CHAPTER II

REVIEW OF RELATED LITERATURE

The review of literature is instrumental in the selection of the topic, formulation of hypothesis and deductive reasoning leading to the problem. It helps to get a clear idea and supports the finding with regard to the problem under study.

The researcher came across several books, periodicals and journals and published thesis, while searching for relevant facts and finding that were related to this present study, such as those were given below for the better understanding and to justify the study.

2.1 REVIEWS ON WEIGHT TRAINING

Rhea MR, et.al. (2009) assess the effect of heavy/slow movements and variable resistance training on peak power and strength development. Forty-eight National Collegiate Athletic Association (NCAA) Division I athletes (age: 21.4 +/- 2.1 years, all men) were recruited for this 12-week training intervention study. Maximum strength and jumping power were assessed before and after the training program. Athletes were randomly assigned to 1 of 3 training groups: heavy resistance/slow movement (Slow), lighter resistance and fast movement (Fast), or fast movements with accommodated resistance (FACC). All training groups performed similar training programs comprising free weight resistance training with lower-body compound exercises. The only difference among the training interventions was the speed at which subjects performed the squat exercise and the use of bands (Slow group: 0.2-0.4 meters/second; Fast group: 0.6-0.8 meters/second; FACC group trained 0.6-0.8 meters/second with the addition of accommodated resistance in the form of large elastic bands). Post-test data revealed a significant difference between power improvements between the Slow and FACC groups (p = 0.02). Percent increases and effect sizes (ES) demonstrated a much greater treatment effect in the FACC group (17.8%, ES = 1.06) with the Fast group (11.0%, ES = 0.80) adapting more than the Slow group (4.8%, ES = 0.28). The FACC and Slow groups improved strength comparatively (FACC: 9.44%, ES = 1.10; Slow: 9.59%, ES = 1.08). The Fast group improved strength considerably less, 3.20% with an effect size of only 0.38. Variable resistance training with elastic bands appears to provide greater performance benefits with regard to peak force and peak power than heavy, slow resistance exercise. Sports conditioning professionals can utilize bands, and high-speed contractions, to increase power development.

Ghigiarelli JJ, et.al. (2009) explored the effects of a 7-week heavy elastic band and weighted-chain program on maximum muscular strength and maximum power in the bench press exercise. Thirty-six (n = 36) healthy men aged 18-30 years old, from the Robert Morris University football team, volunteered to participate in this study. During the first week, predicted 1 repetition maximum (1RM) bench press and a 5RM speed bench press tests were conducted. Subjects were randomly divided into 3 groups (n = 12): elastic band (EB), weighted chain (WC), and traditional bench (C). During weeks 2-8 of the study, subjects were required to follow the prescribed resistance training program. Mean and SD of the predicted 1RM bench press and 5RM speed bench press were computed. A two-factor (method X time) analysis was applied to identify significant differences between the training groups. Significance was set at alpha = 0.05. Results indicated a significant time ($p < 0.05$) but no group effect for both predicted 1RM (kg) and 5RM peak power tests (watts). Although not significant, results did show greater nonsignificant improvements in the EB (848-883 W) and WC groups (856-878 W) vs. control (918-928 W) when the 2 highest and greatest values were selected regarding peak power. The use of EB and WC in conjunction with a general off-season strength and conditioning program can increase overall maximum upper-body strength in a sample of Division 1-AA football players. These types of training modalities add a unique training style and more flexibility with respect to exercise prescription for athletes and strength practitioners.

Clader et al., (1996) examined whole and split weight training routines in young women to three weight training regimes, namely, (a) a whole routine (W) where four upper (five sets of 6-10 RM) and three lower body (five sets 10-12 RM) weight training exercises in two single sections per week (b) a split session routine (S) where the upper body exercise were performed on two days a week and the lower body exercise on two other days of the week and (c) a control group with no training. Both groups changed similarly over 20 weeks of training in terms of 1 RM arm curl, bench press, and leg press, arm and trunk and lean mass in upper body cases. Similarly for increase in leg mass, whole body lean tissue mass increased and whole body percent fat decreased with training in both groups. Thus the results showed that young untrained women respond to weight training in terms of strength increased and lean body mass changes irrespective of the exercise training schedule.

Clutch et al.(2001), examined the effect of depth jumps and weight training on leg strength and vertical jump in two studies. The effects of depth jumping (plyometrics) and traditional weight training on performance of verticial jump and other measures of length were reviewed below.

Study1: Three jumping activities were compared (a) maximum vertical jump (b) 0.3 m depth jumps and (c) 0.75 m and 1.10 m depth jumps. These activities were preceded by three weeks of weight training. Weight training with jumping activities were conducted for twice in a week for four weeks. All groups demonstrated similar improvements on 1 RM squat strength, isometric knee-extension strength, and vertical jump. The lack of significant differences could have been due to the small group sizes. It restricted the statistical power of the analysis.

Study 2: A weights alone group (N=14) was compared to weights plus depth jumping group (N=14). Training was performed twice per week for 16 weeks. The weight training group did not improve vertical jump although strength parameters improved. The weights plus jumping group did improve in the vertical jumping.

It was found that weights plus jumping produced no added beneficial performance improvement than the jumping alone group. The weight training programme did not provide added benefit.

Wilson et al., (1994) conducted a study on the optimal training load for the development of dynamic athletic performance. Traditional weight training group, plyometric training group, dynamic weight training groups and a control group of recreationally weight trained individuals were compared on 30 m sprint, vertical jump without counter movement, maximal cycle test, isotonic leg extension and maximal isometric tests. The results showed that the dynamic weight training was the only training group that produced significant changes in all measures than the traditional weight training group and plyometric training group.

Fletcher and Hartwell, (2002) examined the effect of an 8 week combined weights and plyometrics training program on golf drive performance. Eleven golfers were randomly assigned to control and experimental group. The control group continued their current training programmes. The experimental group performed combined weight and plyometric training twice in a week. The treatment group showed significant changes in head speed and driving distance.

