CHAPTER - II

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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.

The literature in any field forms the foundation upon which all future work will be built. If we fail to build upon the foundation of knowledge provided by the review of literature, the researcher might miss some work already done on the same topic.
Delecluse, et al., (1995) assessed the effects of high-resistance and high-velocity training on different phases of a 100-m sprint run. Two training groups (high-resistance - N = 24; and high-velocity - N = 24) were compared with a passive control group (N = 15) and a running control group (N = 15). Upper and lower-body resistance training was performed twice a week for nine weeks. All groups except the passive control performed running workouts. They found that high resistance training improved performances on the strength training exercises. High velocity training improved performances on the explosive training exercises (including a variety of jumps). Specific training effects were observed. High velocity training increased acceleration (0-10 m) beyond that exhibited by any other group, and improved 100-m run time over the two control groups. The 100-m improvement resulted mainly from the initial acceleration improvements. High resistance training only produced an acceleration difference when compared to the passive group. Both training groups actually lost a significant amount of ability to sustain maximum running velocity when compared to the two control groups. High resistance training programs do not improve sprinting performance. High-velocity training only improves sprinting performance by developing initial acceleration in the total task. Auxiliary training programs of the type used in this study, cause a loss in ability to maintain maximum sprint velocity.

Swensen, et al., (2000) compared the effects of resistance training and short-duration interval training on rowing ergometer performance of collegiate women rowers (N = 24) during the transition
phase of training, that phase typically consisting of low intensity and volume endurance exercise combined with strength training. Subjects were subjected to heavy resistance training or high intensity ergometer interval training two days per week. They concluded that across time, both groups improved 500-m time, 1 RM bench press, and body mass. There was no change in 2000-m time, blood lactate, VO₂max, Profile of Mood States, 1 RM squat, or injury frequency. The added training changed few variables, the primary performance factor being sprint or anaerobic work. Aerobic performance factors were not changed and hence the added work did not interfere with the maintenance of that capacity. Sprint work or heavy resistance training improves short-duration performance but does not affect longer-duration performance in the transition phase of training.

Larson, et al., examined the effects of 3 different rest intervals on resistance training performance. Fifteen resistance-trained men completed 4 testing sessions. Session 1 was used to establish a 10-repetition maximum (RM). During the next 3 sessions, the subjects performed 4 sets of squats to voluntary exhaustion with 85% of their 10-RM. Recovery time among sets was randomly assigned from: achieving a post-exercise heart rate of 60% age-predicted maximum (Post-HR); a timed 3-min interval (3-min); and a 1:3 work-rest ratio (1:3 W/R). They found that no significant differences were observed in repetitions to exhaustion, blood lactate concentrations, or RPE among the 3 recovery conditions. Post-HR, 3-min, and 1:3 W/R recovery
conditions were equally effective methods of recovery during the 4 sets of parallel squats to exhaustion.

Robinson et al., investigated the effects of a high volume 5-wk weight training program and different exercise/rest intervals on measures of power, high intensity exercise endurance (HIEE), and maximum strength. Subjects, 33 weight trained men (M age 20.4±3.5yrs), were divided into 3 equal groups. The groups used the same exercises and set-and-repetition scheme. Rest intervals were 3 min for Gp 1, 1.5 min for Gp 2, and 0.5 min for Gp 3. Pre/post changes were analyzed using G x T ANOVA. They found that Peak power, average peak power, and average total work, as measured during 15 five-sec cycle max-efforts rides and the 1-RM squat, increased significantly (N = 33, p < 0.05). The vertical jump and vertical jump power index did not show a statistically significant change. The 1-RM squat increased significantly more in Gp 1 (7%) than in Gp 3 (2%). Data suggested that, except for maximum strength, adaptations, to short-term, high-volume training might not be dependent on the length of rest intervals.

Majdell and Alexander (1991) conducted a study to determine the effects of regular sprint training and combined over-speed and overload training on the sprinting speed of college male athletes. Eighteen male varsity football players were divided into three groups of six subjects per group. The control group (C) participated in sprint training, free of any external loading; the second group (OS)
participated in over speed two training a sprint master towing device, and the third group (OSW) participated in over speed two training while wearing a ten pound weight vest. The subjects were timed for a maximal forty-metre sprint, as well as being filmed while sprinting at maximum speed both before and after the six-week training programme. The forty-metre sprint times as well as the most important kinematic variables in sprinting were calculated for each subject. Only seven of the twenty kinematic variables measured in this study were significantly different from the pretest to post test in one of the groups. The result of the ANCOVA indicated that there were significant differences between post test means for the three groups for eight of the variables, but least squares means test failed to produce significant, between group differences for all of these. Sprinting speed can be improved by a six-week programme of training including conventional sprint exercises and over speed to training. There were no significant increases in sprinting speed of technique resulting from specific over speed training regime used in this study compared to other methods.

