CHAPTER - II

REVIEW OF RELATED LITERATURE

The aim of every country is to provide its citizens equal opportunity to excel in the socially accepted profession they choose. Providing education, looking after the health of the citizens is the primary concern, apart from providing all other necessary facilities to lead a good and peaceful and healthy life. Education includes physical education, which takes care of the physical and mental, social and psychological development. An educated and healthy individual is an asset to the society in enhancing the work efficiency of the society and boosting the economy. Participation in physical activity is the prime requisite in helping the individual to progress physically and mentally. Although many choose to take part in sports to keep fit, some take it for recreational purposes and few take to competitive sports. The talent available in a child is to be identified, nurtured and trained systematically to achieve top performance over the years at the international level. Sportspersons, who have the required ability, physique and are best suited for a particular sports discipline supported by scientific training, reach the top in competitive sports. It has become very clear that the highest standard of excellence is achievable only by those who have necessary prerequisite in their childhood and youth.

In the present day scenario, participation in games and sports are not just for recreation and to develop fitness, it has become intensely competitive. More and more emphasis is laid on the enhancement of performance at the international level. Use of scientific method of training by highly trained personnel, improved and highly sophisticated equipment and improved surface are extensively adopted to prepare the sportsperson.

Motor tests are a means of diagnosing performance in the process of training control. Performance checks helps in recognizing the individual difference in general, specific skills and psychological abilities. The measure of motor abilities provide an insight into the abilities possessed by an individual, which will have some indication about the manner in which the training is carried out.

‘Kirsch\textsuperscript{2} quotes that as for peak performance and limit of performances, Man has always had an inborn impulse towards “pioneer effort that test the limits of his organism “, and so his profile is flecked with ever changing white spots, that need to be explored. Training at the limit of one’s capacities triggers off a number of internal processes that, at a conscious level, are translated into a sense of euphoria”.

The study undertaken by the investigator was to study the relationship of selected motor ability variables with the game performance of junior national male Kabaddi players. As such, very few studies are available on Kabaddi and this study may throw light on the subject, which is yet to be explored.

Studies and investigations carried out by many experts, gives us the information on the relationship between the motor abilities and game performance. There are many studies, which gives us information on the fitness and motor abilities factors as predictors of performance. Several studies have thrown light on the evaluation of motor fitness, physical fitness and different tests to assess the performance. There are number studies on the specific aspects of skill development and development of coordination. There are few studies on the classification of coordinative abilities and its developments. These studies and many related issues enlighten and make the coaches and

physical education teachers knowledgeable in bringing out the best from the sportspersons and train them to enhance their performance.

Uppal\textsuperscript{3} conducted a study and administered test and performance was recorded in selected strength and body composition variables. The relationship of selected strength and body composition variables to performance in shot put and javelin throw is as follows: Grip strength and shot put ($r=0.63$), arm strength and shot put ($r=0.76$), explosive leg strength and shot put ($r=0.61$), arm strength and javelin throw ($r=0.69$), explosive leg strength and javelin throw ($r=0.58$), lean body weight and javelin throw ($r=0.64$). He concluded that Grip strength, arm strength, explosive leg strength is significantly related to performance in shot put. Arm strength, explosive leg strength and lean body weight are significantly related to performance in javelin throw. The relationship of selected body composition variables namely, body density, lean body weight and percentage of fat to performance in shot put is not significant. Grip strength, fat percentage, body density are not significant.

Keogh\textsuperscript{4} and others in an attempt to develop an effective testing battery for female field hockey, a testing battery that would clearly distinguish female field hockey players of greater ability. The test battery included anthropometric, physiological, and skill related tests to distinguish between regional representative numbering 35 and local clubs level female field hockey players numbering 39. 10 meter sprint, 40 meter sprint, 10 meter repeated sprints, 40 meter repeated sprints, 20 meter multi stage shuttle run, vertical


jump, standing broad jump, hand grip strength, Illinois agility test, agility dribbling index, shooting accuracy and push speed accuracy test were administered on all the subjects. It was observed representative players had a significantly lower body fat then club players and significant difference was observed for standing height or body mass between the two groups. It was observed that representative players were significantly faster over 10 m and 40 m sprint as well as Illinois agility test (with and with out hockey ball). Representative players also had greater aerobic and lower body muscular power and were more accurate in the shooting test. No significant differences between groups were evident for height, body mass, speed decrement in 6x40 m repeated sprints, handgrip, or pushing speed. These result indicate that that body percent, sprinting speed, agility, dribbling control, aerobic and muscular power and shooting accuracy can distinguish between female field hockey players of varying standards. This suggests that talent identification programme for female hockey should include assessments of these physical parameters.

Shergill\(^5\) and others evaluated the importance of a set of specific physical fitness components as contributors in hockey playing ability. They have selected twenty-two relevant test items to measure the fitness components. The sample consisted of one hundred female hockey players from four universities of Punjab and the age ranges from 18 to 25 years. The correlations of various independent variables (fitness components) with dependent variables (performance) were calculated. The multiple regression analysis was applied to data for predicting hockey performance on the basis of selected physical fitness components. Most of the selected variables were having significant correlation with performance that was as follows, age \((r=0.68)\), vertical jump \((r=0.45)\), Harvard step test \((r=0.26)\), standing broad

jump (r=0.33), push up (r=0.28). Sit up, wrist flexion and wrist hyperextension, trunk flexion were found to be not correlated to performance. Endurance run test (dribbling), standing broad jump, grip strength (left), age height, weight, vertical jump and wrist flexion found have significant regression coefficient. The authors concluded that endurance run test, leg power emerge as contributor of performance.

Muzumdar and Edwin\(^6\) studied the comparative relationship of selected physical fitness variables to playing ability in basketball at different levels of performance. For this purpose one hundred and eighty male basketball player in mini, youth and junior category of Bombay Region were selected as subjects. The players were of district level performers and were still playing competitive basketball. Four variables namely (1)vertical jump (Sargent jump) for leg power, (2) Thirty meter dash for running speed, (3).SEMO agility test for agility, (4)Copper’s 12-minute run/walk test for cardiovascular endurance were administered on the players. Basketball playing ability was graded (out of ten points) by a panel of three qualified judges during the competition and average of the three grades was considered as the subjects playing ability. The relationship of physical fitness variables and playing ability was established by computing Pearson product moment correlation. Comparison of the coefficient of correlation for mini, youth and junior playing ability group was computed using ‘t’ test. It was concluded that (1) there was a positive relationship between 30 meter dash and under basket shooting for the junior group, (2) relationship between other physical fitness variables and basketball playing ability for the three group were not significant, (3) the mini group has a significantly higher relationship between playing ability and thirty meter dash

than the youth group, (4) Youth group has a significantly higher relationship between playing ability and endurance than mini group, (5) There are no differences among the three groups, ie., mini, youth and junior as far as the relationship between physical fitness variables and basketball playing ability variables except for the above mentioned differences.

Selvam and Raja\textsuperscript{7} conducted a study on twenty five youth and junior basketball players in the age group of 16-18 years. Following physical fitness variables such as speed, agility, explosive power, cardio respiratory endurance and flexibility were selected as dependent variables and skill performance, like dribbling ability, passing ability and defensive ability were selected as independent variables. The result of the study indicated that there was a significant relationship between (a) speed with dribbling ability and (b) defensive ability and insignificant relationship with passing ability. Further the study showed that there was a (c) significant relationship between agility and explosive power with all skill ability and there was a (d) significant relationship between cardio respiratory endurance and flexibility with passing ability and (e) defensive ability and insignificant relationship with dribbling ability.

Coleman and Lasky\textsuperscript{8} tested two hundred ten professional baseball players for body composition and running speed. Comparisons were made among different levels of performance, between positions and by position and level of performance. Outfielders averaged 8.36 percent body fat and 6.89


seconds in the 60 yard run; infielders, 9.33 percent and 6.97 seconds; catchers, 9.71 percent and 7.09 seconds; pitchers, 10.40 percent (running speed was not assessed). Younger players were leaner than older players, while running speed was similar across all levels of performance. The players' body composition and running speed reflected the movement patterns and defensive requirements of their positions. There were few differences among levels of performance and, in general, the baseball players were comparable to other professional athletes.

James⁹ established the importance of strength, speed and body size for team success in women’s intercollegiate volleyball. Various anthropometrical, strength and speed variables were obtained on 180 intercollegiate women volleyball players who participated in the regional round robin tournament. Factors analysis of the measured variables showed that the variables could be dimensioned as body size, speed, fatness, and strength. Multiple discriminant analysis showed that the teams were significantly different on the factors of strength and speed. The two-dimensional discriminant space was plotted and the graphic representation showed that the stronger, faster and leaner the teams, the more successful in tournament play. The results showed that the basic factors of speed and strength were related to team success.

Singh¹⁰ and others analysed the relationship of Olympic classical lifts with selected anthropometrical measurements, general and specific fitness variables. The study was conducted on 66 trained male weight lifters of Punjab with their


participation in senior national, junior nationals and All India Inter-university competitions. The average age in years (25.7±4.51), height in cms (172.12±9.30) and weight in kilograms (172.12±9.30) of the weight lifters were 89±15.79. The competitions performance (Snatch and Clean & Jerk) was taken by conducting trials where all the rules and regulations of International Weightlifting Federation were followed. In addition to this, the following anthropometrical measurements and performance in specific and general tests were also recorded. They were height, weight, Standing broad jump, Standing vertical jump, 30 meter sprint, Forward bend and reach, One kilometer run, Power snatch, power clean, Front clean, Push press, Push jerk and back squat. The data obtained from the general tests and specific tests, Olympic classical lifts, snatch and clean and jerk performance was compiled and analysed. Inter –correlation among various variables was computed. It was concluded that relationship between Snatch and Clean & Jerk is the highest. Snatch showed a significant relationship with all the specific exercises. Power snatch has the highest significance value with snatch. Relationship of Clean and Jerk with Power Snatch, Back Squat and Push Jerk, Front press, Power Clean is significant. Further it was concluded that 30-meter run showed a significant relationship with Snatch(r=0.55) and Clean and Jerk(r=0.59). Standing broad jump, standing vertical the indicators of leg power, showed non-significant relationship with Snatch and Clean & Jerk. Forward bend and reach, a test for trunk flexibility, shows a positive significant relationship with Snatch(r=0.42) and significant but negative relationship with Clean and Jerk(r=0.50).

Debnath and Dey\textsuperscript{11} examined the relationship of performance with physiological traits of national archers. The present study was conducted at random on twenty male archers who have qualified for the final round in the

senior national archery championship in the year 1995 and 1996. The physiological variables and arm–shoulder strength, right hand grip strength, left hand grip strength and shoulder and wrist flexibility were measured and tested. To know the relationship product moment correlation between performance and score with physiological traits were computed. It was evident from the study that significant correlation exits between the performance and resting pulse rate ($r = 0.44$), right hand grip ($r = 0.48$), left hand grip ($r = 0.48$) and shoulder and wrist flexibility ($r = 0.46$) $p$ at 0.05 level. It was concluded that archery demands a unique strength both in terms of static and dynamic along with flexibility.

