Chapter-II

REVIEW OF RELATED LITERATURE

A study of relevant literature is an inevitable and essential step to get full picture of what has been done with regard to the problem under study. Such a review brings about a deep and clear perspective of the overall field.

The investigator has traced out different types of research works like dissertations, thesis, journals, relevant studies, varieties of relevant books on physical education and sports sciences. The series of relevant studies related to the problem under study have been presented, in this chapter under the following three categories:

1. Studies related to Motor Fitness variables.
2. Studies related to physiological variables.

2.1 STUDIES RELATED TO MOTOR FITNESS VARIABLES

Zagorac N. (2008) assessed the effect of programmed physical education on biomotor changes in girls, and the impact of these changes on relations between the set of morphological and motor variables, and athletic variables evaluating the sprint and throw abilities. Study sample included 310 six- to eight-year-old girls, elementary school first-graders from the Split area, divided into control group (n=138) attending regular physical education classes
and experimental group (n=172) attending programmed physical education classes based on the elements of athletics, apparatus gymnastics, games and general preparatory exercises. Relations between the predictor set of variables consisting of 4 morphological measures and 6 motor tests, and the sprint and ball throw criteria were determined by regression correlation analysis at the beginning and at the end of the academic year. Both groups achieved favorable quantitative result improvement between the two measurement points, however, the improvement was considerably more pronounced in experimental group, especially in the motor abilities of coordination, flexibility, movement frequency, and explosive, repetitive and static strength. On final measurement, the number of significant predictors for the criterion variables of sprint and ball throw increased from the initial measurement in both experimental and control group of subjects. In control group, trunk strength, explosive strength and movement frequency as motor abilities and body height as a morphological characteristic were found to be the best result predictors in sprint. In experimental group, coordination, flexibility, static arm strength and trunk strength as motor abilities were the best result predictors in sprint. In the study sample, as a whole, explosive strength and trunk strength were identified as the best predictors of ball throw as a criterion variable. In experimental group, it was accompanied by muscle mass development and adipose tissue reduction. Based on comparison of these results and those obtained in previous studies, a new model of work in the athletics events of sprint and throw in elementary school physical education is proposed.
Delas S. (2008) identified the biomotor systems that determine performance of competitive gymnastics elements in elementary school male sixth-graders, factor structures of morphological characteristics and basic motor abilities were determined first, followed by relations of the morphological-motor system factors obtained with a set of criterion variables evaluating specific motor skills in competitive gymnastics in 110 male children aged 12 years +/- 3 months. Factor analysis of 17 morphological measures produced three morphological factors: factor of mesoectoendomorphy (general morphological factor) and factor of pronounced endomorphy, i.e., excessive adipose tissue, along with low skeleton longitudinality. Factor analysis of 16 motor variables yielded four motor factors: factor of general motoricity; factor integrating leg flexibility and arm explosiveness; factor juxtaposing body flexibility and repetitive leg strength; and factor predominantly defining leg movement frequency. Three significant canonical correlations, i.e., linear combinations, explained the association between the set of six latent variables of the morphological and basic motor system, and five variables assessing the knowledge in competitive gymnastics. The first canonical linear combination was based on the favorable and predominant impact of the general motor factor (a system integrating leg explosiveness, whole body coordination, relative arm and trunk strength, and arm movement frequency), along with unfavorable effect of morphological factors on the gymnastics elements performance, squat vault and handstand in particular. The relation of the second pair of canonical factors pointed to the effects of leg flexibility and arm explosiveness on the
cartwheel and backward pullover mount performance, whereas the relation of the third pair of canonical factors showed a favorable impact of the general morphological factor and leg movement frequency regulator on the forward shoulder-kip from increase, cartwheel and handstand performance.

**Bavcević T. (2008)** examined the influences of specially programmed physical education lessons on biomotor development in boys, as well as the influence of those changes on relations between the set of morphological and motor variables and athletic variables for the assessment of sprint and throw abilities. For this purpose, an overall sample of 325 primary school first grade pupils from the city of Split area, aged 6-8 years, was divided into control group of subjects (N=140) attending regular physical education lessons and experimental group attending specially programmed lessons based on athletics, sports gymnastics and games elements as well as on general preparatory exercises. The relations between the predictor set of variables composed of 4 morphological measurements and 6 motor tests with the criteria of sprint and ball throwing were established by the regression correlation analysis at the beginning and at the end of the academic year. Both groups of subjects achieved positive quantitative resultant shift between the two points of measurements, whereas this shift was more significant in the experimental group in relation to the control group, especially in motor abilities coordination of flexibility, movement frequency and of explosive, repetitive and static strength. The number of significant predictors for criteria variables of sprint
and ball throwing increased in the final measurement in relation to the first one in both groups of subjects. While in the control group the best results predictor in sprint were the motor abilities of explosive strength and trunk strength, the best results predictor in sprint in the experimental group were coordination, trunk strength, flexibility and explosive strength. As far as the morphological characteristics are concerned muscle mass has a positive and body mass a negative effect on the sprint result. The best results predictor in ball throwing are explosive strength and trunk strength which, in the experimental group of pupils are additionally followed by coordination development as well as the overall body mass development. By comparison of these and the earlier obtained results, a new work model for the disciplines of sprint and throws within the athletic sport school, has been proposed.

**Cavala M. (2008)** identified biomotor structures in elite female handball players, factor structures of morphological characteristics and basic motor abilities, and of variables evaluating situation motor abilities of elite female handball players (n=53) were determined first, followed by determination of differences and relations of the morphological, motor and specific motor space according to handball performance. Factor analysis of 16 morphological measures produced three morphological factors, i.e. factor of absolute voluminosity, i.e. mesoendomorphy, factor of longitudinal skeleton dimensionality, and factor of transverse hand dimensionality. Factor analysis of 15 motor variables yielded five basic motor dimensions, i.e. factor of agility,
factor of throwing explosive strength, factor of running explosive strength (sprint), factor of jumping explosive strength and factor of movement frequency rate. Factor analysis of 5 situation motor variables produced two dimensions: factor of specific agility with explosiveness and factor of specific precision with ball manipulation. Analysis of variance yielded greatest differences relative to handball performance in the factor of specific agility and throwing strength, and the factor of basic motoricity that integrates the ability of coordination (agility) with upper extremity throwing explosiveness and lower extremity sprint (30-m sprint) and jumping (standing triple jump). Considering morphological factors, the factor of voluminosity, i.e. mesoendomorphy, which is defined by muscle mass rather than adipose tissue, was found to contribute significantly to the players' performance. Results of regression analysis indicated the handball performance to be predominantly determined by the general specific motor factor based on specific agility and explosiveness, and by the morphological factor based on body mass and volume, i.e., muscle mass. Concerning basic motor abilities, the factor of movement frequency rate, which is associated with the ability of ball manipulation, was observed to predict significantly the handball players' performance.

