Chapter II
REVIEW OF RELATED LITERATURE

For any specific research project to occupy a place in the development of a discipline, the researcher must be thoroughly familiar with both previous theory and research. To assure this familiarity, every research project in the behavioural sciences has as one of its early stage, a review of the theoretical and research literature.

The literature related to any problem helps the scholar to discover what is already known, which would enable the investigator to have a deep insight, clear perspective and a better understanding of the chosen problem and various factors connected with the study. So a number of books, journals and websites were referred. In the following pages, an attempt has been made to present briefly a few of the important researches and studies conducted abroad and in India as they have significant bearing on the present study.

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The following review of literature addresses the effect of varied intensities of endurance training on physical and physiological parameters. Terms relevant to the study in this thesis are operationally defined.

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Ahtiainen, Pakarinen, Kraemer & Häkkinen (2004) investigated acute hormonal and neuromuscular responses and recovery in strength athletes versus nonathletes during heavy resistance exercise performed with the forced and maximum repetitions training protocol. Eight male strength athletes (SA) with several years of continuous resistance training experience and 8 physically active but non-strength athletes (NA) volunteered as subjects. These data suggest that, at least in experienced strength athletes, the forced-repetition protocol is a viable
alternative to the more traditional maximum-repetition protocol and may even be a superior approach.

Alcaraz, Sánchez-Lorente & Blazevich (2008) compared physical performance parameters and cardiovascular load during heavy-resistance circuit (HRC) training to the responses during a traditional, passive rest strength training set (TS). Ten healthy subjects with strength training experience volunteered for the study. Testing was performed once weekly for 3 weeks. On day 1, subjects were familiarized with the test and training exercises. Thus, HRC sets are quantitatively similar to traditional strength training sets, but the cardiovascular load is substantially greater. HRC may be an effective training strategy for the promotion of both strength and cardiovascular adaptations.

An et al (2003) determined the major gene effects on exercise heart rate (HR) and blood pressure (BP) measured at 50 W and 80 % maximal oxygen uptake (VO(2)max) in 99 White families in the HERITAGE Family Study. Exercise HR and BP were measured both before and after 20 weeks of endurance training. The baseline phenotypes were adjusted for the effects of age and BMI, whereas the training responses (post-training minus baseline) were adjusted for the effects of age, BMI and the
corresponding baseline values, within four sex-by-generation groups. Baseline exercise HR at 50 W was under the influence of a major recessive gene and a multifactorial component, which accounted for 30% and 27% of the variance, respectively. In conclusion, submaximal exercise HR at baseline and in response to endurance training was influenced by putative major genes, with no evidence of interactions with sex, age or BMI, in contrast to a multifactorial etiology for exercise BP.

Anderson, Sforzo & Sigg (2008) determined whether combined elastic and free weight resistance (CR) provides different strength and power adaptations than free weight resistance (FWR) training alone. Forty-four young (age 20 +/- 1 year), resistance-trained (4 +/- 2 years’ experience) subjects were recruited from men's basketball and wrestling teams and women's basketball and hockey teams at Cornell University. Subjects were stratified according to team, then randomly assigned to the control (C; n = 21) or experimental group (E; n = 23). Before and after 7 weeks of resistance training, subjects were tested for lean body mass, 1 repetition maximum back squat and bench press, and peak and average power. It was concluded that, training with CR may be better than FWR alone for developing lower and upper body strength, and lower body power in resistance-trained individuals.
Long-term effects are unclear, but CR training makes a meaningful contribution in the short term to performance adaptations of experienced athletes.

**Bentley et al (2005)** determined the time sustained near VO2max in two interval training (IT) swimming sessions comprising 4x400 m (IT(4x400)) or 16x100 (IT(16x100)). Elite swimmers completed three experimental sessions at a 50-m indoor pool over a one week period. The first test comprised a 5 x 200-m incremental test to exhaustion for determination of the pulmonary ventilation threshold (VT, m.s(-1)), VO2max, the velocity associated with VO2max (VO2max, m(s(-1))) and maximum heart rate (HR(max), b.min(-1)). The remaining two tests involved the IT(4x400) and IT(16x100) performed in a randomised order. In conclusion, this factor deserves further research to establish the characteristics of those athletes which influence the physiological responses in IT of short or longer duration repetitions.

**Boyle et al (2004)** determined the effects of yoga training and a single bout of yoga on the intensity of delayed onset muscle soreness (DOMS). 24 yoga-trained (YT; n = 12) and non-yoga-trained (NYT; n = 12), matched women volunteers were
administered a DOMS-inducing bench-stepping exercise. Muscle soreness, groups were compared on body awareness (BA), flexibility and perceived exertion (RPE) were assessed. The findings have significant implications for coaches, athletes, and the exercising public who may want to implement yoga training as a preseason regimen or supplemental activity to lessen the symptoms associated with muscle soreness.

**Candow & Burke (2007)** determined the effect of short-term equal-volume resistance training with different workout frequency on lean tissue mass and muscle strength. Twenty-nine untrained volunteers (27-58 years; 23 women, 6 men) were assigned randomly to 1 of 2 groups: group 1 (n = 15; 12 women, 3 men) trained 2 times per week and performed 3 sets of 10 repetitions to fatigue for 9 exercises, group 2 (n = 14; 11 women, 3 men) trained 3 times per week and performed 2 sets of 10 repetitions to fatigue for 9 exercises. These results suggest that the volume of resistance training may be more important than frequency in developing muscle mass and strength in men and women initiating a resistance training program.

**Carter, Jones, Barstow, Burnley, Williams & Doust (2000)** examined the effect of endurance training on oxygen uptake
(VO(2)) kinetics during moderate [below the lactate threshold (LT)] and heavy (above LT) treadmill running. Twenty-three healthy physical education students undertook 6 wk of endurance training that involved continuous and interval running training 3-5 days per week for 20-30 min per session. It was calculated that only 9-14% of the slow component could be attributed to the change in minute ventilation. We conclude that the VO(2) slow component during treadmill running can be attenuated with a short-term program of endurance running training.

Cesar Mde et al (2009) investigated the effect of local muscle endurance training on maximal oxygen uptake and ventilatory threshold in young women. Nineteen untrained women, ranging in age from 18 to 26 years, were included in the study and assigned to two groups: the control group (n = 10), and the resistance training group (n = 9). The following variables were obtained at baseline and after 12 weeks: body mass; maximal oxygen uptake, maximal heart rate, maximal oxygen pulse, oxygen uptake at the ventilatory threshold, heart rate at the ventilatory threshold, and oxygen pulse at the ventilatory threshold assessed by cardiopulmonary exercise testing on treadmill; 1-repetition maximum (RM) tests in bench press,
latissimus pull down, military press, lying barbell extension, standing barbell curls, leg press, knee extension, and hamstring curl. These findings indicate that the local muscle endurance training realized produces no improvement in cardio respiratory capacity in young women.

Chen et al (2008) aimed to test older adults' physical fitness after a 24-week silver yoga exercise programme and to examine whether the programme could be further shortened to fit senior activity centres' programme designs. Convenience samples of 204 subjects were recruited from eight senior activity centres and 176 subjects completed the study. Subjects were randomly assigned into three groups based on the centres: (1) Experiment I: complete silver yoga with stretching and meditation, (2) Experiment II: shortened silver yoga without the guided-imagery meditation and (3) Wait-list control. It was concluded that, the physical fitness of older adults in both the 70-minute complete silver yoga group and the 55-minute shortened silver yoga group had significantly improved after the interventions.

