CHAPTER - II

REVIEW OF RELATED LITERATURE
CHAPTER 2

LITERATURE SURVEY

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

2.1 Studies on Resistance Training

Jacobson and Frank (1989) conducted a study on resistive training for prepubescent has met largely with skepticism. Original and possibly premature conclusion with respect to the efficiency of weight training on pre-pubescent considered insufficient circulating androgens in children as the predominant restriction to strength gains. Additionally safety concerns regarding bone integrities, epiphyses continuity and risk of injury are common. A review of the most investigations over when lamely supports significant strength gains in prepubescent as a result of weight training. Further based on recent finding of short-term pre-pubertal weight training, no damage to bone, epiphyses, growth tissue, or muscle has been reported. In the light of these findings, weight training may be recommended provided expert professionals are consulted and strict supervision is maintained. It is also recommended that repetitions be maintained within the 6 – 10 range rather than utilizing maximum weight.
Ozmum, Milkesky and surburg (1994) have conducted a study to determine the effects weeks of resistance training on muscular strength, integrated EMG amplitude (IEMG) and arm anthropometrics of prepubescent youth, sixteen subjects, eight males and eight females were randomly assigned to train and control groups. All subjects, were of pre-pubertal status according to the criteria of Tanner. The trained group performed three sets (7 – 11 repetition) of biceps curls with dumb-bells three days per week for eight weeks. Significant isotonic (22.6%) and Isokinetic (27.8%) strength gains were observed in the trained group without corresponding changes in arm circumstances of skin folds. The IEMG amplitude increased to 16.8% (p<0.005). The control group did not demonstrate any significant changes in the parameters measured. Early gains in muscular strength resulting form resistance training pre-pubescent children may be attributed to increased muscle activation.

Hisacda et. al (1996) conducted a study to assess the influence of two different modes of resistance training in females subject. This study consists of two groups. One group underwent resistance training with low intensity and high volume training and other participated in high intensity and low volume training. The former consisted of sets of 1 – 20 RM with sufficient rest between sets. While the latter consists of 8-9 sets of 4 – 6 RM with go seconds rest in between sets. In both the groups the percentage changes of Isokinetic strength were significantly higher. The result suggests that during the early phase of resistance training two different modes of resistance training may have similar effects on untrained females.
Hetzler et al (1997) have conducted a study on strength and power training in young male Baseball players does not improve functional performance. Two groups of 10 pre-pubescent and pubescent male baseball players trained three times per week for 12 week using a variety of general free weight and machine exercises designed for both strength and power acquisition. For the experienced, notice and control groups respectively the following gains were recorded; leg press –41%, 40% and 14% and bench press 23%, 18% and 0%. Both training groups were significantly better than the control group. Similarly the two training groups improved in vertical jump.

Berger (1963) conducted a study on three groups totaling 48 college student who were trained with progressive resistance exercise for a period of nine weeks three times a week. Each group trained with a different program using the bench press lift. Groups I trained with the 2 – RM for six sets, group – II with the 6-RM for three sets and group – III with the 10 RM for three sets each training session. The 1 – RM for the bench press lift was determined before and after the nine week training period. A comparison was made between groups – II (39-6R and II (3g – 10RI) after nine week of training. In both the studies, group – II had a higher mean then group – III but the mean differences were not significant. In both the studies, group – II has a higher mean than group – III but the mean difference were not significant. In Berger’s study, training continued upto 12 week and at that time the mean of group – II was significant higher than the group – III mean. It is probable that the continuation of the present study to 12 weeks would have resulted in significant differences between groups II and III. The results of this study is that training for nine weeks, three times a weekly with heavy for few
repetitions per set and numerous sets is not more effective for improving strength than training with lighter loads for more repetitions per set and fewer sets.

Sailors and Berg (1987) compared the effects of an eight week training programmes on strength / Muscular endurance and somato – type in pubescent boys (N=11, mean age S.D. =12.6+.69 years) and male college students (N=9; mean age S.D.=240+5.12 years). Control groups were used to account for the effects of maturity in these measures. Strength Muscular endurance was assessed by determining the 5 RM (Repetition Maximum) in the arm curl, Squat and bench press. Both the training groups significant increased the 5 RM in each lift (P<05) while no significant changes were observed in either control groups. The differences in the 5 RM gains between the pubescent and Men’s training groups were not significantly different. Somato type analysis indicated no significant changes in groups except for decrease in mesomorphy in the boys training group (P<05). These boys also showed an increase in height (P<05) and a decrease in skin folds (P<05). It appears that young males at this age are as trainable as mature men as regards performance of 5 RM.

Stone and Cuttler (1994) studied the effects of three resistance training protocols on strength / Endurance with women. Fifty college women were randomly assigned to one of the three resistance training protocols that employed progressive resistance with high resistance / low repetition, medium resistance / Medium repetitions and low resistance / high repetitions. The three groups were trained weeks at three sets of six to eight RM, two sets of fifteen to twenty RM, and one set of thirty to forty RM, respectively. There were significant pre / post strength increase in both upper and body tests, but no post
treatment in Muscular strength in three protocols. Absolute Muscular endurance increased significantly in four of six – pre / post comparison, while relative endurance increased significantly on only for of twelve comparisons. Alight resistance / low repetitions yielded greater strength, gains. Low resistance / high repetitions training generally produced greater muscular endurance gains and percentage in case in absolute endurance was approximately twice the increase in strength for all groups.

Ratzin et al (1990) conducted a study in which 12 subject did two 7.5 week training programs, high resistance – low repetition (for improving strength), and low resistance – high repetition (for Muscular endurance), with a 5.5. week pause between programs. Six subjects did the endurance program first and the strength program second; the other six followed the opposite order. All major fiber types (I, II a, III b) increased in cross-sectional area after the first 7.5 weeks, independent of type of training. However in the second 7.5 weeks, the strength program caused a further increase in the cross sectional areas of the type I and II b fibers, while a decrease occurred in those doing the endurance program.

Anderson and Kearney (1982) have conducted a study on resistance training. Three sets of a) high –resistance-low repetition (HL) group (N=15) performed three sets of 6-8 Rm per session: b) medium –resistance-medium-repetition (MM) group (N=16) performed two sets of 30-40 Rm per session: and c) low resistance – high repetition (LH) group (N=12) performed one set of 100-150 Rm, trained three times per week for nine weeks. Strength (1 Rm) absolute and relative endurance were assessed before and after the training period. Low repetitions and high resistances favour strength, whereas moderate
to high repetitions using a moderate weight that can be accommodated produce endurance and minor strength changes. It is anticipated that the specificity of these effects will be more evident the higher the levels and training states of athletes who engage in this type of exercise.

Starkey, and et al (1996) have conducted a study on different volumes of high intensity resistance training on isometric torque and muscle thickness. Training was conducted three times per week using one set (group N=18) or three sets (group N=20) of exercise. A control group (N=10) performed no exercise of the experimental form. Both groups improved torque similarly at most angles. There were no significant differences in muscle thickness changes.