status of school children was employed at the beginning of academic years in a sample of 635 children (325 male and 310 female) in 1992 and a sample of 850 children (430 male and 420 female) in 2002. The mean age of study children was 7 years (+/- 2 months). Results of canonic discriminative analysis revealed the male children enrolled in elementary school first grade in 2002 to show better performance on the tests of aerobic endurance, static strength and explosive strength, and to have greater mass of muscle tissue and less adipose tissue, while achieving poorer results on the test of movement frequency than their 1992 counterparts. Female children tested in 2002 showed better results on the test of aerobic endurance and all tests of strength factors, with greater mass of muscle tissue and less adipose tissue, while yielding poorer results on the tests of flexibility, coordination and movement frequency as compared with their 1992 counterparts. Factor analysis in the morphological-motor system isolated three varimax factors each in children of both sexes tested in 1992 and 2002. First factor showed a pattern of a general morphological factor predominantly defined by body weight and volume in the children of both sexes from both study years. Second factor showed a pattern of a general motoricity factor predominantly defined by explosive strength, coordination and speed in children tested in 1992, whereas in their 2002 counterparts the general motoricity factor was predominantly defined by the factors of strength and endurance. Third factor was defined by flexibility in both 1992 and 2002 children. In female children tested in 1992, second factor mostly defined energy regulation with predominance of explosive and static strength, followed
by coordination, whereas third factor was defined by movement frequency and aerobic endurance. In female children tested in 2002, second factor mostly defined energy regulation with predominance of explosive and repetitive strength, followed by aerobic endurance and coordination, whereas third factor was defined by movement frequency followed by muscle tone regulation.

Delas S. (2007) identified biomotor systems that determine performance of competitive gymnastics elements in elementary school female sixth-graders, factor structures of morphological characteristics and basic motor abilities were determined first, followed by relations of the morphological-motor system factors obtained with a set of criterion variables evaluating specific motor skills in competitive gymnastics in 126 female children aged 12 years +/- 3 months. Factor analysis of 17 morphological measures yielded three morphological factors: factor of mesoendomorphy and/or adipose body voluminosity; factor of longitudinal body dimensionality; and factor of transverse arm dimensionality. Factor analysis of 16 motor variables produced four motor factors: general motoricity factor (motor system); general speed factor; factor of explosive strength of throwing type (arm explosiveness); and factor of arm and leg flexibility. Three significant canonical correlations, i.e., linear combinations, explained the association between the set of seven latent variables of the morphological and basic motor system, and five variables evaluating the knowledge in competitive gymnastics. The first canonical linear combination was based on a favorable and predominant impact of the general motor factor (a
system integrating whole body coordination, leg explosiveness, relative arm strength, arm movement frequency and body flexibility) on performance of gymnastics elements, cartwheel, handstand and backward pullover mount in particular, and to a lesser extent front scale and double leg pirouette for 180 degrees. The relation of the second pair of canonical factors additionally explained the role of transverse dimensionality of arm skeleton, arm flexibility and explosiveness in performing cartwheel and squat vault, whereas the relation of the third pair of canonical factors explained the unfavorable impact of adipose voluminosity on the performance of squat vault and backward pullover mount.

Katić R. (2007) identified biomotor structures in elite female handball players, factor structures of morphological characteristics and basic motor abilities of elite female handball players (N=53) were determined first, followed by determination of relations between the morphological-motor space factors obtained and the set of criterion variables evaluating situation motor abilities in handball. Factor analysis of 14 morphological measures produced three morphological factors, i.e., factor of absolute voluminosity (mesoendomorph), factor of longitudinal skeleton dimensionality, and factor of transverse hand dimensionality. Factor analysis of 15 motor variables yielded five basic motor dimensions, i.e., factor of agility, factor of jumping explosive strength, factor of throwing explosive strength, factor of movement frequency rate, and factor of running explosive strength (sprint). Four significant canonic correlations, i.e.
linear combinations, explained the correlation between the set of eight latent variables of the morphological and basic motor space and five variables of situation motoricity. First canonic linear combination is based on the positive effect of the factors of agility/coordination on the ability of fast movement without ball. Second linear combination is based on the effect of jumping explosive strength and transverse hand dimensionality on ball manipulation, throw precision, and speed of movement with ball. Third linear combination is based on the running explosive strength determination by the speed of movement with ball, whereas fourth combination is determined by throwing and jumping explosive strength and agility on ball pass. The results obtained were consistent with the model of selection in female handball proposed (Srholj, 2006), showing the speed of movement without ball and the ability of ball manipulation to be the predominant specific abilities, as indicated by the first and second linear combination.

**Krstulović S. (2006)** assessed the impact of motor abilities and morphological characteristics on junior judoka performance. A set of 14 morphological parameters and a set of 14 motor tests as predictor variables, and 3 variables evaluating judo performance as criteria were applied in a sample of 40 judoists aged 17 years +/-6 months. Three factors were isolated by factor analysis in morphological area: factor of muscle mass and bone volume (muscle and bone mass mesoectomorphy), factor of longitudinal skeleton dimensionality, and factor of subcutaneous adipose tissue (endomorphy). Four
factors were isolated by factor analysis in motor area: factor of coordination and strength (regulated force), factor of movement frequency (speed), factor of muscular and cardiovascular endurance (endurance), and factor of tonus regulation and synergy regulation (flexibility/balance). Canonical correlation analysis between latent morphological and motor variables, and variables for assessment of competitive performance of junior judoists yielded two linear combinations, i.e., two pairs of canonical factors. Correlation in the first pair of canonical factors was underlain by the favorable impact of coordination/strength, speed, flexibility and balance, along with above-average muscle mass and bone volume, and above-average skeleton longitudinality on performance in judo. Correlation in the second pair of canonical factors was based on positive determination of above-average endurance along with moderate coordination/strength and speed, and below-average muscle mass and bone volume and skeleton longitudinality upon judo performance as expressed by the fight winning score.