Chromiak et al (2004) investigated whether postexercise consumption of a supplement containing whey protein, amino acids, creatine, and carbohydrate combined with a strength
training program promotes greater gains in fat-free mass (FFM), muscle strength and endurance, and anaerobic performance compared with an isocaloric, carbohydrate-only control drink combined with strength training. Forty-one males participated in a 4 d/wk, 10-wk periodized strength training program. In conclusion, consumption of a recovery drink after strength training workouts did not promote greater gains in FFM compared with consumption of a carbohydrate-only drink; however, a trend toward a greater increase in FFM in the supplement group suggests the need for longer-term studies. Performance variables such as muscle strength and endurance and anaerobic performance were not improved when compared with the carbohydrate-only group.

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 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). It was concluded that, 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.

Clark (2010) examined improvements in cardio respiratory fitness (VO(2)) after the use of a mixed-intensity interval endurance-training (MI-ET) program in female soccer players, to validate the MI-ET program as an appropriate training regimen to improve cardio respiratory fitness (VO(2)) in soccer players. 32 female soccer players (average 18.66 +/- 0.31 years) were recruited from a group of currently conditioning local U-19 and college soccer teams and randomly assigned to participate in an 8-week periodized training program that involved either the MI-ET program or the continuation of a current endurance-training (ET) program. In conclusion, the MI-ET program is shown to be a valid means to improve aerobic fitness as indicated by the MI-ET group exhibiting significantly greater VO₂ measures after training.
Coelho, Hamar & Araújo (2003) compared physiological responses to 2 high-speed resistance training (RT) protocols in untrained adults. Both RT protocols included 12 repetitions for the same 6 exercises, only differing in continuous (1 x 12) or discontinuous (2 x 6) mode. It was concluded that, the discontinuous protocol was significantly less physiologically demanding, although similar or higher CPMP values were obtained.

Cornelissen, Verheyden, Aubert & Fagard (2010) investigated the effects of endurance training intensity (1) on systolic blood pressure (SBP) and heart rate (HR) at rest before exercise, and during and after a maximal exercise test; and (2) on measures of HR variability at rest before exercise and during recovery from the exercise test, in at least 55-year-old healthy sedentary men and women. A randomized crossover study comprising three 10-week periods was performed. In the first and third period, participants exercised at lower or higher intensity (33% or 66% of HR reserve) in random order, with a sedentary period in between. Training programmes were identical except for intensity, and were performed under supervision thrice for 1 h per week. In conclusion, in participants at higher age, both training programmes exert similar effects on SBP at rest, during
exercise and during post-exercise recovery, whereas the effects on HR are more pronounced after higher intensity training.

Cowley, Swensen & Sforzo (2007) evaluated the influence of platform (unstable vs. stable, stability ball vs. flat bench) on strength and work capacity during barbell chest-press exercise. We also sought to determine the effects of a barbell chest-press training program performed on a stability ball or flat bench on strength, work capacity, and abdominal power. Fourteen young women (20 - 23 yr) performed a 1 repetition maximum (1RM) barbell chest-press and the YMCA bench press test (YBT) on a stability ball and flat bench, as well as two field tests measuring abdominal power. Thus, the stability ball is an effective platform for barbell chest-press training in untrained women over a short duration.

Daussin et al (2007) tested the hypothesis that CT and IT might improve peripheral and/or central adaptations, respectively, by randomly assigning 10 healthy subjects to two periods of 24 trainings sessions over 8 weeks in a cross-over design, separated by 12 weeks of detraining. Maximal oxygen uptake (VO2max), cardiac output (Qmax) and maximal arteriovenous oxygen difference (Da-vO2max) were obtained
during an exhaustive incremental test before and after each training period. These results suggest that in isoenergetic training, central and peripheral adaptations in oxygen transport and utilization are training-modality dependant. IT improves both central and peripheral components of Da-vO₂max whereas CT is mainly associated with greater oxygen extraction.

**Davis, Wood, Andrews, Elkind & 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 program. 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 program outcomes, and document a highly effective athletic training protocol.

**DiBenedetto et al (2005)** determined if a tailored yoga programme could improve age-related changes in hip extension,
stride length, and associated indices of gait function in healthy elders. Changes that have been linked to increased risk for falls, dependency, and mortality in geriatric populations. Twenty-three healthy adults who were naive to yoga were recruited; 19 participants completed the programme. An 8-week Iyengar Hatha yoga programme specifically tailored to elderly persons and designed to improve lower-body strength and flexibility. Peak hip extension, average anterior pelvic tilt, and stride length at comfortable walking speed were analysed. Findings of this exploratory study suggest that yoga practice may improve hip extension, increase stride length, and decrease anterior pelvic tilt in healthy elders, and that yoga programmes tailored to elderly adults may offer a cost-effective means of preventing or reducing age-related changes in these indices of gait function.

Dorgo, King & Rice (2009) investigated the effects of a manual resistance training (MRT) program on muscular strength and endurance and to compare these effects with those of an identically structured weight resistance training (WRT) program. To do this, 84 healthy college students were randomly assigned to either an MRT or WRT group and engaged in a 14-week training program. Each participant’s performance was assessed before and immediately after the 14-week training period.
Muscular strength was assessed by the one-repetition maximum (1RM) bench press test and the 1RM squat test. Muscular endurance was recorded as the maximum number of repetitions performed with 70% of pre-training 1RM for the bench press and squat exercises. The improvements in muscular strength and muscular endurance after a 14-week MRT program in the present study were similar to those produced by a WRT program, and well-designed MRT exercises seem to be effective for improving muscular fitness.

Drinkwater et al (2007) investigated the effect of resistance training. Twelve basketball and 10 volleyball players trained 3 sessions per week for 6 weeks, completing either 4 x 6, 8 x 3, or 12 x 3 (sets x repetitions) of bench press per training session. Compared with the 8 x 3 group, the 4 x 6 protocol involved a longer work interval and the 12 x 3 protocol involved higher training volume, so each group was purposefully designed to elicit a different number of forced repetitions per training session. In conclusion, there were no significant differences in strength or power gains between groups. In conclusion, when repetition failure was reached, neither additional forced repetitions nor additional set volume further improved the magnitude of strength gains.
Duffield, Edge & Bishop (2006) examined the effect of high-intensity interval training on the VO2 response during severe, constant-load exercise. Prior to, and following training, 10 females (VO2 peak 37.4+/6.0 ml kg-1 min-1) performed a graded exercise test to determine VO2 peak and lactate threshold (LT) and a 6 min cycle test (CT) at the pre-training VO2 peak intensity. Training involved high-intensity intervals (2 min work, 1 min rest) performed 3x week for 8 weeks. In contrast to previous moderate-intensity research, a high-intensity interval training program increased A1 and VO2 EE for the same absolute exercise intensity, decreasing the AOD during a severe-intensity CT.

Dupont, Akakpo & Berthoin (2004) determined the effects of in-season, high-intensity interval training on professional male soccer players’ running performances were investigated. Twenty-two subjects participated in 2 consecutive training periods of 10 weeks. The first period was considered a control period and was compared with a period where 2 high-intensity interval training exercises were included in the usual training program. Intermittent runs consisted of 12-15 runs lasting 15 seconds at 120% of maximal aerobic speed alternated with 15 seconds of
rest. Sprint repetitions consisted of 12-15 all-out 40-m runs alternated with 30 seconds of rest. This study shows that improvements in physical qualities can be made during the in-season period.