Legg and others compared the physical performance of elite New Zealand and other nations Olympic class sailors and attempted an initial examination of the relation between physical and sailing performance. For this purpose Healthy elite thirty-one national level New Zealand Olympic sailing squad team members and 108 Olympic team sailors from ten other nations were examined. The data for the two groups of subjects was compared using unpaired "$t$"-tests. A qualitative analysis was used to examine the relation between physical and sailing performance. Data collected from the subjects included age; body mass, muscular strength endurance assessed by the maximum number of push-ups, pull-ups and sit-ups that could be performed and aerobic power assessed by the time taken to cover 2500 m and the distance completed in 12 minutes in a maximal effort rowing ergometer test. National coach assessed sailing performance by ranking each New Zealand sailor. Results indicated an average the New Zealanders were younger and lighter than the sailors from the other nations. They tended to have greater shoulder/arm

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strength endurance as reflected in their performance for push-ups and pull-ups, but a lesser ability in their sit-up performance. They also tended to be aerobically fitter. There were clear and logical differences between body mass and both class of vessel and the position of the sailor that is, crew or helmsman. Lighter sailors sailed lighter craft whilst heavier sailors sailed the heavier craft. Crewmembers were generally heavier than helmsmen. Age appeared to be related to sailing performance. They concluded that elite New Zealand Olympic class sailors tends to be younger, lighter, stronger and aerobically fitter than elite sailors from other nations. Age appeared to be related to on-water sailing performance.

Andrade\textsuperscript{13} and others state that anaerobic power in the legs has a moderate relationship to 50-meter sprint performance in swimming, and in particular, the second half of the task. They tested 10 experienced male swimmers in the age group of 21 years in the pre-competition phase of training. Swimming performance was timed 50 meter crawl stroke with a 25 meter split time. Lower limb anaerobic performance was measured through consecutive jumps on an electronic jump platform. Jumping performance was related to the total time and the time for the second half of the swim.

Baker\textsuperscript{14} and others attempted to determine if two popular field tests of strength could be used to assess a concise strength balance in roughly opposing muscle actions for the shoulder girdle. The two opposing movement actions of


pressing away from the shoulder girdle and pulling in towards the shoulder girdle were assessed via the one repetition maximum bench press and one repetition maximum pull-up, respectively. Forty-two rugby league players, comprising twenty-one national league and twenty-one state league players, who regularly performed both exercises in their training, served as subjects in this investigation. The equivalence of the strength ratio (BP/PU x 100) and correlation between tests were also examined. They concluded that the pooled data exhibited a strength ratio of 97.7% (9.0%) and correlation of r = 0.81 between the 1 repetition maximum bench press of 130.1 +/- 20.2 kg and 1 repetition maximum pull-up of 133.1 +/- 17.1 kg. The small standard deviation exhibited tends to indicate that athletes should exhibit a concise ratio of around 100% if pressing and pulling strength have been addressed fairly equally in training. However, some athletes may have body types, preexisting injuries, or training histories that predispose them to either excelling or performing poorly during strength activities for either upper body pressing or pulling actions, with differences in strength of up to 15% existing in some individuals. These factors need to be taken into account when prescribing training based upon the strength ratio between pressing and pulling strength.

Crowe\textsuperscript{15} and others investigated the relationships between muscular strength and dry land power, muscular strength and swimming power, and muscular strength and competitive swimming performance in thirty seven men and twenty eight women collegiate swimmers. Strength measures included one repetition maximum of the bench press, latissimus pull down, and triceps press. Dry land power was assessed using a seated chest put and a two-arm supine overhead throw for distance using a 6-lb medicine ball. Performing a 30-s maximal effort tethered crawl stroke swim assessed swimming power.

Competitive time was taken for 50 and 100-m crawl strokes were used as measures of swimming performance. For the whole group, all relationships were significant. For women, the three strength measures were related to dry land and swimming power. Only the one repetition maximum of latissimus pull down was related to performance. For the men, muscular strength was related to dry land and swimming power but not to performance. Contrary to the authors' interpretation of these results as being indications of an important role of strength in maximal swim velocity, when only one strength exercise in the females was related to performance and none were in the men, a contrary interpretation is warranted. These results support the contention that muscular strength is not related to sprint-swimming performance (velocity) in male or female swimmers.

Yamamura and others examined the relationship between the physiological characteristics of synchronized swimmers and their performance scores. The subjects were 26 trained female synchronized swimmers with a mean age of 17.2 +/- 1.7 years (mean +/- SD). The examined variables were body dimensions (height, width, body mass, circumference of the body and segment length), body composition, isokinetic muscle strength of the elbow and knee during extension and flexion, abdominal muscle endurance, anaerobic power (leg extension power and peak blood lactate concentration), aerobic power (maximum oxygen uptake \{VO2 max\}, swimming velocity at the onset of blood lactate accumulation \{OBLA-V\} and flexibility (standing trunk flexion, prone trunk extension and distance between the open legs). The performance scores had significant correlations (p<0.05) with isokinetic muscle strength of the elbow extension and flexion, and the knee extension, abdominal muscle endurance, leg extension power, VO2 max x wt (-1), onset of blood

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lactate accumulation and distance between the open legs. However, no significant correlations were found between the performance scores and anthropometric variables. This study showed that the performance scores of synchronized swimmers correlated significantly with the functional aspects, and that muscle strength, muscle endurance and aerobic capacity seem to be particularly important determinants.

Spurrs and others in their study attempted to investigate whether changes in running performance resulting from plyometric training were related to alterations in lower leg musculotendinous stiffness. They state that previous research has reported that plyometric training improves running economy and ultimately distance-running performance, although the exact mechanism by which this occurs remains unclear. Seventeen male runners were pre- and post-tested for lower leg musculotendinous stiffness, maximum isometric force, rate of force development, 5-bound distance test, counter movement jump (CMJ) height, running economy RE, VO (2max), lactate threshold and 3-km time. Subjects were randomly split into an experimental group, which completed 6 weeks of plyometric training in conjunction with their normal running training, and a control group, which trained, as normal. Following the training period, the experimental E group significantly improved 3-km performance by 2.7% and running economy at each of the tested velocities, while no changes in VO (2max) or lactate threshold were recorded. Counter movement jump height, 5-bound distance test, and lower leg musculotendinous stiffness also increased significantly. No significant changes were observed in any measures for the control group. The results clearly demonstrated that a 6-week plyometric programme led to improvements in 3-

17 R.W. Spurrs and others, “The Effect of Plyometric Training on Distance Running Performance,” European Journal of Applied Physiology, 89,1, (March, 2003),1-7
km running performance. It is postulated that the increase in lower leg musculotendinous stiffness resulted in improved running economy. They speculated that the improved running economy led to changes in 3-km running performance, as there were no corresponding alterations in VO (2max) or lactate threshold Th (la).

Shorter\textsuperscript{18} and others conducted a study at human performance laboratory, to compare the physiological status of a group of developmental skiers with that of U.S. Biathlon team members to determine the areas in which the developmental skier differ physiologically. Values for VO\textsubscript{2} max; lactate threshold and upper body power were measured, as they have been shown to be important variables in cross-country skiing. Fourteen developmental skiers (seven female, seven male) performed a maximal single-pole ski walk protocol on a treadmill that was equipped with an arm ergometer to determine lactate threshold and VO\textsubscript{2} max. ANOVA was used to analyse the data. The result showed that VO\textsubscript{2} max and lactate threshold was not significantly different between the elite and developmental skiers. However, upper body power was significantly lower in the developmental skiers.

William\textsuperscript{19} and others state that sit up exercises are used extensively to improve abdominal strength. The goals of programme designed to strengthen the abdominal muscles include performance enhancement, postural improvement, and lowering the risk of low back pain. The association between poor trunk muscle strength and chronic low pain is well established. Weak


trunk muscles and reduced flexibility of the back and hamstrings have been identified as risk factors in the recurrence and persistence of low back troubles. Abdominal strength alone is not sufficient to ensure optimal performance and minimize the risk of injury. The antagonist muscles (erector spine) operate in conjunction with the abdominal muscles to control trunk movement. It is important to ensure proper strength balance between the anterior and posterior muscle groups since muscles imbalances are implicated in spinal dysfunction.

Knudson\textsuperscript{20} examined the validity of 2 field tests of abdominal endurance in a sample of 22 male and 22 female college students. Scores on the modified trunk-curl and the 90-second bench trunk-curl were correlated with isometric trunk flexor strength and endurance measured on a Cybex TEF machine. There was no significant correlation ($r=0.21 < r < 0.36$) between the field tests and abdominal strength. Only the bench trunk-curl was significantly correlated ($r$ male = 0.50 and $r$ female = 0.46, $p < 0.05$) with abdominal muscular endurance. The no significant association with the modified curl-up was likely due to a ceiling effect created by the ease of the test. The low correlations between field tests of abdominal endurance and isometric abdominal endurance (about 25% common variance) and a recent longitudinal study suggests that the curl-ups scores and their hypothesized health-related fitness standards should be interpreted with caution.

Cronin and Owen\textsuperscript{21} investigated and assessed the upper body strength and power by using the chest pass throw. The chest pass distance of 12 experienced netball players was measured; thereafter, their bench press 1


repetition maximum and various kinematic and kinetic variables were calculated from a 10-kg bench press throw performed on an instrumented Smith machine. Pearson correlation coefficients were used to establish the relationship between the strength/power variables and the chest pass. Of the kinematic and kinetic variables calculated from the bench press throws, impulse and power were the variables most highly correlated to chest pass distance ($r = 0.775-0.810$), whereas the measures of initial force production ($F_{30ms}$ and $F_{100ms}$) were the lowest ($r = 0.082-0.105$). Four variables had a greater than 50% ($R^2$) shared variance with the netball chest pass-impulse, peak power, mean power and maximal strength. Power and impulse are strong predictors of chest pass performance; however, the value of the chest pass as an assessment tool to map strength and power changes in an athlete needs to be investigated using a training study approach.

Meitei and others examined the relation between shot put performance and selected general and specific tests and control exercise in women shot putters. They selected 25 shot putters of national, inter-university and state level participants and conducted seven groups of tests. The performance of the players ranges between 10.10 to 14.50 meters. In addition to competition performance the performance in twelve general and specific tests was recorded. It was found that specific tests with variation in load structure but similar in movement structure showed significant relationship whereas general tests showed non-significant relationship with competition performance. On the basis of this study he concluded that 1. Movement structure plays an important role in establishing relationship between competition performance and control exercise. 2. General tests should not be considered as performance indicators.

especially with regard to shot put performance. 3. High intensity strength exercises play a role in shot put performance.