Tan (1999) has found that resistance training program variables can be manipulated to specifically optimize maximum strength. After deciding on the exercises appropriate are training intensity (load) and volume. The other factors that are related to intensity are loading form, training to failure, speed of contraction, psychological factors, interest recovery, order of exercise, and number of sessions per day. Repetitions per set, sets per session, and training frequency together constitute training volume. In general, maximum strength is best developed with 1–6 repetition maximum loads, a combination of concentric and eccentric muscle actions, 3–6 maximal sets per session, training to failure for limited periods, long interest recovery time, 3–5 days of training per week and dividing the day’s training into 2 sessions. Variations of the volume and intensity in the course of a training cycle will further enhance strength gains. The increase in maximum strength is affected by neural, hormonal, and muscular adaptations.
Faigenbaum, et. al (1995) have conducted a study on the effects of eight weeks of strength training followed by eight weeks of detraining in children (7-12 years) were evaluated. Sessions were conducted twice per week. A group matched for age and maturity level served as a control group. The trained group improved leg extensions (53.5%) and chest press (41.1%) controls improved 7.9%. Vertical jump and sit and reach flexibility did not change in any significant manner indicating the specificity of training effects. Twice-per-week strength training is sufficient to dramatically improve the strength of children over gains that would be expected by maturation.

Witzke and Snow (1997) has investigated the effects of plyometrics and resistance training on BMD in 14 years old girls. Fifty - three girls completed the 9 month program. Exercises trained 30 – 45 minutes, 3 times / week. Weighted vests were used for squats, lunges, calf raises, and jumping. Plyometrics included hopping, jumping, bounding and depth jumps. MANOVA showed that the changes in all variables for the exercises were not significantly greater than controls. Although improvement in BMD tended to be higher in the exercises, especially for the greater trochanter (GT) these differences were not significant. The variety for the lateral movement activities performed by the exercise group may have contributed to the large differences observed between groups for GT BMD and medial / lateral balance. Since the GT is a common osteoporotic fracture site and since a majority of hip fractures occurs from falls to the side (often related to strength and balance problems), resistance training involving a later component may have implications for fracture prevention. Future studies however, should be longer than 9 months to
determine if this intervention strategy is able to produce significant improvement in BMD, strength and balance.

Nakao et al (1995) investigated the effects of a long term weight lifting programme characterized by high intensity, low repetition and long rest period between sets on maximal oxygen consumption (VO$_2$ max) and to determine the advantage of this programme combined with jogging. Male untrained students were involved in weight training for a period of 3 years. The VO$_2$ max and body composition of the subjects were examined at beginning and 1 year, 2 years (T2) and 3 years after (T3) the training of the group 19 subjects performed the weight lifting programme 5 days each week for 3 years (W – group). 4 subject performed the same weight lifting programme for 3 year with an additional running programme consisting of 2 miles jogging once a week during the 3$^{rd}$ year (R1 – group) and 3 subject performed the weight lifting programme during the 1$^{st}$ year and the same combined jogging and weight lifting, programme as the R1 group during the 2$^{nd}$ and 3$^{rd}$ years (R2 – group). The average VO$_2$ max relative to their body mass of the W – group decrease significantly during the 1$^{st}$ year followed by an insignificant decrease in the 2$^{nd}$ year and a leveling off in the 3$^{rd}$ year. The average VO$_2$ max of the W – group at T2 and T3 was 44.2 and 44.1 ml kg$^{-1}$ min$^{-1}$, respectively. The tendency of VO$_2$ max changes in the R, and R2 group was similar to the W – group until they started the jogging programmer, after which they recovered significantly to the initial level within a year of including that programme and they then leveled off during the next year. Lean body mass estimated from skin fold thickness has increase by about 8% after 3 years of weight lifting. The maximal muscles strength, defined by total Olympic lifts (snatch) and clean
and jerk) of these three groups increased significantly and there was no significant difference among the amounts of the increase in the three groups.

2.2 Studies Related to Endurance Training

Uppal and Tunidon (1984) studied the comparative effect of different frequencies of endurance training on cardio respiratory endurance. According to their findings the cardio respiratory endurance of secondary school students could be effectively improved by administering a progressive programmed of training. To bring about significant improvement in cardio respiratory endurance, varied frequencies of training namely twice, thrice and five days a week out using interval running method, administered effective in developing cardio respiratory endurance when compared to work outs twice a week.

Cearely and others (1984) conducted a study on the effect of two days and three days per week aerobic dancing programme on maximal oxygen uptake. In this study 18 female college students enrolled in an aerobic dance class were randomly assigned to one of his experimental groups. A group of seven students enrolled in physical education badminton courses volunteered to serve as sedentary controls. Individuals who had been previously trained or those engage in any type of physical training were excluded from the study. Training for both group was conducted between the hours 4.00 pm to 6.00 pm two or three times weekly for the period of ten weeks. The subjects were also instructed not to participate in outside class activities. He concluded that three days aerobic dance group per week improved better in maximal oxygen uptake than two days aerobic dance training per week.
Judith Jee (1991) studied the effect of an eight week water aerobic dance programme on selected physiological measurement of 54 female participants aged eighteen to twenty five years. The previously secondary subjects were divided into control group (N = 29) and the experimental group participated in a progressive water aerobic dance programme three times per week for eight weeks. Each subject was pre and post tested on using heart rate, resting systolic blood pressure, resting diastolic blood pressure, body weight and percentage of body fat. Analysis of co-variance was used to determine if any significant difference between the two groups existed on the variables. The result of this study indicated a significant rate between the groups. No difference were found in either systolic or diastolic pressure, body weight or percentage of body fat. It was concluded that water aerobic dance need to be of sufficient intensity to increase fitness in young sedentary individuals.

Barik and Banerjee (1990) studied the effect of six week conditioning programme on some performance variable among tribal students by random sampling. 17 tribal school boys of 14 – 16 years were selected. All the subjects had undergone a six week conditioning programme. The standard fitness test comprised of 50mts dash for speed, vertical jump for strength, squat thrust for agility and co-opefs 12 minute run and walk for endurance. “t” ratio was computed and analysis of data revealed the following. Speed and endurance increased significantly after training. Strength and agility increased significantly after training. There were no significant changes in blood sugar level after training.

Isreel (1987) conducted a study on the effect of aerobic, anaerobic and pulse work out exercise on selected physical fitness and physiological
parameters. Sixty five volunteers male under graduate students were used as subjects. The four treatments utilized consisted of aerobic, anaerobic and pulse work out conditioning programmer as well as a control group. The aerobic treatment consisted of a 30 minute continuous jogging session, while the anaerobic treatment consisted of 15 maximal sprint 40 yards in length. The pulse work out exercise programme was designated to work the subject at his optional work capacity (180 6 pm). All exercise group worked out four days per week for five week. While the control group remained sedentary. Pre and post test measurements were taken on co-oper’s twelve minute run distance. Balke treadmill test measures endurance time and other physiological variables. The data from each variable were analysed by using a one way analysis of variance. It was concluded that the aerobic and pulse work outs exercise programme increase the cardio respiratory endurance most efficiently.