Katić R. (2003) selected a sample consisting of 487 children (249 male and 236 female) aged 7-9 years (+/- 2 months) underwent programmed kinesiologic transformation procedures for 18 months. The morphological and motor development was followed up by use of 14 morphological and 12 motor variables at 9-month intervals. Three taxonomic analyses for each measurement time point were calculated for either sex in order to determine the initial and transitive position for each individual study subject, and to identify most
homogeneous groups within the sample as a whole. Three taxonomic variables were isolated on each measurement for either sex. Study results revealed female children to undergo faster development with earlier formation of the three morphological-motor structures ranked according to their predominance: mass, i.e., ectomesomorphy, motor and endomorphy. Entity projections upon taxonomic variables at particular measurement points clearly identified the morphological-motor variables to be addressed by general and differentiated programs of kinesiologic education in order to achieve optimal effects during the development of the child's body as a whole.

**Leone M. (2002)** identified anthropometric and biomotor variables that discriminated among groups of elite adolescent female athletes aged 14.3 +/- 1.3 years (mean +/- s) from four different sports (tennis, n=15; swimming, n=23; figure skating, n=46; volleyball, n=16). The anthropometric variables included body mass, height, bi-epicondylar breadth of the distal extremity of the humerus and femur, maximal girth of the calf and biceps and the sum of five adipose skinfolds. The biomotor variables were maximal aerobic power, muscular endurance and flexibility of the trunk. Discriminant analysis revealed three significant functions (P<0.05). The first discriminant function primarily represented differences between figure skaters and all other groups of athletes. The other two underlined anthropometric and biomotor differences between swimmers and volleyball players and between tennis players and swimmers, respectively. After validation, the analysis showed that 88% of the athletes
were correctly classified in their respective sports. Our model confirms that elite adolescent female athletes show physical and biomotor differences that clearly distinguish them according to their particular sport.

2.2 STUDIES ON PHYSIOLOGICAL VARIABLES

Durocher, J.J., Leetun, D.T. and Carter J.R. (2008) examined lactate threshold (LT) and maximal aerobic capacity with a sport-specific skating protocol throughout a competitive season in collegiate hockey players. We hypothesized that maximal aerobic capacity and skating velocity at LT would increase as the season progressed. Sixteen Division I college hockey players performed a graded exercise skating protocol to fatigue at 3 different times (pre-, mid-, and post-season). Subjects skated for 80 s during each stage, followed by 40 s of rest to allow for blood lactate sampling. Velocity at LT was similar during preseason (4.44 +/- 0.08 m.s\(^{-1}\)) and post-season (4.52 +/- 0.05 m.s\(^{-1}\)) testing, but was significantly elevated at midseason (4.70 +/- 0.08 m.s\(^{-1}\); p<0.01), compared with preseason. In contrast, LT as a percentage of maximal heart rate (HRmax) was unchanged throughout the season. HRmax remained constant throughout the season, at approximately 190 beats.min\(^{-1}\). Preseason maximal aerobic capacity (48.7 +/- 0.8 mL.kg\(^{-1}\).min\(^{-1}\)) was significantly higher than that at postseason (45.0 +/- 1.1 mL.kg\(^{-1}\).min\(^{-1}\); p<0.01). In conclusion, skating velocity at LT improved from pre- to midseason, but this adaptation was not maintained at post-season. Additionally, maximal aerobic capacity was
reduced from pre- to post-season. These findings suggest a need for aerobic training throughout the college hockey season.

Quinney, H.A. (2008) examined the physiological profile of a National Hockey League (NHL) team over a period of 26 years. All measurements were made at a similar time of year (pre-season) in 703 male (mean age +/- SD = 24 +/- 4 y) hockey players. The data were analyzed across years, between positions (defensemen, forwards, and goaltenders), and between what were deemed successful and non-successful years using a combination of points acquired during the season and play-off success. Most anthropometric (height, mass, and BMI) and physiological parameters (absolute and relative VO₂ peak, relative peak 5 s power output, abdominal endurance, and combined grip strength) showed a gradual increase over the 26 year period. Defensemen were taller and heavier, had higher absolute VO₂ peak, and had greater combined grip strength than forwards and goaltenders. Forwards were younger and had higher values for relative VO₂ peak. Goaltenders were shorter, had less body mass, a higher sum of skinfolds, lower VO₂ peak, and better flexibility. The overall pre-season fitness profile was not related to team success. In conclusion, this study revealed that the fitness profile for a professional NHL ice-hockey team exhibited increases in player size and anaerobic and aerobic fitness parameters over a 26 year period that differed by position. However, this evolution of physiological profile did not necessarily translate into team success in this particular NHL franchise.
Gabbett, T.J. (2007) investigated the physiological and anthropometric characteristics of elite women rugby league players and developed physical performance standards for these athletes. Thirty-two elite women rugby league players underwent measurements of standard anthropometry (body mass, height, sum of 7 skinfolds), muscular power (vertical jump), speed (10-, 20-, and 40-m sprint), agility (505 test), glycolytic capacity (glycolytic agility test), and estimated maximal aerobic power (multistage fitness test). The skinfold thickness, speed, agility, vertical jump height, glycolytic capacity, and estimated maximal aerobic power results were 6.0--38.1% poorer than previously reported for elite women team sport athletes (e.g., rugby union, soccer, and hockey). Although no significant differences (p>0.05) were detected between selected and non-selected players for any of the physiological or anthropometric characteristics, significant differences (p<0.05) were detected between forwards and backs for body mass, skinfold thickness, 10-, 20-, and 40-m speed, and estimated maximal aerobic power. When data were analyzed according to positional similarities, it was found that the hit-up forwards positional group were heavier, had greater skinfold thickness, and had lower 10-, 20-, and 40-m speed, muscular power, glycolytic capacity, and estimated maximal aerobic power than the adjustables and outside backs positional groups. The results of this study show that elite women rugby league players have slower speed and agility, lower muscular power, glycolytic capacity, and estimated maximal aerobic power, and greater body mass and skinfold thickness than previously reported for other elite women team sport athletes. These findings show the
need to develop all physiological parameters to allow elite women rugby league players to more effectively tolerate the physiological demands of competition, reduce fatigue-related errors in skill execution, and decrease the risk of injury.