Medbo and Burgers (1990) made an attempt to know that intense exercise of short duration is heavily dependant on energy from anaerobic sources, and the subject's successful anaerobic types of sports may therefore have a larger anaerobic capacity and be able to release energy at a higher rate. Performances in these kinds of sports are improved by training, suggesting that the anaerobic capacity is trainable. There was no difference in anaerobic capacity between the untrained and endurance trained subjects, whereas the sprinters
anaerobic capacity was 30% larger. Six weeks of training increased the anaerobic capacity by 10%. They concluded that the anaerobic capacity varies significantly between subjects and that it can be improved within six weeks. Moreover there was a close relationship between light anaerobic capacity and a high peak rate of anaerobic energy release.

For a study to find out the effects of combined frequency and sets of resistance training programmes over eight weeks in male military recruits (N = 94), six experimental groups were formed. Three groups trained three times a week, one group performing one, another two, and the third three sets. Three more groups trained fives times per week, each differentiated by one, two, or three sets of repetitions. A non-exercising control group was also formed. All exercise groups gained significantly over the eight weeks. The five days per week, three sets group was significantly stronger than the three times per week, one-set group. There were no differences between groups performing the same number of sets whether for three or five times per week. Essentially, the results showed that one set of strength training exercises is as effective as three or five sets in strength training. One set of strength training exercises is effective for Strength development. Three times per week is as effective as five times per week (M. S. Teixeira, 2001).

K. Jones, et al., (2001) made an attempt to compare changes in velocity-specific adaptations in moderately resistance-trained athletes who trained with either low or high resistance. The
study used tests of sport-specific skills across an intermediate-to high-velocity spectrum. Thirty NCAA Division I baseball players were randomly assigned to either a low-resistance (40-60% 1 repetition maximum [1RM]) training group or a high-resistance (70-90% 1RM) training group. Both of the training groups intended to maximally accelerate each repetition during the concentric phase (IMCA). The 10 weeks of training consisted of 4 training sessions a week using basic core exercises. Peak force, velocity, and power were evaluated during set angle and depth jumps as well as weighted jumps using 30 and 50% 1RM. Squat 1RMs was also tested. Although no interactions for any of the jump tests were found, trends supported the hypothesis of velocity-specific training. Percentage gains suggest that the combined use of heavier training loads (70-90% 1RM) and IMCA tend to increase peak force in the lower-body leg and hip extensors. Trends also show that the combined use of lighter training loads (40-60% 1RM) and IMCA tend to increase peak power and peak velocity in the lower-body leg and hip extensors. The high-resistance group improved squats more than the low-resistance group (p < 0.05; +22.7 vs. + 16.1 kg). The results of this study support the use of a combination of heavier training loads and IMCA to increase 1RM strength in the lower bodies of resistance-trained athletes.

\textit{Jan Hoff and Bjørn Almåsbakk, (1995)} conducted a study on the effect of maximum strength bench-press training combines with normal team skill training in handball was investigated. Subjects, female team-handball players from the Norwegian second division, were randomly divided into a training group (TG) that participated in normal
handball training plus maximal heavy progressive resistance training with free weights, and a control group (CG) that underwent handball training only. Dependent variables were standing-throw velocity, throwing velocity with a 3-step run-in-set shot, and one repetition maximum (1-RM) in the bench press. TG improved significantly in all variables (bench press; 41.6 to 55.1 kg; standing throw, 19.8 to 3.3 m · sec¹) Whereas CG had significant improvements in the throwing variables only (standing throw, 18.5 to 21.1 m · sec¹, running throw, 22.6 to 24.6 m · sec¹). TG had significantly larger improvement than CG in the bench press and throwing velocity with a 3-step run-in.