Gray (1988) studied the effect of three modes of aerobic training on cardio – vascular endurance, which were cycling, jogging and swimming. The subjects for this study were 102 college men and women 17 to 29 years of age. The subjects were allowed to select the mode to training on their own (Cycling, jogging and swimming). These three groups were further divided into two sub groups each of which divided into two sub groups each of which were designated and experimental and control sub groups. Experimental group exercised for forty minutes for thrice a week for seven consecutive weeks. Based on the findings of this study it was concluded that anaerobic exercise programme on cycling, jogging and on swimming produce a significant gain in cardio – vascular endurance and it was further concluded that there was no
significant difference in specific exercise, heart rate training method to produce a significant increase in cardio vascular endurance in the aerobic modes of cycling, jogging and swimming.

Ren from (1989) determined the effects of an aerobic training regimen of second and fourth grade pupils in Feasterville school system. Two hundred and twenty two students were the subjects for this study. The students were measured on the following variables, height weight, skin fold Measurements Fifty yards dash, vertical jump, shuttle run. Flexibility and nine minute run before and after the experimental period. The treatment group participated in a 21 week aerobic programme consisting of twelve minutes of aerobic actability per day. Comparison were made between the treatment and control groups for second graders fourth graders and total groups. The results of this study showed that anaerobic training programme had little or no effect on cardio – vascular endurance in elementary school children. However the aerobic programme did have a significant effect on percentage of body.

Sharkey and Hollman (1989) studied the cardio respiratory adaptations to training at specified intensities. Sixteen college men were randomly divided into three training groups and one control group in a study of selected cardio respiratory adaptations to six weeks of training exercise eliciting either 120, 150 or 180 heart rates. Training consisted of walking on the motor driven treadmill for 10 minutes a day, three days per week. After analyzing the pre and post-test scores, analysis of groups improvements was significantly different form all other groups. The 150 groups was found to be significantly different from the 120 and control group. Results of this study support the hypothesis that intense activity is necessary to bring about the change
associated with cardio – respiratory endurance. These have been numerous 

studies of the effect of training on aerobic aspects of fitness (Bassery 1978). 

One of the most important conclusions was drawn by Sidney and his colleagues (Sidney et al. 1977) for the authors conducted not only that aerobic power could be increased by training but that maximum oxygen intake returned quite quickly to the level participated in a sedentary person 10 to 20 years younger than the test subject. The improvement aerobic capacity is as in younger ages, due to a combination of improvement in the cardiovascular and respiratory systems which transports oxygen around the body and to an improvement in the muscular enzymes which extract and use the oxygen brought to the cells (De vries, 1970).

Most researchers have reported that the cardio-respiratory systems of children and youth respond regular aerobic exercise in a fashion somewhat similar to that seen in adults. Thomas Rowland (1995) of the Baystate Medical Center in Springfield, Massachusetts, has shown that children can improve aerobic fitness after training but that the increase in less than for adults. In one study of 37 boys and girls, ages 11 to 13 years, 12 week of irregular aerobic training improved VO2 max by 6.5 percent, about half what adults typically experience. Rowland conducted that several factors may be responsible for this: Children have high aerobic fitness levels to begin with, Adults may train more effectively than children and the bodies of children may lack of the ability to adapt and respond fully to regular exercise.
2.3 Studies Related to Resistance and Endurance Training

Spodaryk (1993) conducted a study on the effects of long lasting endurance and strength training on the constituents of the blood. The athletes were divided into two groups, endurance trained subjects and strength trained subjects. The control group was composed of untrained male subjects. Blood samples were taken at rest for determinations of several haematological and iron related parameters. The mean haemoglobin packed cell volume and red blood cell measured in the endurance athletes were significantly lower than the control group, but were comparable to those obtained in the strength trained athletes. There were not significant differences in the haematological indices between the groups of athletes and the control group. The results of the investigation showed that some haematological parameters of the endurance athletes differed from the untrained subjects as well as the strength trained subjects.

Stein (1989) studied the cardio respiratory effects of training three days per week at a specified intensity on sedentary college women. Fourteen sedentary college women were trained on a tread mill three times / week for nine weeks at an intensity of 50 % of heart rate reserve added to resting heart rate until 1000 beats were elicited above the resting value. Results showed a significant training effects from pre to post test for Max VO₂ and pulse rate.

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

Broeder, et. al (1992) conducted a study to determine the effects of either 12 week of high intensity endurance or resistance training on resting metabolic rate (RMR) were investigated in 47 males aged 18 – 35 years. Subjects were randomly assigned to either a control (C), resistance – trained (RT) or endurance – trained (ET) group. After training both exercise groups showed significant declines in relative body fat either by reducing their total fat weight and increasing fat-free weight (RT). RMR did not significantly change after eight training regimen although a small decline in energy intake was observed along with an increase in energy expenditure. (ET, 2.721 MJ (650 real) per training day). These results suggest that both endurance and resistance
training may help to present an attention in RMR normally observed during extended periods of negative energy balance (energy intake less than expenditure) by either preserving or increasing a person’s fat free weight.

In 1980 Hickson showed a 10 – week combined strength and endurance training program resulted in similar gains in VO₂ max compared to an endurance only group, but there was some interference with the gains in strength. The strength only group increased strength throughout the entire ten weeks, but the combined strength and endurance group showed a leveling off and a decrease in strength at 10 weeks. In contest to this when a 10 – week (3 day per week) strength training program was added to a run and cycle training program after the group and leveled off in endurance performance, the group experienced a 30% gain in strength, but without hypertrophy. VO₂ max was unaffected, but cycle time in exhaustion at 80 % VO₂ max was increased from 71 to 85 minutes. This suggests that strength training can improve the performance of prolonged heavy endurance exercise.