Sprint running contributes in varying degrees to successful performance in many sports. A variety of training regimes are commonly used to improve sprinting against resistance, weight training, and ploymetric.

Rimmer and Sleivrt\textsuperscript{23} conducted an 8 week training consisting of 15 training sessions to determine the effect of a sprint–specific plyometric program. Twenty-six male subjects completed the training. A Plyometric group numbering 10 performed sprint specific plyometric exercises while a sprint group numbering 17 performed sprints. A control group consisted of 9 subjects. Subjects performed 10- and 40-m distance before and after training. For the ploymetric group, significant decrease in times occurred over 0-10-m distances, but the improvement in the sprint group were not significant over either the 0-10 –m or 0-40 –m, but magnitude of improvement in the ploymetrics group was, however not significantly different from the sprint group. The control group showed no changes in sprint time. It was concluded that a sprint –specific ploymetric program can improve 40-m sprint performance to the same extent as standard sprint training, possibly by shortening ground contact time.

Little and Williams\textsuperscript{24} state that high-speed actions are known to impact soccer performance and can be categorized into actions requiring maximal speed, acceleration, or agility. Contradictory findings have been reported as to


the extent of the relationship between the different speed components. 106 professional soccer players were the subjects who were assessed for 10-m sprint (acceleration), flying 20-m sprint (maximum speed), and zigzag agility performance. Although performances in the three tests were all significantly correlated ($p < 0.0005$), coefficients of determination ($r^2$) between the tests were just 39, 12, and 21% for acceleration and maximum speed, acceleration and agility, and maximum speed and agility, respectively. Based on the low coefficients of determination, it was concluded that acceleration, maximum speed, and agility are specific qualities and relatively unrelated to one another. The findings suggest that specific testing and training procedures for each speed component should be utilized when working with elite players.

Diallo and others examined the effectiveness of plyometric training and maintenance training on physical performances in prepubescent soccer players. Twenty boys aged 12-13 years were divided in two groups of 10 in each group: (1) Jump group and (2) Control group. Jump group trained (3) days/week during 10 weeks, and performed various plyometric exercises including jumping, hurdling and skipping. The subsequent reduced training period lasted 8 weeks. However, all subjects continued their soccer training. Maximal cycling power (Pmax) was calculated using a force-velocity cycling test. Jumping power was assessed by using the following tests: countermovement jump (CMJ), squat jump (SJ), drop jump (DJ), multiple 5 bounds (MB5) and repeated rebound jump for 15 seconds (RRJ15). Running velocities included: 20, 30 and 40 m (V20, V30, V40 m). Body fat percentage (BF percent) and lean leg volume were estimated by anthropometry. The result

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suggests that before training, except for body fat percent, all baseline anthropometric characteristics were similar between jump group and control group. After the training programme, Maximal cycling power (p<0.01), countermovement jump (p<0.01), squat jump (p<0.05), multiple 5 bounds (p<0.01), repeated rebound jump for 15 seconds (p<0.01) and Running velocities 20 m (p<0.05), performances increased in the jump group. During this period no significant performance increase was obtained in the control group. After the 8-week of reduced training, except Maximal cycling power (p<0.05) for control group, any increase was observed in both groups. It was concluded that these results demonstrate that short-term plyometric training programmes increase athletic performances in prepubescent boys. These improvements were maintained after a period of reduced training.

This study was performed to re-examine the validity of the Shuttle Stamina Test and the relationship between the Shuttle Stamina Test and the 20-m Shuttle Run Test. The 20m-multi-stage shuttle run developed by Leger et al. has been newly authorized as an endurance test by the Japanese Ministry of Education. The 20 multi-stage shuttle run was performed on a 20-m shuttle course, in which the running speed was increased every minute until the subject could not continue. The 20 m multi stage test score was evaluated by the total number of repetitions of 20-m runs. The Shuttle Stamina Test designed by Kaneko et al. (1986) was performed by self-paced running for 3 min on a 10-m shuttle course, and the test score was evaluated by the shuttle distance covered in 3 min. The subjects were 344 males and 184 females, comprising 323 primary school children ranging in age from 6 to 11 years and 205 college students ranging in age from 18 to 28 years. Thirty-seven college students underwent V02 max measurements using a maximal bicycle ergometer test. The Shuttle Stamina Test scores and V02 max peak value following Shuttle Stamina Test were closely correlated with V02 max (P<0.01). These significant levels of correlation in the Shuttle Stamina Test were equal to choose among
V02 max, 20mS score and V02 max peak following the 20mS. Shuttle Stamina Test scores demonstrated highly significant correlations with 20 multi-stage shuttle run scores for all age and sex groups, including school children and college students. These results suggest that the Shuttle Stamina Test is an appropriate field test for evaluating an individual aerobic capacity (or general endurance capacity), and that it can be used as a substitute test for the 20-m Shuttle Run Test.\textsuperscript{26}

Mechelen\textsuperscript{27} and others in their study state that to validate the “Maximal Multistage 20 Meter Shuttle Run Test “by Leger and Lambert as an estimate of maximal aerobic power and to compare the results of this test with the results of a 6 minute endurance run. Eight one subjects (forty one boys and forty girls) aged 12-14 months performed the 20 Meter Shuttle Run Test and 6 minute endurance run and had their Vo2 max directly measured during the maximal treadmill running. The mean results of the 20 Meter Shuttle Run Test were, for boys, 8.0 pailer(+1.7) and for girls, 6.4 pailer (1.5.). The mean result of the 6 minute endurance run were for boys, 1264.4 meters (160.8), and for girls, 1103.9 meters (+144.7). The mean Vo2 max for boys was 53.2ml/kg/min (+5.4) and for girls, 44.1(+4.8) ml/kg/min. The correlation coefficient between Vo2 max and 20 Meter Shuttle Run Test was found to be 0.68(+3.9) for boys, 0.69(+3.4) for girls and 0.76(+0.44) for both the sexes, and that of Vo2 max with 6 minute

\textsuperscript{26} Author’s Guide, (Validity of Shuttle Stamina Test and its Correlation to 20-m Shuttle Run Test Based on Data for Primary School Children and College Students,”) Japan Journal of Physical education ,45.(May, 2000),317.

run was 0.51(+4.6) for boys, 0.45(+0.43) for girls and 0.63 (+5.3.) for both sexes. It was concluded that 20 Meter Shuttle Run Test is suitable tool for the evaluation of maximal aerobic power although the difference in validity between the 20 Meter Shuttle Run Test and 6 minutes endurance run were statically not significant (p>0.5), for reasons of practicability the 20 Meter Shuttle Run Test should be preferred to the 6 minutes endurance run when used in physical education classes.

Paliczka\textsuperscript{28} and others with an aim to assess the validity of a 20 metre multi-stage shuttle run as both a field test of cardiorespiratory endurance and as a predictor of competitive performance in a 10 kilometre race administered test on nine male subjects of mean age 35.4 +/- 5.8 years of standard deviation, underwent a laboratory test of maximum oxygen uptake on a treadmill and recorded mean VO2 max 59.0 and standard deviation of +/- 9.9 ml.kg.-1.min-1 completed the 20-MST with a score of 105 +/- 23.7 laps/11.4 +/- 2.7 paliers and competed in a 10 km race with a finishing time 41.8 +/- 7.3 minutes. Analysis using Pearson's Product Moment Coefficient revealed high correlations between these variables 20-MST vs. VO2 max, r = 0.93; 20-MST vs. 10 km, r = -0.93; VO2 max vs. 10 km, r = -0.95. These results confirm that the 20-MST is a valid field test of cardio-respiratory endurance and suggest that it can additionally be used to predict relative running performance over 10 km.

Aziz, Chia, and Teh\textsuperscript{29} have examined the relationship between maximal oxygen uptake and repeated sprint performance in field hockey and soccer players. For this purpose a descriptive study on the aerobic-anaerobic performance of intermittent team game player were conducted. The study was conducted at the Sports Medicine and Research Centre. They participants were forty male national team game players (22.6+/-4.2 years; 1.73+/-0.07 m and 63.7+/-6.2 kg). All subjects completed a treadmill run test to exhaustion to determine maximal oxygen uptake and 8x40 m sprints either on the field or running track to determine repeated sprint ability performance. The results indicated that body mass-normalized maximal oxygen uptake of 58.0+/−4.9 ml x kg(-1) x min(-1) of the group is comparable to values reported in the literature for team game players. No significant correlations were established between the fastest 40 m sprint time and maximal oxygen uptake (r=−0.21 and -0.08, p>0.05). Moderate correlations were established between maximal oxygen uptake and total time for the eight sprints (r=−0.346 and -0.323; p<0.05). They concluded that maximal oxygen uptake was not correlated with the fastest 40 m sprint time but was moderately correlated with total sprint time. Since the shared variance between maximal oxygen uptake and total sprint time was only 12%, improving aerobic fitness further will only be expected to contribute marginally to improve repeated sprint performance of the team game players. It remains possible that a high level of aerobic fitness enhances other aspects of match play in games like soccer and hockey.

Helgerud\textsuperscript{30} and others was to examined the effects of aerobic training on performance during soccer match and soccer specific tests. For this purpose


nineteen male elite junior soccer players, age 18.1 +/- 0.8 yr, randomly assigned to the training group (N = 9) and the control group (N = 10) participated in the study. The specific aerobic training consisted of interval training, four times 4 min at 90-95% of maximal heart rate, with a 3-min jog in between, twice per week for 8 wk. Players were monitored by video during two matches, one before and one after training. In the training group: a) maximal oxygen uptake (VO2max) increased from 58.1 +/- 4.5 mL x kg (-1) x min (-1) to 64.3 +/- 3.9 mL x kg (-1) x min (-1) (P < 0.01); b) lactate threshold improved from 47.8 +/- 5.3 mL x kg (-1) x min (-1) to 55.4 +/- 4.1 mL x kg (-1) x min (-1) (P < 0.01); c) running economy was also improved by 6.7% (P < 0.05); d) distance covered during a match increased by 20% in the training group (P < 0.01); e) number of sprints increased by 100% (P < 0.01); f) number of involvements with the ball increased by 24% (P < 0.05); g) the average work intensity during a soccer match, measured as percent of maximal heart rate, was enhanced from 82.7 +/- 3.4% to 85.6 +/- 3.1% (P < 0.05); and h) no changes were found in maximal vertical jumping height, strength, speed, kicking velocity, kicking precision, or quality of passes after the training period. The control group showed no changes in any of the tested parameters. It was concluded that enhanced aerobic endurance in soccer players improved soccer performance by increasing the distance covered, enhancing work intensity, and increasing the number of sprints and involvements with the ball during a match.

