CHAPTER - II

REVIEW OF RELATED LITERATURE
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2.0 Studies on Aerobic 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 programme of training. To bring about significant improvement in cardio respiratory endurance, varied frequencies of training, namely, twice, thrice and five days a week without using interval running method, was found to be effective in developing cardio respiratory endurance when compared to workouts twice a week.

Cearely et al. (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 engaged in any type of physical training were excluded from the study. The subjects were also instructed not to participate in outside class activities. He concluded that three days per week aerobic dance group improved better in maximal oxygen uptake than two days aerobic dance training group 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 between eighteen and twenty-five years. The secondary subjects were divided into control groups (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 significant between the groups, in variables other than the variables of systolic or diastolic pressure, body weight or percentage of body fat. From the result, it was concluded that water aerobic dance need to be of sufficient intensity to increase fitness in young sedentary individuals.

Isrecl (1987) conducted a study on the effect of aerobic, anaerobic and pulse work out exercise on selected physical fitness and physiological parameters. Sixty - five 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 sprints of 40 yards length. The pulse work out exercise programme was designed to work the subject at his optional work capacity (180 6 pm). All exercise groups worked out four days per week for five weeks. While the control group remained sedentary, pre and post test measurements were taken on Cooper’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 increased 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 with 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 subs - groups and designated as experimental and
control sub-groups. Experimental group exercised for forty minutes 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 swimming produced 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.

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 went through 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 group’s improvements was significantly different from all other groups. The 150 HR group was found to be significantly different from the 120 HR 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 concluded that not only 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 cardio-vascular and respiratory systems which transport 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).
Maria et. al. (2006) found that age-related reductions in basal limb blood flow and vascular conductance are associated with the metabolic syndrome, functional impairments and osteoporosis. Maria et. al. (2006) tested the hypothesis that a strength training programme would increase basal femoral blood flow in aging adults. Twenty-six sedentary but healthy middle-aged and older subjects were randomly assigned to either a whole body strength training intervention group which underwent three supervised resistance training sessions per week for 13 weeks or a control group which participated in a supervised stretching programme. At baseline, there were no significant differences in blood pressure, cardiac output, basal femoral blood flow (via Doppler ultrasound), vascular conductance and vascular resistance between the two groups. The strength training group increased maximal strength in all the major muscle groups tested (P < 0.05). Whole body lean body mass increased (P < 0.05) with strength training, but leg fat-free mass did not. Basal femoral blood flow and vascular conductance increased by 55–60% after strength training (both P < 0.05). No such changes were observed in the control group. In both groups, there were no significant changes in brachial blood pressure, plasma endothelin-1 and angiotensin II concentrations, femoral artery wall thickness, cardiac output and systemic vascular resistance. The results indicate that short-term strength training increases basal femoral blood flow and vascular conductance in healthy middle-aged and older adults.

Emery et. al. (1989) examined the cardio vascular and behavioral adaptations associated with a 4-month programme of aerobic exercise training on 101 older men and women (mean age = 67 years). Subjects were randomly assigned to an aerobic exercise group, yoga and flexibility control group. Prior to and following the four month programme, subjects underwent comprehensive physiological and psychological evaluations. Physiological measures included measurement of blood pressure, lipids, bone density and cardio respiratory fitness including direct measurements of peak oxygen consumption (VO2) and anaerobic
threshold. Psychological measures included measures of mood, psychiatric
symptoms and neuropsychological functioning. This study demonstrated that four
months of aerobic exercise training produced an overall 11.6% improvement in
peak VO\textsubscript{2} and a 13% increase in anaerobic threshold. In contrast the yoga and
control groups experienced no change in cardio respiratory fitness. Other
favourable physiological changes observed among aerobic exercise participants
included lower cholesterol levels and diastolic blood pressure levels and for
subjects at risk for bone fracture, a trend towards an increase in bone mineral
content. Although few significant psychological changes could be attributed to
aerobic exercise training, participants in the two active treatment groups perceived
themselves as improving on a number of psychological and behavioral
dimensions.

Bowman et. al. (1997) studied the effects of aerobic exercise training and
yoga, and a non-aerobic control intervention, on the baroreflex of elderly persons
was determined. Baroreflex sensitivity was quantified by the a- index, at high
frequency (HF; 0.15–0.35 Hz, reflecting parasympathetic activity) and mid-
frequency (MF; 0.05–0.15 Hz, reflecting sympathetic activity as well), derived
from spectral and cross-spectral analysis of spontaneous fluctuations in heart rate
and blood pressure. Twenty-six (10 women) sedentary, healthy and normotensive
elderly (mean 68 years, range 62–81 years) subjects were studied. Fourteen
(14 women) of the sedentary elderly subjects completed 6 weeks of aerobic
training, while the other 12 subjects (6 women) completed 6 weeks of yoga. Heart
rate decreased following yoga (69 ± 8 vs. 61 ± 7 min\textsuperscript{-1}, P<0.05) but not after
aerobic training (66 ± 8 vs. 63 ± 9 min\textsuperscript{-1}, P=0.29). VO\textsubscript{2} max increased by 11%
following yoga (P<0.01) and by 24% following aerobic training.
2.1 Studies on Aerobic and Physical Training

Clayton et. al. (1991) attempted to study the effects of aerobic exercise training and yoga and a non-aerobic control intervention, on the baroreflex of elderly persons was determined. Baroreflex sensitivity was quantified by the alpha-index, at high frequency (reflecting parasympathetic activity) and mid-frequency (reflecting sympathetic activity as well), derived from spectral and cross-spectral analysis of spontaneous fluctuations in heart rate and blood pressure. Twenty-six sedentary, healthy and normotensive elderly subjects were studied. Fourteen of the sedentary elderly subjects completed 6 weeks of aerobic training, while the other 12 subjects completed 6 weeks of yoga. Results show that heart rate decreased following yoga but not after aerobic training. VO2 max increased by 11% following yoga and by 24% following aerobic training.