Sale et al (1990) found that relative to gains in strength and endurance, when endurance training was added to strength training (S+E), additional improvements occurred in endurance than were generated by strength training alone. However, strength measures were unaffected. When strength training was added to E-training (E+S), more gains were made in strength than were generated endurance training alone; endurance measures were unaffected. The authors concluded that concurrent strength and endurance training did not interfere with strength or Endurance development in comparison to strength or Endurance training alone. Thus the effectiveness of added training may depend on a variety of factors, such a intensity volume and frequency of training.
Melrose and Knowlton (2005) investigated to examine the effects of a hybrid, simultaneous, resistance and aerobic training program on aerobic power and muscular strength. Free weight 1 RM elbow flexor strength and cycle ergometer maximal aerobic power (CE VO₂ max) were assessed for 15 untrained subjects. All training was performed three times per week. Aerobic training consisted of five to six, three - minute bouts of high intensity exercise performed on a calibrated monark cycle ergometer. All training intervals occurred at 85 to 100 % of the subject’s CE VO₂ max. Training intervals were separated by three of performing arm – flexion exercise with the subject’s dominant arm using a free – weight dumbbell. The strength training protocol consisted of performing four working sets of exercise per session separated by three minutes of rest. The first two weeks of training consisted of four sets of 10 RM, the third week at 8RM, the fourth at 6 RM, the fifth at 4RM, and the sixth at 2RM. The simultaneous training group performed both the aerobic and strength training protocols simultaneously. The aerobic and simultaneous groups significantly (P<0.05) increased aerobic power 33.6#6.1 to 39.1#6.8 and 36.2 ± 3.7 to 42.3 ± 5 ml x kg −1 x min−1 respectively. There was no significant difference in aerobic power increase between the aerobic and simultaneous training groups. The strength and simultaneous training groups significantly (P<0.05) increased 1 RM strength 11.36 ± 3.2 to 16.81± 5.1 kg and 13.81 ± 5.13 to 17.72 ± 6.15 kg respectively. There was no significant
strength difference between the strength and simultaneous training groups. In conclusion, simultaneous high – intensity, cycle ergometer, aerobic training and one-arm, free weight, strength training can be effectively utilized to increase maximal aerobic power and dynamic elbow – flexor strength. This study shows that the concept of simultaneous, high intensity aerobic and strength training is viable and that this approach to training may perhaps become a conditioning option for athletes and non athletes.

Kraemer et al (2003) and others have studied to compare the physiological and performance adaptations between periodized and non periodized resistance training in women collegiate tennis athletes. Thirty women (19+ / - year) were assigned to either a periodized resistance training group (P) non periodized training group (NU), or a control group (C). Assessments for body composition, anaerobic power, V02 max, speed, agility, maximal strength, jump height, tennis – service velocity and resting serum hormonal concentrations were performed before and after 4, 6. and 9 months of resistance training performed 2 – 3 week. Nine months of resistance training resulted in significant increases in fat – free mass; anaerobic power, grip strength; jump height, one repetition maximum (1 – RM) leg press, bench press, and shoulder press, serve, forehand, and backhand ball velocities. and resting serum insulin – like growth factor – 1, testosterone, and cortisol concentrations, percent body fat and V02 max decreased significantly in the P and NV groups after training. During the first 6 months, periodized resistance training elicited significantly greater increases in 1 – RM leg press (9 + 1 – 2Vs 4.5 + 1 – 2%), bench press (22+15 vs 11+1-8%) and shoulder press (24+1-7 vs 18+1-6%) than the NV group. The absolute 1 RM leg press and shoulder
press values in the P group were greater than the NV group after 9 months. Periodized resistance training also results in significantly greater improvements in jump height \((50 + / - 9 \text{ vs } 37 + 1 - 7\%\) and serve \((29 + / - 5 \text{ vs } 16 + / - 4\%\) for hand \((22 + / - 3 \text{ vs } 17 + / - 3\%\) and backhand ball velocities \((36 + / - 4 \text{ vs } 14 + / - 4 \%\) as compared with non-periodized training after 9 months. These data demonstrated that periodization of resistance training over 9 months was superior for enhancing strength and motor performance in collegiate women tennis players.

Khanna et al (1996) conducted a study on physiological profile of 10–16 year talented children with an aim to assess the cross-sectional development pattern of children (10-16 years) under training. The study is also aim to frame physiological norms. This study was conducted on 777 children of 10-16 years of age group belonging to various schemes (NSTC, NSPDn) of SAI. The morphophysiological parameters studied include somatotype, height, weight, body fat, lean body mass, back strength, aerobic, anaerobic capacity and recovery heart rate. Somatotype was calculated by using health and carter method. Body fat percentage was calculated from skinfold thickness measured with Harpenden skinfold caliper at four different sites namely biceps, triceps, subscapular and suprailiac. For the calculation of the body fat percentage Durkin one Rehman and Siri formulae were used. Back strength was measured by back dynamometer. The other physiological parameters like aerobic anaerobic capacity and recovery heart rate were measured with computerized Eos sprint (Jaeger & Co., Germany). The results indicate that aerobic capacity in 10 years children was 1.651/min. It increased 3.101/min in 16 years age group. A significant increment was observed from 10-11, 11-12, 12-13, 13-14.
and 14-15 years. Anaerobic capacity at the age of 10 years was 1.38 l, it increased to 3.78 l at the age of 16 years. Mean recovery heart rate varied from 172.2 to 175.6. No significant variations were observed amongst the age group. Mean back strength varied from 57.7 kgs to 109.2 kgs. Peak gain is observed from 14-15 years age group (10.1 kgs). Mean body weight of 10 years children was 31.7 kgs. It increased upto 53.3 kgs at the age of 16 years. The maximal gain occurred from 14-15 years of age (4.01 kgs). The average height in children of 10 years age group was 144.10 cms and 166.84 cms, incase of 16 years age group. Average gain in the height is 3.8 cms / year lean body mass increased from 27.46 kgs in 10 years age group to 45.3 kgs at 16 years of age. Maximum gain was observed from 13-14 years. Average body fat of 10-16 years children varied from 12.89% to 14.48%. No significant difference was found within the age group. Average somatotype of all the age group children was mesomorphic ectomorph. Mesomorphic component varied from 2.77 to 3.05. The present morphophysiological study will have much wider application. These normative data will help in talent selection and growth and development of age group children. This study will also help in assessment of effect of training of the talented children.

Majumdar et al (1996) was conducted a research programme on Anthropometric characteristics and motor function of 8-12 years children in relation to auxological changes of children volunteered for National Sports Talent Contest. The morphological characteristics viz., height, weight, viz. 30 meters run, broad jump, co-ordination ability, balance test, 6 x 10 mts run, 800 mts run, vertical jump and ball throw were assessed on 1519 boys and 207 girls. The purpose of the study was to identify the growth and development of
active boys and girls who participated in the contest of various age block and to estimate the influence on anthropometric variables on motor function. Suitable norms was constituted which can act as a tool for future selection. Test results indicate that highest weight gain achieved at the age of 10 years for both boys and girls. Maximum height gain observed at the age of 10 years for boys and 11 years for girls. Highest fat % was recorded at the age of 9 and 10 years for boys and girls, respectively, and after 10-12 years the body fat percentage remain stable. No significant sex difference was observed in somatotype. In motor function test boys and girls of 10-12 years age group proved to be significantly different when compared to 8 and 9 years of age in ball throw, vertical jump and broad jump. This may be due to the gain in strength and neural maturation. In 800 mts run, balancing test and agility (6×10 mts) no significant difference observed among the group of 8-12 years. Sex difference was observed in morphological and motor function test. the difference may be due to increased estrogen level which promoters greater fat deposition of girls. Correlation matrix revealed that gain in strength, speed and power is associated with stature. Regression equation was also formulated to establish morphological relationship with certain motor functions which enable the evaluator to predict/estimate the relative motor potentiality. Percentile distribution was laid which may be used as a frame of reference for rating the fitness level and development of 8-12 years children. It will be helpful for selection of talent and monitoring the growth and development.