Yoon\textsuperscript{31} carried out a study on Physiological profiles of elite senior wrestlers and states that to perform excellently in international competitions, wrestlers have to achieve an excellent level of physical fitness and physical condition during training. In general, successful wrestlers showed higher

dynamic and isokinetic strength than unsuccessful wrestlers. In particular, upper body strength and anaerobic power were significantly different between the two groups. Aerobic capacity is one of the most important physical factors to achieve good results in wrestling competitions. The maximal oxygen uptake of national and international wrestlers taking part in international competition has been shown to be about 53 to 56 ml/kg/min. Around the time of the Seoul Olympics, typical values for wrestlers were about 60 ml/kg/min, with values of >70 ml/kg/min in some cases (the latter being similar to values reported for some endurance runners). The flexibility of the wrestlers was found to be lower than that of weight lifters and gymnasts. However, the flexibility of top-level wrestlers was higher than that of lower level wrestlers. To fully understand the physiological profiles of successful wrestlers, further research regarding anaerobic and aerobic energy metabolism, cardiopulmonary responses, body fat content, and changes in muscle hypertrophy both during the wrestling season and off-season is warranted.

Kho-Kho\textsuperscript{32} is a very popular indigenous game of India, which is being played by both men and women. Sridhar conducted a study to determine the Physical, Anthropometrical variables as determinants in the performance in the Kho Kho. For this study thirty male Kho Kho players in the age group of 19 to 25 years from different colleges of Mysore University were selected as subjects. Under physical variables speed was measured by 50 meters dash, agility was measured by 4x 10 meters shuttle run and boomrang run, left turn and right turn. Endurance was measured by 600 Yard run /walk test, In Anthropometrical variables, height, arm length and leg length, was measured in a steel measuring tape in centimeters and the performance ability of the subjects was determined by a subjective rating of three expert coaches in the

game, rated, application of skills, playing ability, performance (both Past and Present), achievements, adaptability, usefulness of the player in the team, fitness level and manoeuvre variability. Data was analysed by using Multiple Correlation and Step-wise Regression. The following conclusions were drawn from the study.

1. Among the Physical variables motor ability, Speed, Endurance, Agility has been significantly related to Kho Kho performance of university level players.
2. The Anthropometrical variables namely standing Height, Arm Length, and Leg Length are significantly related to Kho Kho performance.
3. The overall obtained valuables is positively significant, but not for high correlation for Kho Kho performance.

Raja\textsuperscript{33} Studied the relationship of selected physical fitness components and skill performance of Kho –Kho players. Twenty-five youth and Junior Kho-Kho players were selected as subjects who represented the Tamil Nadu State Kho –Kho team for the National Championship. The age of the subject ranged between 16 to 18 years, the following physical fitness variables such as Speed, Agility, Explosive power, Cardio respiratory endurance and flexibility were selected as dependent variables and performance was measured through subjective rating by the three experts coaches in field. Speed was assessed by 50 meters run, agility was measured by 6 x10 Mts. Shuttle run, explosive power was assessed through standing broad jump, cardio respiratory endurance was assessed by conducting 12minute/walk, trunk flexibility was measured by bend and reach test. Pearson’s product moment correlation was used to find out the relationship between selected physical fitness variables and skill

\textsuperscript{33} Selvam K. Raja, “Relationship Between Selected Physical Fitness Components and Skill Performance of Kho-Kho Players” (Unpublished Master’s Thesis, Department of Physical Education and Health Sciences Alagappa University, Karikudi, 1996).
performance of Kho-Kho players. The level of significance was fixed at 0.05 levels.

Results indicated that:

1. There was a significant relationship between speed and Kho-Kho playing ability.

2. The results of the study showed that there was a significant relationship with agility and explosive power and endurance to Kho–Kho performance.

3. The results of the study showed that there was an insignificant relationship with flexibility to Kho-Kho performance.

Bhadoria\textsuperscript{34} examined the relationship of agility, strength and flexibility to playing ability in volleyball. For this purpose twenty four-volleyball player of the Lakshmibai National Institute of Physical Education, Gwalior was selected as the subjects. By administering the tests for arm strength, abdominal strength, leg strength, agility, wrist flexibility, and ankle flexibility collected data was statistically treated by using Product moment correlation (Zero). The finding of the study revealed that strength measures of leg, arm, abdomen and agility contributed significantly to the playing ability of volleyball with leg strength dominating the arm and abdomen strength.

Nataraj\textsuperscript{35} undertook a study on 61 junior level Kabaddi players with a view to find out the relationship of selected motor ability variables to the game


\textsuperscript{35}H.V.Nataraj, “Relationship between the Motor Ability Variables and Kabaddi Performance,” (Oral presented at the National Seminar cum Workshop on Physical Education and sports Sciences, Tiruchendur, December, 2004).
performance of Kabaddi players. Tests of muscular endurance, muscular power, speed, agility, aerobic endurance and coordinative ability were administered and data was obtained Three specialists did the subjective rating of performance of Kabaddi players. Pearson’s product correlation was applied to find out the correlation. A Significant relationship was found at p< 0.01 between performance and arm strength(r=0.54) and arm power(r=0.55), abdominal strength(r=0.51), leg power(r=0.38) and kinesthetic differentiation ability of upper limb(r=0.40) and lower limbs(r= -0.32).

Sinclair and others measured the reaction, movement and total response times of the limbs of representative 12 goalkeepers from five levels of organized hockey, under simple and choice test conditions by photoelectric cells and accelerometers Speed of response characteristics fundamental to success at these levels of competition and the developmental improvement, which must occur annually to permit progress through the goalkeeping hierarchy, were suggested. The point at which the beginner's "reaction-type" pattern of goaltending must be augmented with "anticipation-type" behavior was explored. The concept that the ability to react and move is specific to the direction of the response was upheld at all levels of investigation. Standard deviation of the reaction/ movement/ and total response times of each group reflected the degree of variability of performance that is tolerable at each level. This variability generally decreased with each ascending level within both testing conditions, with the exception of the choice reaction time measures. Data collected over a two-year period, for four subjects, revealed that the most evident longitudinal changes occurred in movement time and that the youngest player experienced the greatest degree of overall improvement.

Reviews on Coordinative Abilities

Mechling\textsuperscript{37} while explaining the concept of health and fitness explains a structural model for coordinative aspect was tried and built on the basis of knowledge in physical education, psychology, information theory and physiology and research. This model takes into consideration as one dimension, of sensory regulation and as the other important dimension the motor regulation. The third dimension refers to the learning and development dependent aspect of information processing, and includes the aspect of influences during a time period. Because of diagnostical measurements at one time, this aspect has been left out of consideration. The sensory regulation has been divided into interoceptive part with its kinesthetic, balance, and tactile elements. The motor regulation has been divided into ballistic movement aspect, and the strategic movement aspect.

Szopa and Latinek\textsuperscript{38} state that motor capabilities have been found to be an independent group from other coordinative abilities. They opine that the main reason of this phenomenon is the different mechanism of motor control in neuronal centers. In their study because of the impossibility of separating individual motor skills in tests examining motor capabilities, examinations were made on the group of 150 men and 100 women of relatively uniformed motor skills and fully developed motor potency abilities. The purpose of this study was to evaluate the coordination abilities structure with a special regard to motor capabilities (velocity and accuracy of learning). The studies

\textsuperscript{37} Heinz Mechling, “Is the Concept of ‘Motor Fitness’ still or again all right”? International Journal of Physical Education, Vol. XXIII, Issue 1, (1\textsuperscript{st} Quarter, 1984),18-23

comprised of basic somatic parameters, psychomotor predispositions (different tests of reaction time, eye-movement coordination, space orientation, movement frequency, kinesthetic feeling and balance) as well as of basic elements of motor capabilities: velocity and accuracy of motor learning, examining by three new tests of their own construction. The methods comprised of two kinds of multidimensional statistical analysis: factor analysis and taxonomical method of Ward. Eight separate factors of coordinative abilities were found: reaction time, eye-movement coordination, movement frequency, kinesthetic feeling, balance, space orientation and velocity of learning and accuracy of learning.

Zimmerman\textsuperscript{39} confirmed that in team games, the technical skills couldn’t be applied with the required variability under competitive conditions because of inadequately developed coordinative abilities of the players. By training, related and dominant coordinative abilities, technical skills can be applied with more variability. For this, one must know the coordinative abilities that are dominant in different sports disciplines. He categorized the following, as specific in the game of handball they are: reaction ability, adaptation ability, orientation ability, and differentiation ability. He further grouped the following, as event specific in the game of volleyball. They are: reaction ability, orientation ability and coupling ability.

Hirtz\textsuperscript{40} confirmed that when the skills become stabilised, the segment movements are automatic and concrete, the coordinative abilities are supposed to have developed optimum. Coordinative abilities are the fundamental


\textsuperscript{40} P.Hirtz,“Koordinative Fahigkeiten -Kennzeichnen. Altergang und Beeinflussungs Moglishiten. Medicine und Sports,” Theorie und Praxis der Korperkultur,21(1981),349
prerequisites for executing a complete and complex course of movements. He added the following coordinative abilities, which are: space orientation ability, kinesthetic differentiation ability, rhythmic ability and balancing ability.

Stemmler\textsuperscript{41} concluded that the early school age (7-10 years) could be the age for intensive development and improvement of reaction ability, ability for high frequency movements, space orientation ability and balancing ability. He also opined in a sense that agility between the age of seven and attainment of puberty is in its highest development stage.

Bottcher\textsuperscript{42} confirmed after testing 1000 children from second standard that high correlation was seen between the motor learning of the swimming techniques namely back stroke and breast stroke and the performance specific coordinative abilities namely balancing ability, space orientation ability and kinesthetic differentiation ability. He categorised the following coordinative abilities as event specific in swimming. They are balancing ability, space orientation ability and kinesthetic differentiation ability.

Debnath and Bawa\textsuperscript{43} opined that women artistic gymnastics is highly competitive sport discipline and to perform intricate combination of complicated movements requires high degree of strength, speed, flexibility and coordination. They conducted a study on thirty-two senior national gymnasts who participated in the senior national championship. Following test was


administered to measure flexibility and coordination: Trunk flexion, Bridge test, Split sitting, Grip strength Deviation, Time deviation test, Arm raising test, Bass Stick test Modified bass test of dynamic balance. Official result of the competition was considered as performance as high, mediocre and low performance groups. The thirty-two gymnasts were divided into three groups on the basis of their performance. One-way ANOVA, Post Hoc ‘t’ test was computed. F ratio was also obtained. It was concluded that high performance group significantly better in flexibility static and dynamic balance ability than low performance and mediocre group. The greater flexibility and coordination level might have enabled the high performance group to perform well in the competition.