Egaña & Donne (2004) investigated the metabolic and cardio respiratory improvements following a 12-week aerobic training program using elliptical trainer, treadmill or stair-climbing modalities. Twenty-two moderately active females (28.6 +/- 5.3 y, 1.65 +/- 0.05 m) were randomly assigned to treadmill running (n=7), elliptical trainer (n=8) or stair-climber (n=7) groups and trained 3 days x week(-1) initially at 70-80% of maximum heart rate (HRmax) for 30 min, progressing to 80-90% HRmax for 40 min. Subjects performed incremental exercise to volitional exhaustion using an electronically loaded cycle ergometer before and upon completion of the program. In addition, subjects performed sub-maximal fixed load tests at 0, 4, 8 and 12 weeks, using ergometers specific to their exercise group. It was concluded that, in moderately active females similar physiological improvements were observed using stair-climber, elliptical trainer and treadmill running when training volume and intensity were equivalent.
Elavsky and McAuley (2007) examined the effects of walking and yoga on multidimensional self-esteem and roles played by self-efficacy, body composition, and physical activity (PA) in changes in esteem in previously low-active middle-aged women. Body composition, fitness assessment, and battery of psychologic were measured. The results provide support for the hierarchic and multidimensional nature of self-esteem and indicate that middle-aged women may enhance certain aspects of physical self-esteem by participating in PA.

Esteve-Lanao, Foster, Seiler & Lucia (2007) compared the effect of 2 training programs differing in the relative contribution of training volume, clearly below vs. within the lactate threshold/maximal lactate steady state region on performance in endurance runners. Twelve subelite endurance runners (who are specialists in track events, mostly the 5,000-m race usually held during spring-summer months and who also participate in cross-country races [9-12 km] during fall and winter months) were randomly assigned to a training program emphasizing low-intensity (subthreshold) (Z1) or moderately high-intensity (between thresholds) (Z2) training intensities. These results provide experimental evidence supporting the value of a relatively large percentage of low-intensity training over a long
period (approximately 5 months), provided that the contribution of high-intensity training remains sufficient.

Esteve-Lanao, Rhea, Fleck & Lucia (2008) determined the effects of a running-specific, periodized strength training program (performed over the specific period [8 weeks] of a 16-week macrocycle) on endurance-trained runners' capacity to maintain stride length during running bouts at competitive speeds. Eighteen well-trained middle-distance runners completed the study. In conclusion, periodized, running-specific strength training minimizes the loss of stride length that typically occurs in endurance runners during fatiguing running bouts.

Faigenbaum et al (2007) evaluated the efficacy of an after-school resistance training program on improving the physical fitness of middle school-age boys. 22 boys (M = 13.9 yr., SD = .4 yr.) participated in a periodized, multiple-set, 9-wk. (2x/week) resistance training program. Statistical analysis indicated that subjects significantly improved performance on the squat (19%), bench press (15%), flexibility (10%), vertical jump (5%), medicine ball toss (12%), and the PACER (36%). Although this design minus a control group limits interpretation, this after-school
A resistance-training program can improve muscular fitness and cardiovascular fitness in boys and should be replicated with appropriate experimental controls.

**Ferrauti, Bergermann & Fernandez-Fernandez (2010)** investigated the effects of a concurrent strength and endurance training program on running performance and running economy of middle-aged runners during their marathon preparation. Twenty-two (8 women and 14 men) recreational runners were separated into 2 groups (n = 11; combined endurance running and strength training program [ES]: 9 men, 2 women and endurance running [E]: 7 men and 4 women). The results suggest no benefits of 8-week concurrent strength training for running economy and coordination of recreational marathon runners despite a clear improvement in leg strength, maybe because of an insufficient sample size or a short intervention period.

**Gergley (2009)** examined the effect of two different modes of lower-body endurance exercise (i.e., cycle ergometry 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]).
Thirty untrained participants (22 men and 8 women, ages 18-23) were randomly assigned to one of 3 training groups. This study indicates that the mode of endurance exercise in concurrent training regimens may play a role in the development of strength. Specifically, it seems that cycling is superior to treadmill endurance training for an individual with the goal of developing strength in a multijoint movement (i.e., leg press or squat) in the lower-body because it more closely mimics the biomechanical movement of these exercises.

*Gething, Passfield & Davies (2004)* investigated the relationship between the intensity of an inspiratory muscle training programme and its effect on respiratory muscle strength, exercising heart rate, and ratings of perceived exertion. A total of 66 subjects were randomly assigned to one of three groups. One group trained at 100% of maximum inspiratory pressure (MIP) for 6 weeks (MAX, n=22). A second group performed 6 weeks of inspiratory muscle training at 80% of MIP (SUB, n=21) and a third control group received no inspiratory training (CON, n=23). It is concluded that 6 weeks of both MAX and SUB training were sufficient to improve inspiratory muscle strength. However, exercising heart rate and perceived exertion decreased with MAX training only.
Gonzales & Williams (2010) determined if sex differences are present in exercise-induced inspiratory muscle function in untrained humans. Eight young untrained women (23.8 ± 1.5 y, VO2max = 33.7 ± 4.0 mL/kg/min) and men (26.1 ± 2.0 y, VO2max = 36.7 ± 1.2 mL/kg/min) performed high-intensity cycling exercise (80% WRmax) to exhaustion. Inspiratory muscle strength and endurance were assessed pre- and post-exercise by measuring maximal inspiratory pressure (PImax) and time to task failure during a constant-load breathing test (CLBT), respectively. These data demonstrate that women exhibit a greater reduction in inspiratory muscle endurance following an acute bout of high-intensity exercise than men.

González-Badillo, Izquierdo & Gorostiaga (2006) examined the effect of 3 volumes of heavy resistance, average relative training intensity (expressed as a percentage of 1 repetition maximum that represented the absolute kilograms lifted divided by the number of repetitions performed) programs on maximal strength (1RM) in Snatch (Sn), Clean & Jerk (C&J), and Squat (Sq). Twenty-nine experienced (>3 years), trained junior weightlifters were randomly assigned into 1 of 3 groups: low-intensity group (LIG; n = 12), moderate-intensity group (MIG; n = 9), and high-
intensity group (HIG; n = 8). All subjects trained for 10 weeks, 4-5 days a week. The present results indicate that short-term resistance training using moderate volumes of high relative intensity tended to produce higher enhancements in weightlifting performance compared with low and high volumes of high relative training intensities of equal total volume in experienced, trained young weightlifters.

Gurd, Scheuermann, Paterson & Kowalchuk (2005) examined the effect of prior heavy-intensity warm-up exercise on subsequent moderate-intensity phase 2 pulmonary O2 uptake kinetics (tauVO2) in young adults exhibiting relatively fast (FK; tauVO2 < 30 s; n = 6) and slow (SK; tauVO2 > 30 s; n = 6) VO2 kinetics in moderate-intensity exercise without prior warm up. We conclude that improved muscle perfusion in Mod2 may have contributed to the faster adaptation of VO2, especially in SK; however, a possible role for metabolic inertia in some subjects cannot be overlooked.

Hatfield et al (2006) determined the impact of a very slow (VS) velocity and a self-selected volitional (VOL) velocity at varying intensities on repetition number, peak force, peak power, and total volume in the squat and shoulder press exercises. On
separate testing days, 9 resistance trained men performed a squat (SQ) and shoulder press (SP) exercise at 60 or 80% of 1 repetition maximum (1RM) at either VOL or VS (10-second eccentric and 10-second concentric actions) velocity for as many repetitions as possible. The results of this study indicate that a VS velocity may not elicit appropriate levels of force, power, or volume to optimize strength and athletic performance.