Tanaka et al (1998) studied on impact of resistance training on endurance performance. In accordance with the principles of training specificity resistance and endurance training induce distinct muscular
adaptations. Endurance enzymes, but increases intramuscular substrate stores, oxidative enzyme activities and capillary, as well as mitochondrial density, while marginally impacting capillary density, metabolic enzyme activities and intramuscular substrate stores (except muscle glycogen). The training modalities do induce one common muscular adaptation; they transform type II b myofibres into II a myofibres. This transformation is coupled with opposite changes in fibre size (resistance training increases and endurance training decreases, fibre size), and in general myofibre contractile properties. As a result of these distinct muscular adaptations, endurance training facilitates aerobic processes, whereas resistance training increases muscular strength and anaerobic power. Exercise performance data do not fit this paradigm, however, as they indicate that resistance training or the addition of resistance training to an ongoing endurance exercise regimen, including running or cycling, increases both short and long-term endurance capacity in sedentary and trained individuals. Resistance training also appears to improve lactate threshold in untrained individuals during cycling. These improvements may be linked to the capacity of resistance training to alter myofibre size and contractive properties, adaptations that may increase muscular force production. In contrast to running and cycling, traditional dry land resistance training or combined swim and resistance training does not appear to enhance swimming performance in untrained individuals or competitive swimmers, despite substantially increasing upper body strength combined swim and swim-specific ‘in-water’ resistance training programmes, however, increase a competitive swimmer’s velocity over distances up to 200 mts. Traditional resistance training may be a valuable adjunct to the exercise programmes followed by endurance runners or
cyclists, but not swimmers; these later athletes need more specific forms of resistance training to realize performance improvement.

Kreamer, W.J. and others (2001) found the effects resistance training programs on strength, powered military occupational task performances in women were examined. Untrained women aged (meant ± SD/23+/−4 year were matched and randomly placed in total – (TP, N=17 and TH, N=18) or upper body resistance training (UP, N=18 and UH, N=15), field (Fld, N=14) or aerobic training groups (Aer, N=11). Two periodized resistance-training programs (with supplemental aerobic training) emphasized exercise movements using 3 to 8 RM training loads (TP, UP), whereas the other two emphasized slower exercise movements using 8 to 12 RM loads (TH, UH). The FLD group performed plyometrics and partner exercises. Subjects were bested for body composition, strength, power, endurance, maximal and repetitive box lift, 2-mile loaded run and U.S. Army Physical Fitness Tests before (T₀) and (T₃) and 6 months of training (T₆). For comparison untrained men (N=100) men were tested once. Results of specific training programs resulted in significant increases in body mass (TP) 1 – RM Squat (TP, TH, FLD), bench press (all except AER), high pull (TP), Squat jump (TP, TH, FLD), bench throw (all except AER), squat endurance (all except Aer), 1 – RM box lift (all except aerobic), repetitive box lift (all), pushups all except Aer, Sit-ups (all except AER), and 2 – mile run (all). Conclusions: Strength training improved physical performances of woman over 6 months and adaptations in strength, power and endurance were specific to the subtle differences (eg exercise choice and speeds of exercise movement) in the resistance training programs. (Strength / Power Vs Strength / hypertrophy). Upper and total body
resistance training resulted in similar improvements in occupational task performances, especially in tasks that involved upper-body musculature. Finally, gender differences in physical performances measures were reduced after resistance training in women, which underscores the importance of such training for physically demanding occupations.

Chilibeck, et.al (2002) examined the effect of combined strength and endurance training on quantitative estimates of mitochondria in subsarcomemmal and intermyofibeillar regions of muscle fibers. Ten subjects (Five males five females) participated in a 12 week program of combined strength (three males and for females) served as controls. Biopsy samples from the vastus lateralis were obtained before and after training in both groups and also at the mid point of training in the exercise group. Measurement of succinate dehydrogenase activity throughout muscle fibers, as a quantitative estimate of mitochondrial subpopulations revealed no differences between exercise and control groups before and after training. Within the exercise group, there was a significant increase in succinate dehydrogenase activity in all regions of muscle fibers from before to after training. There was also a significant increase in succinate dehydrogenase activity in the subsarcdemmal, relative to the intermyofibrillar regions from mid-(six week) to after training (regional distribution x time; P<0.05). This may have been associated with an oxidative shift in fiber types, as type I fiber percentage was increased in the exercise, compared to the control group (group x time; P<0.05). To conclude that mitochondrial populations undergo differential changes throughout training. IMF mitochondria increase in a linear manner throughout training, while SS mitochondria undergo a preferential increase late in training. This
increase late in training may be related to an increase in proportion of type 1 fibers.

Newton R.V. et al (2002) examined the effects of mixed – methods – resistance training on young and older men to determine whether similar increases in muscle power were elicited. It reveals the effect of 10 week of a periodized resistance training program designed to increase muscle size, strength and maximal power on isometric squat strength, time course of force development, muscle fiber characteristics and muscle activation (IEMG) as well as force and power output during squat jumps, were compared in young (YM, 30 +/- 5 yr, N=8) and older men (OM, 61 +/- 4 yr, N=10). Results showed that isometric squat strength was higher in the YM compared with OM at all testing occasions and increased ever the training period by 23 +/- 15% an 40 +/- 42% for the YM and Om, respectively. The early phase of the force time curve was shifted upward in both groups over the course of training. During the squat jumps, the YM produced higher force and power at all test occasions and at all loads tested compared with the OM. The YM increased power output by 15 +/- 14%, 33 +/- 16% and 26 +/- 12% and the OM 7 +/- 5%, 36 +/- 23% and 25 +/- 16% for the 17 kg, and 30% and 60% 1 RM loads, respectively. Although the result of this study confirm age related reductions in muscle strength and power, the older man did demonstrate. Similar capacity to young men for increases in these variables via an appropriate periodized resistance-training program that includes rapid, high-power exercises.

Resistance training can improve strength ratios by strengthening a relatively weak antagonist provides deceleration forces (eccentric muscle
action) to the limb or body segment by being activated as it is elongated. Therefore, the stronger it is the better it can act as a shock absorber to the accelerative forces developed by the agonist. With contralateral imbalances, training weights selected should enable the trainee to contribute equally with both sides. This means that until the two partners are approximately equal in strength, the stronger muscle group is not receiving a training stimulus. Otherwise, the imbalance would be maintained. Resistance training can also play a part in augmenting joint stability via increased strength and thickness of connective tissue, such as tendons, legumes and cartilage.

Hickson (1980) showed a 10week combined strength and endurance training program resulted in similar gains in \( V_{02\text{max}} \) compared to an endurance only group, but there was some interference with the gains in strength. The strength only group increased strength throughout the entire ten weeks, but the combined strength and endurance group showed a leveling off and a decrease in strength at 9 and 10weeks. In contrast to this when a 10 week (3 day per week) strength training program was added to a run and cycle training program after the group and leveled off in endurance performance, the group experienced a 30% gain in strength, but without hypertrophy. \( V_{02\text{max}} \) was unaffected, but cycle time to exhaustion at 80% \( V_{02\text{max}} \) was increased from 71 to 85 minutes. This suggests that strength training can improve the performance of prolonged heavy endurance exercise.