Renfrow (1989) conducted a study to determine the effects of an aerobic training regimen by second and fourth grade pupils in Fayetteville 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 activity per day. Comparisons were made between the treatment and control groups for second graders, fourth graders and total groups. The result of this study showed that anaerobic training programme had little or no effect on cardiovascular endurance in elementary school children. However, the aerobic programme did have a significant effect on percentage of body fat.
2.2 Studies on Resistance Training

Hisacda et. al. (1996) conducted a study to assess the influence of two different modes of resistance training in female subjects. This study consisted of two groups. One group underwent resistance training with low intensity and high volume training and the other participated in high intensity and low volume training. The former consisted of sets of 1 – 20 RM with sufficient rest between sets. The latter consisted of 8-9 sets of 4 – 6 RM with 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.

Berger (1963) conducted a study on three groups totalling 48 college students who were trained with progressive resistance exercise for a period of nine weeks, three times a week. Each group trained with a different programme using the bench press lift. Group 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 weeks of training. In both the studies, group – II had a higher mean than group – III but the mean differences were not significant. In both studies, group – II had a higher mean than group – III but the mean difference was not significant. In Berger’s study, training continued upto 12 weeks and at that time the mean of group – II was significantly 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 week with heavy repetitions per set and numerous sets is not more effective for improving strength than training with lighter loads with more repetitions per set and fewer sets.
Ratzin et al. (1990) conducted a study in which 12 subjects went through did two 7.5 week training programmes, high resistance – low repetition (for improving strength) and low resistance – high repetition (for muscular endurance), with a 5.5. week pause between programmes. Six subjects did the endurance programme first and the strength programme second; the other six followed the opposite order. All major fibre 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 programme caused a further increase in the cross sectional areas of the type I and II b fibres, while a decrease occurred in those going through the endurance programme.

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\textsubscript{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\textsubscript{2} max and body composition of the subjects were examined in the 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 subjects performed the same weight lifting programme for 3 years with an additional running programme consisting of 2 miles jogging once a week during the 3\textsuperscript{rd} year (R1 – group) and 3 subjects performed the weight lifting programme during the 1\textsuperscript{st} year and the same combined jogging and weight lifting programme as the R1 group during the 2\textsuperscript{nd} and 3\textsuperscript{rd} years (R2 – group). The average VO\textsubscript{2} max relative to their body mass of the W – group decreased significantly during the 1\textsuperscript{st} year followed by an insignificant decrease in the 2\textsuperscript{nd} year and a levelling off in the 3\textsuperscript{rd} year. The average VO\textsubscript{2} max of the W – group at T2 and T3 was 44.2 and 44.1 1 ml kg – 1 min-1, respectively. The tendency of VO\textsubscript{2} max changes in the R and R2 group was similar to the W – group until they started the jogging programme, after
which they recovered significantly to the initial level within a year of including that programme and they then levelled off during the next year. Lean body mass estimated skin fold thickness has increased 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.

Chtara, et. al. (2008) examined the influence of the sequence order of high-intensity endurance training and circuit training on changes in muscular strength and anaerobic power. Forty-eight physical education students (ages, 21.4 ± 1.3 years) were assigned to 1 of 5 groups: no training controls (C, n = 9), endurance training (E, n = 10), circuit training (S, n = 9), endurance before circuit training in the same session, (E+S, n = 10) and circuit before endurance training in the same session (S+E, n = 10). Subjects performed 2 sessions per week for 12 weeks. Resistance-type circuit training targeted strength endurance (weeks 1-6) and explosive strength and power (weeks 7-12). Endurance training sessions included 5 repetitions run at the velocity associated with VO$_{2}$max (VO2max) for duration equal to 50% of the time to exhaustion at VO$_{2}$max; recovery was for an equal period at 60% VO2max. Maximal strength in the half squat, strength endurance in the 1-leg half squat and hip extension and explosive strength and power in a 5-jump test and counter movement jump were measured pre- and post-testing. No significant differences were shown following training between the S+E and E+S groups for all exercise tests. However, both S+E and E+S groups improved less than the S group in 1 repetition maximum (p < 0.01), right and left 1-leg half squat (p < 0.02), 5-jump test (p < 0.01), peak jumping force (p < 0.05), peak jumping power (p < 0.02), and peak jumping height (p < 0.05). The intra- session sequence did not influence the adaptive response of muscular strength and explosive strength and power. Circuit training alone induced strength
and power improvements that were significantly greater than when resistance and endurance training were combined, irrespective of the intra-session sequencing.

Stults-Kolehmainen et. al. (2008) designed a study to examine the effect of self-reported, stressful life events on strength gains after 12 weeks of resistance training. Participants were 135 undergraduates enrolled in weight training classes that met for 1.5 hours, two times per week. After a 2-week period, to become familiar with weight training, participants completed the college version of the Adolescent Perceived Events Scale (APES), the Social Support Inventory and one-repetition maximal lifts (1RM) for the bench press and squat. Maximal lifts were repeated after 12 weeks of training. Median splits for stress and social support were used to form groups. Results indicated that the low stress participants experienced a significantly greater increase in bench press and squat than their high stress counterparts. Strength gains were, however, unrelated to social support scores in either the low or high stress group. High life stress may lessen a person's ability to adapt to weight training. It may benefit coaches to monitor their athletes' stress both within and outside the training setting to maximize their recovery and adaptation.