Minz\textsuperscript{44} attempted to investigate the relationship of selected coordinative abilities to the performance in Badminton. Subjects for this study were twelve Badminton players of physical education college, Gwalior. The necessary data for analysing the relationship was collected by administering the various coordinative ability tests as suggested by Peter Hirtz. Mainly five-selected coordinative ability namely –Orientation ability, Differentiation ability, Reaction ability, Balance ability and Rhythm ability were taken for this study. The selected subjects were tested on criterion variables by using numbered medicine ball run test, backward medicine ball throw test, ball reaction exercise test, long nose test, sprint at given rhythm test. Administering Bobrich Badminton observational rating scale, necessary data was collected. Doubles match was played between the subjects and three judges appointed to judge the performance of the subjects in the game. Subjects were instructed to play their natural game. On the basis of the points awarded by three judges, mean score was taken and ranking was determined. To find out the significant correlation

\textsuperscript{44} Amar Kumar Minz, “Relationship of Coordinative Abilities to the Performance in Badminton” (Unpublished Master’s Thesis, University of Gwalior, Gwalior, 2003).
between the coordinative abilities and Badminton playing ability coefficient correlation was employed and the level was set at .05. It was concluded that there was no significant relationship found between selected coordinative abilities and playing ability in badminton independently or as whole. The development of different selected coordinative abilities may not be considered as an essential factor to achieve the best playing ability by badminton players. It was concluded that minimum level of coordinative abilities might be sufficient for performance in Badminton.

In a similar study Richharieya attempted to investigate the relationship of selected coordinative abilities to the performance in Volleyball. Subjects for this study were twenty Volleyball players of physical education college, Gwalior. The necessary data for analysing the relationship was collected by administering the various coordinative ability tests as suggested by Peter Hirtz. Mainly five-selected coordinative ability namely – Orientation ability, Differentiation ability, Reaction ability, Balance ability and Rhythm ability were taken for this study. The selected subjects were tested on criterion variables by using numbered medicine ball run test, backward medicine ball throw test, ball reaction exercise test, long nose test, sprint at given rhythm test. Apart from above mentioned coordinative abilities, AAHPER volleyball skill test was also conducted to measure the playing ability. According to the level of playing ability, each player was graded as per AAHPER volleyball playing ability test percentile. Further the data was analysed, to find out the correlation between the coordinative abilities and volleyball playing abilities. Coefficient of correlation was employed to analyse relationship and the level was set at .05. It was concluded that there was no significant relationship found between coordinative abilities and playing ability in volleyball and development of

\[\text{45} \text{ Amit Richharieya, "Relationship of Coordinative Abilities to the Playing Ability of Volleyball Players" (Unpublished Masters thesis, University of Gwalior, Gwalior, 2004).}\]
different coordinative abilities may not be considered as an essential factor to achieve the best playing ability by volleyball players. It was concluded that minimum level of coordinative abilities might be sufficient for performance in volleyball and that the coordinative abilities such as Orientation ability, Differentiation ability, Reaction ability, Balance ability and Rhythm ability were not having any relationship to the playing ability in isolation also.

Bakshi\textsuperscript{46} conducted a study on two groups of sportspersons on coordinative abilities. The two groups were the swimmers and runners. These groups were chosen because both the activities involved cyclic type of movements. Nineteen swimmers and nineteen runners were the subjects for the study. Coordinative ability tests were conducted on all the thirty-eight subjects which were as follows: (1) Orientation ability (2) Balance ability (3) Differentiation ability and (4) Reaction ability. (5) Rhythm ability. The subject’s chosen were either of level of inter-collegiate or of Inter-university. To find out the significant difference between the swimmers and runners in the various coordinative abilities t-ratio was employed. For testing the significant differences in the means of various coordinative abilities of swimmers and runners the level of significance was fixed at 0.05. In using the t-ratio a value of 2.02 was required at 0.05 level of confidence for 37 degree of freedom. The test revealed that there is no significant difference in coordinative abilities of swimmers and runners.

Kumari\textsuperscript{47} examined the relationship between selected coordinative abilities to kicking ability in women soccer players. She has chosen Twenty

\textsuperscript{46} Reema Bakshi, “Comparison of Two Groups in Coordinative Abilities” (Unpublished Master’s Thesis, Jiwaji University, Gwalior, 1994).

\textsuperscript{47} Anita Kumari, “Relationship between Coordinative Abilities to Kicking and Dribbling Ability in Women Soccer Players” (Unpublished Master’s Thesis in Physical Education, Gwalior, 2003).
women soccer player and following administered tests: Speed dribbling, kicking for distance, running with the ball, balance ability, differentiation ability, reaction ability. She concludes:

1. That there was no significant relationship between balance ability and dribbling ability.
2. There was insignificant relationship between differentiation ability and kicking for distance.
3. There was insignificant relationship between reaction ability and kicking for distance.
4. There was insignificant relationship between differentiation ability and speed dribbling.
5. There was significant relationship between reaction ability and speed dribbling.
6. There was an insignificant negative relationship between balance ability and kicking for distance ability.

Valarmathi\(^{48}\) investigated the relationship of selected coordinative abilities to fencing performance. Fifty-one fencers (twenty six males and twenty five females) were selected as subjects from Indian fencing camp held at Sports Authority of India, Bangalore. The necessary data for analyzing the relationship was collected by administrating coordinative abilities test as suggested by Peter Hirtz. Mainly five selected coordinative abilities namely – Differentiation ability of upper limbs, Differentiation ability of lower limbs, Space orientation ability, Balancing ability, Complex reaction time and Simple reaction time were taken for this study. Data was collected by administering backward ball throw test, Jump down on the line test, Numbered medicine ball run test, Ball reaction exercise, Balancing with long nose test and Simple reaction time.

\(^{48}\) S. Valarmathi, “Relationship of Different Coordinative Abilities to Fencing Performance” (Unpublished Project Submitted to Sports Authority of India, Banagalore, 2005).
reaction time test. Apart from coordinative abilities, the scholar through fencing bouts also analyzed fencing performance. According to the point secured by the individual throughout the bout was considered as fencing performance.

Further the data was analyzed to find out the significant relationship between these abilities and fencing performance. Karl Pearson’s coefficient of correlation was employed to analyze the relationship and the level of significance was set at 0.05 level for testing the hypothesis.

On the basis of result obtained from the study, following conclusions may be drawn.

1. There was significant relationship found between Differentiation ability of lower limbs(r=−0.408), Space orientation ability(r=−0.422), Balancing ability(r=−0.526), Complex reaction time (r=−0.583) and Simple reaction time(r=−0.619) to fencing performance.

2. There was no significant relationship found between Differentiation ability of upper limbs(r=0.122)

3. This study also indicated that development of the above said coordinative abilities might be considered as an essential factor to achieve the best performance in fencing.

4. Further it can also be concluded that training may be formulated and planned by the coaches and trainers by giving importance to these abilities specially to achieve the desired performance in fencing.

Kumar⁴⁹ conducted a cross sectional study on two hundred and forty seven boys studying in central school, aged 10-16 years. The subjects were

⁴⁹ P.A. Ramesh Kumar," Cross Sectional Analysis of Coordinative Abilities of Students from Ten to Sixteen Years of Age" (Unpublished Master's Thesis, Jiwaji University, Gwalior, 1993).
classified into 6 groups; each group consists of 40 boys. The necessary data was collected by administering various coordinative ability tests as suggested by Peter Hirtz. For testing the significance of different age groups, one-way analysis of variance was employed for each item, separately and the level of significance was kept at .05 level. The analysis of data revealed that there is significant difference in different coordinative abilities at each level. He concluded that variance existed among different age in the orientation ability, differentiation ability, reaction ability and balancing ability.

Valarmathi\textsuperscript{50} undertook a study to find out the significant differences on selected coordinative abilities among female state level basketball, volleyball and handball players. A total of 45 female players from Tamilnadu, Pondichary and Kerala state were selected as subjects, 15 each for basketball, volleyball and handball. Space orientation ability, Differentiation ability of upper limb and lower limb, Reaction ability, were the criterion variables. The selected subjects were tested on criterion variables by using numbered medicine ball run test, backward medicine ball throw test, jump down the line test and reaction timer. The one-way analysis of variance (ANOVA) was used to find out the significant differences, if any, among the female state level volleyball, basketball and handball players on selected criterion variables separately. Whenever the ‘F’ ratio was found to be significant, the Scheff’s test was applied as post-hoc test to determine the paired mean differences. In all the cases, .05 level of confidence was used to test the significance. Based on the result it was concluded that a) there was no significant difference that exists among state level volleyball, basketball and handball players on space orientation ability, differentiation of upper limbs and lower limbs, and reaction ability.

\textsuperscript{50} S.Valarmathi, “A Comparative Study on Coordinative Abilities among Basketball, Volleyball and Handball players” (Unpublished MPhil Thesis, Annamalai University, Annamalai, 2005).
Manilal, Sebastian and Thomas⁵¹ conducted a study to compare the coordinative abilities of Junior Indian Basketball and Junior Volleyball players. Twenty-one each from Junior National Volleyball and Basketball coaching camp girls camp who had attended the coaching camp were selected as subjects. Four coordinative ability tests such as backward medicine ball throw test, numbered medicine ball run test, balance ability test and ball reaction exercise test suggested by Peter Hirtz to assess differentiation ability of upper limbs, space orientation ability, balancing ability and reaction ability were administered to evaluate the coordinative abilities of the subjects. The ‘t’ test was employed to determine the mean difference in coordinative ability between volleyball and Basketball players. The research study revealed that the female basketball players have better differentiation ability of hands and balancing ability than volleyball players. The results also showed that the volleyball players have better space orientation ability and reaction ability than basketball players.

Ljach and Urchik⁵² stated that sprinters (men and women), jumpers (men and women), handball players (men and women), football players (men and women) totaling about ninety one sportspersons between the age group of 20 and 23 took part in the study. Sprinters of national level had 13% more developed coordinative abilities than the state level sprinters. Jumpers of national level had 11% more developed coordinative abilities than state level jumpers. Volleyball players of national level had 14.7% more developed coordinative abilities than state level volleyball players. They also confirmed

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that the coordinative abilities of hands of the team game players are better than that of the wrestlers and rowers.