Carpinett (2003) studied the effect of varied weight training programmes on strength. The evidence of this study was revived earlier by Berger that a single set for maximal strength gains the validity and practical significance of Berger’s strength training study questioned since this study came into existence with well controlled, methodologically sound studies that minimize confounding variables that was required to support the hypothesis that multiple sets of exercise elicit superior gains in strength.

Messier and Dill (1981) compared Naultilus to free weight training tasks of leg strength which were performed on a cyber II semi-isometric leg extension device. The machine (Nautilus) group used leg extensions in training (open kinetic chain exercises). However, the free weight group used squats (closed kinetic chain) and no leg extension in training. It was found that 1 RM measures of strength carry over from free weights to machines better than machines carry over to free weights.

Berger (1963) has stated in the following about "effect of valid weight training programme on strength." He conducted experiment with varied bench press weight training programme. were different weight training programme had been under taken. Training took place three times weekly with variations in programme. The results showed that six repetition per set were best for improving strength.

Hortobagyi, et al., (1991) examined the effects of simultaneous training for strength and endurance on upper and lower body strength and running performance. High Resistance (HR), Low Resistance (LR) and Control groups of college men were used as subjects without the difference in body compositions in fitness. It was concluded that gains in strength were compromised by simultaneous endurance training. High resistance or low resistance training did not affect the gains in strength and endurance. It would appear to be unproductive to mix strength and endurance training because an athlete would gain maximum benefits in the mixed training.

Schantz and Kallman (1989) conducted a study on the relationship between strength training programme effects and aerobic endurance adaptations. Strength training programmes are considered to be anaerobic in nature. Muscle biopsies were taken from three groups (a) strength trained athletes (b) endurance trained swimmers and (c) a non trained control group. It was concluded that strength training did not effect the enzymes associated with aerobic metabolism.

Gains, et al., (1996) examined the effects of velocity specific isokinetic training on strength, hypertrophy and cross education on 15 male and 15 female subjects. The study showed slow velocity, fast velocity stomach training and no training control group. The results showed that in the untrained individuals strength training was likely to have a more general effect than could be expected with highly trained athletes. It was accounted for the partial generalization of both training speeds to an intermediate speed.

Housh, et al., (1995) examined the effect of eccentric dynamic constant external resistance training on concentric isokinetic torque velocity curve. This study showed that the nature of strength training stimulus (dynamic constant external resistance) only improved strength performances in its training exercises and testing activities. It supported the notion of specificity of testing and training. Concentric isokinetic testing was not sensitive to changes brought about by eccentric training. It implied that strength training was more likely to benefit the activities than other training.

Balabins (2001) conducted a research on the effects of concurrent endurance and strength training. The study was conducted for 26 male basketball players. They were divided into four groups of strength and endurance groups and a control group. All groups except control group was trained four times a week for seven weeks. The strength and endurance groups perfomed both the endurance and strength programme with a seven hours recovery. Improvement were seen for all the groups according to their training in vertical jump, anaerobic power (Wingate Test) and aerobic capacity (1 mile walk). This was higher for the strength and endurance training group than the other groups. On all measures the strength training group alone increased anaerobic power but with decreased aerobic capacity. The endurance training group increased aerobic capacity with decreased anaerobic power. The results of the study showed that the concurrent strength and endurance training improved anaerobic power better than strength training alone and it improved VO_2 max better than endurance training alone.

Sowyer et al.,(2004) analysed a study on relationship between football playing ability and selected performance measures. Forty football players were tested on selected performances – vertical jump, 20 yard dash, pro shuttle run, bench press, squat, power clean and snatch. The players were grouped together based upon position. According to the statistical analysis the vertical jump was the only variable that was significantly correlated with football playing ability in all groups. The results indicated that the temporal aspects of vertical jump were organised in the central nervous system in a similar way to that of football playing ability.

Faigenbaun et al., (2003) investigated the practicality and safety of performing maximal strength testing in healthy children. Ninety six subjects were experimented (32 girls and 64 boys) in the mean age group of 6.3 and 12.3 years. The subjects did not have previous strength training experiences and the subjects performed one upper body exercise and the lower body exercise using weight machines. After training a post exercise survey was conducted to check for any injury. The results showed that 1 RM tests could be performed safely and effectively with proper technique and under the supervision of a trained strength and conditioner.

Watt (2004) examined the effect of three strength training exercises to improve stride length and frequency. The strength training activates the nervous system and there by it controlled muscles and improved the overall requirement of muscle fibers during a workout. The three exercises of the high bench step up, one leg squat and one leg hops in place were conducted for eight weeks. The findings showed that high amount of force can be exerted in a short period of time with an explosive foot strike during running and strength training improved both the stride length and frequency.

Green and Dowson (2002) studied the measurement of anaerobic capacity in human body. The study focuses on laboratory measures which attempts to quantify anaerobic capacities. Maximal blood lactate measure was used in both research and athletic settings to decrease anaerobic capacity. Its uses were supported by (a) the high correlations observed between maximal blood lactate and short duration exercise performance presumably dependant upon anaerobic capacity and (b) the higher maximal blood lactates values observed in sprint and power athletes (who would demonstrate higher anaerobic capacities) compared with endurance athletes or untrained people. The latter findings may be partially related to the confounding influence of blood volume which such high variability response to short and long term exercise demands. Maximal blood lactate was known to be influenced by the intensity and duration of the preceding exercise bout; therefore it was plausible that these factors may also influence the degree for which maximal blood lactate accurately reflects an aerobic capacity.

Williams (2003) conducted a study on children's and adolescents anaerobic performance during cycle ergometry. The anaerobic test, friction braked wingate, other tests such as the fork velocity and isokinetic cycle ergometers were becoming more common. There was unequivocal agreement that children's and adolescents anaerobic power scores were lower than those of adults. Qualitative muscular differences were often cited for this disparity rather than differences in the quantity of muscle, but conclusive research was lacking in this area.