Bishop et. al. (2007) conducted a study to find the effect of altering the rest period on adaptations to high-repetition resistance training. Eighteen active females were matched according to leg strength and repeated-sprint ability and randomly allocated to one of two groups. One group performed resistance training with 20-s rest intervals between sets, while the other group employed 80-s rest intervals between sets. Both groups performed the same total training volume and load. Each group trained 3 days a week for 5 weeks [15 to 20 repetition maximum (RM), 2 - 5 sets]. Repeated-sprint ability (5×6-s maximal cycle sprints), 3-RM leg press strength and anthropometry were determined before and after each training programme. There was a greater improvement in repeated-sprint ability after training with 20-s rest intervals (12.5%) than after training with 80-s rest intervals.
In contrast, there were greater improvements in strength after training with 80-s rest intervals (45.9%) than after training with 20-s rest intervals (19.6%) \((P = 0.010)\). There were no changes in anthropometry for either group following training. These results suggest that when training volume and load are matched, despite a smaller increase in strength, 5 weeks of training with short rest periods results in greater improvements in repeated-sprint ability than the same training with long rest periods.

Shawn et.al. (2004) was interested in determining whether endurance and resistance training performed concurrently produces different performance and physiologic responses compared with each type of training alone. Untrained male volunteers were randomly assigned to one of three groups: endurance training, resistance training and concurrent training. The measurements were made on all subjects before and after 12 weeks of training on weight, percent body fat, peak oxygen consumption, isokinetic peak torque and average power produced during single-leg flexion and extension at 60 and 180[degrees][middle dot]s-1, one-repetition maximum (1RM) leg press, 1RM bench press, vertical jump height and calculated jump power. Weight and lean body mass (LBM) increased significantly in the resistance training and concurrent training groups \((P < 0.05)\). Percent body fat was significantly decreased in the endurance training and concurrent training groups. \(\text{VO}_2\) peak was significantly improved only in the endurance training group. Peak torque during flexion and extension at 180[degrees] [middle dot]s-1 increased in the resistance training group. Improvements in 1RM leg press and bench press were significant in all groups, but were significantly greater in the resistance training and concurrent training compared to the endurance training group. Jump power improved significantly only in the resistance training group, and no group showed a significant change in vertical jump height. Concurrent training performed by young, healthy men does
not interfere with strength development, but may hinder development of maximal aerobic capacity.

2.3 Studies on Aerobic and Resistance 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 hematological and iron related parameters. The mean hemoglobin 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 hematological indices between the groups of athletes and the control group. The results of the investigation showed that some hematological 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 treadmill three times a week for nine weeks at an intensity of 50 % of heart rate reserve added to resting heart rate until 1000 beats elicited above the resting value. Results showed significant training effects from pre to post test for Max VO₂ and pulse rate.

Paavolainen (1999) investigated the effects of simultaneous explosive strength and endurance training on physical performance characteristics of 10 experimental (E) and 8 control (C) endurance athletes who trained for 9 weeks. The total training volume was kept the same in both groups, but 32 % of training in E and 3 % in C were replaced by explosive type strength training. A 5 km time trial (5k) running economy (RE), maximal 20 m speed (VO₂ max) and 5 jump (5J) tests were measured on a track. Maximal anaerobic (MART) and aerobic treadmill
running tests were used to determine maximal velocity in the MART (VMART) and maximal oxygen uptake \( (O_2 \text{ max}) \). The 5K time, RE and VMART improved \((P <0.005)\) in E, but no changes were observed ini C. \( V_0 \_2 \text{ max} \) and \( 5J \) increased in E \((P < 0.01)\) and decreased in C \((P <0.001)\). \( O_2 \text{ max} \) 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 \( (O_2 \text{ uptake}) \) \((r = 0.54)\) 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 \( O_2 \text{ max} \). 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 weeks of high intensity endurance or resistance training on resting metabolic rate (RMR) 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 or by 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, \( 2.721 \text{MJ (650 real)} \) 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.

Hickson (1980) showed a 10 week combined strength and endurance training programme resulted in similar gains in \( V_0 \_2 \text{ max} \) 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 10 weeks, but the
combined strength and endurance group showed a levelling off and a decrease in strength at 10 weeks. In contrast to this when a 10-week (3 day per week) strength training programme was added to a run and cycle training programme 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 by 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 with strength or endurance training alone.

Melrose and Knowlton (2005) examined the effects of a hybrid, simultaneous, resistance and aerobic training programme 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 or 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 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 6 RM, the fifth 4RM and the sixth 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 and 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 becomes a conditioning option for athletes and non-athletes.

Tanaka et. al. (1998) studied impact of resistance training on endurance performance. In accordance with the principles of training specificity, resistance and endurance training induce distinct muscular adaptations. The training modalities do induce one common muscular adaptation; they transform type II b myofibrils into II a myofibrils. This transformation is coupled with opposite changes in fibre size (resistance training increases and endurance training decreases fibre size, and in general myofibril contractile properties. As a result of these distinct muscular adaptations, endurance training facilitates aerobic processes, whereas resistance training increases muscular strength and anaerobic power.

Gergely et. al. (2009) examined the effects of two different modes of lower-body endurance exercise (i.e., cycle ergometer and incline treadmill walking) on
lower-body strength development with concurrent resistance training designed to improve lower-body strength (i.e., bilateral leg press 1 repetition maximum [RM]). Analysis of variance comparisons with repeated measures revealed the following statistically significant changes ([alpha] = 0.05) in the 3 training groups over time: (a) When men and women were combined, body mass of R was significantly greater than RC and RT post-training, (b) Body mass of men only was significantly greater than RC and RT post-training, (c) Body composition of men only was significantly smaller for RC and RT compared with R, (d) When men and women were combined, percent change in strength revealed significantly greater gains in R compared with RT at 6 weeks, (e) When men and women were combined, percent change in strength revealed significantly greater gains in R compared with RC and RT post-training, (f) Percent change in strength for men only was significantly greater for R compared with RT at 3 weeks, (g) Percent change in strength for men only was significantly greater for R compared with RC and RT at 6 weeks, and RC was significantly greater than RT at 6 weeks, (h) Percent change in strength in men only was significantly greater for R compared with RC and RT post-training, and RC was significantly greater than RT post-training, and (i) Percent change in strength in women was significantly greater in R compared with RT post-training.