Three sets of Ss: (a) a high-resistance-low-repetition (HL) group (N = 15) performed three sets of 6-8 RM per session; (b) a medium-resistance-medium-repetition (MM) group (N = 16) performed two sets of 30-40 RM per session; and (c) a low-resistance-high-repetition (LH) group (N = 12) performed one set of 100-150 RM, trained three times per week for nine weeks. Strength (1 RM), absolute, and relative endurance were assessed before and after the training period. The 20% improvement in 1 RM strength in the HL group was significantly greater than the 8% (MM) and 5% (LH) changes in the other two groups. In terms of absolute endurance, the LH (41%) and MM (39%) groups improved significantly more than the HL (28%) group. When relative endurance was considered, it was found that the HL group actually decreased (7%) while the MM group improved by 22% and the LH group improved by 28%. Those differences were significant. These results show that resistance training in untrained males produces
changes in strength and endurance irrespective of the protocol. However, those forms of training which favoured strength development (high resistance) produced strength improvement only while those which favoured endurance development (high repetitions) produced endurance and to a much lesser extent strength. The major anomaly was that the HL group actually decreased in relative endurance. Since, subjects were initially "untrained", any form of overload stimulation would likely provoke a training response. One should be cautious about generalizing these changes to elite or highly-trained athletes. The protocol used in strength or resistance training will largely determine the type of training response that is stimulated. Low repetitions and high resistance favor strength, whereas moderate to high repetitions using a moderate weight that can be accommodated produce endurance and minor strength changes. It is anticipated that the specificity of these effects will be more evident the higher the levels and training states of athletes who engage in this type of exercise (T. Anderson., and J. T. Kearney, 1982).

In a study to examine the effect of an 8-week training programme with heavy- versus light-load jump squats on various physical performance measures and electromyography (EMG), twenty-six athletic men with varying levels of resistance training experience performed sessions of jump squats with either 30% (JS30, n = 9) or 80% (JS80, n = 10) of their one repetition maximum in the squat (1RM) or served as a control (C, n = 7). An agility test, 20 metres sprint, and jump squats with 30% (30J), 55% (55J), and 80% (80J) of
their 1RM were performed before and after training. Peak force, peak velocity (PV), peak power (PP), jump height, and average EMG (concentric phase) were calculated for the jumps. There were significant increases in PP and PV in the 30J, 55J, and 80J for the JS30 group (p \leq 0.05). The JS30 group also significantly increased in the 1RM with a trend towards improved 20 metres sprint times. In contrast, the JS80 group significantly increased both PF and PP in the 55J and 80J and significantly increased in the 1RM but ran significantly slower in the 20-m sprint. In the 30J the JS30 group's percentage increase in EMG activity was significantly different from the C group. In the 80J the JS80 group's percentage increase in EMG activity was significantly different from the C group. This investigation indicates that training with light-load jump squats results in increased movement velocity capabilities and that velocity-specific changes in muscle activity may play a key role in this adaptation (J.M. McBride., et.al., 2002).

To compare the effects of linear periodization (LP) and daily undulating periodization (DUP) for strength gains, twenty men (age = 21 ± 2.3 years) were randomly assigned to LP (n = 10) or DUP (n = 10) groups. One repetition maximum (1RM) was recorded for bench press and leg press as a pre-, mid-, and posttest. Training involved 3 sets (bench press and leg press), 3 days per week. The LP group performed sets of 8 RM during weeks 1-4, 6 RM during weeks 4-8, and 4 RM during weeks 9-12. The DUP group altered training on a daily basis (Monday, 8 RM; Wednesday, 6 RM; Friday, 4 RM). Analysis of variance with repeated measures revealed statistically significant
differences favouring the DUP group between T1 to T2 and T1 to T3. Making programme alterations on a daily basis was more effective in eliciting strength gains than doing so every 4 weeks (Matthew R. Rhea, et al., 2002).

For a study to examine the effects of 4 different resistance training protocols on upper-body strength and local muscle endurance development in children, untrained boys and girls (mean ± SD age, 8.1 ± 1.6 years) were trained twice per week for 8 weeks using child-sized weight machines and medicine balls weighing 1-2.5 kg. In addition to general conditioning exercises, subjects in each exercise group performed 1 set of the following exercise protocols for upper-body conditioning: 6-8 repetitions with a heavy load on the chest press exercise (HL, n = 15); 13-15 repetitions with a moderate load on the chest press exercise (ML, n = 16); 6-8 repetitions with a heavy load on the chest press exercise immediately followed by 6-8 medicine ball chest passes (CX, n = 12); or 13-15 medicine ball chest passes (MB, n = 11). Twelve children served as nontraining controls (CT). After training, only the ML and CX groups demonstrated significant (p < 0.05) improvements in 1RM chest press strength (16.8% and 16.3%, respectively) as compared with the CT group. Local muscle endurance, as determined by the number of repetitions performed posttraining on the chest press exercise with the pretraining 1RM load, significantly increased in the ML group (5.9 ± 3.2 repetitions) and CX group (5.2 ± 3.6 repetitions) as compared with the CT group. In terms of enhancing the upper-body strength and local muscle endurance of untrained children, these
findings favour the prescription of higher-repetition training protocols during the initial adaptation period (Avery D. Faigenbaum. et al.).

