased from 20 to 25 min over the ten week period. The work load for each subject was set to elicit approximately 70% of that subjects pretraining \( \text{Vo}_2 \max \) and to equate the total mechanical work of the two training groups. Both training groups, HR-SR and LR-PR significantly increased relative to the control group in \( \text{Vo}_2 \max \) (12%, 12%) \( \text{O}_2 \) pulse max (12%,12%) work output (79% to 60%) and total ride times (57% to 51%), but difference between the training groups were not significant. No significant alteration in body weight or body composition were found. These results suggest that the cardiorespiratory adaptations measured are independent of those modes of training.

Crawley\(^{25}\) studied the effects of Continuous Vs. Interval training at constant mechanical work on cardiorespiratory fitness. 18 college untrained women were divided into 4 groups which followed training

programmes composed of combinations of two modes of training, continuous and interval and 2 levels of total work, high and low. Ss trained on a bicycle ergometer 3 times/wk for 6-2/3 weeks. Continuous groups trained at loads which elicited HRs roughly equal to 75% of max HR. interval group trained at loads which alternated every two minute between 150 Kpm/ minute below and 150 Kpm/ minute above that load which elicited a HR roughly equal to 75% of max HR. Pre and post training fitness parameters were predicted max \( \text{Vo}_2 \) and HR at a fixed submax load.

Continuous training was significantly more effective than interval training for increasing max \( \text{Vo}_2 \). Both modes of training were equally effective in decreasing HR at a fixed submaximal load. There was no difference in training effects between the high and low total work groups in either of the fitness parameters. These results do not support the hypothesis that total work is the primary training stimulus.

Stewart and others\(^\text{26}\) studied the relationship

\(^{26}\) Kerry J. Stewart, Christine M. Williams and Bernard Gutin "Determinants of Cardiorespiratory Endurance in College Women." Research Quarterly 48 (May 1977), P.413.
between cardiopulmonary (CR) endurance and various physiological and anthropometric measures in 33 college women. Bivariate and multiple regression analysis was used to determine the extent to which the independent variables, individually and collectively, accounted for the variance in the 2-km run. Independent Variables included maximal \( \text{Vo}_2 \), \( V_B \), R and HR. Submaximal HR, response to a standard workloads of steps during a 1 min steptest; percent body fat predicted from skinfolds; body circumferences; height, and weight. \( \text{Vo}_2 \) max in ml kg of body weight accounted for the greatest amount of variance in run time (39%). The steptest added 5.9%, the other physiological measures collectively added 9.7%, while the anthropometric measures collectively added only 2.1% to the explained variance for a total of 56.7%. Although anthropometric factors play a role in CR endurance performance, their influence is small in this population when physiological factors are accounted for.

Burke\(^{27}\) compared the untrained college age males and females in selected physiological alterations as a

\(^{27}\) Edmund J. Burke, "Physiological Effects of Similar Training Programs in Males and Females." \textit{Research Quarterly} \textbf{48} (October 1977), P. 510.
result of training. Experimental group trained three times weekly for eight weeks at a heart rate (HR) intensity between 75% and 85% of HR max with total distance run held equal between sexes. MANOVA revealed significant training effects for the experimental group as well as a significant difference between sexes in response to training. Univariant ANCOVA revealed a significant training effects for \( V_{O_{2}} \) max expressed in ml/kg min\(^{-1}\) and l.min\(^{-1}\), \( V_{E} \) max expressed in ml/kg min\(^{-1}\) and 1/kg. min\(^{-1}\), \( O_{2} \) pluse at \( V_{O_{2}} \) max and body weight. Sex differences were found for \( V_{E} \) max (l.min\(^{-1}\)), and weight. No significant training effects were found for HR max or \( V_{E} \) at \( V_{O_{2}} \) max.

Moffatt et. al.\(^{28}\) investigated whether the placement of triweekly training sessions would enhance aerobic capacity. Forty eight male under graduate students enrolled at the university of Louisville participated as a subject. Group I (n=16) performed exercise in the form of high intensity interval type running (five 3-min exercise bout) on Monday, Tuesday

and Wednesday for ten weeks. Group 2 (n=16) followed a similar exercise protocol with the exception that training sessions were conducted on Monday, Wednesday and Friday. Group 3 (n=16) served as non exercising controls.

Significant (P 0.01) within the group (Pre versus post training) differences were found for aerobic capacity (Vo$_2$ max) and associated physiological variable for Group I and 2. Analysis of covariance demonstrated significant (P 0.01) differences (Vo$_2$ max) among groups. Post hoc comparisons revealed significant difference between the control and each experimental groups.

No significant difference was found between experimental groups. It was concluded that placement of triweekly training session is not critical with respect to enhancement of aerobic capacity in college males.

Stromme and others$^{29}$ studied maximal aerobic power

of 37 athletes (14 females ten male cross country skiers, eight male rowers and five male cyclists) were determined during uphill running on the treadmill and during maximal performance of their specific sports activity. For the skiers significantly (P 0.005) higher VO2 max was found during uphill skiing than during running the differences being 2.9 and 3.1% for the females and males respectively. The rowers and cyclists obtained a difference of 4.2 and 5.6% respectively (P 0.01). The largest individual difference between the two test procedures were 12.2, 5.4, 14.3 and 7.9% for females and male cross country skiers, rowers and cyclists respectively. It is concluded that in evaluation of maximal aerobic power of athletes, it becomes important to select a work situation which allows optimal use of the specifically trained muscle fibers. This means that the test preferably should be identical with the subjects specific sport activity, under the assumption that a reasonably large muscle mass is engaged during the performance.
Anderson studied to determine the effect of an eleven week bicycle ergometer programme of varying intensity and durations on the following variables. Cardiovascular efficiency, eleven blood constituents (Glucose, Bun, Cholestrol, LDH, Albumin, SGOT, total bilirubin, uric acid, Alkaline phosphate, calcium and organic phosphorus) branchial pulse wave amplitude and body composition of adult women. Twenty volunteers enrolled at the university of Mississippi were assigned to one of the five groups. Group I was the control group. Group II and III were assigned work load intensities of 125-135 b pm and 145-155 b pm respectively for duration of twelve minutes five days per week. Group IV and V were assigned similar work load intensities for duration of twenty minutes three days per week. Pre and Post measures were obtained on each of the variables. The 0.05 level of significance was selected for this study. A one way ANOVA revealed a significant decrease in the percent of body fat in group IV and significant increase in cardiovascular

efficiency of group V. A two way ANOVA revealed a significant increase in uric acid between the means of group II and V in favour of group V. A significant increase in cardiovascular efficiency was revealed between the means of group III and group V using a two way ANOVA. The difference was in favour of group V. Correlated t-ratios were computed between pre and post test means. Significant differences were found on one variable in group I, three variables in group II, three variables in group III, one variable in group IV, and two variables in group V.

Gutin, et.al.\textsuperscript{31} examined the extent to which variance in endurance performance could be explained by various physiological and morphological factors in 11 to 12 year old girls (N=33). $V_{O_2 \text{ max}}$ (ml/kg/minute), determined in a multistage treadmill test was significantly related to run time ($r=-.70$). However when percentage of fat, as estimated from skinfolds and girths was held constant. The partial correlation was .09. The correlation between the sum of five skinfolds

\textsuperscript{31}Bernard Gutin, et. al., "Morphological and Physiological Factor Related to Endurance Performance of 11 to 12 Year Old Girls." Research Quarterly 49 (March 1978), P.44.
and run time was .92, the greater amount of subcutaneous fat was associated with poorer performance. The second independent variable to be selected into a forward selectin regression equation was the score on all out 1-minute steptest, an indirect measure of anaerobic capacity. The third variable selected was an index of maturity—whether or not the girls had achieved menarche; the more mature girls tended to do worse on the run. These three variables accounted for 90% of the variance in run time (R=.95). The dominance of fat as predictor of endurance performance was attributed to the extraordinary variability that exists in this parameter in girls of this age.