Lopez et. al (2008) conducted a study on effects of concurrent resistance and endurance training (CT) on distance running performance in highly competitive endurance runners. Original research was reviewed using the Physiotherapy Evidence Database (Pedro) scale. Five studies met inclusion criteria: highly trained runners (>or= 30 mile x week (-1) or >or= 5 d x wk(-1)), CT intervention for a period >or= 6 weeks, performance distance between 3K and 42.2K, and a PEDro scale score > or= 5 (out of 10). Exclusion criteria were prepubertal children and elderly populations. Four of the five studies employed sport-specific, explosive resistance training, whereas one study used traditional
heavy weight resistance training. Two of the five studies measured 2.9% improved performance (3K and 5K) and all five studies measured 4.6% improved running economy (RE; range = 3-8.1%). After critically reviewing the literature for the impact of CT on high-level runners, it was concluded that resistance training likely has a positive effect on endurance running performance or RE. The short duration and wide range of exercises implemented are of concern, but coaches should not hesitate to implement a well-planned, periodized CT programme for their endurance runners.

Okamoto et. al. (2007) conducted a study on the effect of aerobic exercise before and after RT on vascular function with the perception of how aerobic exercise performed before or after a bout of RT affects vascular function while combination effects of aerobic exercise training combined with resistance training (RT) might prevent the deterioration of vascular function. For this study, thirty-three young, healthy subjects were randomly assigned to groups that ran before RT (BRT: 4 male, 7 female), ran after RT (ART: 4 male, 7 female), or remained sedentary (SED: 3 male, 8 female). The BRT and ART groups performed RT at 80% of one repetition maximum and ran at 60% of the targeted heart rate twice each week for 8 weeks. Both brachial-ankle pulse wave velocity (baPWV) and flow-mediated dilation (FMD) after combined training in the BRT group did not change from baseline. In contrast, baPWV after combined training in the ART group reduced from baseline (from 1,025 ± 43 to 910 ± 33 cm/s, P < 0.01). Moreover, brachial artery FMD after combined training in the ART group increased from baseline (from 7.3 ± 0.8 to 9.6 ± 0.8%, P < 0.01). Brachial artery diameter, mean blood velocity and blood flow in the BRT and ART groups after combined training increased from baseline (P < 0.05, P < 0.01 and P < 0.001, respectively). These values returned to the baseline during the detraining period. These values did not change in the SED group. These results suggest that although
vascular function is not improved by aerobic exercise before RT, performing aerobic exercise thereafter can prevent the deteriorating of vascular function.

Davis (2008) evaluated the effects of concurrent strength and aerobic endurance training on muscle strength and endurance, body composition and flexibility in female college athletes and compared two concurrent exercise (CE) protocols. Twenty-eight women (mean age 19.6 years) were divided into two matched groups and evaluated before and after a vigorous, 11-week, 3-days per week CE training programme. One group did serial CE consisting of a warm-up, resistance exercise at low heart rate (HR), aerobics and a range of motion cool down. The other group did integrated CE consisting of aerobics, the same resistance exercises at high HR achieved by cardio acceleration before each set and the same range of motion cool down. The two protocols were balanced, differing only in the timing and sequence of exercises. They concluded that serial CE produces adaptations greater than those reported in the literature for single-mode (strength) training in athletes, whereas, integrated CE produces discernibly greater gains than serial CE. The results suggest synergy rather than interference between concurrent strength and aerobic endurance training, support prescription of CE under defined conditions, establish the importance of exercise timing and sequence for CE programme outcomes, and document a highly effective athletic training protocol.

2.4 Studies on Yoga

Baldwin (1999) conducted a study to explore the psychological and physiological differences between adult exercisers who added a weekly yoga class to their regular exercise programme and those who did not. Their results suggested: (1) More positive mood change in the Yoga Group over eight weeks, (2) More immediate positive affect from yoga than from cardio vascular or resistance training activities, (3) More compliance with yoga than with cardio vascular or resistance training activities, (4) Comparable perceived exertion
ratings for 'moderate' Hatha Yoga and routine aerobic exercise, (5) An 8% gain in spinal and hamstring flexibility in the yoga group over eight weeks, and (6) Decreased vulnerability to stress in the yoga group, at the same time sources of stress for that group increased.

Makwana et. al. (1988) studied the effect of yogic exercises on cardio pulmonary variables. Twenty-five normal male volunteers undergoing a ten week yoga course were assessed by ventilator function tests. The observations recorded at the end of ten weeks of the course showed improved ventilator functions in the form of lowered respiratory rate, increased forced vital capacity, FEV1, maximum breathing capacity and breath holding time, while tidal volume and %FEV1 did not reveal any significant change.

Visweswaraiah (2004), for his study, screened 1009 pulmonary tuberculosis patients and 73 were alternately allocated to yoga or breath awareness groups. The results of the study showed that at the end of 2 months, the yoga group showed a significant reduction in symptom scores and an increase in weight, FVC and FEV(1). The breath awareness group also showed a significant reduction in symptom scores and an increase in weight and FEV(1). Significantly, more patients in the yoga group showed sputum conversion based on microscopy on days 30 and 45 compared to the breath awareness group. Improvement in the radiographic picture occurred in 16/25 of the yoga group compared to 3/22 of the breath awareness group on day 60. The improved level of infection, radiographic picture, FVC, weight gain and reduced symptoms in the yoga group suggest a complementary role for yoga in the management of pulmonary tuberculosis.