Competitive field hockey requires a substantial amount of muscular strength, speed, and cardiovascular endurance. It is unknown how these parameters of physical fitness change between preseason conditioning to postseason recovery. Therefore, Division III female field hockey athletes (n = 13) completed tests of muscular strength, body composition, and maximal oxygen uptake (Vo(2)max) during each phase of their season. Muscular strength was assessed using 1 repetition maximum (RM) leg and bench press tests. Body composition was assessed by anthropometry (skin folds [SKF]), circumferences ([CC]), and bioelectrical impedance analysis (BIA). Incremental treadmill testing was administered to assess VO2max. VO2max was unchanged during the season, although a trend (p > 0.05) was shown for a higher VO2max during and after the season vs. before the season. Upper- (10%) and lower-body strength (14%) decreased (p > 0.05) during the season. Percent body fat (%BF) from BIA, fat mass (FM) from CC, and body mass index (BMI) were significantly lower (p < 0.05) in-season and postseason vs. preseason. In conclusion, preseason training was effective in decreasing %BF and increasing VO2max, yet muscular strength was lost. Coaches should incorporate more rigorous in-season resistance training to prevent strength decrements. Moreover, these data support the superior levels of muscular strength and leanness in these athletes compared with age-matched peers (T.A. Astorino, et al., 2004).
Edg E.J., et al., (2005) measured the muscle buffer capacity (betam) and repeated-sprint ability (RSA) of young females, who were either team-sport athletes (n=7), endurance trained (n=6) or untrained but physically active (n=8). All subjects performed a graded exercise test to determine $\text{[Formula: see text]}$ followed 2 days later by a cycle test of RSA (5x6 s, every 30 s). Resting muscle samples (Vastus lateralis) were taken to determine betam. The team-sport group had a significantly higher betam than either the endurance-trained or the untrained groups (181+/−27 vs. 148+/−11 vs. 122+/−32 mumol H(+) g dm(−1) pH(−1) respectively; P<0.05). The team-sport group also completed significantly more relative total work (299+/−27 vs. 263+/−31 vs. 223+/−21 J kg(−1), respectively; P<0.05) and absolute total work (18.2+/−1.6 vs. 14.6+/−2.4 vs. 13.0+/−1.9 kJ, respectively; P<0.05) than the endurance-trained or untrained groups during the RSA test. The team-sport group also had a greater post-exercise blood lactate concentration, but not blood pH. There was a significant correlation between betam and RSA ($r = 0.67; P<0.05$). Our findings show that young females competing in team sports have a larger betam than either endurance-trained or untrained females. This may be the result of the intermittent, high-intensity activity during training and the match play of team-sport athletes. The team-sport athletes also had a greater RSA than either the endurance-trained or untrained subjects. The greater total work by team-sport athletes was predominantly due to a better performance during the early sprints of the repeated-sprint bout.
A study to examine the influence of three different high-intensity interval training (HIT) regimens on endurance performance in highly trained endurance athletes was conducted. METHODS: Before, and after 2 and 4 wk of training, 38 cyclists and triathletes (mean +/- SD; age = 25 +/- 6 yr; mass = 75 +/- 7 kg; VO(2peak) = 64.5 +/- 5.2 mL x kg(-1) min(-1)) performed: 1) a progressive cycle test to measure peak oxygen consumption (VO(2peak)) and peak aerobic power output (PPO), 2) a time to exhaustion test (T(max)) at their VO(2peak) 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. RESULTS: All HIT groups improved TT(40) performance (+4.4 to +5.8%) and PPO (+3.0 to +6.2%) significantly more than G(CON) (-0.9 to +1.1%; P < 0.05). Furthermore, G(1) (+5.4%) and G(2) (+8.1%) improved their VO(2peak) significantly more than G(CON) (+1.0%; P < 0.05). CONCLUSION: The study showed 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. Moreover, the data confirmed prior research, in that repeated supramaximal HIT can significantly improve 40-km time trial performance (Laursen PB, et al., 2002).
To investigate the effects of sprint training on the anaerobic performance characteristics in well-trained sprint runners employing the maximal anaerobic running test (MART) and to study the applicability of MART in the prescription of sprint training, nine male sprint runners performed the MART before and after a 10-week intensive training period. The MART consisted of n.20-s runs on a treadmill with a 100-s recovery between the runs. Initial power, expressed as \( O_2 \) demand (74 ml.kg-1.min-1), was increased by 6 ml.kg-1.min-1 for each consecutive run until exhaustion. Blood lactate concentration was measured at rest and after each run. Maximal power (Pmax), power at 10 mM (P10mM) and 3 mM (P3mM) blood lactate levels, and peak blood lactate concentration (peak BLa) were determined from the blood lactate vs \( O_2 \) demand curve. The Pmax increased from 118.6 +/- 6.0 to 122.6 +/- 4.9 ml kg-1.min-1 (\( P = 0.009 \)) during the training period and the changes of Pmax correlated positively with the volume of bounding exercises (\( r = 0.64 \); \( p = 0.032 \)). The volume of extensive interval training correlated positively with the changes of P3mM (\( r = 0.62 \); \( p = 0.040 \)) and negatively with the changes of P[10mM-3mM] (\( r = -0.68 \); \( p = 0.016 \)) and peak BLa (\( r = -0.69 \); \( p = 0.019 \)) during the particular training period. A positive correlation was also found between the changes of CMJrest and the volume of bounding and strength training (\( r = 0.60 \); \( p = 0.044 \)). The results suggested that sprint training induces an adaptive increase in the maximal anaerobic running power in well-trained male sprint runners. Furthermore, correlation analysis revealed that individual changes in P3mM, peak BLa, Pmax and CMJrest were related to the
volume of specific training methods. Therefore we could conclude that the results of the MART could provide guidance in prescribing training for sprint running (Nummela A, Mero A and Rusko H., 1996).