Kobayshi et. al.\(^{32}\) conducted study to measure maximal aerobic power for 5-6 successive years in 50 Japanese school boys starting from the age of 9 or 13 years and for 2-3 years in six superior junior runners from the age of 14 years. A large increase in aerobic

power was observed during the adolescent growth spurt for 7 school boys, who were trained between the ages of 9 and 14 years. Aerobic power for 43 average school boys increased from 45.0 to 52.2 ml/kg min between the age of 13 and 17 years. The aerobic power of 6 superior junior runners increased from 63.4 to 73.4 ml/kg min between the ages of 14 and 17 years. A remarkable increase in aerobic power was not observed in trained boys before the age of peak height growth velocity (PHV). Beginning approximately one year prior to the age of (PHV) and thereafter training effectively increased aerobic power above the normal increase attributable to age and growth. The highly developed aerobic power found in superior junior runners may have been derived from strenuous training and partially by genetically superior endowment.

Burke and Brush\textsuperscript{33} conducted study in order to determine physiological and anthropometric assessment in a group of young women, mean age=16.2 years, who had been trained regularly by running approximately 50

\textsuperscript{33}Edmund J. Burke and Florence C. Brush, "Physiological and Anthropometric Assessment of Successful Teenage Female Distance Runners." \textit{Research Quarterly} 50 (May 1979), P.180.
miles per week for 2 years. Their mean $\text{Vo}_2$ max of 63.24 ml/kg min$^{-1}$ is among the highest ever recorded in a group of young women. Anthropometric measures included selected segment, lengths diameters, skinfolds and circumferences. These young women appear to be of average height, low body weight and subcutaneous body fat, have a high component of ectomorphy and a smaller overall skeletal frame work than non athletes.

Thomas $^{34}$ determined if an interval training program of submaximal activity involving controlled running, calisthenics and weight training is an effective technique for conditioning women aged thirty to thirty nine. Thirty one females served as the subjects for the study. They were pretested, provided an interval program and then posttested, on the following measurements. The Astrand – Rhyming Submaximal Work test on a bicycle ergometer, the female Eastern Michigan University step test and Cooper's 12 min test, bent knee, sit ups, the Margaria Aghemo,

$^{34}$McPeak Clifford Thomas, " Effects of An Interval Training Program on Aerobic, Anaerobic and Anthropometric parameters on women." Dissertation Abstracts International 38 (May 1978), P.6602.
Rovelli power test, the fifty yard dash, the grip strength with hand dynamometer and elbow flexion and knee extension strength with a cable tensiometer, height, weight, biceps circumference flexed and extended, breast abdomen 2, hip upper thigh and calf circumference and biceps, triceps, subscapular and suprailliac skinfolds and body surface area, body density, percent body fat, absolute fat and lean body mass.

The training program was submaximal in nature and continued for seven and one-third weeks for three days a week for 60 minutes of activity for the most highly conditioned subjects; included two flexibility exercises, six weight training activities, three calisthenics and running. The paired t value between the means was computed and was significant at .05 and 0.1 level of confidence. There were statistically significant positive physical conditioning changes in all but three parameter: weight, body, surface area and elbow flexion strength. Example include: 1) initial mean percent body fat of 36.74 which was reduced to 33.64 or an 8.6% decrease. 2) initial predicted maximal oxygen uptake using Astrand-Rhyning bicycle
ergometer work test of 27.29 ml-kg/min, increased to 32.77 ml-kg/min or a 23.6% increase. 3) an increase of 55.8% on the F-EMU step Test and 4) a 13.3% increase on Cooper's 12 minute test. The results allow the conclusion that all of the parameters but three can be positively changed by providing a seven and one third week, submaximal interval training program for women thirty to thirty nine years of age.

Gregory conducted a study on untrained college males who were randomly assigned to one of two experimental groups or a control group. There were five, seven and nine subjects in the control, interval and continuous groups, respectively.

Training consisted of jogging or running on a quarter mile track for a distance of 2 miles, 5 days a week for 6 weeks. The continuous group trained at an intensity of 162 beats per minute (bpm), while the interval group trained at 174 bpm. A minimum of three-four minute work intervals and a work/rest ratio of 1:1 were utilized by the interval group. Significant (P .01) within group (Pre-versus post training)

differences were found in the experimental group for oxygen uptake (ml/kg·minute) at 180 bpm and Balke treadmill performance.

Analysis of covariance demonstrated significant (P < 0.05) difference in aerobic capacity and treadmill performance among groups. Post hoc comparisons revealed significant (P < 0.05) differences between the control group and each experimental groups. It was concluded that continuous and interval training methods were equally effective in developing endurance when the same total work is performed.

Smith compared the effects of a six week aerobic dance and folk dance program with the effect of a six week aerobic jogging program on the cardiovascular efficiency and percent of body fat. Seventy-six post pubescent females enrolled in physical education classes at Petal junior high school were the subjects. The Cooper modification of the Balke Treadmill test was

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used to determine cardiovascular efficiency. The skinfold method was used to determine percent of body fat. The subjects were divided into three groups - dancers, joggers, and control group. The subjects met five days a week for six weeks. They were pretested and posttested. Results of the study indicate that 1) a six week program of aerobic dance and folk dance will increase cardiovascular efficiency and reduce percent of body fat 2) a six week program of jogging will increase cardiovascular efficiency and reduce percent of body fat. Results also indicate no significant difference in the effect of the two programs.

Uppal\textsuperscript{37} conducted a study to determine the effects of interval training and continuous load methods in cardiorespiratory 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

\textsuperscript{37} 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).
a period of ten weeks, the load was progressively increased after every two weeks. He found that all the three groups had equal training effects on maximal oxygen uptake, vital capacity, leg strength, positive breath holding time and negative breath holding time. Slow continuous and Fartlek method resulted in significantly higher improvement in cardiopulmonary endurance when compared to interval training. Slow continuous running 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.

Holt\textsuperscript{38} investigated the relationship between performance on a circulorespiratory (CR) endurance run of 3.2 km and several physiologic and morphologic measures for 20 males and females ($\bar{X}$ age = 27.9 years) performance of the run was measured on a 400 meter track and evaluated as both total time of the run (run

time) and by the subjects critical running pace (CRP) over the middle six laps of the eight lap run. The run time and CRP were very highly correlated \((r=.98 \text{ and } 0.01)\) Physiologic measures were taken during a treadmill run at both submaximal and maximal levels and included evaluation of heart rate, respiratory exchange ratio, ventilation and oxygen consumption as well as a determination of the subject's anaerobic threshold (AT) using gas exchange variables. During this incremental test, a second change in the gas exchange variable was noted for 31 subjects and later identified as the threshold of respiratory compensation (RCt) before the treadmill test and again four to six minutes after the test four milliliters of blood was drawn for determination of blood lactate values, haemoglobin and hematocrit assessment. Additional measures for each subjects included weight percent body fat, height and activity level of the variable hypothesized to be related to running performance, maximal oxygen consumption \((\text{Vo}_2 \text{ max})\) was most highly correlated to runtime \((r=.89, P < 0.01)\) other variables correalted to runtime with simple r of at least 60 were AT (mph) percent body fat, activity level and maximal ventilation with r's of -.67, .79, .64 and .70
respectively. However for each of these variables the significance of the sample correlation with runtime was reduced if the common variance with \( V_{O_2} \) max was held constant. Maximal blood lactate (an index of anaerobic capacity) was not found to significantly correlate with runtime. Thus of the hypothesized variables, \( V_{O_2} \) max was determined to be the most powerful predictor of runtime. Similarly a stepwise multiple regression predicting runtime using these variables resulted in \( V_{O_2} \) max and the sum of the three skinfolds (a body composition measures) as the first and second variable respectively included in the regression accounting for 80.8% of the variance. Inclusion of the rest of the variables added only 6% to the explained variance. However, the unhypothesized variable, Rct was more highly correlated to runtime than \( V_{O_2} \) max (\( r = .90 \ 0.01 \)) and if used in conjunction with \( V_{O_2} \) max to predict runtime was the first variable chosen accounting for 81.9% of the known variance. The addition of \( V_{O_2} \) max to equation added 4.3% to the known variance. These results suggest that Rct and \( V_{O_2} \) max provide somewhat independent information about running performance. In general men performed better than women on all exercise tests. However the addition of gender to the multiple
regression predicting runtime did not add significantly to the known variance suggesting there was no sex-linked factor affecting performance other than the ones already included in the analysis. Thus, the subjects that performed best on the 3.2 km run were the individuals who not only had high $V_o_2$ max and low percent body fat but were able to utilize a percentage of their fat but were able to utilize a large percentage of their aerobic capacity during the run. (i.e. have a high Rct).