Bacharach and Davillard (2004) examined a study of intermediate and a long term anaerobic performance of elite Alpine skiers. Many researchers identified that Alpine skiers need muscular strength and complex motor skill abilities. After verifying a variety of tests short test of anaerobic capacity came into existence. Seventeen Nationally ranked male and female Alpine ski racers from USA were used. The power was measured in them by keeping 30.5 and 90.5 Wingate Cycle Ergometer tests. Through this study they found that the capacity of anaerobic power can be altered.

Hoffman et al., (2004) have conducted a study on the comparison between the Wingate Anaerobic power test both vertical jump motive drill tests in basketball players. Israel National Youth basketball team players participated as subjects. The field tests of 15 second anaerobic jump test and a sprint test was taken and laboratory test of Wingale Anaerobic power test was taken three times for the same group. Laboratory test of Wingate Anaerobic power test was taken to determine peak power, mean power and fatigue index. No significant correlations were observed between peak power and sprint test, but significant positive correlations were noted between vertical jump and the peak power and mean power. The results suggested that the line skill and jump tests might be acceptable field measures of anaerobic power specific to basketball players.

2.2 REVIEWS ON VARIED INTENSITY AND FREQUENCIES

Meyer et al, (2007) recent studies pointed to the preventive efficacy of low-intensity endurance training in terms of cardiovascular risk factor modification and mortality reduction. In addition, it was frequently recommended as a means of stimulating fat metabolism. It was the intention of this study to clarify 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: "moderate intensity" (MOD, n = 13, 5 sessions per week, 30 min each, intensity 90 % of the anaerobic threshold [baseline lactate + 1.5 mmol/l]), "low intensity" (LOW, n = 13, 5 sessions per week, intensity 15 bpm below MOD, duration proportionally longer to arrive at the same total energy output as MOD), and control (CO, n = 13, no training). 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. VO (2max) improved similarly in both training groups (MOD + 1.5 ml x min (-1) x kg (-1); LOW + 1.7 ml x min (-1) x kg (-1); p = 0.97 between groups). Compared with CO (- 1.0 ml x min (-1) x kg (-1)) this effect was significant for LOW (p < 0.01) whereas there was only a tendency for MOD (p = 0.07). However, objective criteria (HR (max), maximal blood lactate) indicated that a different degree of effort was responsible for this finding. In comparison with CO (mean decrease of 3 bpm), average HR during incremental exercise decreased significantly by 9 bpm (MOD, $p < 0.05$ vs. CO) and 6 bpm (LOW, $p = 0.26$), respectively. However, there was no significant difference between MOD and LOW ($p = 0.60$), but for changes in oxygen uptake at the anaerobic threshold (VO (2AT)) it was observed that MOD was significantly more effective than CO ($p = 0.048$) and LOW ($p = 0.04$). 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.

Impellizzeri et al. (2002) this study was designed the study to quantify and describe the intensity profile of cross-country mountain-biking races using heart rate (HR) recorded during competitions. Nine mountain bikers participated in four cross-country circuit races of international and national levels. Each cyclist was tested before the competitions to determine lactate threshold (LT), the onset of blood lactate accumulation (OBLA4), and the relationship between percentage of maximum HR and percentage of VO(2max). To control for intersubject variability, only the five off-road cyclists who completed all four competitions were included in the statistical analysis. The four races' mean absolute and relative time expressed in percentage of race duration (147 +/- 15 min) spent in the EASY(ZONE) (HR below LT) were 27 +/- 16 min and 18 +/- 10%, in the MODERATE(ZONE) (HR between

LT and OBLA4) were 75 +/- 19 min and 51 +/- 9%, and in the HARD(ZONE) (HR above OBLA4) were 44 +/- 21 min and 31 +/- 16%. The average HR was 171 +/- 6 beats x min(-1), corresponding to 90 +/- 3% of maximum (84 +/- 3% of VO(2max). This study shows that cross-country events are conducted at very high intensity, especially at the start of the race. Coaches must take into account the distribution of the effort and the high exercise intensity characteristic of mountain-biking cross-country events when prescribing specific training programs.

Padilla et al. (2001) evaluate exercise intensity and load during mass-start stages in professional road cycling, using competition heart rate (HR) recordings. Seventeen world-class cyclists performed an incremental laboratory test during which maximal power output (Wmax), maximal HR (HRmax), onset of blood lactate accumulation (OBLA), lactate threshold (LT), and a HR-power output relationship were assessed. An OBLAZONE (HROBLA +/- 3 beats.min-1) and an LTZONE (HRLT +/- 3 beats.min-1) were described. HR was monitored during 125 flat (< 13 km uphill, < 800-m altitude change; FLAT), 99 semi-mountainous (13-35 km uphill, 800- to 2000-m altitude change; SEMO), and 86 high-mountain (> 35 km uphill, > 2000-m altitude change; HIMO) stages. Each cyclist's competition power output was estimated from competition HR and individual HR-power output relationships. Competition training impulse (TRIMP) values and time spent at "easy," "moderate," and "hard" zones were estimated from HR and race duration. RESULTS: Average %HRmax were 61 +/- 5%, 58 +/- 6%, and 51 +/- 7% in HIMO, SEMO, and FLAT stages, respectively, and estimated average power outputs were 246 +/- 44, 234 +/- 43, and 192 +/- 45 W. Competition HR values relative to HROBLA and HRLT were, respectively, 69 +/- 6, 79 +/- 9% in HIMO; 65 +/- 7, 74 +/- 11% in SEMO; and 57 +/- 8, 65 +/- 10% in FLAT stages. The amount of TRIMP in HIMO, SEMO, and FLAT stages were, respectively, 215 +/- 38, 172 +/- 31, and 156 +/- 31. Percentage time spent in the "moderate" and "hard" zones was highest in HIMO (22 +/- 14, 5 +/- 6%) followed by SEMO (15 +/- 13, 5 +/- 5%) and FLAT (9 +/- 7, 2 +/- 2%) stages. %HRmax, time distribution around HROBLA and HRLT, TRIMP, and load zones reflected the physiological demands of different mass-start cycling stage categories. The knowledge of these demands could be useful for planning precompetition training strategies.