A large number of team games require participants to repeatedly produce maximal or near maximal sprints of short duration with brief recovery periods. In a study to determine the relationship between a repeated sprint ability (RSA) test that is specific to the energy demands of Australian Rules football (ARF), and the aerobic and anaerobic energy systems, seventeen ARF players participated. Each participant was assessed for VO\textsubscript{2} max, accumulated oxygen deficit (AOD), best 20 m sprint time and RSA. The RSA test involved 12x20 m sprints departing every 20 s. When including the work performed during the time taken to decelerate, the test involved a work to rest ratio of approximately 1:3. Total sprinting time and the percentage decrement of repeated sprinting times were the two derived measures of RSA. The results indicate that the best 20 m sprint time was the only factor to correlate significantly with total sprinting time \((r = 0.829, P < 0.001)\) and percentage decrement \((r = -0.722, P < 0.01)\). VO\textsubscript{2} max and AOD were not related to the total sprinting time or the percentage decrement that was produced by the RSA test. This was interpreted to signify that the phosphagen system was the major energy contributor for this test (Wadley G, Le Rossignol P., 1998).

For a study to develop a descriptive profile and examine the relationships between grip strength, power and sport specific test
performance, 37 elite, female collegiate field hockey players (N=8 backs, N=13 forwards, N=4 goalkeepers, N=8 midfield players, N=4 wings) were selected. METHODS: The tests included circumference and limb lengths, %body fat, Margaria-Kalamen stair test, 50-yard dash test, Queen's College step test, grip strength, Illinois agility test, field hockey specific skills tests, and a coordination test. RESULTS: Mean (+/-SD) height, weight, percent body fat, and predicted oxygen consumption were 164.26 (+/-5.17) cm, 63.06 (+/-8.60) kg, 17.29 (+/-3.79)% and 42.87 (+/-9.08) ml x kg(-1) x min(-1), respectively. Although the goalkeepers were significantly (p<0.05) heavier and had a higher %body fat, there were no significant differences (p>0.05) between any of the player positions in height, limb length, 50-yard dash time, predicted VO2max, grip strength, agility, or in the field hockey specific tests. There were no significant (p>0.05) correlations (r=0.03 to -0.13) between right and left grip strength and sport-specific test scores but significant (p<0.05) relationships were found between power and pushing accuracy, as well as between the 50 yard dash and coordination test, pushing power and pushing accuracy. CONCLUSIONS: In profiling a sample of elite collegiate field hockey players in the United States, the results of this study indicate that there are similarities amongst the defensive and offensive players with international level field hockey players, and that measures of power and sport specific tests are significantly correlated (Wassmer DJ and Mookerjee S, 2002).