Glenn\textsuperscript{39} determined if the physiological responses due to training are the same for walkers and joggers when the distance is kept equal. Experiments were designed to determine the effect of 20 week training program on the following body composition variables: body density, percent fat, fat weight, lean body weight, total weight. Experiments were also designed to determine the effect of the training on the following cardiorespiratory variables during submaximum exercise and recovery: oxygen consumption, respiratory exchange

\textsuperscript{39} Rowe Deryl Glenn, "Effects of Walking and Jogging on the Body Composition and Cardiorespiratory System of Adults." Dissertation Abstracts International 40 (January 1980), P. 3874.
ratio oxygen pulse, heart rate and blood pressure. Under water weighing using maximum inspiration was used to determine body composition changes. A modified Balke treadmill test to a heart rate of 150 and a standard treadmill walk at three miles per hour on a five percent grade for five minutes and a ten minute recovery were used to determine cardiorespiratory changes. Expired gas samples were taken for one minute at a heart rate of 150 during the modified balke and during the last minute of the standard treadmill walk, blood pressure was taken at rest and immediately after exercise in both treadmill test and during the last minute of recovery in the standard treadmill walk. Heart rate was recorded at the end of each minute of exercise and recovery in the standard treadmill walk. Twenty five untrained subjects age 25-52, participated in the training and testing. A two way analysis of variance with subjects repeated across time was used to determine if any significant differences existed between the means due to time, type of training or an interaction of time and type. If significant F-ratio were found for time, Duncan's multiple range test was utilized to determine where the differnces occured.
There was significant increase in density with corresponding decreases in percent fat and fat weight with no significant changes in lean body weight or total weight. There were significant increase in oxygen consumption, respiratory exchanges ratio, oxygen pulse and treadmill in the modified Balke. The significant changes in the standard treadmill test included a decrease in oxygen consumption and increased respiratory exchange ratio. There were significant increases in exercise systolic pressure in the Balke test, and decreases in exercise diastolic pressure in both treadmill tests. Recovery diastolic blood pressure decreased significantly at the end of the standard treadmill walk. There were significant decreases in heart rate during exercise and recovery in the standard treadmill walk. It was concluded that 20 weeks of training resulted in significant improvements in body composition and cardiorespiratory systems of adults and that the two groups responded same to the training.

Smith\textsuperscript{40} and others determined the relationship of marathon performance time with maximum aerobic power.

(V_o_2 max), body composition and training factors recorded for 9 weeks prior to the race, taking fifty males. These findings of the study suggest that a high maximal aerobic power, low body mass, daily workouts and training runs of long durations and distance contribute to better performance time in the marathon.

Conley et. al.\(^{41}\) studied to determine the relationship between female distance running performance on a 10 km road race and body composition, maximal aerobic power (V_o_2 max), running economy (steady-state V_o_2 at standardized speeds), and the fractional utilization of V_o_2 max at submaximal speed (% V_o_2 max). The subjects were 14 trained and competition experienced female runners. The subjects averaged 43.7 min on the 10 km run, 53.0 ml.kg\(^{-1}\) min\(^{-1}\) on V_o_2 max and 33.9, 37.7 and 4.18 ml.kg\(^{-1}\) min\(^{-1}\) for steady state V_o_2 at three standardized running pace 177, 196 and 215 m.min\(^{-1}\). The mean value for fractional utilization of aerobic capacity for these three submaximal speed were 64.3, 71.4 and 79.3% V_o_2 max.

\(^{41}\)Douglas L. Conley et. al., "Physiological Correlates of Female Road Racing Performance." Research Quarterly 52 (December 1981), P.441.
respectively. Significant (P 0.01) relationship with performance were found for $V_o_2$ max ($r=-0.66$) and $\% V_o_2$ max at a standardized speed ($r=0.65$). No significant (P 0.05) relationship was found between running performance and either running economy or relative body fat. As with male heterogeneous groups, trained female road racing performance is significantly related to $V_o_2$ max and $\% V_o_2$ max, but not related to body composition or running economy. It was further concluded that on a 10 km road race trained females operate at a $\% V_o_2$ max similar to that of their trained male counterparts.

Butts$^{42}$ investigated on percent body fat, rating of perceived exertion and maximal oxygen consumption during a continuous running treadmill test were obtained on 127 high school female cross country runners. These young runners ($x=15.6$ years) were running approximately 25 miles per week at the time of testing. They had an average $V_o_2$ max of 50.8 ml.min$^{-1}$ and an HR max of 198.0 bpm. The mean percent body fat,

as determined from hydrostatic weighing was 15.4%. The onset of metabolic acidosis was estimated to occur at 78% of \( \text{Vo}_2 \text{ max} \). A stepwise multiple regression with the 3000 meter run as the dependent variable indicated that maximum treadmill run time weight relative \( \text{Vo}_2 \text{ max} \) and \( V_E \text{ max} \) entered the equation in that order, yeilding an \( R \) of 0.67. Both HR and RPE increased with work intensity, but not at equal rates. These high school female runners had higher \( \text{Vo}_2 \text{ max} \) than previously reported for this age group; however they were considerably below these values reported for national caliber distance runners.

Arlette\(^{43}\) studied the effects of varying intensities of aerobic interval training, on lipid fractions, body weight, body composition and cardiorespiratory function, were studied in 49 sedentary male Brooklyn College faculty, 30-63 years of age. The subjects trained three times per week for 12 weeks on the stationary bicycle ergometer. Training

\(^{43}\)Cohen Arlette C. "The Effects of Varying Intensities of Aerobic Interval Training Upon the Plasma Lipid Profile of Sedentary Male Faculty Members, 30-63 Years." Dissertation Abstract International 42 (June 1982), P. 5054.
included a two minute warm up followed by 30 minutes of cycling at 85%, 75%, or 65% of the individual's maximum heart rate and concluded by a three minute cool down. A control group went through the same sequence of stress testing and blood analysis with the exception of the aerobic training program.

The analysis of covariance F test showed that there were no significant differences in lipid levels among groups as a result of conditioning.

Additional analysis using the t test for paired observations showed significant intragroup increases in maximum oxygen consumption in the experimental groups training at 85%, 75% (P < .001) and 65% (P < .01) of maximum heart rate. Significant intragroup increases in H.D.L. levels were also seen following training at 85% (P < .01) and 75% (P < .01) of maximum heart rate and significant intragroup decrease in the L.D.L level (P < .01) and LDL/HDL risk ratio (P < .001) were seen following training at 75% of maximum heart rate. There were no significant within group differences in body weight, body consumption, dietary habits or alcohol consumption following training.
Although a possible trend was demonstrated between H.D.L. level and training intensity. It was found that varying intensities of aerobic interval training in a sedentary adult male population did not result in significant alterations in the plasma lipid profile.

Amanda investigated the effects of fourteen weeks of aerobic training on the plasma lipids and lipoproteins, body composition and functional capacity of sedentary adult women. Women who smoked or were taking birth control pills were eliminated from the study because of their effect on plasma lipids and lipoproteins.