Boyle et. al. (2004) conducted a study to determine the effects of yoga training on the intensity of delayed onset muscle soreness. 24 yoga-trained and non-yoga-trained women were administered a bench-stepping exercise. Muscle soreness was assessed using a Visual Analog Scale. Groups were also compared on body awareness, flexibility using the sit-and-reach test and perceived exertion.
Muscle soreness decreased and flexibility increased using the sit-and-reach-test after yoga.

Bowman et. al, (1997) studied the effects of aerobic exercise training and yoga, a non-aerobic control intervention and the baroreflex of elderly persons were determined. Baroreflex sensitivity was quantified by the alpha-index, at high frequency (reflecting parasympathetic activity) and mid-frequency (reflecting sympathetic activity as well), derived from spectral and cross-spectral analysis of spontaneous fluctuations in heart rate and blood pressure. Twenty-six sedentary, healthy and normotensive elderly subjects were studied. Fourteen of the sedentary elderly subjects completed 6 weeks of aerobic training, while the other 12 subjects completed 6 weeks of yoga. As a result, it was observed that heart rate decreased following yoga but not aerobic training. VO2 max increased by 11% following yoga and by 24% following aerobic training. No significant change in alpha MF or alpha HF occurred after aerobic training. Following yoga, alpha HF but not alpha MF increased.

Harinath et. al. (2004) studied the comparative effects of yoga and physical activity. Thirty healthy men were randomly divided into two groups. Controls performed body flexibility exercises for 40 minutes and slow running for 20 minutes during morning hours and played games for 60 minutes during evening hours daily for 3 months. Group 2 subjects practiced selected yogic postures for 45 minutes. Yogic practices for 3 months resulted in improved cardio respiratory performance and psychologic profiles. Plasma melatonin also increased after three months of yogic practices.

Bhuntkaret. al. (2008) tested efficacy of regular practice of ‘Suryanamaskar’ in improving the cardio-respiratory fitness. The present study was conducted on 78 subjects, (48 males and 30 females). It was observed that 6 months of Suryanamaskar practice decreases resting pulse rate and blood pressure. At the same time it increases cardio-respiratory efficiency and respiratory capacity
as evaluated by bicycle ergometry and various lung functions tests, in both male and female subjects. From this study, they concluded that Suryanamaskar practice can be advocated to improve cardio-respiratory efficiency for patients as well as healthy individuals.

Hart and Tracy (2008) explored the effect of a popular type of yoga (Bikram) on strength, steadiness and balance. Young adults performed yoga training (n = 10, 29 ± 6 years, 24 yoga sessions in 8 weeks) or served as controls (n = 11, 26 ± 7 years). Yoga sessions consisted of 1.5 hours of supervised, standardized postures. Measures before and after training included maximum voluntary contraction (MVC) force of the elbow flexors (EF) and knee extensors (KE), steadiness of isometric EF and KE contractions, steadiness of concentric (CON) and eccentric (ECC) KE contractions and timed balance. After yoga training, MVC, force increased 14% for KE (479 ± 175 to 544 ± 187 N, p < 0.05) and was unchanged for the EF muscles (219 ± 85 to 230 ± 72 N, p > 0.05). The CV of force was unchanged for EF (1.68 to 1.73%, p > 0.05) but was reduced in the KE muscles similarly for yoga and control groups (2.04 to 1.55%, p < 0.05). The variability of CON and ECC contractions was unchanged. For the yoga group, improvement in KE steadiness was correlated with pertaining steadiness (r = -0.62 to -0.84, p < 0.05); subjects with the greatest KE force fluctuations before training experienced the greatest reductions with training. Percent change in balance time for individual yoga subjects averaged +228% (19.5 ± 14 to 34.3 ± 18 seconds, p < 0.05), with no change in controls. For young adults, a short-term yoga programme of this type can improve balance substantially, produce modest improvements in leg strength and improve leg muscle control for less-steady subjects.

Aslan and Livanelioglu (2002) investigated whether Hatha Yoga (HY) training affects aerobic and anaerobic power in healthy young adults. 33 sedentary, healthy and young adult subjects, aged 18 to 26 were divided into two
groups. Young adults were trained with Hatha Yoga (HYG). The aerobic exercise group (AEG) consisted of 9 female and 7 male (mean 19.75 ± 1.81 years, range 18-26 years) young adults who performed aerobic type strength and stretch exercises of at least 60% maximal heart rate or higher. As a result it was observed that aerobic and anaerobic power increased by 9.8%, 5.5% following HY and by 6.6%, 2.3% following aerobic training respectively. A significant increase was found in aerobic power and anaerobic power (p < 0.001) in Hatha Yoga. There was a significant increase in aerobic power (p < 0.01) in AEG, while anaerobic power of subjects in AEG were consistently higher compared to that before training, statistically the difference was not significant (p > 0.05). Although there was no substantial differences between the groups concerning cardiovascular endurance (p > 0.05), anaerobic power was significantly higher (p < 0.05) in the HY. Conclusion: The results of this study suggest that HY training has positive effects on cardiovascular aerobic and anaerobic power. Therefore HY could be an exercise option for enhancing aerobic and anaerobic power in young adults.

Birkel (2000) conducted a study to determine the effects of yoga postures and breathing exercises on vital capacity. Using the Spiro pet spirometer, researchers measured vital capacity. Vital capacity determinants were taken near the beginning and end of two 17-week semesters. No control group was used. Midwestern University yoga classes are taken for college credit. A total of 287 college students, 89 men and 198 women subjects were taught yoga poses, breathing techniques and relaxation in two 50-minute class meetings for 15 weeks. The study showed a statistically significant (P < .001) improvement in vital capacity across all categories over time. It is not known whether these findings were the result of yoga poses, breathing techniques, relaxation or other aspects of exercise in the subjects’ life. The subjects’ adherence to attending class was 99.96%. The large number of 287 subjects is considered to be a valid number for a
study of this type. These findings are consistent with other research studies reporting the positive effect of yoga on the vital capacity of lungs.