Sebastian\textsuperscript{53} studied the relationship of coordinative abilities with different sports and levels of performance. For this purpose he has chosen six hundred male subjects from various disciplines such as Athletics, Hockey, Kabaddi, Kho-Kho, Swimming, Volleyball, and Weightlifting, twenty-five each from eight sports disciplines and three different levels namely collegiate level, university level and state level. For the present study kinesthetic differentiation ability of upper limbs and lower limbs, space orientation ability, complex reaction ability dynamic reaction ability was selected. To assess the differentiation ability of upper limbs and lower limbs medicine ball back ward throw and jump down the line test was chosen. To assess the space orientation ability, complex reaction ability and balancing ability numbered medicine ball test, ball reaction exercise test and balancing with long nose test was chosen and data were collected. Correlation, multiple stepwise regression and goodness of fit test was applied to find out the correlation among the coordinative abilities, dominating coordinative abilities and to verify the validity of the results respectively. Further to find out the differences in selected coordinative abilities among different sports disciplines and at different levels of performance two-way analysis of variance for independent group was applied. He found that dominating coordinative abilities differ from one sport discipline to another. Each characteristic of the coordinative abilities varies from one another. Coordinative abilities vary among different among different levels of performance. It was concluded from the study that complex reaction ability was found to be dominating in athletics, volleyball and weight lifting. Space orientation ability is found to be dominating in hockey and Kho-

Kho, where as kinesthetic differentiation ability of upper limbs and balancing ability and kinesthetic differentiation ability of lower limbs were found to be dominating in football, Kabaddi and swimming. On the basis of result it was emphasized by the investigator (a) coordinative ability assessed different coordinative characteristics and hence each coordinative ability is a separate entity (b) selected coordinative abilities vary from one sports discipline to another. The magnitude of variations is constant. (c) Selected coordinative abilities vary among different levels of performance; mostly state level players are found to be better than university and collegiate level players. The magnitude of variation was constant.

Roy and others in their study states that competence in executing a motor skill one must have a good kinesthetic sense and body awareness. Perception is an essential part of performance at all levels of skill in Kabaddi. Kinesthetic sensitivity refers to spatial position and movement information occurring from stimulation of muscles, tendons, and mobile joints. Seventeen Kabaddi players (8 novice and 9 experts) selected for high level training based on their fitness and participation at a certain competitive level constituted the subjects. These trainees are selected to undergo training under the specialized schemes sponsored by the government. The subject’s active and passive movements were evaluated in the field conditions. The results revealed that the accuracy in the active series was better than the passive series implying that efference copy mechanism appears to have a parallel in the evaluation of limb movement. <Novice> players were found to have better kinesthetic sensitivity than the < experts> in this study. Accuracy in the initial half of the court from the ‘end line’ (start) was found to be better than the latter half. Implications in

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the training are discussed in the study focusing the game aspects. Further they suggested that in Kabaddi, kinesthetic sensitivity is important in all skills involving muscular movements, maintaining the position, posture and movements of body upward, downward or forward. Kinesthetic sensitivity will help a player to know and be aware of things such as push, pull and other movements.

Ljach\textsuperscript{55} in his study stated that the Manifestation of Asymmetries – Symmetries in Children Aged 7–17 while doing motion exercises which require coordinative abilities, that the most of the individual’s evinced right-sided asymmetry in the movement’s characteristic for sports games guided by the leading cortical level of subject actions D. No such preponderance was found in the activities characterized by “agility of the entire body” controlled by quite symmetrical leading level of spatial field C (according to N.A. Bernstein 1947). The above data were confirmed by this pedagogical experiment. To define the percentage of children of both sexes from 7 to 17 having right – left – sided dominant and ambidexterity while performing different exercises which require the manifestation of coordinative abilities; to reveal the influence of purposeful year’s pedagogical experiment on the change of the correlation of coordinative – motive dominant of different type in children; to compare the individual aspects of coordinative abilities of children with left – sided motor behavior and ambidecstry with the average data of the group of children of the same age having right – sided type of motive dominant. The findings of the conducted research showed that 74,7\% of children with left-sided asymmetry and 75,4\% of those with ambidexterity

have a higher level of individual motor co-ordination abilities in throw to a target and in exercises during sports games performed with the hands and legs than the average level in groups of analogous age and gender. The subjects for his study were 1183 pupils of classes 1-10 in this of 568 boys and 615 girls at the age of 7-17. They were divided into 3 groups according to the age, sex and level of development of motor co-ordination abilities and the control groups were later divided into three groups. The pupils of all experimental groups had 50 lessons. The aim of the pedagogical experiment was symmetrical coordination preparation.

Klocek and Stanislawzak\textsuperscript{56} in order to find the relationship between the level of the motor abilities, the features of the body build and a game efficiency tested two hundred and eighty eight women volleyball-players in the age group of between 13-26 of age who represented different sports level which includes national level players were in cross-sectional research (1992-1998). Multiple regression analysis was used for this purpose. They stated that connecting the final effects in volleyball game only with a somatic factor is incorrect. Evaluating of high speed and movement co-ordination abilities should be also an important step in volleyball selection. Determination of efficiency of the game is changing in following stages of training – influence of co-ordination abilities is dropping at the speed-strength abilities.

Zisi, Derri and Hatzitaki\textsuperscript{57} conducted a study on dynamic analysis of the ground reaction forces developed on the supporting foot during instep kicking.


\textsuperscript{57} V.Zisi, V. Derri and V. Hatzitaki, “Role of Perceptual And Motor Abilities in Instep-Kicking Performance of Young Soccer Players,” Perceptual Motor Skills, 96,2, (April, 2003), 625-36.
to investigate the relation between specific perceptual and motor abilities and the performance of the skill. Forty five young soccer players in the age group between 11-13 years of age participated in a series of laboratory tests assessing simple, choice, and discrimination reaction time, sustained attention, depth perception, and sense of kinesthesis. Kicking performance measured by the amount of impulse (calculated as the integral of force) developed on the supporting foot during kicking. There was a significant correlation of the kicking impulse with choice reaction time \((r = -.54)\) and attention reaction time \((r = -.41)\). Stepwise regression analysis indicated that choice reaction time accounted for 29% of the variation in the anterior/posterior kicking impulse and 16.4% of the variation in the medio/lateral kicking impulse. The significant relation between kicking impulse and measures concerning speed of information processing suggests that processes associated with fast response selection may play an important role in instep-kicking performance. These findings can provide useful information for designing of training schemes and testing protocols.

Kioumourtzoglou and others examined the differences between experts and novices in a number of perceptual abilities. Three groups of elite athletes, 44 members of Greek national teams, 12 in basketball, 13 volleyball, and 19 in water polo were selected. Two groups of physical education students (ns = 18 and 21) were novices. The measured abilities were selected as the most important for an elite athlete by expert coaches in the three sports. The four most frequently selected abilities for each sport, according to the coaches' opinions, were finally assessed. Analysis showed that differences were fewer than expected. Basketball experts were better on prediction and selective attention. Volleyball experts performed better on perceptual speed, focused

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attention, prediction, and estimation of speed and direction of a moving object. Water-polo players had significantly better scores than the novices on decision-making, visual reaction time, and spatial orientation. It seems that the nature of each sport strongly influences the way perceptual abilities differentiate elite athletes from novices.

Argov and Daniel\textsuperscript{59} conducted a study on the exploratory study of perceptual-motor abilities of women: novice and skilled players of team handball. They examined a variety of perceptual, e.g., anticipation time, reaction time, and motor, e.g., throwing tasks, abilities of skilled and novice female team-handball players 13 First Division skilled and 10 recreational novice players (M age = 25.3 yr.) performed two laboratory activities for measurement of anticipation time, reaction time and movement time and three field tasks for measurement of accuracy and speed of throwing abilities in random order. Reaction time and movement time were collected during a unique team-handball motor activity. Analyses of variance with repeated measures on trial blocks indicated high mean proficiency for the skilled participants in reaction time and all field-throwing tests compared with the novice participants. These reliable differences in team-handball activities further support superiority in sport settings gained by physical achievements and psychomotor excellence. In other words, skilled female team-handball players threw faster and more accurately and responded more rapidly than novice players.

Kioumourtzoglou and others conducted a study with a group of 13 men on the elite male national team of basketball players of 22 to 23 years of age, and a control group of 15 men of equal age (physical education class) to assess differences in their scores on cognitive skills (memory-retention, memory-grouping analytic ability), perceptual skills (speed of perception, prediction, selective attention, response selection), and motor skills (dynamic balance, whole body coordination, wrist-finger dexterity, rhythmic ability). Analysis showed that elite male basketball players scored higher on hand coordination and lower on dynamic balance given their anthropometric measurements. Elite players were better on memory-retention, selective attention, and on prediction measures than the control group. The above skills are important in basketball performance. They suggested that researchers may examine whether other factors contribute more in the development of perceptual and cognitive skills.

Ghai and Biswakarma and Dey undertook a study on forty-five men gymnasts from the All India Intervarsity Level tournament between the age group of 19 to 24 years. On the basis of their performance in the tournament in all apparatuses, the subjects were divided into three different groups, that is, point 5 and below as low ability, 5.10 to 7 as medium ability and 7.10 and above as high ability and each group consisted as fifteen subjects. The test selected for the study was, medicine ball run test (Orientation ability), backward medicine ball throw test (Differentiation ability), long nose balance

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test (balance ability), Straight and rhythm run test (rhythm ability) Ball reaction exercise (Reaction ability) and points obtained in all the six apparatus of men’s gymnastics. Administering the test as suggested by Peter Hirtz data was collected. For testing the significant difference between the means the means of various coordinative abilities of different level gymnasts, one-way analysis of variance was employed for each item separately. The result of the study revealed that reaction ability varies among different level of gymnasts and no significant differences had been observed in other coordinative abilities.

Bruke\textsuperscript{62} examined the effect of stimulus condition and direction on reaction time and movement time of closed and open skill athletes. The stimulus conditions were simple as well as complex. The direction of movements was to the front, the left, and the right and to rear. The 42 closed skilled athletes were gymnasts, cross country runners and swimmers: while the 42 open skills athletes were soccer, base ball and basketball players. A significant interaction was achieved between the stimulus condition and direction and the following conclusions were made:

1. The reaction time and movement time measures were faster under complex stimulus conditions.
2. The open skill athletes had faster reaction time movement time measures than the closed skill athletes.

Gross and Thompson\textsuperscript{63} undertook a study to determine the relationship of dynamic balance to the speed and ability in swimming. Nineteen factors in


motor educability were considered in this study. One of the factors listed was balance. The findings of the study indicated that the individuals who had better dynamic balance as determined by the Bass Test of Dynamic balance could swim faster than those who had poor dynamic balance.

Welch\textsuperscript{64} analysed cross-sectional development of agility. The boys and girls selected for the tests were between five to seventeen years of age. Five agility tests selected for this purpose were, thirty feet shuttle run, the Illinois Agility Run, Icot Obstacle race run and zig-zag run. The \textit{t} – ratio noted significant difference between age levels on every test for both boys and girls. The Duncan multiple Range Test noted significant difference the following age levels: Five to six, seven to eight, eight to nine for boys and six to seven, seven to eight for girls. No significant differences were obtained between the following the levels: Nine to ten, ten to eleven, fourteen to fifteen, fifteen to sixteen and sixteen to seventeen for boys and nine to ten, ten to eleven, eleven to twelve, sixteen to seventeen for girls. The Illinois Agility run was selected by factor analysis as the best test for all age groups sexes, by motor control process. Athlete's coordinative abilities help them in training and perfecting the technical skills in the training period. The level of coordinative abilities determines the speed and quality of learning, stabilizing and applying the technical skills of sports.