All participants were given a pretest \( (T_1) \) intermediate test \( (T_2) \) and a posttest \( (T_3) \) on the following variables. 1) Blood test measured high density lipoprotein cholestrol (HDL-C) low density lipoprotein cholestrol (LDL-C) triglycerides, total cholessterol and the HDL-C/total cholessterol ratio.

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2) Body composition—percent body fat as estimated from the sum of four skinfolds using the Harpenden skinfold callipers. 3) Body weight. 4) Functional capacity—measured by the Bruce Treadmill test.

The experimental group (group I) participated in an aerobic exercise class that met for one hour three days per week for 14 weeks. Subjects exercised at a 75% maximum heart rate as determined by use of the Karvonen formula. The control group (group II) was asked to maintain normal activity and diet. The result of 14 weeks of aerobic training on sedentary adult women are significantly increased functional capacity and significantly decreased percent body fat. HDL-C, LDL-C, triglyceride, total cholesterol and HDL-C / total cholesterol ratio were unchanged in this particular study.

Belle\(^{45}\) investigated the effects of aerobic dance on physical work capacity, cardiovascular functions and

body composition of middle aged women. Maximal oxygen uptake, heart rate during submaximal treadmill walking, resting heart rate, blood pressure and body composition assessed using hydrostatic weighing and skinfold. Circumference measures were determined before and after a ten week aerobic dance conditioning program in 28 women (18 experimental and 10 control), aged 25 to 44 years. During the 10 week treatment period, the experiment's subjects participated in 45 minute of aerobic dance that utilizes 70-85% of the heart rate reserve, 3 days/week whereas the control group continued their normal physical activity pattern. \( \text{VO}_2 \text{max} \) increased significantly (P < 0.05) in the experimental group by 0.142 (l/min 16%) or 1.8 ml/kg min(5%) whereas the control group decreased significantly (P < 0.05) by 0.1171/min (6.0%) and 2.5 ml/kg min (7.7%). Time on the modified Balke treadmill test increased significantly by 2.1 minutes in the experimental group and did not change in the control group. Heart rate of submaximal workloads on the treadmill test decreased 14-18 beats /min in the experimental group and increased 1-4 beats/min in the control group. Resting heart rate and systolic blood pressure decreased significantly in the experimental groups by 5 beats/min.
and 6 mm Hg, respectively, but did not change in the control group. Body weight, % fat, fat weight, fat free weight estimated using hydrostatic weighing; sum of 7 skinfolds and sum of 7 circumferences did not change significantly in either groups. It was concluded that a 10 week aerobic dance program produces small but significant improvement in physical work capacity and cardiovascular functions, but without dietary control, does not alter body composition in sedentary middle-aged women.

Weldon\textsuperscript{46} designed the study to determine which measures significantly changed after seven weeks of training. A further purpose of this investigation was to determine the degree of relationship of these variables to 10,000 meter run times in university cross country runners.

Thirteen members of the East Texas State University cross country team were tested during the

\textsuperscript{46} Priest Joe Weldon "The Effect of Aerobic Training Upon Cardiorespiratory Function, Body Composition And Training Indices and the Relationship of These Variables to 10,000 Meter Run Performance." Dissertation Abstracts International 44 (May 1984), p. 3320.
fall of 1982 pretests and posttest for cardiorespiratory function and body composition were administered at the institute for Aerobics Research in Dallas, Texas. Running times for the fifteen meter, 600 meter, two mile and 10,000 meter run were recorded at the East Texas State University all weather track.

Significant improvements were identified between the following pretest and posttest variables. Maximum treadmill stress test, \( V_{o2} \) 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.

Significant correlations were identified in the maximum treadmill stress test, \( V_{o2} \) max, oxygen pulse, resting heart rate, body mass index 600 mt. run, two mile run, maximum steady state, submaximal heart rate, total workout distance in previous nine weeks, total workout days in previous nine weeks, average workout distance and average workout pace.

He concluded that 1) Training for the 10,000 meter run produces improved performance at all running
distance 2) Training for the 10,000 meter run effects cardiorespiratory functions more than it effects body composition in well trained runners. 3) Training indices accumulated over a seven week period prior to competition are important determinants of optimal performance in the 10,000 meter run. More mileage is apparently beneficial in optimal development of maximum aerobic power. 4) Superior performance in the 10,000 meter run may be predicted from laboratory determinations of submaximum heart rate and anaerobic capacity. 5) Superior performance in the 10,000 meter run is dependent upon optimal development of maximum aerobic power. 6) Superior performance in the 10,000 meter run is dependent upon a runner's ability to perform well at distance of 600 meters or greater. 7) Superior performance in the 10,000 meter run depends more upon a runner's cardiorespiratory function than upon body composition.

Kamil47 studied and identified the effects of a conditioning program on selected physiological

47 Salih Kamil Am, "The Effect of Physical Conditioning Program on Selected Physiological Variables of College Age Women Gymnasts." Dissertation Abstracts International 45 (June 1985), P. 3578 A.
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 conditioning program consisted of running, warm up including stretching flexibility exercise, formal gymnastic training and strength training. A modified Balke treadmill protocol was used to determine the anaerobic threshold and maximal oxygen uptake. Also measured were resting blood pressure, resting heart rate, percent body fat by skinfold and underwater weighing and strength. Descriptive data for each subject at the conclusion of conditioning programme was presented in a case study form. The data for pre and post test were statistically analysed using 't' test to determine if any significant differences existed in regard to the physical and physiological variables. The .05 level of confidence was chosen for all results. The results of this study revealed significant differences in trail effect indicating an increase or decrease from pre and post test. Significant improvements were found in anaerobic threshold, heart rate, resting blood pressure in the standing position, percent body fat from both skinfold
and underwater weighing and all strength measures except for right leg strength. No significant differences were found in the means of $V_{O_2 \, max}$ (ml/kg/min), percentage of max $V_{O_2}$ at anaerobic threshold, supine resting blood pressure, resting heart rate and right leg strength.

Lou\textsuperscript{48} determined the effectiveness of two training modes relative to Max $O_2$ uptake and body composition. The two modes were jogging and use of Nordic track, a CV exercise device that stimulate cross country skiing. Twenty four volunteer male subjects, 18-22 yrs of age from Tarrant Country Junior College. N.E. campus participated in the 12 week training programme of jogging or skiing. Twelve were randomly assigned to each group and trained 20 min 3 days/wk at an intensity of 60 to 85% of maximum heart rate range. Eight male volunteers comprised the control group; they were, from physical education classes, not involved in C.V. training. The subjects were pre and post tested on the

2 dependent variables: max $V_{O_2}$ was determined by the Bruce max treadmill stress test, the underwater weighing technique was used to determine body density from which body fat was estimated by the Brozek et al formula. The data was treated statistically with a multivariate ANOVA, A Scheffe post hoc analysis was applied to the adjusted posttest means when appropriate.

The results showed no significant C.V changes with jogging and training on the Nordic track; however slight changes did occur in body composition. If frequency, intensity and duration are similar, the training results appeared to be independent of the mode of aerobic activity.

Dowdy\textsuperscript{49} et. al. conducted the study to determine the effects of aerobic dance on physical work capacity, cardiovascular functions and body composition of young middle age women. Maximal oxygen uptake $V_{O_2}$ (max), heart rate during submaximal treadmill walking, resting

\textsuperscript{49}Deborah B. Dowdy et. al., "Effects of Aerobic Dance on Physical Work Capacity, Cardiovascular Functions and Body Composition of Middle Aged Women." Research Quarterly 56 (September 1985), P.227.
heart rate, blood pressure and body composition was determined before and after a 10 week aerobic dance conditioning programme in 28 women (18 experimental and 10 control) age 25 to 44 years. During the 10 week treatment period, the experimental subjects participated in 45 min of aerobic dance at 70-85% of the heart rate reserve 3 days a week$^{-1}$, whereas the control group did not participate in any regular strenuous physical activity. Changes in the experimental group were significantly greater than in the control group for $V_o_2$ max expressed in $\text{lm} \text{min}^{-1}$ or relative to body weight or fat free weight (5 to 7% VS -5 to -8%) time on a continuous grade incremental walking treadmill test (16% VS 1%) heart rate during submaximal stage of treadmill test (-9% VS 10%) and resting heart rate (-8% VS 2%). Resting systolic and diastolic blood pressure, body weight, percent fat, fat weight and fat free weight estimated using underwater weighing, sum of seven skinfolds and sum of seven circumference did not change significantly in either group. It was concluded that aerobic dance performed 30-45 minutes 3 days a week$^{-1}$ for 10 weeks significantly improves physical work capacity and cardiovascular functions, but without dietary control,
does not alter body composition in sedentary middle aged women.