Padilla ,et al. (2008) examined the exercise intensity and load of the mountain passes of the major 3-week races according to their difficulty (length and slope) and position within the stage, using competition heart rate (HR). Sixteen world-class cyclists performed a laboratory test to assess maximal power output (W (max)), maximal HR (HR(max)), HR reserve (HRR), onset of blood lactate accumulation (OBLA), lactate threshold (LT) and a HR-power output relationship. HR was monitored during 68 OFF, 172 FIRST, and 134 SECOND category passes. Passes were also classified as BEGINNING, MIDDLE or END if they were placed in the first, second or final thirds of a stage, respectively. The training impulse (TRIMP) was calculated from HR and climb duration. %HRR was significantly higher in OFF and FIRST (77 +/- 7% in both), than SECOND (74 +/- 7%). Competition HR relative to HR(OBLA)R and HR(LT)R were higher in OFF (86 +/- 8, 98 +/- 11%) and FIRST (87 +/- 7, 100 +/- 11%) than SECOND (83 +/- 9, 95 +/- 13%). %HRR was lower in OFF situated in BEGINNING (66 +/- 1%) than in MIDDLE (82 +/- 5%) and END (77 +/- 7%); in FIRST situated in BEGINNING (74 +/- 9%) than in MIDDLE (79 +/- 5%); and in SECOND situated in BEGINNING (69 +/- 9%) compared to END (75 +/- 8%). The amount of TRIMP in OFF, FIRST and SECOND were 115 +/- 30, 72 +/- 29 and 41 +/- 19 ($P < 0.05$). In conclusion, the present study showed that mountain passes are highly demanding and that their intensity is related not only to the difficulty of the ascents but also to the position within the stage. The knowledge of these demands could be useful for planning pre-competition training strategies.

García et al. (2000) study was to quantify the intensity of competition during two professional bicycle stage races: the Tour de France (Tour) and Vuelta a España (Vuelta). The HR responses of 18 world class cyclists were recorded during the races and compared with HR ranges that corresponded to four intensities of exercise that were measured in the laboratory with an incremental test to exhaustion 2 wk before each race. The four intensities were: Anaerobic (AN) over the individual anaerobic threshold, which was over 90% of VO2max; intense aerobic (IA), which was between 70 and 90% of VO2max; moderate aerobic (MA), which was between 50 and 70% of VO2max; and recovery (RE), which was < 50% of VO2max. The stages were divided in individual time trial (ITT), flat, or mountain. The mean HR of the Vuelta and Tour were, respectively, 133.8 +/- 17.9 and 134 +/- 18.6 beats x min(-1). The mean total time of each stage was 269.6 +/- 122 and 259.4 +/- 119.9 min. The mean stage time over IAT was 17.5 +/- 15.7 and 24.7 +/- 26 min; the IA time was 75.2 +/- 47.6 and 79.6 +/- 48.3 min; the MA was 97.2 +/- 57.4 and 89.5 +/- 54.9 min. Finally the RE time was 79.6 +/- 60.5 and 65.4 +/- 69.7 min. The percentage of participation related to total time of the race was, respectively, in the Vuelta and the Tour, 12.99 and 16.8% in AN exercise intensity, 29.5 and 29.2% in IA, 32.4 and 31.9% in MA, and 25.1 and 25.2% in RE. There are no differences in AN time among flat, mountain, and ITT stages in each race, except for the mountain stages in the Tour. Cycling is a high intensity sport because approximately 93 min in flat and 123 min in mountain stages were above 70% of VO2max. In addition, the time spent at IAT was roughly 20 min regardless of stage type, suggesting that the anaerobic capacity limits performance.

Smith et al. (2003) compare the effects of two high-intensity, treadmill interval-training programs on 3000-m and 5000-m running performance. Maximal oxygen uptake (.VO(2max)), the running speed associated with .VO(2max) (v.VO(2max)), the time for which v.VO(2max) 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.VO(2max) and the interval duration at the assigned T(max). These subjects completed two interval-training sessions per week (60% T(max)=six intervals/session, 70% T(max) group=five intervals/session). Subjects were re-tested on all parameters at the completion of the training program. There was a significant improvement between pre- and post-training values in 3000-m time trial (TT) performance in the 60% T(max) group compared to the 70% T(max) and control groups [mean (SE); 60% T(max)=17.6 (3.5) s, 70% T(max) =6.3 (4.2) s, control=0.5 (7.7) s]. There was no significant effect of the training program on 5000-m TT performance [60% T(max)=25.8 (13.8) s, 70% T(max)=3.7 (11.6) s, control=9.9 (13.1) s]. Although there were no significant improvements in .VO(2max), v.VO(2max) and RE between groups, changes in .VO(2max) and RE were significantly correlated with the improvement in the 3000-m TT. 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).

Fox et. al. (1975) study was designed to ascertain whether 7- and 13-wk interval training programs with training frequencies of 2 days/wk would produce improvement in maximal aerobic power (VO2max) comparable to that obtained from 7- and 13-wk programs of the same intensity consisting of 4 training days/wk. Sixty-nine young healthy college males were used as subjects. After training, there was a significant increase in VO2max (bicycle ergometer, open-circuit spirometry) that was independent of both training frequency and duration. However, there was a trend for greater gains after 13 wk. Maximal heart rate (direct lead ECG) was significantly decreased following training, being independent of both training frequency and duration. Submaximal VO2 did not change with training but submaximal heart rate decreased significantly with greater decreases the more frequent and longer the training. Within the limitations of this study, these results indicate that: 1) maximal stroke volume and/or maximal avO2 difference, principle determinants of VO2max, are not dependent on training frequency nor training duration, and 2) one benefit of more frequent and longer duration interval training is less circulatory stress as evidenced by decreased heart rate, during submaximal exercise.