Hautala et al (2006) tested the subjects with a poor responsiveness to endurance training might benefit from resistance training in terms of aerobic fitness. The study population consisted of sedentary healthy male and female subjects assigned to either a training (n=73) or a control group (n=18). The randomized cross-over study design included a 2-week laboratory-controlled endurance or resistance training period with a 2-month detraining period between the interventions. In conclusion, the healthy males and females whose training response is low after endurance training seem to result in a marked improvement in their cardio respiratory fitness by resistance training.

Haykowsky et al (2005) examined the effect that aerobic and strength training has on improving aerobic endurance and
muscle strength in female cardiac transplant recipients. 20 female cardiac transplant recipients participated in this investigation. The subjects performed a baseline six-minute walk test and a leg-press strength test when they were discharged following cardiac transplantation. The subjects then participated in a 12-week exercise program consisting of aerobic and lower extremity strength training. Baseline assessments were repeated following completion of the exercise intervention. It was concluded that, aerobic and strength training are effective interventions that can partially restore the impaired aerobic endurance and strength found in female cardiac transplant recipients.

Helgerud et al (2007) compared the effects of aerobic endurance training at different intensities and with different methods matched for total work and frequency. Responses in maximal oxygen uptake (VO2max), stroke volume of the heart (SV), blood volume, lactate threshold (LT), and running economy (CR) were examined. Forty healthy, nonsmoking, moderately trained male subjects were randomly assigned to one of four groups: 1) long slow distance (70% maximal heart rate; HRmax); 2) lactate threshold (85% HRmax); 3) 15/15 interval running (15 s of running at 90-95% HRmax followed by 15 s of active resting
at 70% HRmax); and 4) 4 x 4 min of interval running (4 min of running at 90-95% HRmax followed by 3 min of active resting at 70% HRmax). All four training protocols resulted in similar total oxygen consumption and were performed 3 days per week for 8 weeks. In conclusion, high-aerobic intensity endurance interval training is significantly more effective than performing the same total work at either lactate threshold or at 70% HRmax, in improving VO2max. The changes in VO2max correspond with changes in SV, indicating a close link between the two.

Helgerud, Engen, Wisloff & Hoff (2001) studied the effects of aerobic training on performance during soccer match and soccer specific tests. Nineteen male elite junior soccer players, age 18.1 +/- 0.8 yr, randomly assigned to the training group (N = 9) and the control group (N = 10) participated in the study. The specific aerobic training consisted of interval training, four times 4 min at 90-95% of maximal heart rate, with a 3-min jog in between, twice per week for 8 wk. Players were monitored by video during two matches, one before and one after training. In conclusion, enhanced aerobic endurance in soccer players improved soccer performance by increasing the distance covered, enhancing work intensity, and increasing the number of sprints and involvements with the ball during a match.
Hill-Haas, Bishop, Dawson, Goodman & Edge (2007) discussed the effect of altering the rest period on adaptations to high-repetition resistance training is not well known. 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]. 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.

Humburg, Baars, Schröder, Reer & Braumann (2007) investigated the effects of a 1-set and 3-set strength training program. The subjects were untrained men and women who were randomly signed into 1 of 3 groups: 10 subjects trained during the first 9 weeks (training period 1) with 1 set and 8-12 repetitions per set. After the break (9 weeks), they trained with 3 sets and 8-12 repetitions in training period 2. Twelve subjects started with the
3-set program and continued with the 1-set regime after the break. The control group (n = 7) did not train. In conclusion, depending on the goals of each trainee, these differences between the effects of different strength training volumes indicate that it may be worth spending more time on working out with a 3-set strength training regime.

Hunter, Seelhorst & Snyder (2003) compared the cardiovascular and energy expenditure demands of "Super Slow" (SST) and traditional (TT) resistance training. 7 resistance-trained young men (24.3 +/- 3.8 years) had energy expenditure (using indirect calorimetry) and heart rate evaluated during and for 15 minutes after a workout on separate days. Blood lactate levels were also evaluated before and after each intervention. In conclusion, no significant repeated measures analysis main effect was found for either resting energy expenditure or respiratory exchange ratio. The metabolic and cardiovascular stimuli were low with SST. Traditional resistance training increases energy expenditure more than SST does and thus may be more beneficial for body weight control.

Impellizzeri et al (2006) compared the effects of specific (small-sided games) vs. generic (running) aerobic interval
training on physical fitness and objective measures of match performance in soccer. Forty junior players were randomly assigned to either generic (n=20) or specific (n=20) interval training consisting of 4 bouts of 4 min at 90-95 % of maximum heart rate with 3 min active rest periods, completed twice a week. The results of this study showed that both small-sided games and running are equally effective modes of aerobic interval training in junior soccer players.

James, Barnes, Lopes & Wood (2002) investigated the effect of exercise on heart rate variability by analysing the heart rate power spectrum prior to, and 1 and 72 h following, an interval training session. Subjects initially performed a graded test to exhaustion to determine maximal oxygen uptake (VO(2) max) and the running speed at which VO(2) max was first attained (vVO(2) max). The training session was completed on a separate day and comprised six 800 m runs at 1 km x h (-1) below vVO(2) max. Whilst these findings illustrate the importance of controlling the timing of exercise prior to the determination of heart rate variability, the time course of the post-exercise heart rate variability response remains to be quantified.
Judelson et al (2007) examined the isolated effect of hydration state on 1) strength, power, and the performance of acute resistance exercise, and 2) central activation ratio (CAR). Seven healthy resistance-trained males completed three resistance exercise bouts in different hydration states: euhydrated (EU), hypohydrated by approximately 2.5% body mass (HY25), and hypohydrated by approximately 5.0% body mass (HY50). Investigators manipulated hydration status via exercise-heat stress and controlled fluid intake 1 d preceding testing. These data indicate that hypohydration attenuates resistance exercise performance; the role of central drive as the causative mechanism driving these responses merits further research.

Judge & Burke (2010) determined the effects of training sessions, involving high-resistance, low-repetition bench press exercise, on strength recovery patterns, as a function of gender and training background. The subjects were 12 athletes (6 males and 6 females) and age-matched college students of both genders (4 males and 4 females). The subjects completed a 3-wk resistance training program involving a bench press exercise, 3 d/wk, to become familiar with the testing procedure. After the completion of the resistance training program, the subjects, on three consecutive weeks, participated in two testing sessions per
week, baseline session and recovery session. It was concluded that, for bench press exercises, using different recovery times of 48 h for males and 4 h for females may optimize strength development as a function of gender.

Kin-Isler & Kosar (2006) investigated the effects of 10 weeks of step aerobics training on anaerobic performance of men and women. College-age volunteers (64 women and 54 men) were divided into step aerobics (33 women, 27 men) and control (31 women, 27 men) groups. Before and after the 10-week period, the subjects' body composition, muscular strength, Wingate anaerobic performance, and vertical jump anaerobic performance were determined. The step aerobics group participated in step aerobics sessions of 50 minutes per day, 3 days per week for 10 weeks, at 60-80% of their heart rate reserve. It can be concluded that 10 weeks of step aerobics was not effective in improving all of the measured anaerobic indices in men and women.