Pace\textsuperscript{50} investigated the 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, suprailium and thighs) and the predicted max $V_o_2$. The study was conducted in four stages: two training stages and two detraining stages. The 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 and second was for 15 weeks. Data were analyzed by factorial ANOVA. Predicted Max $V_o_2$ was significantly increased after training and was either maintained or reduced, following training and after detraining levels. Body weight, heart rate and systolic and diastolic blood pressure underwent almost no changes from training through the detraining period.

\textsuperscript{50} Tasterman Edwyne Pace "Training and Detraining Effects on Selected Physiological Measures of Fitness in Adult Black Women." Dissertation Abstracts International 46 (December 1985), P. 1556.
Lynn designed the study to examine the effects of endurance training on the cardiovascular system and body composition of Down's syndrome adolescents and young adults. Fourteen sedentary males and females (average age = 18) were tested for maximal oxygen consumption using the Balke treadmill protocol. Body composition indices included weight and body circumferences and skinfolds at selected sites. Following the initial test, the subjects were divided into an exercise group (N=18) and a control group (N=4), the training group participated in a 10 week walking/jogging programs, three times per week for 30 minutes per session. At the end of the training period all the subjects were retested. There were no statistically (P≤0.05) significant differences between the exercise and the control group for maximal oxygen consumption or body composition either before or after the training program. Thus, the null hypotheses concerning oxygen consumption and body composition either before and after the training programme were accepted. There was a

51 Millar Audrey Lynn, "Effects of Endurance Training on Down's Syndrome Adolescents and Young Adults." Dissertation Abstracts International 46 (December 1985), P. 1554.
statistically (P 0.05) significant difference between the two groups for the treadmill test duration following training in addition, $V_e \text{STPE l.min}^{-1}$, $V_o_2 \text{ml.min}^{-1}$, $V_o_2 \text{ml.kg}^{-1} \text{min}^{-1}$ and heart rate were all slightly lower at the comparable workloads for the trained group. This trend suggests that training effects in the form of greater economy occurred although further research will be required to substantiate the suggested improvements in submaximal oxygen consumption.

Amusa and Sohi\textsuperscript{52} studied to examine the changes in muscular strength, muscular endurance, muscular power, speed, agility, cardiorespiratory endurance and body composition in college age soccer players following a twenty weeks training. The study concluded that all the muscular, speed, agility and cardiorespiratory endurance improved significantly, whereas a reduction in fat percentage was also seen.

\textsuperscript{52}Lateef O. Amusa and A.S. Sohi, "The Effects of Soccer Training on Muscular Performance, Cardiovascular Efficiency and Body Composition." \textit{SNIPES Journal} 8 (January 1985), P. 3.
Alfred\textsuperscript{53} investigated the effects of an aerobic exercise programme on the physiological cognitive and behavioral functioning of ten institutionalized retarded children. The subjects aged 12–21 years were trainable mentally retarded students who were randomly divided into experimental (group I) treatment and control (group II) groups. Group I participated in 30 minute aerobic exercise programme three times per week for ten weeks. Groups II spent the same time participating in physical education motor skill class. All subjects were evaluated at the beginning and end of the ten week period with Durnin and Rahaman skinfolds to estimate the body fat. The Skubic Hodgkins step test, 600 yard run/walk, Goal attainment scale and Vineland Adaptive behaviors Scales - Socialization Domian.

A post test revealed a significant improvement among the experimental treatment group within the areas of body fat composition and cardiovascular

efficiency. Cognitive and behavioral functioning did not improve significantly as a result of the treatment.

Self\textsuperscript{54} investigated the effects of a 10 week physical training (aerobics) and nutrition education/counselling programme on body fat which was conducted on 443 children attending Tarrant Elementary school. The students participated in regular physical education classes or aerobics classes. Students found to be obese at the beginning of the programme were given nutrition education/counselling by either handouts or lectures for their parents. Skinfolds were taken prior to and following a treatment period of 10 weeks. ANOVA was used to determine: 1) differences made in body fat between treatment and regular groups. 2) difference in body fat between obese children receiving handouts or lectures.

Results were that statistically significant, differences were found between body fat of aerobics

and regular physical education groups, (P<.05). The aerobics group demonstrated significantly greater decrease in skinfold fat than regular physical education group. No statistically significant difference in body fat was found between the three nutrition education/counselling groups. It was concluded that the aerobics program was more effective than regular physical education programme for fat reduction. Neither nutrition education/counselling strategies were shown to be effective in reducing body fat.

Marie investigated the effects of a 13 week circuit interval training protocol on functional capacity, hyperlipidemia, hypertension and obesity. After training, functional capacity significantly improved as evidenced by increase in Vo2 max (F(2.63) = 16.53, P<.0001) and maximal MET levels achieved (F(2.63) = 15.45, P<.0001) on a graded exercise test. It was suggested that the mechanism, by which functional

capacity improved, was largely peripheral, skeletal muscle adaptation and a widening of the \( A-V_o_2 \) difference. Since the time at which S.T. segment depression (an indicator for myocardial ischemia) occurred during the significantly increased GXT (\( F_1 \), 2.18=4.01 \( P<.0364 \)) over the course of 12 week, some evidence of myocardial adaptation was provided. A longer duration of training may result in further support for the acquisition of training effects via central adaptation. Blood lipid analysis showed a significant decrease in triglycerides (180±55.9 Vs 142.3±48 mg/dl) with the greatest change occurring after the first six weeks of training. The remaining blood lipids (total cholesterol, LDLs, HDLs) demonstrated favourable although non significant alteration. Resting BP and HR were not affected by training. These findings were attributed to intense regulation of BP and HR by a variety of drugs, including beta blockers, anti anginal and anti-hypertensive agents. The data relating to changes in body composition revealed that training did not provide a sufficient stimulus to decrease body weight or body fat significantly. It was suggested that the training performance in conjunction with appropriate dietary
compliance may have resulted in more favourable alteration in body composition.

Based upon the results of this study a circuit interval training protocol does not alter hypertension, hyperlipidemia and obesity in isolation. Rather, the effectiveness of training protocol as a means to favourably alter coronary risk factors may be demonstrated when it is used as an adjunct to other form of therapy.

In summary this study supports the utilization of a circuit interval protocol for patients with CAD. The highly intense nature of the exercise prescription (70-85% of heart rate reserve) combined with upper and lower body training served to favourably alter important physiological (functional capacity) and metabolic (triglycerides) mechanisms.

Chagas\(^{56}\) assessed 33 male subjects on their initial relative \(\text{VO}_2\) max by means of a progressive

\(^{56}\)Gomes Paulo Sergio Chagas, "Effects of Continuous and Intermittent Training on Body Composition and Selected Physiological Parameters. Dissertation Abstracts International 50 (March 1990), P.2827.
cycle ergometer test and ranked the subjects in descending order. Subsequently they were subdivided into three groups and were submitted to twelve weeks of physical training on cycle ergometer. In addition a group of six male subjects served as non-exercising controls (C.G.). The first group (VTG) training continuously at the Ventilatory threshold. The second (BVTG) group trained continuously at 15% below the VT2. The third group (ITG) exercised intermittently (1:1) at 100% of the $V_{O_2}$ max. The total amount of work done per training session was equated in three groups. The experimental group (Pre, Mid & Post) and the C.G. (Pre and Post) were submitted to a protocol of anthropometric measurements which included weight, seven skinfold and the determination of body density. During the course of the study a nutritional assessment was conducted in all experimental groups by means of recall diaries.