Lesmes et al. (1978) examined the effects of frequency and distance of high intensity, interval training on females. Thirty-two females participated in an eight-week program of interval run training. Subjects were assigned to either a 2 day/week or a 4 day/week group, as well as a high intensity, short distance (50,101,201 meters), or high intensity longer distance (604, 805, 1208 meters) group. Estimates of training intensity were 170% and 130% Vo2max for the short and longer distance groups, respectively. Maximal and submaximal measures of oxygen consumption

(Vo2), heart rate (HR), and venous blood lactic acid were determined prior to and following the training program. After training, there was a significant increase (P less than 0.01) in Vo2max (13%) (deltax = 0.32 1/min or 5.2 ml/kg.min). Maximal VE increased approximately 12% after training (P less than 0.01). Max HR, max lactic acid, and submax Vo2 were not altered by the training. However, HR submax decreased significantly (P less than .05) after training by approximately 6%. Analysis of coveriance indicated that these changes were independent of training frequency, distance, and intensity. It was concluded that the changes in aerobic power and submaximal HR of females were independent of frequency, distance, and intensity of high-intensity interval training programs.

Denadai et al. (2006) analyzed the effect of two different high-intensity interval training (HIT) programs on selected aerobic physiological indices and 1500 and 5000 m running performance in well-trained runners. The following tests were completed (n=17): (i) incremental treadmill test to determine maximal oxygen uptake (VO2 max), running velocity associated with VO2 max (vVO2 max), and the velocity corresponding to 3.5 mmol/L of blood lactate concentration (vOBLA); (ii) submaximal constant-intensity test to determine running economy (RE); and (iii) 1500 and 5000 m time trials on a 400 m track. Runners were then randomized into 95% vVO2 max or 100% vVO2 max groups, and undertook a 4 week training program consisting of 2 HIT sessions (performed at 95% or 100% vVO2 max, respectively) and 4 submaximal run sessions per week. Runners were retested on all parameters at the completion of the training program. The VO2 max values were not different after training for both groups. There was a significant increase in post-training vVO2 max, RE, and 1500 m running performance in the 100% vVO2 max group. The vOBLA and 5000 m running performance was significantly higher after the training period for both groups. We conclude that vOBLA and 5000 m running performance can be significantly improved in well-trained runners using a 4 week training program consisting of 2 HIT sessions (performed at 95% or 100% vVO2 max) and 4 submaximal run sessions per week. However, the improvement in vVO2 max, RE, and 1500 m running performance seemed to be dependent on the HIT program at 100% vVO2 max

Laursen and Jenkins (2002) While the physiological adaptations that occur following endurance training in previously sedentary and recreationally active individuals were relatively well understood, the adaptations to training in already highly trained endurance athletes remained unclear. While significant improvements in endurance performance and corresponding physiological markers were evident following submaximal endurance training in sedentary and recreationally active groups, an additional increase in submaximal training (i.e. volume) in highly trained individuals does not appear to further enhance either endurance performance or associated physiological variables [e.g. peak oxygen uptake (VO2peak), oxidative enzyme activity]. It seemed that, for athletes who were already trained, improvements in endurance performance could be achieved only through high-intensity interval training (HIT). The limited research which has examined

changes in muscle enzyme activity in highly trained athletes, following HIT, had revealed no change in oxidative or glycolytic enzyme activity, despite significant improvements in endurance performance ($p < 0.05$). Instead, an increase in skeletal muscle buffering capacity may be one mechanism responsible for an improvement in endurance performance. Changes in plasma volume, stroke volume, as well as muscle cation pumps, myoglobin, capillary density and fibre type characteristics were yet to be investigated in response to HIT with the highly trained athlete. Information relating to HIT programme optimisation in endurance athletes is also very sparse. Preliminary work using the velocity at which VO2max was achieved (V(max)) as the interval intensity, and fractions (50 to 75%) of the time to exhaustion at V(max) (T(max)) as the interval duration has been successful in eliciting improvements in performance in long-distance runners. However, V(max) and T(max) have not been used with cyclists. Instead, HIT programme optimisation research in cyclists had revealed that repeated supramaximal sprinting may be equally effective as more traditional HIT programmes for eliciting improvements in endurance performance. Further examination of the biochemical and physiological adaptations which accompany different HIT programmes, as well as investigation into the optimal HIT programme for eliciting performance enhancements in highly trained athletes was required.

2.3 REVIEWS ON MOTOR ABILITY COMPONENTS

Anish Kumar Marais (2006) conducted the study on effect of aerobic exercise and circuit training on selected motor abilities and physiological variables among high school boys. The study was delimited to fifty high school boys of St. Joseph's higher secondary school, Thiruvananthapuram, Kerala as subjects at random age group between 13 to 15 years. The selected variables were Motor Ability, 1) Abdominal muscular endurance, 2) Trunk flexibility, 3) agility, 4) endurance of the arm and shoulder girdle, Physiological Variables 1) resting pulse rate, 2) cardio respiratory fitness, 3) cardio vascular fitness. The collected data was analysis of variable of comparing co-related (paired) samples. The study showed that there was a significant improvement in the total physical fitness of high school boys.