Kippelen et al (2005) identified in a follow up study airway changes occurring during the course of a sport season in healthy endurance athletes training in a Mediterranean region. Respiratory pattern and function were analysed in 13 healthy
endurance trained athletes, either during a maximal exercise test, or at rest and during recovery through respiratory manoeuvres (spirometry and closing volume tests). The exercise test was conducted on three different occasions: during basic endurance training and then during the pre-competition and competitive periods. This study does not provide significant evidence of lung function impairment in healthy Mediterranean athletes after one year of endurance training.

Kiviniemi, Hautala, Kinnunen & Tulppo (2007) tested utility of heart rate variability (HRV) in daily endurance exercise prescriptions. Twenty-six healthy, moderately fit males were randomized into predefined training group (TRA, n = 8), HRV-guided training group (HRV, n = 9), and control group (n = 9). Four-week training period consisted of running sessions lasting 40 min each at either low- or high-intensity level. TRA group trained on 6 days a week, with two sessions at low and four at high intensity. Individual training program for HRV group was based on individual changes in high-frequency R-R interval oscillations measured every morning. Increase or no change in HRV resulted in high-intensity training on that day. It was concluded that, no significant differences were observed in the changes of VO(2peak) between the groups. We concluded that
cardio respiratory fitness can be improved effectively by using HRV for daily training prescription.

**Kraemer et al (2001)** evaluated the effects of resistance training programs on strength, power, and military occupational task performances in women were examined. Untrained women aged (mean +/- SD) 23 +/- 4 yr 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 explosive 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). In conclusion, gender differences in physical performance measures were reduced after resistance training in women, which underscores the importance of such training for physically demanding occupations.

**Lagally, Robertson, Gallagher, Gearhart & Goss (2002)** examined perceived exertion was measured at 30% and 90% of the one-repetition maximum (1-RM), while holding work constant between intensities. Ratings for the active muscles and for the
overall body were examined during both intensities. 10 male volunteers underwent a one-repetition maximum procedure for each of the following exercises: bench press, leg press, latissimus pull down, triceps press, biceps curl, shoulder press, and calf raise. All subjects then completed two experimental trials on separate days. The high-intensity trial consisted of one set of five repetitions at 90% of the one-repetition maximum. The low-intensity trial consisted of one set of 15 repetitions at 30% of the one-repetition maximum. This information suggests that ratings of perceived exertion can provide information regarding the intensity of resistance exercise.

Larsen, Nolan, Borch & Søndergaard (2005) investigated the response to endurance training on physiological characteristics, 10 Nandi town boys and 14 Nandi village boys 16.5 and 16.6 years of age, respectively, from western Kenya performed 12 weeks of running training. The study was performed at altitude (approximately 2000 m.a.s.l. approximately 595 mm Hg). Training heart rate and speed were registered during every training session throughout the entire training period. It is concluded that no difference was observed in trainability with respect to VO2max, running economy, submaximal heart rate, and submaximal blood lactate and ammonia concentration
between Kenyan Nandi town and village boys. The higher performance level of the village boys was likely due to a higher VO2max of these boys.

Laursen, Shing, Peake, Coombes & Jenkins (2002) examined the influence of three different high-intensity interval training (HIT) regimens on endurance performance in highly trained endurance athletes. Before, and after 2 and 4 wk of training, 38 cyclists and triathletes a progressive cycle test to measure peak oxygen consumption (VO2peak) and peak aerobic power output (PPO), 2) a time to exhaustion test (T(max)) at their VO2peak power output (P(max)), as well as 3) a 40-km time-trial (TT(40)). Subjects were matched and assigned to one of four training groups (G(2), N = 8, 8 x 60% T(max) at P(max), 1:2 work:recovery ratio; G(2), N = 9, 8 x 60% T(max) at P(max), recovery at 65% HR(max); G(3), N = 10, 12 x 30 s at 175% PPO, 4.5-min recovery; G(CON), N = 11). In addition to G(1), G(2), and G(3) performing HIT twice per week, all athletes maintained their regular low-intensity training throughout the experimental period. The present study has shown that when HIT incorporates P(max) as the interval intensity and 60% of T(max) as the interval duration, already highly trained cyclists can significantly improve their 40-km time trial performance.
Laursen, Shing, Peake, Coombes & Jenkins (2005) examined the influence of 3 different high-intensity interval training regimens on the first and second ventilatory thresholds (VT(1) and VT(2)), anaerobic capacity (ANC), and plasma volume (PV) in well-trained endurance cyclists. Before and after 2 and 4 weeks of training, 38 well-trained cyclists (V_{O2\text{peak}} = 64.5 \pm 5.2 ml.kg^{-1}.min^{-1}) performed (a) a progressive cycle test to measure V_{O2\text{peak}}, peak power output (PPO), VT(1), and VT(2); (b) a time to exhaustion test (T(max)) at their V_{O2\text{peak}} power output (P(max)); and (c) a 40-km time-trial (TT(40)). In conclusion, peripheral adaptations rather than central adaptations are likely responsible for the improved performances witnessed in well-trained endurance athletes following various forms of high-intensity interval training programs.

Leveritt, MacLaughlin & Abernethy (2000) determined the effects of a single bout of endurance exercise on subsequent strength performance. Eight males with a long history of resistance training performed isokinetic, isometric and isotonic leg extension strength tests 8 and 32 h after 50 min of cycle ergometry at 70-110% of critical power. The participants also completed a control condition in which no cycling was
performed. Plasma lactate and ammonia were measured before and immediately after each strength test. Our results suggest that leg extension strength was not compromised by an earlier bout of endurance cycling.

López-Segovia, Palao Andrés & González-Badillo (2010) assessed the effect of the training executed by 2 under-19 teams from the first Spanish division on aerobic power, strength, and acceleration capacity. Two under-19 soccer teams that competed in the same league were evaluated on 2 occasions. The first evaluation (E₁) was done at the beginning of the competitive period, and the second evaluation (E₂) was done 16 weeks later, coinciding with the end of the first half of the regular season. The present study demonstrates that the use of loads as a function of the speed of movement, without the need to determine maximum repetitions is a methodology that is adequate for the improvement of the application of strength in under-19 soccer players.

Machek, Stopka, Tillman, Sneed & Naugle (2008) examined the effects of a resistance-training program on athletes with intellectual disabilities (ID). 2-way (2 x 2), repeated-measures analysis of variance on 2 groups (males and females); 30 Special
Olympics (SO) athletes, age 16-22 (16 males, 14 females). Resistance training, twice per week, for 3 months on Med-X weight equipment. Exercises tested: chest press, abdominal crunch, seated row, overhead press, seated dip, lower back extension, and biceps curl. It was concluded that, significant strength gains can be accomplished by adolescents with ID via a supervised resistance-training program.

Malathi et al (2000) assessed on Subjective Well Being Inventory (SWBI) before and after the course in order to evaluate the effect of practice of yoga on subjective feelings of well-being and quality of life. Forty eight healthy volunteers participated in the practice of yoga over a period of 4 months. It was concluded that, a significant improvement in 9 of the 11 factors of SWBI was observed at the end of 4 months, in these participants. The paper thus, reiterates the beneficial effects of regular practice of yoga on subjective well being.

Mangine et al (2008) investigated the additive effects of ballistic training to a traditional heavy resistance training program on upper- and lower-body maximal strength. Seventeen resistance-trained men were randomly assigned to 1 of 2 groups: (i) a combined ballistic and heavy resistance training group or
(ii) a heavy resistance training group and subsequently participated in an 8-week periodized training program. Training was performed 3 days per week, that is, 6-8 exercises per workout (6-8 traditional exercises for HR; 4-6 traditional + 2 ballistic exercises in COM) for 3-8 repetitions. The results of this study support the inclusion of ballistic exercises into a heavy resistance training program for increasing 1RM bench press and enhancing lower-body power.