Pivarnik et al (1993) examined the study to determine the aerobic capacities (\( V_{02\text{max}} \)) of a group of black female adolescents age = 11.4 – 15.8 years randomly chosen from a single urban school of .91 girls selected, 64 performed an incremental treadmill running test to volitional exhaustion and
achieved \( V_{O2max} \) as determined from expired gas measures. Other measures included height (m), weight (kg) and calf and triceps skin folds (for % fat estimates). Girls were also asked whether they had achieved menarche. \( V_{O2max} \) averaged 37.3 ± 6.2 ml kg\(^{-1}\) x min \(^{-1}\) and was significantly correlated with height (-.32, P<.01) body mass index (-.63, P<.001), and % fat (-.65, P<.001) but not with age (-.16, P>10). Post menarchal girls were significantly taller and older than premenarchal girls. Contrary to previous studies the girls \( V_{O2max} \) values were not related to biological age. Our subjects aerobic capacity values averaged 14% less than those of non-black U.S. female adolescents previously reported in the literature. This difference in \( V_{O2max} \) was primarily a function of body weight. Study implications support the possibility that overweight in adult black women may originate prior to or during early adolescence. Future longitudinal studies should be designed to investigate the effects of aerobic fitness on cardio-vascular risk factor reduction in black adolescent girls.

Gonzalez-Badillo et al (2005) examine the effects of 3 resistance training volumes on maximal strength in the snatch (sn), clean & jerk (C&J) and squat (sq) exercises during a 10 weeks training period. Fifty one experienced (73 years) trained junior lifters were randomly assigned to one of 3 groups a low volume group (LVG, n=16), a moderate-volume group (MVG, n=17) and a high volume group (HVG, n=18). All subjects trained 4-5 days 9 weeks with a periodized routine using the same exercises and relative intensities but a different total number of sets and repetitions at each relative load: LVG (1,923 repetitions), MVG (2,481 repetitions) and HVG (3,030 repetitions). The training was periodized from moderate intensity (60 – 80 %
of 1 repetition maximum [1 RM] and high number of repetitions per set (2-6) to high intensity (90 – 100 % of 1 RM) and low number of repetitions per set (1 – 3). During the training period, the MVG shaved a significant increase for the snatch, Clean & Jerk, and squat exercises (6.1, 3.7, and 4.2% respectively, \( P<0.01 \)), whereas in the LVG and HVG, the increase took place only with the Clean & Jerk exercise (3.7 and 3 % respectively, \( P<0.05 \)) and the squat exercise (4.6% \( P<0.05 \), and 4.8%, \( P<0.01 \) respectively). The increase in the snatch exercise for the MVG was significantly higher in the LVG (\( P=0.015 \)). Calculators of effect sizes showed higher strength gains in the MVG than in the HVG or LVG. There were no significant differences between the LVG and HVG training volume induced strength gains. The present results indicate that junior experienced lifters can optimize performance by exercising with only 85 % or less of the maximal volume that they can tolerate. These observations may have important practical relevance for the optional design of strength training programs or resistance trained athletes, since we have shown that performing at a moderate volume is more effective and efficient than performing at a higher volume.

Paulsen et al (2003) investigate to compare the effects of single-set strength training and 3 set strength training during the early phase of adaptation in 18 untrained male subjects (age, 20-30 years). After initial testing subjects were randomly assigned to either the 3 L - IV group (\( n = 8 \)), which trained 3 sets in leg exercises and 1 set in upper-body exercises, or the 1 L – 3U group (\( n = 10 \)), which trained 1 set in leg exercises and 3 sets in upper-body exercises. Testing was conducted at the beginning and at the end of the study and consisted of 2 maximal isometric tests (Knee extension and bench press) and 6
maximal dynamic tests (1 repetition maximum [1 RM] tests). Subjects trained 3 days per week for 6 weeks. After warm-up, subjects performed 3 leg exercises and 4 upper-body-exercises. In both groups, each set consisted of 7 repetitions (reps) with the load supposed to induce muscular failure after the seventh repetition (7 RM load). After 6 weeks of training, 1 RM performance in all training exercises was significantly increased (10-26 %, P<0.01) in both groups. The relative increase in 1 RM load in the 3 leg exercise was significantly greater in the 3 L – 1U group than in the 1L-3U group (21% Vs 14%, P=0.01). However the relative increase in 1 RM load in the 3L – 1U group (16%) and 1L – 3U group 14%) These results show a superior adaptation to 3 set strength training, compared with 1-set strength training, in leg exercises but not in upper-body exercises during the early phase of adaptation.

Docherty and Sporer (2000) noted that aerobic training to increase maximum oxygen consumption and hence the body’s ability to transport and use oxygen is dependent upon both a central component involving adaptations in the cardiopulmonary system and a peripheral component involving adaptations in muscle tissues, central and peripheral adaptations are in turn, dependant upon different mechanisms. It does appear that the higher the intensity of the stimulus used to increase maximum oxygen consumption (eg high intensity interval training), the greater the increase in oxygen consumption. However, the location of the adaptation to aerobic training may shift depending upon the intensity of the stimulus. At lower levels of intensity, it appears that most of the adaptations occur centrally. With higher intensity training more adaptations occur peripherally. The authors suggests that training at between 70% and 80 % of Vo2max (70% to 80% of heart rate reserve; about
80% to 85% of maximum heart rate; just slightly below the anaerobic times (bold) results in maximal contractile force in the heart and thus maximizes central adaptations important for health benefits. Aerobic training at very high intensities through its effects of mechanisms associated with peripheral adaptations may be the cause of blunting of strength gains and hypertrophy when aerobic training is done along with resistance training.

Paavolainen et al (1991) studied the effects of dynamic resistance training on maximal isometric strength and aerobic power of 15 national class cross-country skiers during six weeks of their pre-season training period. Seven of the skiers supplemented their normal aerobic workouts with “explosive” strength sessions. These sessions consisted of plyometrics jumping exercises and heavy resistance (80% of 1 RM) squats and contributed about a third of the total training load. The other eight skiers performed the same aerobic training, but during the last three weeks of the study added “endurance strength training” which comprised many repetitions of “specific” leg and arm exercises. Jumping height and time to reach maximal isometric force production improved significantly in the explosive strength trained group. There were no differences in these measures before or after the six weeks training period for the endurance trained group. But neither were there any differences in $\text{V}O_2\text{max}$ or measures of the aerobic and anaerobic “thresholds” between the two groups after the different training regimens. They concluded that endurance athletes can undertake explosive strength training programs without a concomitant reduction in aerobic capacity. Thus the present study is highly emphasized the changes in variation of training and practicing the high intensity training more than one sessions into lane field gains in strength.
Concepts of there challenging the characteristics of preciosity affairs there alternate the field volumes of training by high and low during the course of training.