The results of the study showed that power output at maximum exercise capacity increased significantly in all training groups but decreased in the CG at NT$_2$. Power output significantly increased only in the VTG. The absolute $V_{O_2}$ max increased significantly in the VTG
and ITG but did not change in the BVTG and ITG groups. All training groups significantly increased in the $V_{o_2}$ max relative to body weight. Both the relative and absolute $V_{o_2}$ at VT2 significantly increased in the VTG and ITG but did not change in BVTG.

Changes in $V_{o_2}$ at max and at the VT2 were not related in all training groups (for individual groups or pooled data). Body density increased significantly in the BVTG, with no significant changes in the other experimental groups. Changes in the body density seemed to be due to training since the subjects did not alter their nutritional intake during the twelve week training programme, a significant reduction in the sum of skinfolds was observed in the BVTG, but this change was not related to the alteration in body density. Changes in blood lactate and FFA concentrations during training did not seem to be related in any of the experimental groups.

Carlota-selected previously sedentary women ($\bar{X}$

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age = 30 years) who were assigned to a walking (n=16, $\bar{V}O_2_{\text{max}} = 32 \text{ ml kg}^{-1} \text{ min}^{-1}$) or non exercise control (n=11, $\bar{V}O_2_{\text{max}} = 35 \text{ ml kg}^{-1} \text{ min}^{-1}$) group randomly for 40 week period. The walking group walked three miles, four times per week on treadmill. Phase I involved walking 56 minutes at 3.2 MPH and 5% grade. Phase II entailed walking '53 minutes at a speed of 3.4 MPH and a grade of 6%. Phase III involved walking 50 minutes at a speed at 3.6 MPH and 7% grade. Estimated training intensities were 62.8%, 71.7% and 80% per $V_O_2_{\text{max}}$ for phase I, II and III. Overall exercise compliance was 89%, ANOVA'S were conducted for all dependent variables. Follow up independent t Tests were employed at each test level to identify the 5 courses of the differences. Additional analysis were performed on body composition, blood lipid and lipoprotein variable utilizing the Wilcoxon matched pair signed rank test.

$V_O_2_{\text{max}}$ increased 22% ($P\leq0.05$) from baseline for walkers and remained unchanged for controls. Walkers submaximal responses to standardized exercise showed decreased ($P\leq0.05$) in heart rate, pulmonary ventilation, respiratory exchange ratio and ratings of percieved exertion (Borg Scale) Patterns of Changes ($P\leq0.05$) were noted in body constitution for both
walking and control group as indicated by decrease in body weight, body mass index, sum of skinfolds and fat weight for walkers and increase in body weight, body mass index and sum of skinfolds for controls. Walkers maintained above average high density lipoprotein cholesterol level throughout forty weeks, while controls exhibited an unfavourable decline ($P < .05$) in high density lipoprotein cholesterol over the study period. There were no significant changes in levels of total cholesterol, triglyceride, low density lipoprotein or high density lipoprotein or its subfractions over the 40 weeks period. These data suggest that a long term, 12 mile per week walking program in sedentary women substantially increases cardiorespiratory fitness and decreases body fat. In contrast, long term periods of physical inactivity result in increased body fat. This study also demonstrates that walking can reverse declines in high density lipoprotein cholesterol associated with progressive increase in fatness related to physical inactivity.

Lee\textsuperscript{58} studied to determine the effects of an eight

\textsuperscript{58}Grayston Judith Lee, "The Effect of an Eight Week Water Aerobics Program on Selected Physiological Measurements of Female Participants," Dissertation Abstracts International 51 (January 1991), P. 2312.
week water aerobics program on selected physiological measurements of 54 female participants aged 18 to 25 years. The previously sedentary subjects were divided into a control group (n=29) and an experimental group (n=25). The experimental group participated in progressive water aerobics program three times per week for eight weeks. Each subject was pre and post tested on resting heart rate, resting systolic blood pressure, resting diastolic blood pressure, body weight and percentage of body fat. Analysis of covariance was used to determine if any significant difference between the two groups existed on the variables. The result of the study indicated a significant difference at the .05 level in resting heart rate between the two groups. No differences were found in either systolic or diastolic blood pressure, body weight or percentage of body fat. It was concluded that water aerobics can be of sufficient intensity to increase fitness levels for young sedentary individuals.

59DeBlieck and associates evaluated the effects of

high intensity training (HIT) on body composition. In order to better understand this relationship the sum of seven skinfolds (sum 7), % body fat, (% BF) and body weight (BW) were assessed from eleven male collegiate cyclists during six weeks of aerobic interval training. Weekly training consisted of 4 consecutive days of interval training (30 minute @ 88.2 ± 0.74 % HR max; 1:1 work:recovery) and five continuous training sessions (65-85% HR max), resulting in approximately 8-9 hrs of total training per week. Subject's caloric intake was voluntarily regulated. However, nutritional counselling helped the subject to maintain a 64.4% carbohydrate diets during HIT. Dietary intake was estimated each week using a two day dietary recall. Body composition was estimated on Friday's at 7 a.m. each week using 7 conventional skinfold measurements. Significance was determined using repeated measures ANOVA. A significant reduction was observed in the % caloric intake from fat with a corresponding increase in % CHO intake. % BF was decreased from a baseline value of 8.7 ± 0.88% by 14% and 22% following a four and six weeks of HIT respectively. Subjects with the highest initial % BF exhibited the greatest reduction in % BF (r=.86). BW did not change with training
suggesting an increase in lean body mass. Based on body composition changes and caloric intake (n=8), 6 weeks of HIT lead to an estimated deficit of 217 kcal/day. These results suggest that decrease in caloric intake is not necessary for significant reduction in % BF in response to six weeks of high intensity training for cyclist.

ALLIED STUDIES

Alexander\textsuperscript{60}, et.al. investigated the effects of a four week training program on changes in body girth, subcutaneous tissue, muscular strength and endurance and cardiovascular fitness of physically conditioned young men. Seventeen members of karate class from the University of Minnesota were randomly assigned to an experimental group (n=11) and a control group (n=6). The experimental group did heavy resistive isotonic exercise (10-RM) geared for total body participation. The experimental group exercised for 20 minutes three

\textsuperscript{60}John F. Alexander, Stephen L. Martin and Kenneth Metz, "Effects of a Four Week Training Program on Certain Physical Fitness Components of Conditioned Male University Students." Research Quarterly \textbf{39} (March 1968), P.16
times per week in addition to participate in karate class. The control group participated in karate class only. The experimental group decreased in all skinfold measurements and increased in all girth measurements except the waist girth. The control group displayed marked differences in the triceps skinfold (decreases) and the waist girth (increase) measurements. The experimental group significantly improved on the physical fitness index while the control group did not improve. Both groups displayed small gains in cardiovascular fitness. The results of the study indicate that for physically conditioned young males, exercising of this kind brings about changes in girth and skinfold measurements, improves muscular strength and endurance and has a small positive effect on improvement of the cardiovascular fitness level.