Martínmäki, Häkkinen, Mikkola & Rusko (2008) evaluated the effects of low-dose endurance training on autonomic HR control. We assessed the heart rate variability (HRV) of 11 untrained male subjects (36.8 +/- 7.2 years) at rest and during an incremental maximal aerobic exercise test prior to a 7-week preparatory period and prior to and following a 14-week endurance training period, including a low to high intensity exercise session twice a week. In conclusion, low-dose endurance training enhanced vagal control during exercise, but did not alter resting vagal HR control.

McCurdy, Langford, Doscher, Wiley & Mallard (2005) compared the effects of short-term unilateral resistance training (UL) and bilateral resistance training (BL) with free weights on several
tests of unilateral and bilateral lower-body strength and power in men and women. Thirty-eight untrained men and women completed the study. The groups trained 2 days per week for 8 weeks with free weights and 2 days per week for 5 of the 8 weeks with plyometric drills. The resistance-training program consisted of a progression from 3 sets of 15 repetitions at 50% of the subject's predicted 1 repetition maximum (1RM) to 6 sets of 5 repetitions at 87% 1RM. Training volume and intensity were equal for each group. The free-weight squat was used to measure unilateral and bilateral strength. Power was measured by the Magaria-Kalamen stair-climb test and the unilateral and bilateral vertical jump test. It was concluded that, no significant interactions on all tests were found for the men or women comparison between training groups. These results indicate that UL and BL are equally effective for early phase improvement of unilateral and bilateral leg strength and power in untrained men and women.

McKay, Paterson & Kowalchuk (2009) examined during high-intensity interval (HIT) and lower-intensity continuous endurance (END) training. Twelve male volunteers underwent eight sessions of either HIT (8-12 x 1-min intervals at 120% maximal O(2) uptake separated by 1 min of rest) or END (90-120
min at 65% maximal O(2) uptake). Subjects completed step transitions to a moderate-intensity work rate (approximately 90% estimated lactate threshold) on five occasions throughout training, and ramp incremental and constant-load performance tests were conducted at pre-, mid-, and posttraining periods. Thus faster kinetics of Vo(2)(p) during the transition to moderate-intensity exercise occurs after only 2 days HIT and END training and without changes to muscle deoxygenation kinetics, suggesting concurrent adaptations to microvascular perfusion.

McNicol, O'Brien, Paton & Knez (2009) compared differences in endurance performance after a training regime where treadmill-running intensity was incrementally elevated to a regime where running intensity remained unchanged. Twenty-eight healthy untrained males and females were randomly and equally assigned into both regimes. The present data show that 20 min treadmill-running sessions performed 3 times a week for 6 weeks improves endurance performance and that progressively elevating exercise intensity is important to maximise improvements in LTVO(2) and LTv.
Meyer, Auracher, Heeg, Urhausen & Kindermann (2007) clarified if endurance training effectiveness remains unimpaired when exercise intensity is reduced by a certain amount from "moderate" to "low", but total energy expenditure held constant. For this purpose, 39 healthy untrained subjects (44 +/- 7 yrs, 82 +/- 19 kg; 173 +/- 9 cm) were stratified for endurance capacity and sex and randomly assigned to 3 groups: Training was conducted over 12 weeks and each session monitored by means of portable heart rate (HR) recorders. Identical treadmill protocols prior to and after the training program served for exercise prescription and documentation of endurance effects. It is concluded that within a middle-aged population of healthy untrained subjects, endurance training effectiveness might be slightly impaired when the training heart rate is chosen 15 bpm lower as compared to moderate intensity, but the total energy output held equal.

Mikkola, Rusko, Nummela, Pollari & Häkkinen (2007) assessed the effects of concurrent explosive strength and endurance training on aerobic and anaerobic performance and neuromuscular characteristics, 13 experimental (E) and 12 control (C) young (16 - 18 years) distance runners trained for eight weeks with the same total training volume but 19% of the
endurance training in E was replaced by explosive training. It was concluded that, the concurrent explosive strength and endurance training improved anaerobic and selective neuromuscular performance characteristics in young distance runners without decreases in aerobic capacity, although almost 20% of the total training volume was replaced by explosive strength training for eight weeks. The neuromuscular improvements could be explained primarily by neural adaptations.

Morton & Cable (2005) determined whether short-term intermittent hypoxic training would enhance sea level aerobic and anaerobic performance over and above that occurring with equivalent sea level training. Over a 4-week period, two groups of eight moderately trained team sports players performed 30 min of cycling exercise three times per week. One group trained in normobaric hypoxia at a simulated altitude of 2750 m (F(I)O2= 0.15), the other group trained in a laboratory under sea level conditions. These data suggest that if there are any advantages to training in hypoxia for sea level performance, they would not arise from the short-term protocol employed in the present study.
Oken et al (2006) determined the effect of yoga on cognitive function, fatigue, mood, and quality of life in seniors. One hundred thirty-five generally healthy men and women aged 65-85 years. Participants were randomized to 6 months of Hatha yoga class, walking exercise class, or wait-list control. It was concluded that, there were no relative improvements of cognitive function among healthy seniors in the yoga or exercise group compared to the wait-list control group. Those in the yoga group showed significant improvement in quality-of-life and physical measures compared to exercise and wait-list control groups.

Palmer & Sleivert (2001) determined whether a low-volume high-intensity resistance training session influenced running economy during a subsequent aerobic treadmill run. Nine well trained distance runners with resistance training experience performed treadmill running at two different speeds (0.56 m x sec(-1) and 0.20 m x sec(-1) below speed corresponding to lactate equilibrium) either rested or 1, 8 or 24 hours after a 50-minute whole body resistance training session. Running economy was assessed using open circuit spirometry while heart rate was recorded telemetrically. In conclusion, the mechanism responsible for increased oxygen consumption following resistance training may be related to impairment of the force
generating capacity of skeletal muscle, as there was a significant decrement in the contractile properties of the quadriceps femoris following resistance training.

**Prakash et al (2007)** conducted tests to determine if yoga and athletic activity (running) are associated with better lung functions as compared to subjects with sedentary lifestyles and how do athletes and yogis differ in lung function. Spirometric parameters were assessed in randomly selected 60 healthy male, non-smoking; non-obese subjects-athletes, yogis and sedentary workers. It was concluded that, yogis and athletes had similar lung functions. Involvement in daily physical activity or sport preferably yoga can help in achieving better pulmonary function.

**Rana et al (2008)** investigated the effects of a six-week (16-17 training sessions) low velocity resistance training program (LV) on various performance measures as compared to a traditional strength (TS) and a traditional muscular endurance (TE) resistance training program. Thirty-four healthy adult females (21.1 +/- 2.7 y) were randomly divided into 4 groups: control (C), TS, TE, and LV. Workouts consisted of 3 exercises: leg press (LP), back squat (SQ), and knee extension (KE). Each subject was pre- and posttested for 1 repetition maximum (1RM), muscular
endurance, maximal oxygen consumption (VO2max), muscular power, and body composition. In conclusion, muscular strength improved with LV training however, TS showed a larger improvement. Muscular endurance improved with LV training, but not above what TE or TS demonstrated. For all other variables, there were no significant improvements for LV beyond what C demonstrated.