Reilly, T. and Seaton, A. (1990) studied on unique requirements of field hockey include dribbling the ball and moving quickly in a semi-crouched posture. First, the net physiological strain due to dribbling was examined. Seven male hockey players completed a 5 min run on the treadmill at 8 km h\(^{-1}\) and 10 km h\(^{-1}\): subjects also ran at these speeds whilst dribbling a hockey ball. Dribbling increased energy expenditure by 15-16 kJ min\(^{-1}\) above that observed in normal running. Heart rates and perceived exertion were also increased. The posture in dribbling is likely to cause back ache among players: 53% of respondents (n=81) reported experience of lower back pain. Finally, the shrinkage of spinal length during dribbling was examined. Subjects (n=7) ran for 7 min. on the treadmill whilst dribbling a ball. Shrinkage occurred at a rate of 0.4 mm min\(^{-1}\), which is greater than previously reported for other activities. The peculiar postural requirements of field hockey seem to cause physiological strain and spinal loading in excess of orthodox motion.

Stagno K.M. (2007) modified the training impulse (TRIMP) method of quantifying training load for use with intermittent team sports, and to examine the relationship between this modified TRIMP (TRIMP (MOD)) and changes in the physiological profile of team sport players during a competitive season. Eight male field hockey players, participating in the English Premier Division,
took part in the study (mean+-s: age 26+-/4 years, body mass 80.8+-/5.2 kg, stature 1.82+-/0.04 m). Participants performed three treadmill exercise tests at the start of the competitive season and mid-season: a submaximal test to establish the treadmill speed at a blood lactate concentration of 4 mmol. l(-1); a maximal incremental test to determine maximal oxygen uptake ([V]O(2max)) and peak running speed; and an all-out constant-load test to determine time to exhaustion. Heart rate was recorded during all training sessions and match-play, from which TRIMP (MOD) was calculated. Mean weekly TRIMP (MOD) was correlated with the change in [V]O(2max) and treadmill speed at a blood lactate concentration of 4 mmol x l (-1) from the start of to mid-season (P<0.05). The results suggest that TRIMP(MOD) is a means of quantifying training load in team sports and can be used to prescribe training for the maintenance or improvement of aerobic fitness during the competitive season.

Montgomery, D.L. (2006) examined the size, strength, and aerobic fitness of players from a professional hockey team. Beginning in 1917, data on body size were obtained from historical records of the Montreal Canadiens. Body composition, strength, and VO2 max were obtained through physiological testing of Canadiens players between 1981 and 2003. Compared with players in the 1920s and 1930s, current players were an average of 17 kg heavier and 10 cm taller, with BMI increased by 2.3 kg/m^2. The gain in BMI was not attributed to added fat mass, since percent body fat remained unchanged over the past 22 years. From 1992 to 2003, upper body strength was assessed using a bench
press test. Predicted 1 repetition maximum (1 RM) for the 17- to 19-year-old group was 107.0 kg with the highest values attained by the 25- to 29-year-old age group (128.1 kg). Gains in body mass were associated with an increase in upper body strength. VO(2 max) was measured annually on a treadmill between 1992 and 2003 with annual mean values ranging between 54.6 and 59.2 mL x (kg x min)(-1). Compared with values from players in the early 1980s, VO(2 max) has increased with the improvements independent of body mass; however, given the variability in the data, we are hesitant to infer that VO(2 max) has increased significantly during the 1990s.

Spencer M. (2005) documented that field-based team sports, such as soccer, rugby and hockey are popular worldwide. There have been many studies that have investigated the physiology of these sports, especially soccer. However, some fitness components of these field-based team sports are poorly understood. In particular, repeated-sprint ability (RSA) is one area that has received relatively little research attention until recent times. Historically, it has been difficult to investigate the nature of RSA, because of the unpredictability of player movements performed during field-based team sports. However, with improvements in technology, time-motion analysis has allowed researchers to document the detailed movement patterns of team-sport athletes. Studies that have published time-motion analysis during competition, in general, have reported the mean distance and duration of sprints during field-based team sports to be between 10-20 m and 2-3 seconds, respectively. Unfortunately, the
vast majority of these studies have not reported the specific movement patterns of RSA, which is proposed as an important fitness component of team sports. Furthermore, there have been few studies that have investigated the physiological requirements of one-off, short-duration sprinting and repeated sprints (<10 seconds duration) that is specific to field-based team sports. This review examines the limited data concerning the metabolic changes occurring during this type of exercise, such as energy system contribution, adenosine triphosphate depletion and resynthesis, phosphocreatine degradation and resynthesis, glycolysis and glycogenolysis, and purine nucleotide loss. Assessment of RSA, as a training and research tool, is also discussed.

**Spencer M. (2004)** studied repeated-sprint ability is thought to be an important fitness component of team sports. However, little is known about the effect sport-specific training has on this fitness component. Therefore, the purpose of this study was to investigate the effects of field-hockey specific training on repeated-sprint ability, plasma hypoxanthine (Hx) concentration and other blood parameters in 18 elite female field-hockey players. All subjects performed a repeated-sprint ability test on a cycle ergometer (5 x 6-sec. maximal sprints every 30 secs) before and after seven weeks of training, designed to improve repeated-sprint ability. Following training, there was a significant (P<0.05) increase in absolute total work (20.73+/−2.00 to 21.15+/−2.07 kJ, mean+/−SD). However, there was no significant change in total work when expressed per kg of body mass (341.3+/−16.4 to 345.5+/−18.8 J x kg(-1)).
In addition, training resulted in a significant (P< 0.05) decrease in change values (peak-rest values) for Hx (8.2+/−3.8 to 5.5+/−2.7 micromol x L(-1)) and hydrogen ion concentration (22.8+/−5.2 to 19.1+/−5.1 nmol x L(-1)). The significant increase in absolute total work following seven weeks of field-hockey specific training was most likely due to an increase in lean muscle mass. The significant decrease in plasma Hx concentration (post-test minus rest values) following seven weeks of field hockey-specific training provides evidence that Hx production and/or efflux from the muscle are reduced. Therefore, one adaptation of sport-specific repeated-sprint training may be to conserve the purine nucleotide pool.