Karry and Dernard (1976) studied the effect of physical training and cardio-respiratory fitness in children. Change in sub-maximal heart rate and $\text{Vo}_2$ maximum as a result of eight weeks of interval training were studied in boys aged ten to twenty years. Thirteen boys were trained while eleven acted as the control group. Heart rate and $\text{Vo}_2$ maximum did not change significantly with training on the other hand sub-maximal during bicycle and treadmill exercise decreased significantly with training. The $\text{Vo}_2$ cost of their maximal task remained unchanged. The findings suggested that the use of $\text{Vo}_2$ maximum as the only training criteria for cardio-respiratory fitness may be misleading. Since most work tasks proved at a sub-maximal response was demonstrated without improvement at a maximal efforts. Perhaps sub-maximal psychological performance measures are more important than maximal once in the assessment of cardio-respiratory fitness.

2.4 Studies on Periodized Strength Training

Stone and others (1981), conducted a study on a hypothetical modal for strength training for trained college age males for 6 weeks. The project compared a non-periodized program 3x6 (sets x repetitions per set) Vs a strength/power periodized program that progressed from high volume and low intensity to lower volume and higher intensity training. Both groups increased resistance used during training at their own rate. The periodized group increased significantly more than the non-periodized group in one repetition
maximum (1 RM) parallel back squat and vertical jump power using the Lewis formula (4.9 x body mass [kg] x vertical jump (m)) but not in vertical jump ability (centimeters improvement). In addition, the periodized group demonstrated a significantly greater increase in lean body mass and decrease in percent body fat than the non-periodized group as determined by hydrostatic weighting. Total body mass did not change significantly in either group. Unfortunately, absolute or percent changes in any variable were not published. It was concluded that periodized weight training in greater gains in vertical jump ability or motor performance than non-periodized training. The periodized training resulted in a greater increase in vertical jump power and not a significantly greater increase in vertical jump height than the non-periodized training. Thus the results support periodized training in some strength / power-type activities, like American football or the shot put, where leg strength power may enhance performance. However the results do not support the conclusion that the periodized training model used in this study is superior to the non-periodized training in increasing performance in an event like the jump where total jump height and not jump power is a major deciding factor in determining success.

Stowers and others (1983) conducted a study on the short-term effects of three different strength power training methods utilized untrained college age males as subjects. Training consisted of performing either 1x10, 3x10, or a strength / power periodized program for 7 weeks. Total body mass did not change significantly in any group. One RM bench press and back squat ability significantly increased in all training groups, with the periodized group demonstrating a significantly greater increase in 1 RM squat ability than the
other two training groups. The 3x10 training group demonstrated no significant change in vertical jump ability or power (Lewis formula) at any point in the 7-week training period. The 1x10 group showed an increase in vertical jump ability after 5 weeks of training; however this group’s vertical jump ability decreased after this time point and showed no significant difference from pertaining after the 7-week training period: only the periodized group showed a consistent significant increase in vertical jump ability and vertical jump power throughout the training period and a significant increase after all 7 weeks of training. The results of this study do support the conclusion that short-term periodized training does increase 1 RM strength and vertical jump ability in untrained males to a greater extent than single and multiple set, non-periodized training.

O Bryant and others (1980) have conducted a study on cycle ergometer performance and maximum leg and hip strength adaptations to two different methods of weight-training on college-aged males as subjects. Training lasted 11-weeks and consisted of either 3x6 or a strength/power periodized program. Both training groups performed the same exercises. One RM back squat ability increased with both types of training, but a significantly greater increase was shown by the periodized group. Total power output (Watts) during cycling was also examined. This test consisted of cycling at 0 watts for 1 minute, 60 watts for 3 minutes, where after the workload was increased 30 watts every minute until exhaustion. After the 11-weeks training period, both groups increased significantly in maximal cycling power, with the periodized group demonstrating a significantly greater increase than the 3x6 group. Both groups showed a non-significant increase (1.0 kg) in total body mass. The results
support the concept that periodized weight training does result in greater gains in 1 RM strength and short-term high intensity work ability.

McGee and others (1992) conducted a study on leg and hip endurance adaptations to three weight training programmes 7 weeks in length on leg and hip endurance. The training status of the subjects previous to the programs is not defined. Adaptations of young men to two non-periodized programs, 1x8-12 and 3x10, and a strength/power periodized program were examined leg and hip endurance were measured during a cycling test and back squat repetitions to exhaustion. Cycling endurance time was repetitions to exhaustion. Cycling endurance time was defined as time to exhaustion at 265 watts after 2 minutes at 30 watts and 2 minutes at 120 watts. Back squat endurance was determined by squatting with 60 kg at a cadence of one squat per 6 seconds. Mass squatted was increased 2.5 kg each minute until exhaustion. The 1x8-12 group showed increases in both tests, however, the increases were not significant. Both the 3x10 and periodized groups showed significant increases in both tests. Although the increases of the 3x6 and periodized groups were substantially greater than for the 1x8-12 group, no significant differences between groups were shown. In addition, although not significant, the periodized group showed almost a two fold (15 Vs 29%) greater increase in cycling endurance time than did the 3x10 group. Total body mass was not significantly changed in any of the groups. The results indicate the type of training program does not significantly affect high-intensity endurance during short-term training (7 weeks) periods.

Willoughby (1992), concluded a study on comparison of three selected weight training progress on the upper and lower body strength of trained
males. In his study he examined the effects in trained young men of two non-periodized programs and a periodized program on 1 RM strength in the bench press and back squat were equal to or greater than 120 and 150% of total body weight, respectively. One non-periodized group trained using their pertaining 10 RM (no increase in resistance) for 3x10 for the bench press and backs squat during the entire training period. A second non-periodized group trained using 3x6-8 with the weight used increased 4.54 kg after each set during a training session and increases in the starting resistance for a training session and increases in the starting resistance for a training session as strength gains were made. The periodized group followed a traditional periodized program of initial high volume, low intensity programme to low volume, high intensity. All groups significantly increased in 1 RM bench press and back squat ability, with the 3x6-8 and the periodized groups showing, with the 3x6-8 and the periodized groups showing significantly greater increases that the 3x10 group. The periodized group also demonstrated significantly greater increases than the 3x6-8 group in both the bench press and back squat. The results show that, in order for continued gains in 1 RM strength to occur, the weight used in training must be increased as strength gains occur. The results support that, in trained subjects, a periodized programs results in greater 1 RM strength gains than non-periodized multiple set programs.