In the study of Carroll et. al. (2003) to quantify the hemodynamic and metabolic demand of Ashtanga Vinyasa Yoga (aka power yoga), and compare the heart rate/oxygen consumption relationship of yoga to a maximal treadmill GXT, thirteen yoga practitioners (age 36.7 ± 6.5 yrs, body mass 62.1±13.2 kg, height 166.1 ± 9.4 cm, max VO2 46.6 ± 4.5 mL / kg-min) with yoga experience of 3-36 months participated in the study. From the results is conduced that despite the lack of relationship between HR and VO2, and the mild blood lactate level, Ashtanga Vinyasa Yoga can provide a moderate cardiovascular stimulus through a combination of anaerobic and aerobic energy requirements. The anaerobic exercise and isometric muscle actions involved in Vinyasa Yoga, may in part be responsible for the disproportionate HR/VO2 response and thus preclude the use of HR to estimate exercise intensity. The 6.7 MET energy cost of Vinyasa Yoga is similar to the moderate exercise intensity required by aerobic dance and walking.

Clay et. al. (2005) conducted a study to determine the metabolic and heart rate (HR) responses of Hatha Yoga in which 26 women (19-40 years old) performed a 30- minute hatha yoga routine of supine lying, sitting and standing asanas (i.e., postures). Subjects followed identical videotaped sequences of Hatha Yoga asanas. Mean physiological responses were compared to the physiological responses of resting in a chair and walking on a treadmill at 93.86 m.min (- 1) [3.5 miles per hour (mph)]. During the 30-minute Hatha Yoga routine, mean absolute oxygen consumption (Vo(2)), relative Vo(2), percentage maximal oxygen consumption (%Vo(2)R), metabolic equivalents (METs), energy expenditure, HR and percentage maximal heart rate (%MHR) were 0.45 L.min(-1), 7.59 ml.kg (-1).min(-1), 14.50%, 2.17 METs, 2.23 kcal.min(-1), 105.29 b.min(-1), and 56.89%, respectively. When compared to resting in a chair, Hatha Yoga required 114% greater O(2) (L.min(-1)), 111% greater O(2)(ml.kg(-1).min (-1)), 4.294%
greater \%Vo(2)R, 111\% greater METs, 108\% greater kcal.min(-1), 24\% greater HR and 24\% greater \%MHR. When compared to walking at 93.86 m.min(-1), Hatha Yoga required 54\% lower O(2) L.min(-1)), 53\% lower O(2)(ml.kg(-1).min(-1)), 68\% lower \%Vo(2)R, 53\% lower METs, 53\% lower kcal.min(-1), 21\% lower HR and 21\% lower \%MHR. The Hatha Yoga routine in this study required 14.50\% Vo(2)R, which can be considered a very light intensity and significantly lighter than 44.8\% Vo(2)R for walking at 93.86 m.min(-1) (3.5 mph). The intensity of Hatha Yoga may be too low to provide a training stimulus for improving cardiovascular fitness.

Harinath et. al. (2004) evaluated the effects of Hatha Yoga and Omkar Meditation on cardio-respiratory performance, psychologic profile and melatonin secretion. As a result, it was observed that yogic practice for 3 months resulted in an improvement in cardio respiratory performance and psychological profile. The plasma melatonin also showed an increase after three months of yogic practices. The systolic blood pressure, diastolic blood pressure, mean arterial pressure and orthostatic tolerance did not show any significant correlation with plasma melatonin. However, the maximum night time melatonin levels in yoga group showed a significant correlation (r = 0.71, p < 0.05) with well-being score. From the results, it was conducted that yogic practices can be used as psycho physiologic stimuli to increase endogenous secretion of melatonin, which in turn might be responsible for improved sense of well-being.

Udupa et. al. (2002) in their study planned to determine if Shavasan could modulate the physiological response to stress induced by cold pressor test (CPT) and the possible mechanisms involved. Ten normal adults were taught Shavasan and they practiced the same for a total duration of seven days. RR interval variation (RRIV), deep breathing difference (DBD) and heart rate, blood pressure and rate-pressure-product (RPP) response to CPT were measured before and immediately after Shavasan. Shavasan produced a significant increase in DBD and
an appreciable but statistically insignificant increase in RRIV suggesting an enhanced parasympathetic activity. Significant blunting of cold pressor-induced increase in heart rate, blood pressure and RPP by Shavasan was seen during and even five minutes after CPT suggesting that Shavasan reduces the load on the heart by blunting the sympathetic response. It is concluded that Shavasan can enhance one's ability to withstand stress induced by CPT and this ability can be achieved even with seven days of Shavasan training.

Udupa et. al. (2002) reported that the effects of yoga training on cardiovascular response to exercise and the time course of recovery after the exercise. Cardiovascular response to exercise was determined by Harvard step test using a platform of 45 cm height. The subjects were asked to step up and down the platform at a rate of 30/min for a total duration of 5 min or until fatigue, whichever was earlier. Heart rate (HR) and blood pressure response to exercise were measured in supine position before exercise and at 1, 2, 3, 4, 5, 7 and 10 minutes after the exercise. Rate-pressure product \[\text{RPP} = (\text{HR} \times \text{SP})/100\] and double product \[\text{DoP} = \text{HR} \times \text{MP}\], which are indices of work done by the heart, were also calculated. Exercise produced a significant increase in HR, systolic pressure, RPP and DoP and a significant decrease in diastolic pressure. After two months of yoga training, exercise-induced changes in these parameters were significantly reduced. It is concluded that, after yoga training, a given level of exercise leads to a milder cardiovascular response, suggesting better exercise tolerance.