To determine the reliability of two field hockey specific tests: the shuttle sprint and dribble test (ShuttleSDT) and the slalom sprint
and dribble test (SlalomSDT), the shuttle sprint and dribble performances of 22 young male and 12 young female field hockey players were assessed on two occasions within 4 weeks. Twenty one young female field hockey players took part in the slalom sprint and dribble test twice in a 4 week period. The ShuttleSDT required the players to perform three 30 m shuttle sprints while carrying a hockey stick alternated with short periods of rest and, after a 5 minute rest, three 30 m shuttle sprints alternated with rest while dribbling a hockey ball. The SlalomSDT required the players to run a slalom course and, after a 5 minute rest, to dribble the same slalom with a hockey ball. RESULTS: There were no differences in mean time scores between the two test sessions. The mean differences were small when compared with the means of both test sessions. With the exception of the slalom sprint time, zero lay within the 95% confidence interval of the mean differences indicating that no bias existed between the two measurements. With the exception of delta shuttle time (0.79), all intraclass correlation coefficient values for the ShuttleSDT, met the criterion for reliability of 0.80. Intraclass correlation coefficient values for SlalomSDT were 0.91 for slalom sprint time, 0.78 for slalom dribble time, and 0.80 for delta slalom time. ShuttleSDT and the SlalomSDT are reliable measures of sprint and dribble performances of young field hockey players (Lemmink KA, Elferink-Gemser MT, and Visscher C., 2004).

Mokha R. et al., (1996) conducted a study on 18 female players of the Punjabi University hockey team during their camp held
at Punjabi University from 4.10.1988 to 24.10.1988. Before participating in the Inter-varsity competition held at Ranchi, Weight, heart rate and blood pressure of each subject were taken before doing the exercise on the treadmill. The players were asked to run on the treadmill for four minutes at the speed of 10 km/hr. Recovery heart rate and blood pressure were also taken. All these tests were taken twice on each player, i.e. initially at the commencement of the training and finally at the completion of the training camp. It has been observed that there is a reduction of body weight in all the categories of players, the maximum being in halves (2.5 kg). There is an improvement in the percentage recovery in the heart rates of all the categories of players except the halves where the recovery is much less at the end of the training camp as compared to the values in the beginning of the camp.

Greer N., et al., attempted to identify the effects of training on performance measures related to ice hockey. The present study was designed to examine the effects of a 7-week hockey-specific training program on the on- and off-ice test performance scores of 14- and 15-year-old (Bantam) hockey players. Pre- and post-training tests of percent fat (ultrasound), center of gravity location, 40-yard dash, vertical jump, and on-ice tests of top speed, acceleration, and concerning ability were completed on 28 male subjects (16 in a training group, 12 in a control group of summer league participants). The training group showed significant improvements (p less than .01) in percent fat, top speed, acceleration, and cornering test performance
whereas only percent fat was significantly improved for the control group. The results suggest that performance on tests related to ice hockey can be improved by training specifically for hockey but that performance is not affected by summer league play alone.

Celho C.W. et al., 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. For discontinuous mode, there was a 15-second rest interval between sets. He hypothesized that the 2 x 6 protocol was less physiologically demanding than the 1 x 12 protocol. Fifteen untrained adults randomly performed the protocols on 2 different days while heart rate (HR), blood lactate (BL), rate of perceived exertion (RPE), and concentric phase mean power (CPMP) were measured. Significantly lower values (mean +/- SE) were seen with the discontinuous protocol for exercise HR (119 +/- 5 vs. 124 +/- 5 b x min (-1)), BL (5.7 +/- 0.5 vs. 6.7 +/- 0.3m Mol/L), and RPE (5.4 +/- 0.3 vs. 5.8 +/- 0.4) (p < 0.05). CPMP tended to be higher in the discontinuous protocol, especially for the 2 last repetitions. The discontinuous protocol was significantly less physiologically demanding, although similar or higher CPMP values were obtained. These findings may help foster long-term adherence to RT in untrained individuals. However, future studies are needed to compare physiological adaptations induced by these 2 RT protocols.
Elferink-Gemser M.T. et al., conducted a study to determine the relationship between multidimensional performance characteristics and level of performance in talented youth field hockey players, elite youth players (n = 38, mean age 13.2 years, s = 1.26) who were compared with sub-elite youth players (n = 88, mean age 14.2 years, s = 1.26) on anthropometric, physiological, technical, tactical and psychological characteristics. Multivariate analyses with performance level and gender as factors, and age as the covariate, showed that the elite youth players scored better than the sub-elite youth players on technical (dribble performance in a peak and repeated shuttle run), tactical (general tactics; tactics for possession and non-possession of the ball) and psychological variables (motivation) (P < 0.05). The most discriminating variables were tactics for possession of the ball, motivation and performance in a slalom dribble. Age discriminated between the two groups, indicating that the elite youth players were younger than the sub-elite players. In the guidance of young talented players to the top as well as in the detection of talented players, more attention has to be paid to tactical qualities, motivation and specific technical skills.