Ann\textsuperscript{65} conducted a study to investigate whether trends of balancing performance would be distinguished by levels of perceptual complexity. It was expected that the levels of kinesthetetic and three of visual complexity would be


represented by different patterns of performance change over eight trials. Three levels of visual complexity were full vision, rearranged vision and no vision. Three balance tasks representing three levels of kinesthetic complexity were the beam walk, the hoping pattern and the dynabalometer. Thirty adult males served as subjects. Graphic comparisons of performance on the sigma scale however suggested that there were differences in performance change. These findings were discussed in relation to open and closed loop theories of motor performance. The order of dynabalometer performance from best to poorest was; full vision rearranged vision and no vision. Performance on the beam walking tasks in the no vision condition was significantly superior to performance in the rearranged vision condition.

Sebastian attempted to evaluate the coordinative abilities among schoolboys and girls of different age groups and selected sports disciplines and attempted to compare the selected coordinative abilities among boys and girls of selected age groups and sports disciplines. She has carried out the tests on 327 male subjects and 276 female girls students who belongs to 11, 13 and 15 years of age and play basket ball, volley ball and kho-kho for their schools. She selected following coordinative ability to achieve the purpose. (1) Kinesthetic differentiation ability of upper extremities (Backward ball throw). (2) Kinesthetic differentiation ability of lower extremities (Jump down on the line). (3) Space orientation ability (numbered medicine ball). (4) Complex reaction ability (Ball reaction exercise). (5) Dynamic balance ability (Balancing with long nose). Two-way analysis of variance and ‘t’ ratio was applied to obtain the results.

The investigator concluded that (a) There is no significant variation in kinesthetic differentiation ability of upper extremities between boys and girls on the same selected games and age groups. (b) There is no significant variation in kinesthetic differentiation ability of upper extremities between boys and girls on the selected games and age groups. (c) The kinesthetic differentiation ability of lower extremities did not vary between boys and girls among 11 and 13-year age groups. (d) Kho-Kho boys are better than girls in kinesthetic differentiation ability of lower extremities only among 15-year age group. (e) Space orientation ability did not vary between boys and girls up to the age of 15 among volleyball and Kho-Kho players. (f) Basketball boys of 15-year age showed better space orientation ability than girls. (g) There was no variation in complex reaction ability among the selected three categories of games and age groups. (h) The dynamic balancing ability was better for basketball and volleyball boys than girls in all the three age groups. (i) Dynamic balancing ability was better for 15-year-old Kho-Kho boys than their respective girls.

Review on Prediction of Performance

Roetert\textsuperscript{67} and others have examined the relationship between performance ability in junior tennis players, tennis stroke ratings and United States Tennis Association (USTA) rankings. A performance test battery evaluating strength, agility, speed and endurance was completed by 83 ranked male junior tennis players between the ages of 8 and 12. Ratings and videotape analysis of actual match play, along with USTA rankings, were quantified for tennis skill evaluation. Both sectional and national rankings were significantly related to tennis stroke ratings but higher correlations emerged between tennis

stroke ratings and national rankings (r's from 0.57 to 0.68). Regression analysis indicated that 47 percent of the shared variance in national ranking was explained by the forehand tennis stroke rating. The results of this study appear to suggest that agility is the only physical performance variable used to predict competitive rankings in younger male tennis players (age 11.62 ± 0.62 yr.). No other physical performance measures were related to the level of tennis rankings. Conversely, tennis-specific skills as measured by tennis stroke ratings may be very good indicators of competitive tennis rankings in this age group. In young prepubescent and pubescent male tennis players, physical maturation may differentiate between tennis skills and ability.

Campbell68 tested forty male members of the 1978 Springfield College varsity football squad for height, weight, 10,20, 30 and 40-yard dash speed, vertical jump, agility, upper body strength and lateral movement. In addition, each player had a game performance score assessed by the grading of a game film selected at random. Data was treated using multiple regression and correlation. (Multiple R and regression and r treated data.) No relationships were found between height and weight and performance or between agility and performance. No relationship was found between upper body strength and performance. Speed was found to be related positively to performance. It was concluded that combinations of the structural and physical performance variables utilized in the study couldn’t effectively predict performance in football.

Davis\textsuperscript{69} and others investigated the relationship among 6 physical characteristics and 3 functional measures in college football players. Data were gathered on 46 NCAA Division I college football players. The 3 response variables were 36.6-m sprint, 18.3-m shuttle run, and vertical jump. The 6 other regresor variables were height, weight, percentage of body fat, hamstring length, bench press, and hang clean. A stepwise multiple regression analysis was performed to screen for variables that predict physical performance. Regression analysis revealed clear prediction models for the 36.6-m sprint and 18.3-m shuttle run. They opine that the results of this investigation will help strength and conditioning specialists better understand the variables that predict athletic performance in Division I college football players.

Angyan\textsuperscript{70} and others investigated the importance of the athlete's motor capabilities in success in sport. The subjects for this study were seven elite basketball players. The anthropometrical and physiological features were measured to establish the physical fitness of the subjects at the end of the competitive season. Both general and sport-specific motor tests were done. The coach estimated the performance of each player during the games of the competitive season. The coach's data sheet incorporated 14 parameters of the game. Regression analyses indicated significant correlation between certain variables of the laboratory tests and the data of the coach's estimation statistics. Knowing these relationships provided valuable predictive information about player's capabilities in basketball.

\textsuperscript{69} D.S.Davis and others, “Physical Characteristics that Predict Functional Performance in Division I college Football Players,” Journal of Strength and Conditioning Research, 18, 1, (February, 2004), 115-20.

\textsuperscript{70} L.Angyan et and others, “Relationship of Anthropometrical, Physiological and Motor Attributes to Sport-Specific Skills,” Journal of Sports Medicine and Physical Fitness, 29, 4, (December, 1989), 369-78
Bracko and George\textsuperscript{71} made a study to identify the off-ice variables associated with high-performance skating acceleration, speed, agility, and on-ice anaerobic capacity and power in women’s ice hockey players. Sixty-one women’s ice hockey players between the ages of 8 and 16 years (age = 12.18 ± 2.05 years, playing experience = 4.68 ± 2.69 years) participated in the study. Subjects were 1–4 months postseason. Some players were continuing to play once per week during the off-season. Skating tests included (a) 6.10-m acceleration, (b) 47.85-m speed, (c) agility cornering S turn, and (d) modified repeat skate test. Two trials of each skating tests were measured with a photoelectric timing system (except modified repeat skate, which was measured with 1 trial). The off-ice variables that were evaluated included age, years of playing experience, height, body mass, predicted fat percentage, sit-and-reach flexibility, vertical jump height, 40-yd dash time, and 1-minute timed sit-ups and push-ups. The results of this study show that 40-yd dash time is the strongest predictor of skating speed in women’s hockey players’ ages 8–16 years old. From the regression procedure the best prediction equation was speed = 4.913 – (0.0107 × kilograms) + (0.4356 × 40-yd dash time).

Uppal and Roy\textsuperscript{72} attempted to assess the motor fitness components as predictors of Soccer Playing ability. For this purpose thirty male football university level players were the subjects who were in the camp prior to interuniversity tournament. They were administered five motor fitness components namely Speed (50 meter dash), agility (4x10 meter shuttle run) maximum leg strength (leg dynamometer), explosive leg strength (standing


broad jump) and cardio-respiratory endurance (copper’s twelve minute run/walk test). Soccer playing ability of the subjects as assessed with the help a panel of three judges. Correlation analysis using zero-order correlation, multiple correlation and prediction equation, Wherry-Dolittle method of regression was used. All the independent variables, speed (r= -0.580), agility (r= -0.618), maximum leg strength (r =0.402), explosive leg strength (r=0.663) and cardio-respiratory endurance (r=0.636) have been found to be significantly related to dependent variable (soccer playing ability). When the multiple correlation coefficient was computed with the help of partial correlation method the r= shows a high magnitude of .828 which indicates that all the independent variables contribute towards good soccer performance. On the basis of the multiple regression analysis an equation was for the prediction of the soccer playing ability from the motor fitness components. The equation developed was Y (predicted soccer playing ability) = 11.72(standing broad jump in meters) + .52 (copper’s 12 minute run/walk) –2.06 (4x10 meter shuttle run) +4.94. It was evident from the result that good speed, agility, maximum leg strength, explosive leg strength and cardio-respiratory endurance can predict soccer playing ability.

Raman conducted tests on 30 male cricket players from graduate and undergraduate courses at Lakshmibai National College of Physical Education Gwalior in order to determine the relationship of grip strength, leg power, agility and hand and foot reaction times to performance in cricket. Data was collected on grip strength (grip dynamometer), leg power (standing broad jump). Agility (40 yard shuttle run) and hand and foot reaction time (electronic reaction timer) and performance were the average of subjective rating of three judges.

experts during practice and match situations. Product moment correlation was employed to statistically treat the data. It was concluded that; 1) hand and foot reaction time is the most important variable in the prediction of performance of a cricketer. 2) Leg power is another important variable in the prediction of performance in cricket, 3) Grip strength is also an important variable of prediction in cricket playing ability and 4) agility is not an important factor in the prediction of performance in cricket.

Joseph\textsuperscript{74} determined the relationship of power, agility, shoulder flexibility, arm length and leg length to volleyball playing ability. Thirty male volleyball players of Lakshimibai National College of Physical Education, Gwalior, were selected as subjects. Power was measured by sergeant jump, flexibility by graded stick and arm length by steel tape, playing ability was placed on average of subjective judgment of three experts. Product moment correlation was used statistically analyse the data and it was concluded that: (1) Power was the most reliable single variable in predicting playing ability of men volleyball layers: (2) Arm length and leg length were also reliable in prediction of playing ability of male volleyball and (3) the variables of agility and shoulder flexibility did not show significant relationship and also prediction of playing ability of male players.

Garden\textsuperscript{75} in his study determined the value of cardiovascular capacity measures (Copper’s 12 minute run/walk) a leg power measure modified


(Sergeant jump reach) and upper body muscular strength and endurance measure (flexed arm hang) a percentage of body fat measure (skin fold thickness) and measure of body height as predictors of basketball playing ability. The basketball playing ability or criterion measure was an ability rating, a personality ability rating, a composite ability personality, the comparative rating scale and a ranking of players by the coaches. The sample consists of twenty female basketball players. Stepwise regression programme was utilized to form the prediction equation. The predictor variables were correlated with each of the five basketball playing ability measures. The prediction equation was selected using criteria only those variables, which had the lowest standard error of estimate and the greatest F value. The results indicated that the greatest prediction ability was the 12 minute run and height as the measure of the basketball playing ability. The equation produced a correlation coefficient of 0.0786 and a standard error of estimate was 0.392. From the result of the study the following conclusion were made for the prediction of basketball playing ability of college women.