Ray et. al. (2001) undertook a study to observe any beneficial effect of yogic practices during training period on the young trainees on psychological, psycho-physiological and psychomotor aspects. Results describe that initially there was relatively higher sympathetic activity in both the groups due to the new work/training environment but gradually it subsided. Later, on at the 5th and 10th month, yoga group had relatively lower sympathetic activity than the control
group. There was improvement in performance at sub maximal level of exercise and in anaerobic threshold in the yoga group. Shoulder, hip, trunk and neck flexibility improved in the yoga group. There was improvement in various psychological parameters like reduction in anxiety and depression and a better mental function after yogic practices.

Shridharan, et. al. (1981) carried out a study on 10 healthy subjects [male soldiers; mean age 24.9 years] to evaluate the effect of yogic training [prayer, asanas, pranayama and meditation taught by instructors from Vishwayatan Yogashram in Delhi] on some autonomic responses and biochemical indices. Yogic training was administered daily in the morning for one hour under the supervision of qualified yoga teachers. Physiological and biochemical responses were assessed before and after three months of training [subjects took one month to learn the programme, followed by three months of practice for this study]. A significant decrease in heart rate, blood pressure and elevation of mean skin temperature and alpha index of EEG were recorded, followed by reduction in blood glucose and plasma cholesterol level. Changes in the dopamine-beta-hydroxylase (DBH) activity, monoamine oxidizes (MAO) and adrenal steroids along with the physiological parameters indicated a shift in the autonomic balance towards relative parasympathodominance.

According to Satyanarayana et. al. (1992) Santhi Kriya is a mixture of combined yogic practices of breathing and relaxation. Preliminary attempts were made to determine the effect of Santhi Kriya on certain psycho physiological parameters. Results indicate a gradual and significant decrease in the body weight from 1st to 30th day (P less than 0.001) and an increase in alpha activity of the brain (P less than 0.001) during the course of 30 days of Santhi Kriya practice. Increase of alpha activity both in occipital and pre- frontal areas of both the hemispheres of the brain denotes an increase of calmness. This study also revealed that Santhi Kriya practice increases oral temperature by 3 degrees F and decreases
respiratory rate significantly (P less than 0.05) on all practice days. Other parameters were not found to be altered significantly. It is concluded that the Santhi Kriya practice for 30 days reduces body weight and increases calmness.

Tori et. al. (2000) tried to determine the physical, physiological and psychological effects of practicing Iyengar yoga. 367 Iyengar Yoga practitioners, from North and South America, Asia, South Africa, New Zealand and Australia, who attended the “Iyengar Yoga Festival”, Pune in 1998, participated in this study. All these participants answered three questionnaires pertaining to their yoga practice, the perception and coping of stress and their personality traits. It took each participant at least one hour to answer all the questions listed. Their replies were then assessed using specific statistical tests. The results of this study clearly document that practice of Iyengar Yoga improves the physical, physiological and psychological well-being of the practitioner, a heightened self-control, an enhancement of personal growth and a low perception of stress. The personality of the practitioners indicated that they were more sensitive, flexible and self-reliant but at the same time exhibited a “mind of their own” by being non-conforming and submissive.

Tran et. al. (2001) conducted a study with ten healthy, untrained volunteers (nine females and one male), ranging in age from 18-27 years. They were studied to determine the effects of Hatha Yoga practice on the health-related aspects of physical fitness, including muscular strength and endurance, flexibility, cardio respiratory fitness, body composition and pulmonary function. The subjects were evaluated before and after the 8-week training programme. Isokinetic muscular strength for elbow extension, elbow flexion and knee extension increased by 31%, 19% and 28% (p<0.05) respectively, whereas isometric muscular endurance for knee flexion increased 57% (p<0.01). Ankle flexibility, shoulder elevation, trunk extension and trunk flexion increased by 13% (p<0.01), 155% (p<0.001), 188% (p<0.001) and 14% (p<0.05) respectively. Absolute and relative maximal oxygen
uptake increased by 7% and 6% respectively (p<0.01). These findings indicate that regular Hatha Yoga practice can elicit improvements in the health-related aspects of physical fitness. Copyright © 2001 CHF, Inc.

In the study by Sengupta and Banerjee (1994), body flexibility, resting heart rate and blood pressure, physical fitness index by Harvard step test, state and trait anxiety and performance on digit symbol substitution test were measured before and after 6 weeks of supervised training in 2 groups of male healthy volunteers taken from ab initio medical assistant trainees. The yoga group (n is equal to 60) performed 1 h yogic exercise schedule 5 days a week and the other group (n is equal to 35) played volley-ball during the same period. The pre-training scores of Harvard step test indicated a physically active sample population. Pre and post training assessments indicated significant reduction in resting heart rate and blood pressure, significant improvements in trunk flexion ability and performance in digit symbol substitution score in the yoga group.

Manjunath, Shirley Telles (2001) took twenty girls between 10 and 13 years of age, studying in a residential school. They were randomly assigned to 2 groups. One group practiced yoga for one hour and fifteen minutes per day, 7 days a week, while the other group was given physical training for the same time. Time for planning and for execution and the number of moves required to complete the Tower of London task were assessed for both groups at the beginning and end of a month. These three assessments were separately tested in increasingly complex tasks requiring 2 moves, 4 moves and 5 moves. The Pre and Post data were compared using the Wilcoxon Paired Signed Ranks Test. The yoga group showed a significant reduction in planning time for both 2 moves and 4 moves tasks (53.9 and 59.1 percent respectively) execution time in both 4 moves and 5 moves tasks (63.7 and 60.3 percent respectively) and in the number of moves in the 4 moves tasks (20.9 percent). The physical training group showed no change. Hence, yoga training for a month reduced the planning and execution time in...
simple (2 moves) as well as complex tasks (4, 5 moves) and facilitated reaching the target with a smaller number of moves in complex tasks (4 moves).