Conger and Wessel\(^{61}\) investigated the inter-relationship of selected functional and body form measures, and to examine the differences between groups varying in activity levels. The volunteers for the

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\(^{61}\)Patricia R. Conger and Janet A. Wessel, "Physical Performance and Body Form as Related to Physical Activity of College Women." Research Quarterly 39 (December 1968), P. 908.
study, 35 college women were placed in activity groups termed "most active" and "least active" according to their response on an activity history-recall questionnaire. Functional measures included strength and flexibility. Strength was measured with a cable tensiometer and followed the procedures outlined by H.H. Clarke. Flexibility was measured using a leighton flexometer. Body form measures included height, weight, percent body fat, fat free body weight, specific gravity and Ponderal index. The range, mean and standard deviation were computed for all parameters. The pearson product moment correlation was employed to determine interrelationships of all variables. Equality of variance among selected parameters was determined by the 'F' test, Coch ran-Cox and two sample 't' tests were used to determine the equality of means among selected parameters in the activity groups. Significant differences at the .05 level were found between the means of weight, fat free body weight, trunk extension flexibility with the most active group exhibiting higher values. The least active group showed significantly greater shoulder extension flexibility, shoulder inwarded rotation flexibility and ankle flexion flexibility.
Parizkova et al. studied body composition, aerobic capacity and density of muscle capillaries in a group of young men (I, 20.7 years) and two subgroups of old men (IIA - Sports activity at least 45 years, 72.4 years, IIC - inactive Controls, 73.9 years). Physique and body composition (densitometry), maximal oxygen uptake, and density of capillaries and muscle fibres from quadriceps muscle biopsies (PAS reaction) were taken. In the young (I) body height and weight, relative and absolute amount of lean body mass, maximal oxygen uptake, maximum pulse rate and maximal oxygen pulse were significantly higher than in the both subgroups of old men (IIA,C), the number of capillaries per square millimeter was the same in the young and old, the number of muscle fibres per square millimeter was significantly higher in the old. The capillary fibre ratio was therefore significantly higher in the young i.e. more favourable with regard to oxygen and nutrients supply to muscle fibres. There were no significant differences in any of the indicators mentioned between subgroups of the old men (II A,C). A

significant relationship between maximal oxygen uptake and maximal oxygen pulse on one hand and capillary fibre ratio on other hand was found only in the young men.

Kamon\textsuperscript{63} selected twelve female and eleven male healthy subjects who were tested for maximal aerobic power while climbing a laddermill inclined 30\textdegree from the vertical, running up on inclined treadmill, and cycling at 60 rpm. The mean maximal work load (kpm/min) on the laddermill was higher than on the cycle ergometer by 6\% for the males and by 3.6\% for the females. The mean $V_{O_2}\text{ max}$ was progressively higher for climbing uphill running, and cycling for the females and for uphill running, climbing and cycling for the males. The mean $V_{E}\text{ max}$ values did not differ between ergometers for either sex. For most of the subjects $HR_{max}$ was similar for climbing and uphill running but was lower for cycling as compared to that obtained on the other two ergometers.

The ratio $VE/\text{Vo}_2 \text{ max and Vo}_2/\text{HR}$ reflected the difference observed for the $\text{Vo}_2 \text{ max}$.

Gleser and Vogel\textsuperscript{64} conducted a study to find whether endurance time, 't' the maximal length of time, an individual can work at a given work intensity. They found equation related to work intensity.

$$\log(t) = A \text{ lr} + B$$

Where lr is the work load, divided by $\text{Vo}_2 \text{ max}$ the parameter $A$ and $B$ are sufficient to describe individual's "endurance capacity" i.e. his ability to sustain prolonged work at any relative work load. Furthermore these parameters can be used to compare the endurance capacity of different individuals or the same individual before and after training. The values of the parameter are found empirical but it is suggested that they may reject the rate and quantity of anaerobic metabolism which takes place during prolonged exercise at a given submaximal load.

\textsuperscript{64} M.A Gleser and J.A.Vogel, "Endurance Capacity for Prolonged Exercise on the Bicycle Ergometer." Journal of Applied Physiology\textsuperscript{34} (April 1973), P. 438.
Katch and Danielson\textsuperscript{65} investigated endurance in 29 women who were measured on a bicycle ergometer. Subjects pedaled against a consultant frictional resistance of 2.5 kg for 6 min at an initial rate of 60 rpm (900 kg\textsuperscript{m}) decrement in performance from minute 1 to 6 averaged 28.1%. Reliability of test retest endurance was high (r = 90 after minute 1). Maximal leg force (MLF) measured during cycling at 60 rpm on an isokinetic ergometer correlated r = .73 and .74 with performance at minutes 2 and 3 but r = .51 to .57 for the other minute. Removing heterogeneity in body weight and lean body weight from the MLF versus performance correlations by use of partial correlations reduced the correlations by 75% and 18.30% respectively. The correlation was significant but low (P < .05) between endurance, leg volume and body composition. Prediction of cumulative endurance of 6 min duration was satisfactory with a shorter 2 to 4 minute performance since the correlation in predicting the 6 min results were higher after minutes 2 (R = .76), minute 3 (r = .87) and minute 4 (r = .90).

Cureton et. al.,66 studied the relative importance of body size, body composition, cardiovascular respiratory capacity and running speed to determine the individuals performance in 600 yard and mile run test. They investigated data on 196 children age 7 to 12 years. A multivariant, multistage path model was developed in which height, % fat, \( V_{O_2} \text{ max} \) (ml/kg FFW min) and the 50 yd dash time were postulated as determinants of individual differences on the two distance running tests. These four independent variables accounted for 71% and 66% of the variance in the 600 yard run and mile runs respectively. All four variables had significant associations with the two distance runs when the influence of the other independent variables was taken into account. The 50-yd dash time and % fat were found to be most important determinants of both distance runs. It was concluded that determinants of the 600 yd run and mile run in elementary school age children are complex and that individual difference on these tests reflect a number of attributes in addition to cardiovascular respiratory capacity.

Gettmen et. al. 67 studied to determine the changes elicited by circuit weight training (CWT) and running (RN) programmes conducted 3 days a week for 20 weeks. Subjects were randomly assigned to one of the three groups. CWT(n=11), RN(n=16) and control (n=14). CWT consisted of 10 exercises performed in 2 sets of 15 repetitions with 20 to 25 sec rest between exercises. CWT workout times 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 IRM strength and total weight increased 81% (1506 to 2720 lbs/workout). Multivariate and step down analysis 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 \( \text{Vo}_2 \text{ max} \) (l/min).

The RN group was significantly different from CWT group in \( \text{Vo}_2 \text{ max} \) and treadmill time.

Univariate analysis revealed no differences between the CWT and control group in \( \text{VO}_2 \text{ max} \) expressed

at ml/kg LBW min but did not show a significant superiority of the RN group over the other two groups in this variable. It was concluded that CWT programme was most specific in improving strength and changing body composition and produced only a small aerobic effects as measured on the treadmill running test.

Wells et. al.\textsuperscript{68} prepared the study to investigate the physical characteristics, body composition, pulmonary function, and aerobic capabilities of male and female marathon runners. Oxygen uptake values obtained at sub-maximal treadmill running speed were used to estimate oxygen utilization during a particular marathon event. Seven males and four females training for the 1978 fiesta Bowl marathon (Scottsdale Arizona) were subjects for the study. The subjects were engaged in serious endurance training, running 37 to 120 miles per week but none was considered elite class marathon performer. All data were collected two weeks prior to the race. All subjects completed an informed consent

form and a questionnaire on health status, training activities, and running performance. Vital capacity (Vc) and residual volume (RV) were obtained in the sitting position utilizing a 13.5 L. Collins Respirometer and Helium dilution method. Body density (D) was calculated from hydrostatic weighing utilizing the procedure of Behnke and Wilmore (1974). The formula of Brozek, Grande, Aderson and Keys (1963) was used to calculate percent body fat. It is concluded that the elite class male female distance runners have been described as slight in build, with little body fat and large lung volumes. The marathon runners of this study, although not elite performers did not differ from those described elite. The above 'average' male and female marathoners were able to work at a high fraction of their aerobic power for a prolonged period. The fractional utilization of aerobic capacity was similar to that of elite male performers. The women studied performed the marathon at least as well and perhaps better than men with similar maximal aerobic capacities relative to body weight. It is estimated that male and female subjects expanded 2903 and 2191 kcal respectively to complete the 42.2 km distance.
Sharma undertook to study the relationship of Cardiovascular Endurance to somatotypes of professional Physical Education Men students to determine the relation of each somatotype component to cardiovascular endurance after eliminating the effects of remaining two somatotypes to develop a multiple regression equation for the prediction of cardiovascular endurance on the basis of somatotype components and to compare the somatotype of subjects belonging to high middle and low-cardiovascular endurance groups through somatotype dispersion distances.