Willoughby (1993) published a second paper on the effectiveness of periodized training. Young men with previous weight-training experience and capable of a minimum bench press and back squat of 120 and 150% of total body weight, respectively, trained for 16 weeks. Two non-periodized groups trained with 5x10 or 6x8 for the entire training period. The periodized group
followed a classic strength program starting with high volume, low intensity training. All groups significantly increased 1 RM bench press and squat ability. However, by week 16, the 6x8 group’s improvement in 1 RM squat was significantly greater than the 5x10 group’s and the periodized group’s increases in both the bench press and squat were significantly greater than both non-periodized groups. The late Dr. Robert Hickson, for the university of Illinois, Chicago circle was one of the first scientists to study the use of strength training with concurrent endurance training. His investigative team found that concurrent high intensity resistance and endurance training tended to hinder strength development in the long term. However, concurrent strength and endurance training did not appear to hinder development of endurance. Prior to the work of Hickson and Colleagues, it was hypothesized that concurrent strength training might hinder the acquisition of endurance or actually reduce existing aerobic capacity (Vo2max) through the dilution of capillary and mitochondrial densities in the active muscles.

Sporer and Wenger (2002) conducted a study on effect of aerobic exercise on strength performance following various periods of recovery. The purpose of the study was to determine if the type and intensity of aerobic training affects performance in a subsequent strength-training session after varying periods of recovery. Sixteen male subjects participated in the study and were divided into 2 groups based on aerobic training, high intensity-intervals (MAX n=8) and continuous sub-maximal (SUB n=8). Each subject performed 4 sets of both bench press and leg press at approximately 75% 1 repetition maximum (1 RM) following aerobic training with recovery periods of 4, 8 and 24 hours as well as once in a control condition. Both the 4 and 8 hours
conditions resulted in fewer total leg press repetitions than the control and 24 hours conditions. There was no difference between both the control and 24-hours conditions. No main effect was shown with respect to type of aerobic training. It was concluded that when aerobic training proceeds strength training, the volume of work that can be performed is diminished for up to 8 hours. The impairment appears to be localized to the muscle groups involved in the aerobic training.

Marx et al (2001), investigate to determine the long term training adaptations associated with 10 volumes circuit type versus periodized high volume resistance training women were randomly placed into one of the following groups; low-volume, single-set circuit (SSC; N=12); periodized high-volume multiple set (MS; N=12); or non-exercising control (con) group (N=10). The SSC group performed one set of 8-12 repetitions to muscular failure 3d x wk(-1). The MS group performed two to four sets of 3-15 repetitions with periodized volume and intensity 4 day x wk(-1). Muscular strength, power, speed, endurance, anthropometrics and resting hormonal concentrations were determined pertaining (T1), after 12 weeks (T2), and after 24 weeks of training (T3). Results: 1-RM bench press and leg press and upper and lower body local muscular endurance increased significantly (P\(\leq\)0.05) at T2 for both groups, but only. MS showed a significant increase at T3. Muscular power and speed increased significantly at T2 and T3 only for MS. Increases in testosterone were observed for both groups at T2 but only Ms showed a significant increase at T3. Cortisol decreased from T1 and T2 and from T2 and T3, in Ms. Insulin-like growth factor–I increased significantly at T3 for SSC and at T2 and T3 for Ms. No changes were observed for growth
hormone in any of the training groups. To conclude that significant improvements in muscular performance may be attained with either a low-volume single-set program or a high-volume, periodized multiple-set program during the first 12 week of training in untrained women. However dramatically specific domains of training program design which contrast in speed of movement, exercise choices and use of variation (periodization) in the intensity and volume of exercise.

Kraemer et al (2000) found the influence of resistance training volume and periodization on physiological and performance adaptations in collegiate women tennis players. Twenty-four tennis players were matched for tennis ability and randomly placed into one of three groups; a no resistance exercise control group, a periodized multiple-set resistance training group, or a single-set circuit resistance training group. No significant changes in body mass were observed in any one of the groups throughout the entire training period. However, significant increases in fat-free mass and decreases in percent body fat were observed in the periodized training group after 4, 6 and 9 months of training. A significant increase in power output was observed after 9 months of training in the periodized training group only one repetition maximum. Strength for the bench press, free-weight shoulder press and leg press increased significantly after 4, 6 and 9 months of training in the periodized training group. Where as single set circuit group increased only after 4 months of training. Significant increases in serve velocity were observed after 4 and 9 months of training in the periodized training group, where as no significant changes were observed in the single set circuit group. These data demonstrate that sport-specific resistance training using a periodized multiple-set training method is
superior to low-volume single-set resistance exercise protocols in the development of physical abilities in competitive, collegiate women tennis players.

Hickson et al (1988) m, a frequently cited investigation supporting the use of strength training to improve endurance, found that a three-times-a-week strength training program undertaken for 10 weeks did not change the Vo2 max of moderately trained runners and cyclists. But a short-term (4-8 minutes) endurance test was improved by 12% for both running and cycling, while long term endurance improved from 70 to 85 minutes for cycling.

Marcinik et al (1991) showed that strength training had positive effects of endurance cycling capacity. Eighteen males performed 12 weeks of strength training three times a week. The strength training consisted of 8-12 repetitions of upper body exercise (bench press, push-ups, lat pull-downs, arm-curls) and 15-20 repetitions and lower body exercises (knee extensions, hip flexions, parallel squats) with a 30 second rest between exercises. The strength training program had no effect on the subjects Vo2 max. However, 1 RM for three extension and hip flexion improved by 30 % and 52 % respectively. More important cycle time to exhaustion at 75% of Vo2 max improved a massive 33% from 26.3 minutes before strength training to 35.1 minutes after training. To conclude that strength training improves cycle endurance performance independently of changes in Vo2 max and that this improvement appears to be related to increase in leg strength.

Briath and others (1989) studied the comparison of 2 Vs 3 days/weeks of program. The purpose of this study was to adulate the effectiveness of
Resistance training performed either 2 days/week or 3 days/week. One hundred and seventeen sedentary volunteers were randomly assigned to one of the two training groups or a control group. Twenty-two men (27 ± 5 years) and 22 women (26 ± 5 years) trained for 10 weeks. Twenty-five men (26 ± 5 years) and 22 women (24 ± 5 years) trained for 18 weeks. Twenty-six subjects served as controls and did not variable resistance bilateral knee extensions performed to volitional fatigue with a weight load that allowed seven to ten repetitions, prior to and immediately following training, isometric strength was evaluated at 70, 85, 100, 115, 130, 145, 160 and 171 degrees of knee extension with a Nautilus knee extension tensiometer. All groups who trained showed a significant increase in peak isometric strength when compared with controls (p less than 0.01). Groups that trained 3 days/weeks increased peak isometric strength (10 weeks = 21.2%; 18 weeks = 28.4%) to a greater extend (p less than 0.05) than groups that trained 2 days/weeks (10 weeks = 13.5%; 18 weeks = 20.9%). We conclude that resistance training 2 days/week significantly improves knee extension isometric strength; however, the magnitude of strength gain is greater when training is performed 3 days/week. These data indicate that the adult exerciser (18 to 38 years) training 2 days/weeks may derive approximately 80% of the isometric strength benefits achieved by those training 3 days/weeks.