Varschuren(2007) evaluated the effects of an 8-month training program with standardized exercises on aerobic and anaerobic capacity in children and adolescents with cerebral palsy. Pragmatic randomized controlled clinical trial with blinded outcome evaluation between July 2005 and October 2006. Participants were recruited from 4 schools for special education in the Netherlands. A total of 86 children with cerebral palsy (aged 7-18 years) classified at Gross Motor Function Classification System level I or II. Participants were randomly assigned to either the training group (n = 32) or the control group (n = 33). The training group met twice per week for 45 minutes to circuit train in a group format that focused on aerobic and anaerobic exercises. Aerobic capacity was assessed by the 10-m shuttle run test, and anaerobic capacity was assessed by the Muscle Power Sprint Test. Secondary outcome measures included agility, muscle strength, self-competence, gross motor function, participation level, and health-related quality of life. A significant training effect was found for aerobic (P < .001) and anaerobic capacity (P = .004). A significant effect was also found for agility (P < .001), muscle strength (P < .001), and athletic competence (P = .005). The intensity of participation showed a similar effect for formal (P < .001), overall (P = .002), physical (P = .005), and skilled-based activities (P < .001). On the health-related quality of life measure, a significant improvement was found for the motor (P = .001), autonomy (P = .02), and cognition (P = .04) domains.

It was concluded exercise training programme improved physical fitness, participation level, and quality of life in children with cerebral palsy when added to standard care.

Maiorana et al. (2001) aimed to investigate the effect of 8 wk of exercise training on functional capacity, muscular strength, body composition, and vascular function in sedentary but healthy subjects by using a randomized, crossover protocol. After familiarization sessions, 19 subjects aged 47 +/- 2 yr (mean +/- SE) undertook a randomized, crossover design study of the effect of 8 wk of supervised circuit training consisting of combined aerobic and resistance exercise. Peak oxygen uptake (.VO(2peak)), sum of 7 maximal voluntary contractions and the sum of 8 skinfolds and 5 segment girths were determined at entry, crossover, and 16 wk. Endotheliumdependent and -independent vascular function were determined by forearm strain-gauge plethysmography and intrabrachial infusions of acetylcholine (ACh) and sodium nitroprusside (SNP) in 16 subjects. Training did not alter ACh or SNP responses. .VO(2peak), (28.6 +/- 1.1 to 32.6 +/- 1.3 mL.kg(-1).min(-1), P < 0.001), exercise test duration (17.4 +/- 1.1 to 22.1 +/- 1.2 min, P < 0.001), and muscular strength (465 +/- 27 to 535 +/- 27 kg, P < 0.001) significantly increased after the exercise program, whereas skinfolds decreased (144 +/- 10 vs 134 +/- 9 mm, P < 0.001). These results suggest that moderate intensity circuit training designed to minimize the involvement of the arms improves functional capacity, body composition, and strength in healthy, middle-aged subjects without significantly influencing upper limb vascular function. This finding contrasts with previous studies in subjects with type 2 diabetes and heart failure that employed an identical training program.

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. The study was double blind and randomized, and the experimental supplement was compared with a carbohydrate-only control. Forty-one males (n = 20 in control group, n = 21 in the supplement group; mean age, 22.2 y) participated in a 4 d/wk, 10-wk periodized strength training program. Subjects had to complete at least 70% of the workouts. Before and after 10 wk of strength training, subjects were tested for body composition by using hydrostatic weighing and skinfold thicknesses, one repetition maximum strength and muscular endurance for the bench press and 45-degree leg press, and anaerobic performance using a 30-s Wingate test. Thirty-three subjects (80.5%) completed the training program (n = 15 in control group, n = 18 in the supplement); these 33 subjects also completed all post-training test procedures. Data were analyzed with two-way analysis of variance with repeated measures on time. P <== 0.05 was set as statistically significant. All statistical analyses, including calculation of effect size and power, were completed with SPSS 11.0. Across groups, FFM increased during 10 wk of strength training. Although there was no statistically significant time x group interaction for FFM, there was a trend toward a greater increase in FFM for the supplement group (+3.4 kg) compared with the control group (+1.5 kg; P = 0.077). The effect size (eta(2) = 0.100) was moderately large. Percentage of body fat declined and fat mass was unchanged; there were no differences between groups. One repetition maximum strength for the bench press and 45-degree leg press increased, but there were no differences between groups. Muscular endurance expressed as the number of repetitions completed with 85% of the one repetition maximum was unchanged; external work, which was estimated as repetitions completed x resistance used, increased for the 45-degree leg press but not for the bench press over the 10-wk training period; there were no time x group interactions for either measurement. Anaerobic power and capacity improved, but there were no differences between groups for these variables or for fatigue rate. 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 suggested 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.

Powerman (2003) elaborated his idea in the article of “Super Training” in which he described about speed. The researcher used a method of training to improve speed by the maximal and dynamic effect methods, heavy load training, light load training, shock method (plyometrics) and researcher prescribed the entire training period in a macrocycle. It was found that connective tissues strengthened and adapt to stresses imposed because of the training. The researcher concluded that any property applied programme would generally implement and increased the loading involved for any means of training, so as to minimize the risk of injury – speed and strength.

Mackenzie (2004) detailed seven step model to develop speed was the quickness of movement of a limb, whether it might be the legs of a runner or the arm of the shot put. Thus speed was integral part of every sport in the seven step model of training

i. Functional strength and explosive movements against medium to heavy resistance.

ii. Ballistics to develop high speed sending and receiving movements.

iii. Plyometrics to develop explosive hopping, jumping, bounding, hitting and kicking.

iv. Sprinting form to develop sprinting technique

v. Speed endurance to improve the length of time

vi. Speed loading to develop specific speed and

vii. Over speed training.

The researcher concluded that through the above steps speed could be enhanced.

Reynold (2004) emphasized that workout could boosts, speed, endurance and correct weaknesses. The researcher introduced “run-play” workouts which was a variation of conventional fartlek or “speed-play”. The training method involved a mixture of running, bounding and sprinting exercises that were combined with mobility and agility drives. It can be altered according to the needs of athletes. The results concluded that organised training emphasized the specific characteristics for a sprinter. It developed greater leg power, acceleration and maximal speed for a middle distance competitor. It improved basic speed and speed endurance and for a distance runner better speed endurance and aerobic endurance were developed.