No significant differences were found between the groups for maximal force. Maximal force at the end of each exercise bout decreased 43%, 22%, and 28% on each respective day. Those reductions were positively correlated with reduced work performed (r = .85). Intense work of a strength nature rapidly reduces the ability to perform strength-
related work. The amount of strength work performed in training before competitions should be limited so that no performance degradation occurs (T.C. Chen., 1998).

Eight female handball players from the Norwegian national team were tested for maximal oxygen uptake, maximal isometric strength and maximal running velocity on four occasions during a year. The first test (T1) was made at the beginning of the preparation for a new season, the second (T2) in the middle of the preparation period, the third (T3) at the beginning of the season for the national league, and the fourth (T4) just before the most important tournament for the national team that year. Between T1 and T2 strength training had priority, between T2 and T3 endurance and sprint training had priority, and between T3 and T4 physical training was reduced. Mean maximal oxygen uptake was 51.3 +/- 2.3 ml x kg (-1) x min(-1) at T1 and was at the same level at T2. At T3 and T4 maximal oxygen uptake was increased to 53.8 +/- 2.7 and 53.5 +/- 2.9 ml x kg (-1) x min(-1) (p < 0.05), respectively. Mean maximal isometric strength increased from 154.6 +/- 25.7 at T1 to 168.9 +/- 26.8 N at T3 (p < 0.03). Mean maximal running velocity was 7.85 +/- 0.24 m x s(-1) at T1 and was not significantly changed at T2 and T3, but was increased to 8.02 +/- 0.22 m x s(-1) at T4 (p < 0.03).

In conclusion with the training model, where strength training had priority in the first part of the training period, followed by a period where sprint and endurance training had priority, increase in both maximal oxygen uptake and maximal running velocity among female
elite handball players was made in the period with the most important tournament (J. Jensen et al., 1997).

The general purpose of the circuit training is to develop muscular strength, muscular endurance and cardio vascular endurance (Annario, 1972).

In circuit training, the athlete can increase her strength endurance by (1) doing great number of exercises at each station (2) doing the exercises in a shorter length of time or combining (1) and (2). This method of training emphasizes time rather than the resistance and is based on the theory that athlete can increase her strength and endurance by working harder in a given length of time by exerting the same amount of energy in less time (Pasty, 1968).

Circuit training is based on the promise that the athlete must do the same amount of work in a shorter period of time or must do considerably more work within the limits on an assigned training period (Kalfs and Arnheim, 1969).

Circuit training can provide vigorous activity in a number of selected fitness and motor ability activities and is aimed at developing all the basic physical fitness components, performed in an interesting and imaginative fashion. The individual works on each activity within the circuit and in his individual capacity attempts to complete the present circuit within a specified time limit (Johnson and Stolberg, 1971).
Circuit training is designed to stimulate the cardiorespiratory organs and as a result the endurance aspect is stressed (Muthiah, 1973).

Circuit training is designed to develop cardio vascular respiratory endurance as well as flexibility, strength and muscular endurance in essential muscle groups (Miller, 1974).

Circuit training can become an excellent addition to well balanced programme of sports and physical fitness. In general, it is a form of high intensity training to provide allround development (Gatchell, 1976).

Circuit training has been adopted throughout the world as a simple but effective method of improving the performance factors (Nicholis, 1978).

An experimental study with different periods of circuit concluded that circuit training would develop large muscle groups and improve agility and endurance (Kula, 1963).