Keogh, J.W. (2003) developed an effective testing battery for female field hockey by using anthropometric, physiological, and skill-related tests to distinguish between regional representative (Rep, n=35) and local club level (Club, n=39) female field hockey players. Rep players were significantly leaner and recorded faster times for the 10-m and 40-m sprints as well as the Illinois Agility Run (with and without dribbling a hockey ball). Rep players also had greater aerobic and lower body muscular power and were more accurate in the shooting accuracy test, p<0.05. No significant differences between groups were evident for height, body mass, speed decrement in 6 x 40-m repeated sprints, handgrip strength, or pushing speed. These results indicate that %BF, sprinting speed, agility, dribbling control, aerobic and muscular power, and shooting accuracy can distinguish between female field hockey players of varying
standards. Therefore talent identification programs for female field hockey should include assessments of these physical parameters.

**Spiering, B.A. (2003)** documented that preparation for the physical demands of competition often involves game simulation during practice. This paradigm is thought to promote physiological adaptations that enhance maximal performance. However, a mismatch between practice intensity and actual competition intensity may not provide adequate training to achieve optimal game-play fitness. The purpose of this study was to evaluate the effectiveness of practice in meeting the cardiovascular demands of a women's ice hockey game. Heart rate (HR) data from 11 U.S. National Women's Ice Hockey team members were collected (5-second intervals) during a game and a typical practice session. Data was normalized to individual HRmax determined during Vo(2)max testing. Working time was defined as a game shift or practice-working interval. Mean working HR was greater during the game than the practice, 90 +/- 2% and 76 +/- 3% of HRmax, respectively (p<0.05). Mean percent session time (game or practice) >90% HRmax was also longer during the game than the practice, 10.5 +/- 4.1% and 5.6 +/- 3.5% (p<0.05), respectively. Mean session HR, percent time >80% HRmax, and mean resting HR were not different between game and practice (68 +/- 7% vs. 69 +/- 5%, 23.2 +/- 5.3% vs. 26.1 +/- 9.2%, and 59 +/- 8% vs. 56 +/- 5% respectively). Elite women hockey players experience significantly greater cardiovascular load during game play than during practice. This mismatch in cardiovascular
demand may prevent players from achieving "game shape," thus affecting competition play.

Reilly, T. and Borrie, A. (1992) reported that Field hockey is a sport with a long history that has undergone quite rapid and radical change within the past decade. The advent of the synthetic playing surface has changed the technical, tactical and physiological requirements of the game at all levels, but in particular at the elite level. In order to cope with the technical evolution within the game, the hockey player has also had to develop physiologically to meet the physical standards required at elite levels. Analysis of the physiological cost and energy expenditure of playing hockey has placed it in the category of 'heavy exercise', with reported VO₂ values during a game of 2.26 L/min. Energy expenditure has been estimated to range from 36 to 50 kJ/min. Physiological profiling of female hockey players has shown that somatotype tends towards 3.5/4.0/2.5. Figures for percentage body fat in female players range from 16 to 26%. Anaerobic power output has been shown to compare favourably with other groups of sportswomen and has also been shown to be a discriminating factor between elite and county level female players. Aerobic power amongst female players has been shown to range from 45 to 59 ml/kg/min. The reported somatotypes of male hockey players have shown considerable variation but there seems to be a trend away from ectomorphy towards mesomorphy. Anaerobic power output in male players has been shown to be the same as that of soccer players and better than other sports, e.g.
basketball and also higher than reference norms. The range of aerobic power reported in the literature is 48 to 65 ml/kg/min and it would appear that an aerobic power in excess of 60 ml/kg/min is required for elite level play. The physical strain of hockey play has been shown to be considerable, in particular with respect to spinal shrinkage. There is a greater injury risk inherent in playing on synthetic surfaces than on grass.

2.3 STUDIES ON EFFECT OF WEIGHT TRAINING AND RESISTANCE TRAINING

Hoffman J.R. (2009) examined the efficacy of periodization and to compare different periodization models in resistance trained American football players. Fifty-one experienced resistance trained American football players of an NCAA Division III football team (after 10 weeks of active rest) were randomly assigned to 1 of 3 groups that differed only in the manipulation of the intensity and volume of training during a 15-week off-season resistance training program. Group 1 participated in a non-periodized (NP) training program, group 2 participated in a traditional periodized linear (PL) training program, and group 3 participated in a planned nonlinear periodized (PNL) training program.

Strength and power testing occurred before training (PRE), after 7 weeks of training (MID), and at the end of the training program (POST). Significant increases in maximal (1-repetition maximum [1RM]) squat, 1RM bench press, and vertical jump were observed from PRE to MID for all groups; these increases were still significantly greater at POST; however, no MID to POST changes were seen. Significant PRE to POST improvements in the medicine
ball throw (MBT) were seen for PL group only. The results do not provide a clear indication as to the most effective training program for strength and power enhancements in already trained football players. Interestingly, recovery of training-related performances was achieved after only 7 weeks of training, yet further gains were not observed. These data indicate that longer periods of training may be needed after a long-term active recovery period and that active recovery may need to be dramatically shortened to better optimize strength and power in previously trained football players.