**Ray et al (2001)** determined any beneficial effect of yogic practices during training period on the young trainees. 54 trainees of 20-25 years age group were divided randomly in two groups i.e. yoga and control group. Yoga group was administered yogic practices for the first five months of the course while control group did not perform yogic exercises during this period. From the 6th to 10th month of training both the groups performed the yogic practices. Physiological, psychological parameters were recorded. It was concluded that, there was improvement in performance at sub maximal level of exercise and in anaerobic threshold in the yoga group. There was improvement in various psychological parameters like reduction in anxiety, depression and a better mental function after yogic practices.
Rozenek, Funato, Kubo, Hoshikawa & Matsuo (2007) designed to characterize selected physiological responses to short-duration (< or = 60 seconds) interval work performed at velocities corresponding to 100% of vVO2max. Twelve men participated in 3 randomized trials consisting of treadmill running using work (W)/recovery (R) intervals of 15 seconds W/15 seconds R (15/15); 30 seconds W/15 seconds R (30/15); and 60 seconds W/15 seconds R (60/15). Work intervals were performed at 100% of vVO2max, whereas R intervals were performed at 50% of vVO2max. A fourth trial consisting of continuous work (C) at 100% of vVO2max was also performed. It was concluded that, high intensity, short-duration 2:1 W/R intervals appear to produce responses that may benefit both aerobic and anaerobic energy system development. A 4:1 W/R ratio may be an upper limit for individuals in the initial phases of interval training.

Saunders, Pyne & Gore (2009) evaluated the endurance training at altitude. Over a period of several weeks, one primary acclimatization response is an increase in the volume of red blood cells and consequently of (.)Vo2max. Altitudes > approximately 2000 m for >3 weeks and adequate iron stores are required to elicit these responses. The substantial reduction in (.)Vo2max of athletes at moderate altitude implies that their
training should include adequate short-duration (approximately 1 to 2 min), high-intensity efforts with long recoveries to avoid a reduction in race-specific fitness. At the elite level, athlete performance is not dependent solely on \( \dot{V}O_{2\max} \), and the "smallest worthwhile change" in performance for improving race results is as little as 0.5%. Consequently, contemporary statistical approaches that utilize the concept of the smallest worthwhile change are likely to be more appropriate than conventional statistical methods when attempting to understand the potential benefits and mechanisms of altitude training.

Schwarz, Urhausen, Schwarz, Meyer & Kindermann (2006) investigated the cardiovascular and metabolic load resulting from different walking intensities derived from maximal velocity (Vmax) during an incremental treadmill walking test. Oxygen uptake, heart rate (HR), blood concentrations of lactate and catecholamines, and rating of perceived exertion were recorded in 16 recreational athletes (mean (SD) age 53 (9) years) during three 30 minute walking trials at 70%, 80%, and 90% of Vmax (V70, V80, and V90) attained during an incremental treadmill walking test. In conclusion, intensity and heart rate prescriptions for walking training can be derived from an incremental treadmill walking test. The cardiovascular and
metabolic reactions observed suggest that V80 is the most efficient workload for training in recreational athletes. Further studies are needed to confirm these findings.

Seiler & Sjursen (2004) compared running velocity, physiological responses, and perceived exertion during self-paced interval training bouts differing only in work bout duration. Twelve well-trained runners (nine males, three females, 28+/-5 years, VO2 max 65+/-6 mL min(-1) kg(-1)) performed preliminary testing followed by four "high-intensity" interval sessions (Latin squares, 1 session week(-1) over 4 weeks) consisting of 24 x 1, 12 x 2, 6 x 4, or 4 x 6-min running bouts with a 1:1 work-to-rest interval (total session duration 48 min). In conclusion, the optimal interval duration for eliciting a high physiological load is 3-5 min under these training conditions. Increases in RPE during an interval bout are not associated with increasing blood lactate concentration.

Sentija, Marsić & Dizdar (2009) explored the influence of an Olympic weight lifting training programme on parameters of aerobic and anaerobic endurance in moderately physically active men. Eleven physical education students underwent a 12-week, 3 times/wk training programme of Olympic weight lifting.
Specific exercises to master the lifting technique, and basic exercises for maximal strength and power development were applied, with load intensity and volume defined in relation to individual maximal load (repetition maximalis, RM). The results of this study indicate that changes in both, anaerobic and aerobic endurance due to a 12-wk period of strength training in untrained persons can be determined from a single incremental treadmill test to exhaustion.

Shaw, Shaw & Brown (2009) compared the effects of 16 weeks of resistance training and concurrent resistance and endurance training on muscular strength development in 38 sedentary, apparently healthy males (25 yr +/- 8 mo). Subjects were age-matched and randomly assigned to either a control (Con) group (n = 12), resistance training (Res) group (n = 13), or concurrent resistance and endurance training (Com) group (n = 13). As such, concurrent resistance and endurance training does not impede muscular strength gains and can be prescribed simultaneously for the development of strength in sedentary, apparently healthy males and thus may invoke all the physiologic adaptations of resistance and endurance training at once.
Shields, Taylor & Dodd (2008) determined whether progressive resistance training improves muscle strength, muscle endurance, and physical function in adults with Down syndrome. Adults (N=20) with Down syndrome (13 men, 7 women; mean age, 26.8+/−7.8 y) were randomly assigned through a concealed allocation block randomized method to either an intervention group (n=9) or a control group (n=11). The outcomes measured by blinded assessors were muscle strength (1-repetition maximum [1-RM]), muscle endurance (number of repetitions at 50% of 1-RM) for chest press and leg press, timed stairs test, and the grocery shelving task. It was concluded that, progressive resistance training is a safe and feasible fitness option that can improve upper-limb muscle endurance in adults with Down syndrome.

Sirotic & Coutts (2007) determined the physiological factors that best relate to a generic PHIIR simulation that reflects team sport running activity. The second purpose of this study was to determine the relationship between common performance tests and the generic PHIIR simulation. Following a familiarization session, 16 moderately trained (VO2max = 40.0 +/- 4.3 ml x kg(-1) x min(-1)) women team sport athletes performed various physiological, anthropometrical, and performance tests and a
30-minute PHIIR sport simulation on a non-motorized treadmill. We suggest that training programs should focus on improving both LT and Vmax for increasing PHIIR performance in moderately trained women. Future studies should examine optimal training methods for improving these capacities in team sport athletes.

Smith, Coombes & Geraghty (2003) compared the effects of two high-intensity, treadmill interval-training programs on 3000-m and 5000-m running performance. Maximal oxygen uptake (\( \text{VO}_{2}\text{max} \)), the running speed associated with \( \text{VO}_{2}\text{max} \) (\( v.\text{VO}_{2}\text{max} \)), the time for which \( v.\text{VO}_{2}\text{max} \) can be maintained (T(max)), running economy (RE), ventilatory threshold (VT) and 3000-m and 5000-m running times were determined in 27 well-trained runners. Subjects were then randomly assigned to three groups; (1) 60% T(max), (2) 70% T(max) and (3) control. Subjects in the control group continued their normal training and subjects in the two T(max) groups undertook a 4-week treadmill interval-training program with the intensity set at \( v.\text{VO}_{2}\text{max} \) and the interval duration at the assigned T(max). Furthermore, VT and T(max) were significantly higher in the 60% T(max) group post-compared to pre-training. In conclusion, 3000-m running performance can be significantly improved in a group of well-
trained runners, using a 4-week treadmill interval training program at v.VO(2max) with interval durations of 60% T(max).