Schall, et al.,(2003) conducted a study of effects of magnetic therapy on selected physical performances. Fourteen soccer players were put through a battery of four tests to evaluate athletic performance. It includes vertical jump, 40 yard sprint, bench squat and soccer specific fitness test. During their training sessions of seven weeks magnetic insules were applied. The results showed that there was no significant improvement between the control and treatments group in pre and post testing scores indicating no increase in performance. Specifically 40 yards sprint scores and vertical jump scores declined. There was only a minor increase in bench squat and soccer fitness tests. Thus the results do not support using magnets for increasing performance in the athletic arena.

Lockie, et al. (2003) tested and examined the effects of resisted sled towing on spring kinematics in field sport athletes. Twenty men completed a series of sprints without resistance and with loads equating to 12.6 and 32.21 of their body mass. Stride length was significantly reduced by approximately 10 and 24 percent for each load. Stride frequency also decreased but not to the extent of stride length. Other notable changes in kinematics were increased ground contact time, trunk lean and hip flexion and increased shoulder range of motion with the greater resistance. Generally, the greater the load the greater the disruption from normal acceleration mechanics. The conclusions arrived were:

1 A resisted sled towing protocol was be very effective in order to overload on athletics sprint technique and develop the specific recruitment of fast twitch muscle fibres.

2 A coach wanted minimal disruption and a lighter load would be more appropriate

3 Extended periods of heavy loaded sprint training may lead to lower speed, high type muscular adaptation, which would be detrimental to sprint performance. Therefore, it was suggested that sled towing be appropriately periodized in an athlete's training programme.

Krancuburg and Smith (1996) compared critical speed determined from a field test of maximal effort runs between 3 and 15 min on a running track and a laboratory test of high speed runs on a treadmill will a 10 km criterion perform ance. Nine highly trained male runners participated in the study. Critical speed was determined from three maximal runs on a 453.5 m indoor running track and from three high speed runs on a treadmill. The treadmill speeds were individualized so that exhaustion was reached in approximately 3.7 and 13 min. All subjects participated in a 10 km cross country race (measured distance 9.8 km) on a flat and dry course. Track critical speed (293 m x min –a) , whereas treadmill critical speed (300 m x mn -1) had the same correlation but over predicted role performance. It was concluded that although both testes were correlated with 9.8 km race performance, track determined critical with 9.8 km rate performance, the track determined critical speed was easy to administer with highly trained runners and was very similar to 10 km race speed.

2.4 REVIEWS ON PHYSIOLOGICAL VARIABLES

Ahmadizad et al. (2007) investigated the effects of resistance and endurance training on serum adiponectin and insulin resistance index (SI) in healthy men. Twenty-four healthy males (age, 35-48 years) participated in the study. The subjects were randomly assigned to one of three groups: endurance training group (n=8), resistance training group (n=8) and control group (n=8). Blood samples were taken in fasting state from all subjects. The experimental groups performed either endurance or resistance training 3 days a week for 12 weeks. The endurance training programme included continuous running at an intensity corresponding to 75-85% of maximal heart rate, while resistance training consisted of four sets of circuit weight training for 11 stations and at an intensity corresponding to 50-60% of one-repetition maximum. The maximum numbers of repetitions in each station was 12. There were significant negative correlations between serum adiponectin and body fat percentage, waist-to-hip ratio, body mass index and the insulin resistance index at baseline, whereas changes in response to training were not significantly correlated. Both endurance and resistance training resulted in a significant decrease in the SI in comparison with the control group. However, serum adiponectin did not change significantly in response to resistance and endurance training. Endurance and resistance training caused an improvement in insulin resistance in healthy men, but this improvement was not accompanied by increased adiponectin levels

Berthelot G,et al.(2008) studied World records (WR) in sports illustrate the ultimate expression of human integrated muscle biology, through speed or strength performances. Analysis and prediction of man's physiological boundaries in sports and impact of external (historical or environmental) conditions on WR occurrence were subject to scientific controversy. Based on the analysis of 3263 WR established for all quantifiable official contests since the first Olympic Games, we show here that WR progression rate follows a piecewise exponential decaying pattern with very high accuracy (mean adjusted r(2) values = 0.91+/-0.08 (s.d.)). Starting at 75% of their estimated asymptotic values in 1896, WR have now reached 99%, and, present conditions prevailing, half of all WR will not be improved by more than 0,05% in 2027. Our model, which may be used to compare future athletic performances or assess the impact of international antidoping policies, forecasts that human species' physiological frontiers will be reached in one generation. This will have an impact on the future conditions of athlete training and on the organization of competitions. It may also alter the Olympic motto and spirit.

Heitkamp et al. (2008) he effects of endurance training and of exhaustive treadmill running on low density lipoprotein (LDL) oxidation in women are not clearly established. Twenty training and 10 control persons, all not endurance trained, aged 26+/-4 and 23+/-3 years, were recruited for 8 weeks of running training 3x/week 30 min. The susceptibility of LDL to in vitro oxidation, conjugated dienes, malondialdehyde (MDA), nitric oxide (NO) and cholesterol, lipoproteins, triglycerides, apolipoprotein (apo) A-I, apo B and lipoprotein (a) were determined before and after training, at rest and after exhaustive spiroergometric exercise. The training was tailored individually at the speed of the 4 mmol/L lactate threshold. At rest and after treadmill running, training induced an increase in lag-time ($P<0.05$), a decrease in MDA ($P<0.05$), and lower values for cholesterol ($P<0.001$), LDL ($P<0.01$), triglycerides ($P<0.05$) and apo B ($P<0.001$), but no increase for high density lipoprotein (HDL) or apo A-I. Before training, treadmill running induced lower conjugated dienes and malondialdehyde, after training an increase for LDL and decrease for cholesterol and triglycerides, no increase for HDL or apo A-I. In the control group, all parameters remained unchanged, only NO lowered ($P<0.01$). Endurance training in women shows favorable effects on LDL oxidation, cholesterol, LDL-cholesterol, triglycerides and apo B.