Faigenbaum A.D. (2007) evaluated the efficacy of an after-school resistance training program on improving the physical fitness of middle school-age boys. 22 boys (M=13.9 yr., SD=.4 yr.) participated in a periodized, multiple-set, 9-wk. (2x/week) resistance training program. All subjects were pre- and post-tested on their 10-repetition maximum squat, 10-repetition maximum bench press, vertical jump, medicine ball toss, flexibility, and also percentage of body fat and the progressive aerobic cardiovascular endurance run (PACER). Statistical analysis indicated that subjects significantly improved performance on the squat (19%), bench press (15%), flexibility (10%), vertical jump (5%), medicine ball toss (12%), and the PACER (36%). Although this, design minus a control group limits interpretation, this after-school resistance-training program can improve muscular fitness and cardiovascular fitness in boys and should be replicated with appropriate experimental controls.
Nash M.S. (2007) examined the effects of circuit resistance exercise (CRT) training on muscle strength, endurance, anaerobic power, and shoulder pain in middle-aged men with paraplegia. Academic medical center. Seven men (age range, 39-58y) with motor-complete paraplegia from T5 to T12 and confirmed shoulder pain occurring during daily activities. Not applicable. Subjects underwent a 4-month CRT program using alternating resistance maneuvers and high-speed, low-resistance arm exercise. One-repetition maximal force was measured before training and monthly thereafter. Pre-training and post-training peak oxygen uptake (Vo(2)peak) was measured by graded arm testing. Anaerobic power was measured before and after training using a 30-second Wingate Anaerobic Test. Shoulder pain was self-evaluated by an index validated for people with spinal cord injury (Wheelchair Users Shoulder Pain Index [WUSPI]). Strength increases ranging from 38.6% to 59.7% were observed for all maneuvers (P range, .005-.008). Vo(2)peak increased after training by 10.4% (P=0.01), and peak and average anaerobic power increased by 6% (P=0.001) and 8.6% (P=0.005), respectively. WUSPI scores +/- standard deviation were lowered from 31.9+/-24.8 to 5.7+/-5.9 (P=0.008), with 3 of 7 subjects reporting complete resolution of shoulder pain. CRT improves muscle strength, endurance, and anaerobic power of middle-aged men with paraplegia while significantly reducing their shoulder pain.

Dixon, C.B. (2006) determined whether acute resistance exercise increases serum malondialdehyde (MDA) levels post-exercise, and if so,
whether resistance exercise training status influences the magnitude of the exercise-induced lipid peroxidation response. Twelve recreationally resistance-trained (RT) and 12 untrained (UT) men who did not have resistance exercise experience in the past year participated in this study. All subjects completed an 8-exercise circuit resistance exercise protocol consisting of 3 sets of 10 repetitions at 10 repetitions maximum for each exercise. Blood samples were obtained pre-exercise, at 5 minutes post-exercise, and at 6, 24, and 48 hours post-exercise. At pre-exercise, MDA (nmol.ml(-1)) averaged 3.41 +/- 0.25 (RT) and 3.20 +/- 0.25 (UT) and did not differ (p > 0.05) either between groups or over time. Creatine kinase (IU.L(-1)) was significantly (p<0.05) elevated 5 minutes post-exercise (170.6 +/- 25.8), 6 hours post-exercise (290.3 +/- 34.4), 24 hours post-exercise (365.5 +/- 49.9), and 48 hours post-exercise (247.5 +/- 38.5) as compared with pre-exercise (126.4 +/- 20.2) for both groups. There was no difference (p>0.05) in CK activity between groups. This study indicated that moderate-intensity whole-body resistance exercise had no effect on serum MDA concentration in RT and UT subjects.

Takeshima N. (2004) determined the physiological effects of a programmed accommodating circuit exercise (PACE) program consisting of aerobic exercise and hydraulic-resistance exercise (HRE) on fitness in older adults. Thirty-five volunteers were randomly divided into two groups [PACE group (PG) 8 men and 10 women, 68.3 (4.9) years, and non-exercise control group (CG) 7 men and 10 women, 68.0 (3.4) years]. The PG participated in a
12-week, 3 days per week supervised program consisting of 10 min warm-up and 30 min of PACE (moderate intensity HRE and aerobic movements at 70% of peak heart rate) followed by 10 min cool-down exercise. PACE increased (P<0.05) oxygen uptake (\(V_{\text{\text{\text{\text{\text{\text{O}}}}}\text{\text{\text{\text{\text{\text{2}}}}}}}\)) at lactate threshold [PG, pre 0.79 (0.20) l min\(^{-1}\), post 1.02 (0.22) l min\(^{-1}\), 29%; CG, pre 0.87 (0.14) l min\(^{-1}\), post 0.85 (0.15) l min\(^{-1}\), -2%] and at peak \(V_{\text{\text{\text{\text{\text{\text{O}}}}}\text{\text{\text{\text{\text{\text{2}}}1}}}}}\) [PG, pre 1.36 (0.24) l min\(^{-1}\), post 1.56 (0.28) l min\(^{-1}\), 15%; CG, pre 1.32 (0.29) l min\(^{-1}\), post 1.37 (0.37) l min\(^{-1}\), 4%] in PG measured using an incremental cycle ergometer. Muscular strength evaluated by a HRE machine increased at low to high resistance dial settings for knee extension (9-52%), knee flexion (14-76%), back extension (18-92%) and flexion (50-70%), chest pull (6-28%) and press (3-17%), shoulder press (18-31%) and pull (26-85%), and leg press (21%). Body fat (sum of three skinfolds) decreased (16%), and high-density lipoprotein cholesterol (HDLC) increased (10.9 mg dl\(^{-1}\)) for PG. There were no changes in any variables for CG. These results indicate that PACE training incorporating aerobic exercise and HRE elicits significant improvements in cardio-respiratory fitness, muscular strength, body composition, and HDLC for older adults. Therefore, PACE training is an effective well-rounded exercise program that can be utilized as a means to improve health-related components of fitness in older adults.

Jacobs, P.L. (2001) tested the safety and the effects of circuit resistance training (CRT) on peak upper extremity cardio-respiratory endurance and
muscle strength in chronic survivors of paraplegia due to spinal cord injury. Ten men with chronic neurologically complete paraplegia at the T5-L1 levels participated in the study. Subjects completed 12 wk of CRT, using a series of alternating isoinertial resistance exercises on a multi-station gym and high-speed, low-resistance arm ergometry. Peak arm ergometry tests, upper extremity isoinertial strength testing, and testing of upper extremity isokinetic strength were all performed before and after training. None of the subjects suffered injury from exercise training. Significant increases were observed in peak oxygen consumption (29.7%, P<0.01), time to fatigue (P<0.01), and peak power output during arm testing (P<0.05). Significant increases in isoinertial strength for the training maneuvers ranged from 11.9% to 30% (P<0.01). Significant increases in isokinetic strength were experienced for shoulder joint internal rotation, extension, abduction, adduction, and horizontal adduction (Ps<0.05). Chronic survivors of paraplegia safely improve their upper extremity cardiorespiratory endurance and muscle strength when undergoing a short-term circuit resistance training program. Gains in fitness and strength exceeded those usually reported after either arm endurance exercise conditioning or strength training in this subject population.