Smith, Fry, Weiss, Li & Kinzey (2001) determined the effect of high intensity exercise on sprint. Nine men (25.11 +/- 1.16 years) performed 3 different test sessions. In the control session, subjects performed a 10-second sprint cycle test and 1 repetition maximum (1RM) in the back squat. The authors conclude that this particular squat protocol could have a potential carry-over effect into improvements in 100-m sprint times when performing the squats 5-minutes prior to performance.

Souza et al (2007) evaluated the effects of 2 modes of aerobic exercise (continuous or intermittent) on maximum strength (1 repetition maximum, 1RM) and strength endurance (maximum repetitions at 80% of 1RM) for lower- and upper-body exercises to test the acute hypothesis in concurrent training (CT) interference. Eight physically active men were submitted to: (a) a graded exercise test to determine strength tests in a rested state (control); and 4 experimental sessions, at least 7 days apart. In conclusion, the acute interference hypothesis in concurrent training seems to occur when both aerobic and strength
exercises produce significant peripheral fatigue in the same muscle group.

**Sporis, Ruzic & Leko (2008)** evaluated changes in anaerobic endurance in elite First-league soccer players throughout 2 consecutive seasons, in 2 phases, with and without high-intensity situational drills. Eighteen soccer players were tested before and after the 8-week summer conditioning and again in the next season. The measured variables included 300-yard shuttle run test, maximal heart rate, and maximal blood lactate at the end of the test. During the first phase of the study, the traditional sprint training was performed only 2 x weeks and consisted of 15 bouts of straight-line sprinting. As a result, this study showed some indication that situational high-intensity task training was more efficient than straight-line sprinting in improving anaerobic endurance measured by the 300-yard shuttle run test.

**Stojiljković, Mazić, Nesić, Velkovski & Mitrović (2005)** compared changes in running velocity at ventilatory threshold with the velocity at VO2max, before and after the eight-week exercise program. 32 male subjects performed a progressive test for ventilatory threshold (VT) measurement and VO2max on
treadmill. After 8 weeks of endurance training (3 times per week, 30 to 70 min, in different zones in respect to the ventilatory threshold) the performed the same test. Comparison between the initial and final test demonstrated a significant increase of observed variables, under experimental conditions: at final test running velocity has increased at ventilatory threshold, in respect to absolute values and expressed as percentage at VO2max.

**Stueck and Gloeckner (2005)** aimed the Training of Relaxation with Elements of Yoga for Children. The technique introduced and evaluated is the communication of self-control and relaxation based on experience using breathing exercises, imagination journeys and specifically selected yoga techniques for children. This stress-handling programme has been investigated by means of a test/control/group design with 48 pupils of the fifth grade. The result indicated that yoga is suited for children as an independent control method.

**Tanisho & Hirakawa (2009)** examined the effects of 2 different training regimens, continuous (CT) and interval (IT), on endurance capacity in maximal intermittent exercise. Eighteen lacrosse players were divided into CT (n = 6), IT (n = 6), and non-
training (n = 6) groups. Both training groups trained for 3 days per week for 15 weeks using bicycle ergometers. Continuous training performed continuous aerobic training for 20-25 minutes, and IT performed high-intensity pedaling comprising 10 sets of 10-second maximal pedaling with 20-second recovery periods. Maximal anaerobic power, maximal oxygen uptake (V(O2max)), and intermittent power output were measured before and after the training period. The intermittent exercise test consisted of a set of ten 10-second maximal sprints with 40-second intervals. These results indicated that the endurance capacities for maximal intermittent and continuous exercises were not identical. Ball game players should therefore improve their endurance capacity with high-intensity intermittent exercise, and it is insufficient to assess their capacity with only V(O2max) or continuous exercise tests.

Taşkin (2009) determined the effect of circuit training directed toward motion and action velocity over the sprint-agility and anaerobic endurance. A total of 32 healthy male physical education students with a mean age of 23.92 +/- 1.51 years were randomly allocated into a circuit training group (CTG; n = 16) and control group (CG; n = 16). A circuit training consisting of 8 stations was applied to the subjects 3 days a week for 10
weeks. Circuit training program was executed with 75% of maximal motion numbers in each station. In conclusion, circuit training, which is designed to be performed 3 days a week during 10 weeks of training, improves sprint-agility and anaerobic endurance.

Udupa et al (2005) determined the effect of slow and fast pranayams on reaction time and cardio respiratory variables. Thirty student volunteers were divided into two groups of fifteen each. Group I was given training in savitri pranayam that involves slow, rhythmic, and deep breathing. Group II was given training in bhastrika pranayam, which was bellows-type rapid and deep breathing. Parameters were measured before and after three week training period. It is concluded that different types of pranayams produce different physiological responses in normal young volunteers.

Uusitalo, Laitinen, Väisänen, Länsimies & Rauramaa (2002) studied the influences of a 1-year controlled, randomized endurance exercise training period on heart rate (HR) and blood pressure variability in a representative sample of Finnish men in their late middle age. Subjects were 140 sedentary men aged 53-63 years. The men were randomized into two identical groups:
an intervention (EX) and a reference (CO) group. One hundred and twelve of them remained in the final analysis (EX: n=59, CO: n=53). In conclusion, regular low- to moderate-intensity exercise training could retard the declining tendency in cardiac autonomic nervous function in older men during 1 year.

Winett et al (2003) determined the effect of low volume resistance and cardiovascular training on strength and aerobic capacity. A randomized control group design was used with 17 unfit males and females (mean age = 37.1 +/- 6.5 year) assigned to an exercise group (n = 9) who performed a progressive cardiovascular graded exercise protocol and resistance training twice a week for 12 weeks or a nonexercising control group (n = 8). The intervention included a graded exercise protocol involving a 3-min warm-up, exercising 3-4 min at 70-80% of maximum heart rate, and a 3-min cool down. The results support a threshold model and show that time for effective exercise can be substantially reduced.

Wong, Chaouachi, Chamari, Dellal & Wisloff (2010) examined the effect of concurrent muscular strength and high-intensity running interval training on professional soccer players’ explosive performances and aerobic endurance. Thirty-nine
players participated in the study, where both the experimental group (EG, n = 20) and control group (CG, n = 19) participated in 8 weeks of regular soccer training, with the EG receiving additional muscular strength and high-intensity interval training twice per week throughout. Muscular strength training consisted of 4 sets of 6RM (repetition maximum) of high-pull, jump squat, bench press, back half squat, and chin-up exercises. It was concluded that, high-intensity interval running can be concurrently performed with high load muscular strength training to enhance soccer players' explosive performances and aerobic endurance.

Summary of Literature

The review of literature helped the investigator to spot out relevant topics and variables. Further the literature helped the investigator to frame the suitable hypothesis leading to the problems. The latest literature also helped the investigator to support her findings with regard to the problem. Further the literature collected in the study will also help the research scholar understanding in the similar areas.

The reviews were presented under the two sections such as studies on the varied intensities of endurance training on
physical and physiological parameter with chronological and alphabetical order. All the research studies were presented in the section proves that there is a significant improvement on physical and physiological parameters due to endurance training, yogic practices and combination of training.

The research studies reviewed are from many journals available in the websites such as pubmed, Science Direct Journals, ERIC websites etc., employ the physical variables such as speed, explosive power, agility cardio respiratory endurance, flexibility and abdominal strength and physiological variables such as resting pulse rate, blood pressure and breath holding time that too among student athletes at college level.

The review of literature helped the researcher from the methodological point of view too. It was learnt that most of the research studies cited in this chapter on the varied intensities of endurance training would effectively improve the various physical and physiological parameter.