Blumenthal et al. (1991) examined the effects of aerobic exercise on lipid levels in premenopausal and postmenopausal women. Fifty healthy middle-aged women (mean age, 50 years) were randomly assigned to 12 weeks of either aerobic exercise (walking and jogging) or nonaerobic strength exercise (circuit Nautilus training). Concentrations of total cholesterol, high density lipoprotein cholesterol, low density lipoprotein cholesterol, and very low density lipoprotein cholesterol were assessed, along with apolipoprotein (apo) A-I, apo A-II, apo B, and triglycerides. To document changes in aerobic capacity, maximum treadmill testing was performed with expired-gas analysis before and after the exercise program.

Aerobic exercise was associated with an 18% improvement in peak VO2. Women in the aerobic group had an increased VO2, from 26.7 to 31.4 ml/kg/min (p less than 0.0001), while the VO2 of the women in the strength training group did not change (25.8 ml/kg/min before and after). There were no differential changes in lipid levels because all subjects experienced slight reductions in high density lipoprotein cholesterol and total cholesterol and increases in apo A-I and the apo A-I to apo B ratio. There was a tendency for the aerobic group to exhibit lower levels of apo A-II and a greater apo A-I to apo A-II ratio, however. We conclude that premenopausal and postmenopausal women experience similar changes in aerobic capacity and lipid levels with exercise and that the short-term effects of aerobic and nonaerobic exercise on lipid profiles are generally comparable.

Kenefick et al. (2002) compare physiological variables during a 20-k TT with those corresponding to the athlete's LT. Thirteen male cyclists (22.7+/-0.8 yrs; 180.6+/-8.0 cm; 77.1+/-10.0 kg; 8.3+/-2.5% fat; 4.9+/-2.2 l x min(-1), VO2max) participated in the study. Subjects performed a graded protocol starting at 150 Watts (W) to determine LT (2 mmol x L(-1) above baseline) which consisted of 20 W increases every 4-min. Following an 8 min-recovery, subjects cycled at the wattage corresponding to LT-20 W for 1 min and then workload increased 20 W every minute until volitional exhaustion to determine VO2max x On a separate occasion a self-paced, 20-k TT was completed. Mean values of blood lactate, HR and % HRmax, VO2 and % VO2max, and power output throughout the 20-k TT were greater ($p<0.01$) than those at LT. During the TT these cyclists performed at an intensity well above LT (blood lactate=252.0+/-0.1%, HR=9.4+/-0.03%, %HRmax=9.2+/-0.15%, VO2=26.5+/-0.7%, %VO2max=17.2+/-0.08% and power out-put=14.8+/-0.14% above LT) for over 30 min. Therefore, while LT may be highly correlated to performance, it may not be representative of race pace for a cycling TT, and may be questionable as a benchmark used to prescribe training intensity for competitive TT-cycling.

Hoffman et al., (2004) have conducted a study on the comparison between the Wingate Anaerobic power test both vertical jump motive drill tests in basketball players. Israel National Youth basketball team players participated as subjects. The field tests of 15 second anaerobic jump test and a sprint test was taken and laboratory test of Wingale Anaerobic power test was taken three times for the same group. Laboratory test of Wingate Anaerobic power test was taken to determine peak power, mean power and fatigue index. No significant correlations were observed between peak power and sprint test, but significant positive correlations were noted between vertical jump and the peak power and mean power. The results suggested that the line skill and jump tests might be acceptable field measures of anaerobic power specific to basketball players.

Hue (1998) conducted a study to find that triathletes were right to combine cycling and running in the same training session. To find the differences existed in the 10 K run immediately following a 40th cycle (Olympic distance triathlon) compared with 10 K running alone triathletes were tested for two testing sessions on two different days.

Forty kilo meters of cycling followed by a 10 K treadmill run a 10 K treadmill run at the same speed as cardiorespiratory data was collected during both runs and stride length and frequencies were analysed using videotape. The results showed that cycling section prior to the run in a triathlon competition placed an extra physiological demand on the run. It held because of the reduced physiological economy, such as increased lipid metabolism, increased body temperature and dehydration status.

Astrand and Radahl (1986) defined lactate system as anaerobic glycolysis which has essentially the incomplete breakdown of glycogen in the absence of oxygen. It occurred during the period of maximal exercise testing approximately 90 seconds in duration. The result showed that the corresponding increase in muscle activity which caused muscle fatigue due to the accumulation of H+ one possible explanation for the fatigue was due to the inhibition of phosphor fructoknare (PFK) which was essential for the production of ATP.

Bernard (1998) examined the differences between the results of three different anaerobic power test: a 50 m dash, vertical jump and differences between the results of three different trials of day. A group of 23 men undertook each of the three tests on three separate days at 0900, 1400 and 1800 hours. Results showed that anaerobic power and max running speed were significantly lower in the morning compared with the afternoon with 56.07% greater power achieved in the afternoon. There were no differences between either afternoon test times. For fitness testing procedures, trainers needed to be consistent with time at day when the tests were performed. The best time of day for anaerobic training was early evening.

2.5 SUMMARY OF RELATED LITERATURE

The investigator had reviewed related literature on effect of weight training, effects of exercises and training on varied frequencies and intensities; effect of weight training on motor fitness variables and physiological variables.

Through the review of related literature the investigator found about what had been done so far and what coould be done in this research and concluded that there was further scope research in the area.

Based on the experience gained through the review of related studies, the investigator formed suitable methodology to be adopted in this research, which as detailed in Chapter III.