Kaikkonen H. (2000) studied the effects of a 12-week low resistance circuit weight training (CWT) on cardiovascular and muscular fitness were studied in 90 healthy sedentary adults. The subjects were randomized into three equally fit groups: CWT, Endurance (END) and Control (CON) according to
their maximal aerobic power (VO\textsubscript{2max}). Both training groups exercised for 12 weeks, 3 days a week in sessions of 40 min, with a heart rate (HR) level of 70-80% \(\text{HRmax}\). The CWT group trained with air resistance machines. Heart rate was controlled by setting the speed of movement. The END group walked, jogged, cross-country skied or cycled. The net differences (between pre- and post-training changes) between the CWT and CON groups was statistically significant for VO\textsubscript{2max} (2.45 ml x min\textsuperscript{-1} x kg\textsuperscript{-1}, 95% CI 1.1; 3.8), for abdominal muscles (3.7 reps, CI 0.3; 7.1), for push-ups (1.1 reps, CI 0.2; 2.1), and for kneeling (2.25 reps, CI 0.01; 4.5). The net difference (between pre- and post-training changes) in the END and CON groups was statistically significant for VO\textsubscript{2max} (2.75 ml\textsuperscript{-1} x min\textsuperscript{-1} x kg\textsuperscript{-1}, 95% CI 0.9; 4.6), and kneeling (3.0 reps, CI 0.7; 5.3). Low resistance CWT with moderately hard HR level has effects comparable to an equal amount of endurance training on the cardiovascular fitness of sedentary adults. The CWT model was beneficial also on muscular fitness. Based on the results, this type of exercise can be recommended for beginners because of its multilevel effects.

**Verrill, D.E. and Ribisl, P.M. (1996)** documented that resistive exercise training has become very popular for patients of cardiopulmonary rehabilitation programmes (CRPs). For decades, CRPs focused almost exclusively on improving cardiorespiratory endurance and most programmes ignored muscular fitness development. Moreover, resistance training was thought to be potentially hazardous for the cardiac patient due to the risk of
cardiovascular complications from adverse haemodynamic responses. We now know that resistive exercise testing and training is very safe for properly screened patients, even at relatively high workloads. Improvement in muscular strength facilitates return to daily vocational and avocational activities and is important for the CRP participant to regain lost strength and resume work soon after a cardiac event. Circuit weight training (CWT) is helpful in this respect and has been shown to increase muscular strength, cardiovascular endurance, body composition, bone density and mineral content, self-confidence, and self-efficacy in various populations. This article presents an update on current research in cardiac patients and also presents guidelines for implementing a properly supervised cardiac resistive exercise programme.

Faigenbaum, A.D. (2001) examined 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) 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 non-training 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 post-training on the chest press exercise with the pre-training 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 favor the prescription of higher-repetition training protocols during the initial adaptation period.

Butler, R.M. (1992) evaluated the feasibility, safety, and efficacy of upper body circuit weight training (CWT) in 25 stable male cardiac patients entering the initial out-of-hospital phase of cardiac rehabilitation. Both groups performed 30 minutes of aerobic exercise only for 6 weeks. The aerobic exercise group (N=13) continued this regimen for 6 more weeks, during which time the CWT group (N=12) performed 15 minutes of aerobic exercise followed by CWT (two loops, eight upper body exercises). The only adverse response was in one CWT patient in whom restenosis developed. Peak heart rate during aerobic exercise and CWT was similar, but peak systolic blood pressure during aerobic exercise was significantly greater than during CWT. Peak rate pressure product during aerobic exercise and CWT was similar. Treadmill time increased significantly in both groups. Upper body strength (cumulative pounds lifted)
increased significantly only in the CWT group. A coordinated program of CWT and aerobic exercise can be performed safely in stable cardiac patients during phase 2 cardiac rehabilitation, resulting in improved upper body strength and aerobic capacity.

Hortobágyi, T. (1991) examined simultaneous training for strength and endurance during a 13-week, 3-day a week program of hydraulic resistive circuit training and running. Eighteen college males (U.S. Army ROTC) were placed into low resistance (LR; n=10) or high resistance (HR; n=8) groups, and 10 college males were controls and did not train. There were 20 exercise stations (7 upper and lower body, and 6 supplementary). LR and HR performed 2 circuits with a work/rest ratio of 20 to 40 s during the 40 min workout. LR trained at two low resistances (approximately 100 cm.s⁻¹), while HR trained at a higher resistance (approximately 50 cm.s⁻¹). Following the workout, subjects ran 2 miles. Pre- and post-tests included strength, physical fitness, and anthropometry. Strength was assessed with (1) hydraulic resistance dynamometry for 4 exercises at 2 speeds using a computerized dynamometer (Hydra-Fitness, Belton, TX); (2) isokinetic and isotonic upright squat and supine bench press using the Ariel Exerciser (Trabuco Canyon, CA); (3) concentric and eccentric arm flexion/extension at 60 and 120 degrees.s⁻¹ on the Biodex dynamometer (Shirley, NY), and (4) 1-RM free weight concentric and eccentric arm flexion and extension. The fitness tests included 2-mile run, sit-ups, and push-ups. Anthropometry included 3 fat folds, 6 girths, and arm and
leg volume. There were no significant changes in body composition or interactions between the fitness test measures and the 2 training groups (p greater than 0.05). Improvements averaged 15% (run time), 30% (push-ups), and 19% (sit-ups; p less than 0.05). Significant improvements also occurred in 3 of 8 measures for hydraulic testing (overall change 8.8%), in 3 of 4 1-RM tests (9.4%), and in 2 of 8 Biodex tests (6%), but no significant changes for isokinetic and isotonic squat and bench press (1.9%). The change in overall strength averaged 6.5% compared to 16% in a prior study that used hydraulic resistive training without concomitant running. The researcher’s conclude that gains in strength were somewhat compromised by the simultaneous run training, and that improvements in strength and run performance were independent of LR and HR training intensity.

**McMurray, R.G. (1990)** determined the effectiveness of a fitness program designed as an alternative to the standard weight-training and running program and using limited resources and facilities. Forty-three men from the North Carolina Justice Academy, randomly assigned into two groups, completed 12 weeks of physical training. The WT group used a standard weight training and running, whereas the REC group ran and completed a resistive exercise circuit. The REC circuit consisted of nine exercises designed to improve muscular strength and endurance separated by 30 seconds of aerobic exercise. The exercises used chairs, tables, sawhorses, and body weight to provide the resistance. The results indicated that the REC program improved
muscular strength and aerobic capacity as well as the WT program. Furthermore, the REC group lost more weight, reduced body fat, and improved their lipid profiles significantly more than the WT group. Thus, the REC program is a viable alternative for the training of public safety officers when only limited resources are available.