The effects of circuit training on cardio vascular endurance was studied with the experimental group making three circuits thrice a week, against time using primarily weight training exercises and running between stations. The control group used a traditional training method of calisthenics, weight lifting and play. The experimental group gained significantly in cardiovascular endurance (Richard Roman, 1954).
In a study conducted to determine the effects of different lengths of practice period of training motor skills, three groups of junior high school boys were selected and the practice period varied suitably as two circuits for the first group, five circuits for the second group and eight circuits for the third group, on each practice day. All groups practiced two days per week for five weeks. After the third practice period, however, it was observed that groups using longer periods improved in all items and their total physical fitness improved significantly at the 0.01 level of confidence (Harmon and Oxendine, 1961).

In a study on forty-two businessmen from Vancor Y.M.C.A., the subjects were equated into three groups, one group underwent a programme of calisthenic, another a circuit training programme and the third acted as a control group. All subjects were given the Larson muscular strength and the Harvard step test at the end of eight week of experimental period. Both experimental groups showed gains in performance with statistically significant difference between them. It was concluded that both the calisthenics and circuit training programmes were the effective methods of improving the cardiovascular and muscular states of businessmen (Taylor, 1963).

In a study to find out the effects of circuit training on the performance skills of beginner-swimmers and advance swimmers, 52 male and female students at North Carolina Central University acted as the subjects. The variables measured for beginner-swimmers were
breath holding, prone glide, arm stroke and crawl stroke and for advance swimmers, treading water front crawl and back stroke. Students were randomly divided into two equal groups. The experimental group was engaged in six weeks circuit training and swimming, while the control group engaged in six weeks swimming only. Experimental students had circuit training on a ten stations universal gym, 3 days per week, 30 minutes per day. Completing the entire circuit twice in each training session, they swim for a remaining 20 minutes of the class period concentrating on the pre-test skills. It was found that the circuit training had a significant effect on the performance skills of the experimental beginners based on the red cross progressive swimming test for beginner swimmers, but there was no significant difference between the experimental and control beginner swimmers (Smith, 1980).

In a study to assess the effects of a 12 week circuit training programme on cardio-respiratory endurance and muscular strength in adolescent males, the training programme consisted of 30 different activities in five stations. The results of the study showed significant increases in maximum oxygen consumption, resting cardiac output and muscular strength (Masher, 1990).

In a study to find out the comparative effects of specific circuit training and combination of training on selected skills among basketball players, ninety six male students from 14 to 16 years in Kendriya Vidyalaya, Gwalior were selected as subjects and divided into 4 groups each comprising of 24 students. Group I was treated with
specific circuit training, Group II with weight training, Group III with combination of training and Group IV acted as a control group. The training period was 12 weeks. The three experimental groups were found to be significantly better than the control groups in the enhancement of skill performance. The combination training method was superior to the other two training methods in improving the Basket Ball performance (Singh, 1991).

In a study to determine the effects of continuous running, interval running and their combined effects on cardio respiratory endurance, forty five untrained boys were selected as subjects and 15 subjects for each group were randomly assigned. ANOVA was adopted for the comparison of the training effects. It was found that (i) all kinds of endurance training caused a significant improvement in developing cardio respiratory endurance due to six weeks of endurance workout and (ii) though there was no significant difference among the training groups, a trend towards the interval running group was shown (Dhayanithi, 1991).

In a study to find out the comparative effects of an interval training and a continuous training programme, one group (N = 7) performed interval training and other group (N = 7) participated in continuous training programme. In this study, both the training programmes significantly improved the maximum oxygen consumption and decreased the resting heart rate of the subjects (May, 1999).
In a study on the effects of circuit training on speed, endurance and striking ability of footballers, the experimental group made three circuits, thrice a week, against time using primarily weight training exercises and running between stations. The control group used a traditional training method of calisthenics, weight lifting and play. The experimental group gained significantly in endurance (Raman, 1961).

In a study to find out the effect of circuit training and parcours training on physical and physiological variables on college men, it was decided to select untrained men students who were not participating in any of the games or sports or in any special training or coaching programme. For this purpose, thirty men students, free from deformities and ailments, were selected at random by lots from His Highness The Rajah’s College, Pudukottai. The age of the subjects ranged from seventeen to nineteen. The subjects were randomly assigned equally to one of the three groups in which group I acted as control (N = 10), group II underwent circuit training (N = 10), and group III underwent parcours training (N = 10). The results of the study clearly indicate that both circuit training and parcours training for a period of 12 weeks had significantly increased leg explosive power, speed, agility, strength endurance, flexibility, cardiorespiratory endurance and maximum oxygen consumption and decreased the resting heart rate. The study indicated that circuit training had improved leg explosive power, speed, agility and strength endurance to a greater degree than parcours training (K. Padmanabhan, 2000).