Eighty randomly selected students from bachelor degree classes of the Lakshmibai National College of Physical Education, Gwalior, were the subject for this study. They were administered two tests of cardiovascular endurance, namely, Cooper's 12 minute Run/Walk test. and Jonsen, Brouha Darling Treadmill test. Somatotype ratings for the subjects were obtained by the Health Carter Anthropometric variables used.

being height, weight, skinfold measurements at triceps, subscapular, Suprailia and calf regions, biepicondylar diameters of humerus and femur, and girths of biceps and Calf regions. It was concluded that endomorphy and mesomorphy have been negatively related with endurance while ectomorphy has no relation to endurance. The relationship of ectomorphy to cardiovascular endurance is subject to the nature of test used to measure endurance. The role played by endomorphy and mesomorphy in influencing the relationship of ectomorphy to cardiovascular endurance varies with the nature of test of endurance.

Cardiovascular endurance scores can be predicted from somatotype rating. The somatotype of high middle and low middle cardiovascular endurance groups does not differ. There is a real difference in the somatotypes of high and low cardiovascular endurance groups.

Singh et. al.\textsuperscript{70} conducted the study on seventeen

\textsuperscript{70} Hardyal Singh, Asok Ghosh, and Ashok Ahuja, "The Effects of Four Week Training Camp on Physical Fitness and Body Fat of National Women Hockey Team." \textit{SNIPES Journal} 8 (April 1985), P. 50.
women hockey players selected for a 4 week national training camp at Delhi in September-October 1983. The subjects were pre tested and post tested on physical fitness test and skinfold thickness measurements. The training programme for the subjects consisted of general conditioning and technical-tactical training.

It was concluded that training for technique, tactics and general conditioning given to the subjects has resulted in the improvement of all components of physical fitness. In case of body fat the thickness at biceps and subscapular region has decreased but total body fat and body weight of the subjects was not significantly changed due to the effects of training.

Clanton et al. investigated the effects of swim training on lung volumes and inspiratory muscle conditioning. Lung volume and inspiratory muscle (IM) function tests were measured in 16 competitive female swimmers (age 19 ± 1 yr) before and after 12 weeks of swim training. Eight underwent additional IM training the remaining eight were controls. Vital capacity (VC)

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increased 0.25+0.25 liters (P<0.01), functional residual capacity (F.R.C.) increased 0.35+0.47 (P<0.025) in swimmers, irrespective of 1M training, residual Volume did (RV) not change. Maximum inspiratory mouth pressure (P=max) measured at FRC changed -43+18 CMHO₂ (P<0.005) in swimmers undergoing 1M conditioning and -29+25 (P<0.05) in control groups, the time that 65% of pre study P1Max could be endured increased in IM trainers (P<0.001) and control (P<0.05).

All results were compared with similar 1M training in normal females (age 21.1+0.8 yr.) in which significant increase in P1max and endurance was observed in 1M trainers only and no change in VC, FRC or TLC (Clanton et. al. chest 87; 62-66 1985). We concluded that 1) Swim training in mature females increases VC, TLC and FRC with no effects on RV and 2) swim training increases 1M strength and endurance measured near FRC.

Pallock et. al. 72 investigated to determine the

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aerobic capacity and body composition of 24 master track athletes and to evaluate the relationship to age and maintenance of training over a 10 years period. The subjects (50-82 years of age) were retested after a 10.1 year follow up \((T_2)\). All continued their aerobic training but only 11 were still highly competitive (Comp) and continued their aerobic training at the same intensity. The other 13 athletes studied became non competitive (post comp) and reduced their training intensity. The results showed the comp group to maintain its \(V_{O_2}\) max and maximum \(O_2\) pulse while the post comp group showed a significant decline (54.2-53.3 Vs 52.5-45.9 ml kg\(^{-1}\) min\(^{-1}\), 20.7-20.8 Vs 22.4-20.0 ml/beat from test one \((T_1)\) to \((T_2)\) for the comp Vs post comp group respectively). Maximum heart rate decline was 7 beats/min for both groups. Body composition showed no differences between groups from \(T_1\) to \(T_2\). For both groups body weight declined slightly (70.0-68.9 kg). Percent fat increased significantly (13.1-15.1%) and fat free weight decreased significantly (61.0-59.0 kg). Thus, when training was maintained, aerobic capacity remained unchanged over the follow up period. Body composition changed for both groups and may have
been related to aging and for the type of training performed.

Steven studied to determine if significant changes would occur following participation in selected physical education activities relative to the health related physical fitness components of body composition, cardiorespiratory endurance, flexibility and dynamic strength. In addition it was to determine if there were also significant differences among the selected activities relative to the health related physical fitness components and if applicable to locate the differences.

132 students enrolled in physical education activity courses at Tarleton State University were the subjects. Experimental group included those students who were enrolled in weight training, aerobic dance racquetball. A control group was also analyzed in this study and consisted of those students enrolled in

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archery. Pretest procedures involved evaluation of body composition by skinfold measurements and cardiorespiratory endurance by the 1.5 mile run. In addition flexibility was measured by the sit and reach test and dynamic strength by the sit up test following completion of the program activities; identical procedures were used to collect post-test data. A correlated T. test was performed to determine if there were significant differences in pre-test and post-test scores of each item in the test battery. An analysis of covariance (ANOVA) was calculated on the post-test scores for the four performance variables to determine significant difference among groups. Tukey's HSD was used to locate the differences. A difference was considered significant if it reached the .05 level.

Results of the study indicated that all groups experienced significant changes due to participation in the program activities. Subjects involved in the weight training and aerobic dance groups experienced significant positive change in body composition, flexibility and dynamic strength. The racquetball group observed positive changes in flexibility and dynamic strength. The control group experienced significant
negative changes in cardiorespiratory endurance. It was concluded that improvement in body composition, flexibility and dynamic strength can occur due to participation in weight training and aerobic dance, participation in requsetball was found to produce improvement in flexibility and dynamic strength. In addition no improvements can be expected due to participation in archery.

Cooper determined if obesity was a significant negative factor in the ability of children to learn manipulative, non locomotor skills. Three novel manipulative skills were chosen for this purpose: juggling, flip-sticks and the chinese yo-yo. A group of 48, twelve year old children, 26 males and 22 females served as subjects for this study. Two groups of children were determined for this study: obese and non-obese. Criteria for inclusion in the obese group were: a percentile rank of twenty or less on the AAHPERD-HRFT percentile norms. Skinfold chart, and a chronological

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age of between eleven years, eleven months, and twelve years eleven months. Criteria for inclusion in the non-obese group were: a percentile rank of 80 or greater on the AAHPERD-HRPT percentile norms skinfold chart and a chronological age between eleven years, eleven months.

The study consisted of teaching the subjects the three skills over a six weeks period. The subjects were allowed fifteen minutes each day per skill to practise and ultimately perform each of the skills. The subjects were timed to the nearest minute of accumulated time once they satisfactorily demonstrated the skill. The subjects met each day Monday to Friday.

The two group were compared to each other on the amount of time to learn the three skills. T test was used to test the group statistically for significance between the group means at the .05 level of significance. Statistical treatment of the data indicated that obesity was not a significant negative factor in the amount of time required to learn the novel skills. A further analysis of the data was conducted by subdividing the subjects into sub groups.
(male non-obese, male obese, female non-obese and female obese). The sub groups were compared on the amount of time to learn the three novel skills with regard to sex, male to male and female to female. Male to female comparison was not made.

In this comparison as well, obesity according to sex was not indicated to be significant negative factor in the amount of time required to learn the skills of juggling, flip-sticks and Chinese yo-yo. It should be noted that in some instance the obese subjects had a lower group composite time than their non-obese counterparts. The obese group of subjects and obese female sub group had lower times on the Chinese yo-yo skill.