Jürimäe, T. (2000) compared circulatory responses to circuit weight (CWT) and aerobic walking training sessions of similar energy cost in middle-aged overweight females. Thirty-three middle-aged pre-menopausal females participated in the experiment. They were divided into overweight (n=18, 36.2 +/- 6.3 years, 166.3 +/- 8.0 cm, 83.5 +/- 9.7 kg, BMI 30.2 +/- 3.1 kg m-2) and non-overweight control (n=15, 34.1 +/- 6.3 years, 165.0 +/- 5.6 cm, 61.6 +/- 5.0 kg, BMI 22.7 +/- 1.5 kg m-2) groups. Individual physical working capacity (PWC) was measured using the cycle ergometer test (calculated at the level of predicted HRmax (205 - (1/2) age). A CWT session consisted of leg extension, bench press, sit-ups and leg press exercises. The subjects performed four circuits at the maximal possible speed, using a work-to-rest ratio of 60 s. Blood pressure (BP) was measured during every rest period between the exercises, and the heart rate (HR) was recorded continuously during the whole CWT programme. During the walking training session, the subjects walked as fast as possible on the indoor track. The total energy cost of the walking training session was the same as during the CWT session, approximately 270 kcal, and was controlled by a CALTRAC accelerometer. HR and BP were measured
every 5 min during the walking training session. The PWC index was significantly (P<0.05) higher in the overweight group in comparison with the control females (215.4 +/- 76.1 and 187.9 +/- 42.4 W, respectively). The resting BP was normal in both groups (<140/90 mmHg). HR was between 120 and 140 beats min\(^{-1}\) during CWT and walking sessions. There were no differences in BP during both training sessions in overweight and control subjects. It was concluded that both CWT and walking training sessions were acceptable forms of physical activity to increase cardiovascular fitness in middle-aged overweight and normal body weight females.

**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 vertical jump and other measures of length are reviewed below:

**Study 1:**

Three jumping activities were compared

a) Maximum vertical jump

b) 0.3 m depth jump, and

c) 0.75 m depth jump

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.

**Carpinett, R.N. (2003)** studied the effect of varied weight training programmes on strength. The evidence of this study was revived earlier by Bargar that a single set for maximal strength gains the validity and practical significance of Bargar’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.

**Billy Graham (1985)** conducted a study on the effect of various methods of resistance training on hitting ability in hockey. For that forty boys
belonging to the Brindavan Public School, Athur, Chingleput were selected. The initial performance of every subject in hitting for distance was recorded in meters. On the basis of their performance, they were divided into four equivalent group of equal strength. One group assigned as control group, another three were assigned as experimental groups. Each experimental group was given different specific resistance training. All the three groups were finally tested and the record of scores showed that all the three resistance training methods improved the hitting ability in hockey for distance.

Sankaran (2000) conducted a study on the effect of weight training exercises on the performance of scooping in hockey on sixty hockey players of Sivagangai District. Six weeks weight training was given to the students. During the six weeks training period, the subjects of experimental group were given weight training with the bar bells. They were also asked to do the skill scooping. The result showed a highly significant improvement in the subjects of the experimental group after six weeks of training with specific weight training and exercises.

Mecklish (2001) conducted a study on the effect of resistance training programme on hitting ability for distance and shooting accuracy in Hockey on 30 students of YMCA College of Physical Education. Six weeks resistance training was given to the students. During the six weeks training period, the subjects of experimental group were given the resistance training with the addition of weights to their hockey stick and their forearms using sand bags.
They were also asked to do the downward swinging action with proper stance against the resistance using wall pulley. The results showed a highly significant improvement in the subjects of the experimental group after six weeks of training with specific resistance training and exercise.

**Soosai Siluvai Michael (1984)** conducted a study on the effect of resistance training on hitting ability in hockey for distance on thirty women students of YMCA College of Physical Education. Six weeks resistance training was given to the students. During the six weeks training period, the subjects of experimental group was given the resistance training with the addition of weight to their hockey stick and their forearms using sand bags. They were also asked to do the downward swing action with proper stance against the resistance using wall pulley. The result showed highly significant improvement in the subjects of the experimental group after six weeks of training with specific resistance training and exercises.

It will be appropriate to state the word of **Philip J. Rasch (1983)** has made a special mention that weight training has become extremely popular as a method of preparation for participation in Athletics, particularly among weight throwers football players and swimmers.

Three different resistance training programme on muscular strength and a absolute and relative muscular endurance were investigated by **Anderson and Kearney (1982)**.
Forty three male college students were randomly selected as subjects to his study. Three experimental groups were formed. They were:

1. High resistance low repetition group (N=15) performed three sets of 6 – 8 per session.

2. The medium resistance medium repetition subjects (N=16) trained by doing two sets of 30–40 RM per session.

3. The low resistance – high repetition group (N=12) used a single set of (100-150) RM.

All subjects were trained with the bench press exercise three times per week for nine weeks. At the end of the experimental period of nine weeks, the statistical analysis of pre- and post-test proved that the high resistance low repetition group showed poor improvement and the other two training programmes demonstrated significant improvement in muscular endurance.

Therefore in designing a resistance training programme one may adjust the resistance and repetitions used to optimize specific outcomes, so that concomitant gain will be made in muscular strength or muscular endurance.

2.4 SUMMARY OF RELATED LITERATURE

The investigator reviewed a lot of related literatures pertaining to this study. Researches reviewed proved that weight training has improved selected motor fitness and physiological variables of different groups of players and
different other populations. Similarly researches reviewed proved that resistance training improved selected motor fitness and physiological variables. However, there was further scope for research to find out the influence of structured resistance training and varied intensities of weight training on selected motor fitness and physiological variables. So the investigator intended to conduct a study on the effect of structured resistance training and varied intensities of weight training on selected motor fitness and physiological variables among athletes.

Based on the experience gained through review of related literature, the investigator formulated suitable methodology to be adopted in this study, which is presented in Chapter-III.