Hubert (1974) studied the effects of yoga on selected physiological parameters. The results indicated an increase in basal metabolic rate, total volume in basal state, T-4 thyroxine, haemoglobin, expansion, breath holding time and flexibility after yoga training. Decrease in heart rate in basal state and respiratory rate also were observed. When yogic training was discontinued for six weeks following six week treatment, a significant decline in the values of PWC 130, flexibility and breath holding time were noticed.

Moorthy (1982, c) tried to find the training effect of selected yogic exercise on fitness. A group of 60 boys and 60 girls were selected from the failures of the fitness test and were randomly allotted to each group in control and experimental groups. The subjects were tested twice before and after 6 weeks of yogic training on fitness tests. On all other days, except Sundays, eight yogic exercises (slides) were imparted to experimental group for a period of 30 minutes in the afternoon every day. The control group did not participate in yogic exercises. He found that the experimental group made statistically significant gains in muscular fitness after six weeks of yogic training. Even though the control group boys made a numerical gain of 3.33, this was not statistically significant.

Chakrabarthi et. al. (1984) studied the effects of individual asanas by dividing the volunteers into three groups, each group practicing one of the three important ‘asanas’ namely Sarvangasana (standing on shoulder), Sirasana (standing on head) and Halasana (plough pose). Each was practiced along with its complementary postures i.e., Matsyasana, Mayurasana and Paschimotanasana for optimal results. The effect of Sarvasagana induced more cardio respiratory response and less endocrine and metabolic responses. Sirasasana induced less physiological changes and Halasana produced more physical changes and less physiological changes.
Oberg et. al. (1986) observed that good muscular strength reduces the number and severity of injuries and delays muscular fatigue. It increases confidence in athletic ability, because it enhances better technique, power and speed of movement. Football players must work with strength training programme as it brings about beneficial changes on the adaptation process. A high level of flexibility fosters a saving in energy during vigorous movements because of this better mechanical advantage. Because of this better physiological and mechanical adjustment of the joint and muscles, the individual may be less vulnerable to injury. Flexibility plays its part in maintaining good posture and it is related to such components as endurance, speed and agility.

Selvarajan (1987) made a study on the effect of practice of asanas on stretching movements. The asanas not only supply the organs with an external massage, but also give them unique internal exercises which cannot be equalled by any other system of sports in the world. It is a recognized fact of therapeutics that the muscle can only retain their strength and elasticity only if they are obliged to perform contracting and stretching movements. Among the asanas, Bhujangasana, Salabasana and Dhanurasana are the most magnificent exercises for stretching the abdominal muscles and contracting the back muscles.

Balasubramanian and Pansare (1991) in their study “Effect of yoga on aerobic and anaerobic power of muscles” inferred that aerobic power (VO$_2$ max) and anaerobic power were estimated in medical students before and after 6 weeks of yoga training. A significant increase in aerobic power and a significant decrease in anaerobic power were observed. This may be due to conversion of some of the Fast Twitch (FT) muscle fibres into slow Twitch fibres (ST) during yoga training.

Sinha et. al. (2001) reported on the effect of yogic exercises on perceived exertion (PE) after maximal exercise. In this study the effect of training in Hatha Yogic exercises on aerobic capacity and PE after maximal exercise was observed. Forty men from the Indian army (aged 19-23 yr) were administered maximal
exercise on a bicycle ergometer in a graded work load protocol. The oxygen consumption, carbon dioxide output, pulmonary ventilation, respiratory rate, heart rate (HR), etc., at maximal exercise and PE score immediately thereafter were recorded. Results of the study explained that absolute value of VO2Max increased significantly (P < 0.05) in the yoga group after 6 months of training. The PE scores after maximal exercise decreased significantly (P < 0.001) in the yoga group after 6 months but the PT group showed no change. The practice of Hatha Yogic exercises along with games helps to improve aerobic capacity like the practice of conventional exercises (PT) along with games. The yoga group performed better than the PT group in terms of lower PE after exhaustive exercise.

Allolio et. al. (1994) examined the effects of yogic exercises on physiological and psychological variables. Data were collected on heart rate, blood pressure and the hormones cortisol, prolactin and growth hormone using the subjects of yoga group and a control group. From the results, it was observed that the yoga group had decreased heart rate during yoga. The yoga group had higher scores on life satisfaction and lower scores on excitability, aggressiveness, openness, emotionality and somatic complaints and coping with stress and mood by the end of the experiment. The yoga group also had higher scores on high spirits and extravertedness.

Tells et. al. (2004), in their study, determined whether yoga reduced heart rate and whether the reduction would be more after 30 days of yoga training. Two groups (yoga and control, n = 12 each) were assessed on Day 1 and Day 30. During the intervening 30 days, the yoga group received training in yoga techniques while the control group carried on with their routine. At each assessment the baseline heart rate was recorded for one minute. This was followed by a six-minute period during which participants were asked to attempt to voluntarily reduce their heart rate, using any strategy. As a result it was observed that both the baseline heart rate and the lowest heart rate achieved voluntarily
during the six-minute period were significantly lower in the yoga group on Day 30 compared to Day 1 by a group average of 10.7 beats per minute (i.e., bpm) and 6.8 bpm, respectively. In contrast, there was no significant change in either the baseline heart rate or the lowest heart rate achieved voluntarily in the control group on Day 30 compared to Day 1.