1. The coopers 12 minute run and height are the best measures for predicting basketball ability.
2. Measure of leg power and upper body strength are of limited value when the cooper’s 12-minute run is used to predict basketball-playing ability.
3. Body composition measure has some value in predicting basketball ability of some college women.

Meir\textsuperscript{76} and others conducted a study on one hundred and forty six professional rugby league football players, of two teams competed in England (n = 45) and Australia (n = 101), and participated. All players completed the

following series of physical fitness performance tests: 1 repetition maximum squat and bench press, 15- and 40-m sprint, agility run, 5-minute run for distance, 60-second sit-up, 30-second plyometric push-up, and measurement of body weight and subcutaneous skinfolds. Analysis of variance with a criterion alpha level of \( p < 0.05 \), was used to determine if any significant difference could be found when grouping players into 3 different positional categories typically identified in the sport. There were a number of significant differences with respect to test results between categories, and this was apparent for all 3 systems of categorization. On the basis of these findings, they recommend (1) more efficiently structured physical fitness training of players, (2) the players should be grouped either according to the 2 broad positional categories of forwards or backs or according to the 4 categories of forwards, distributors, adjustable, and outside backs. (3) Grouping players according to the 9 specific positions played on the team is not warranted.

Sawyer and others examined the relationship between football playing ability and selected anthropometric and performance measures were determined among 40 NCAA Division I-A football players. Football playing ability (determined by the average of coaches' rankings) was significantly correlated with vertical jump in all groups (offense, defense, and position groups of wide receiver-defensive back, offensive linemen-defensive linemen, and running back-tight end-linebacker). Eleven of 50 correlations (groups by variables), or 22%, were important for football playing ability. Five of the 11 relationships were related to vertical jump. Forward stepwise regression equations for each group explained over half of the criterion variable, football playing ability, as indicated by the R (2) values for each model. Vertical jump

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was the prime predictor variable in the equations for all groups. The findings of this study are discussed in relation to the specificity hypothesis. Strength and conditioning programs that facilitate the capacity for football players to develop forceful and rapid concentric action through plantar flexion of the ankle, as well as extension of the knee and hip, may be highly profitable.

Carlson and others studied the Physique and motor performance characteristics of US national rugby players. Anthropometric and performance data were collected on 65 US rugby players (mean age = 26.3 years) to make comparison on characteristics by player position and performance level. Anthropometry included stature, body mass, nine skinfolds, two girths and two bone breadths. Skinfold patterns, estimated percent fat and Heath-Carter somatotypes were calculated from anthropometry. Motor performance measures included standing vertical jump, 40 yard dash, 110 yard dash, shuttle run, repeated jump in place, push-up, sit-up and squat thrust. Descriptive statistics were used for the total sample as well as selected sub-groups. Discriminant function analyses were employed to determine which combination of variables best discriminated between position and level of performance for the anthropometric and performance data. The results indicated that forwards were taller, heavier and had more subcutaneous adiposity than backs. Additionally, forwards and backs differed in somatotypes, with forwards being more endo-mesomorphic than backs and with a greater scatter about their mean. The anthropometric variables that best discriminated between backs and forwards were body mass, femur breadth and arm girth, with 88% correctly classified using these variables. The motor performance variables that best discriminated between backs and forwards were repeated

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jump in place, push-up and standing vertical jump, with 76% correct classification using these variables. Classification into three playing levels was unsatisfactory using either anthropometric or motor performance variables. These data can be used to assess present status and change in players, or potential national players, by position to locate strengths and weaknesses.

Roetert\textsuperscript{79} and others examined the relationship between performance ability in junior tennis players, tennis stroke ratings and United States Tennis Association (USTA) rankings. A performance test battery evaluating strength, agility, speed and endurance was completed by 83 ranked male junior tennis players between the ages of 8 and 12. Ratings and videotape analysis of actual match play, along with USTA rankings, were quantified for tennis skill evaluation. Both sectional and national rankings were significantly related to tennis stroke ratings but higher correlations emerged between tennis stroke ratings and national rankings (r's from 0.57 to 0.68). Regression analysis indicated that 47 percent of the shared variance in national ranking was explained by the forehand tennis stroke rating. The results of this study appear to suggest that agility is the only physical performance variable used to predict competitive rankings in younger male tennis players (age 11.62 ± 0.62 yr.). No other physical performance measures were related to the level of tennis rankings. Conversely, tennis-specific skills as measured by tennis stroke ratings may be very good indicators of competitive tennis rankings in this age group. In young prepubescent and pubescent male tennis players, physical maturation may differentiate between tennis skills and ability.

Datta\textsuperscript{80} predicted Hockey playing ability from physical, physiological and psychological factors. The subjects were male hockey players. The dependent variable was hockey-playing ability. Hockey playing ability was determined by the average of subjective grading by three experts who based their judgment on the strait field hockey rating scale. Physical variables included speed, grip strength, power, agility, dynamic balance, and flexibility and kinesthetic perception which were measured by test items that is 50 yards run, Dynamometer, standing broad jump, jogging run, Hohnson’s modification pass test, forward bend trunk, upward backward movement of arms and a test of horizontal distance respectively. Physiological variables included cardio respiratory endurance, resting pulse rate, reaction time, movement time, response time and body composition which were measured by 12 minute cooper’s run/walk test, resting pulse rate per minute, Nelson’s hand and arm reaction test, Nelson’s speed of movement test, four way alternate response test and ski fold calipers respectively. Psychological variables included anxiety and intelligence tests. Analysis of data revealed significant relationship of hockey playing ability to each of the following physical, physiological and psychological variables: Speed\( (r=0.29) \), right grip strength\( (r= 0.29) \), left grip strength \( (r=0.30) \), resting pulse rate \( (r=0.48) \), hand reaction time \( (r=0.38) \) and body composition\( (r=0.23) \) and anxiety \( (r=0.46) \)

Champman\textsuperscript{81} selected 106 Field Hockey International level players. The specific areas of investigation made by him were anxiety, visual perception, manual dexterity, ball control and dynamic balance. Five tests were selected to


\textsuperscript{81} Nancy Champman, “An Investigation of Prediction of Success in Women’s Field Hockey,” Research Abstract Papers AAHPERD Convention , 40, 8(April, 1980).
assess the prediction variables. (1) Sports Competition anxiety test (2) Herkowikz’s moving Embedded Figure test. (3) Minnesota Rate of Manipulation test (4) Champmen ball control test and (5) Scatt sideward leap test. Player’s subjective field hockey playing ability served as the criterion measure for the participation in the camp. A multiple discriminant function analysis was computed to identify those variables, which discriminated between the groups of selected camp participants. An one way analysis of variance was employed to assess the difference between groups of players according to their playing positions. The shuffle part hockey test was applied when a significant ‘F’ ratio indicated that the differences existed. The Pearson’s correlation technique was utilized to determine the relationship between some selected predictors variables for the groups selected women field hockey players. Visual perception and manual dexterity, as measured in this study did not discriminate between successful and unsuccessful field hockey players. Years of playing experience were not an important factor in-group classification. Classification of subjects determined by the stepwise discriminant functions analysis indicated that on the basis of three discriminating variables correct group membership could be predicted 78.95% of the time, provided the goalkeepers ball control skill were analysed separately from those of forwards and backs.

Amusa\textsuperscript{82} selected forty-six students, who were well-conditioned soccer players with at least two years playing experience at college level. They were tested for running speed, power, and agility, VO2 max, strength, anaerobic capacity and flexibility and anthropometric measurements consisting of skin fold and body dimensions. Soccer playing, ability was measured by the rating

of three experienced soccer coaches. Analysis of data was by zero order correlation and multiple R analysis resulting in the following conclusions. 

(1) Age (experience) was the best single predictor of playing ability. (2) Body weight and height were also considered as good predictors of playing ability. (3) VO$_2$ max and running speed was considered important factors in soccer performance.

Marey$^{83}$ and others attempted to determine if the factors, which coaches feel, indicated superior player potential were the same as those factors, which contribute to successful competition outcome in volleyball. Players from two colleges were evaluated for general and specific performance variables prior to a regular season match between the teams. A player's ability rating was the total of four coaches' ranking on a 1-to-10 scale. Multiple regression analysis to predict player ability rating selected age, vertical jump, total body movement time, and agility ($R = 0.87$). However, step-wise discriminant analysis to differentiate winning and losing team members selected shoulder flexibility, agility, forearm bump, and sit-and-reach flexibility. The canonical correlation between the winning-losing dichotomy and these skills was 0.74 and resulted in proper classification of 84.6% of the correct team members. It was concluded that the skills coaches consider indicative of superior ability are not necessarily the factors, which dictate winning performance.

Uppal and Datta$^{84}$ studied the motor fitness components as predictors of Hockey Performance. Then purpose of the study was to identify those motor fitness components which could predict the performance of the game. Seventy-

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four male hockey players from different universities of India served as the subjects for the study. The motor fitness components included, speed, strength, power, dynamic balance, flexibility and kinesthetic perception. Strait field hockey rating scale served as criterion measure to evaluate the playing ability. The study concluded that motor fitness components namely speed, grip strength (both right and left), agility, balance, kinesthetic perception contributed to hockey playing ability, where as power and flexibility was not significant to performance.

Hollan\textsuperscript{85} conducted a study on the predictive value of selected variable in determining the ability to play basketball in small high schools. The testing included speed, agility, upper arm strength, power, ball handling ability, reaction time, shooting ability, passing ability, height, weight, age and previous experience. The criterion was the ratio of the basketball playing ability of each squad member by his coach. The most important variables were experience ball handling ability, passing ability and shooting ability. The weighted index was $R= .76$, basketball ability score= (1.54); number of year experience+ (1.23); score on speed dribble” (.26); score on wall volley+ (.15); score on shooting test= -(10.11).

Shetty\textsuperscript{86} examined the leg power by using two variable methods. He states that leg power is an essential component for success in sports and athletic performance, which helps athletes, coaches, athletic trainers, and rehabilitation specialists in selecting, treating, and training athletes for a specific sport. Using a conventional 'jump and reach' test, one can accurately predict the leg power


and success in anaerobic-type sports. For this purpose nineteen untrained male subjects performed 'jump and reach' vertical jumps on a force platform. Power values were calculated from the force versus time data obtained from the force platform. A regression equation was obtained to predict the power values using the weight of an individual and the 'jump and reach' height as independent variables. The regression equation is given by $p = -666.3 + 14.74 \text{ [Mass (kg)]} + 1925.72 \text{ [Height (m)]}; [R\text{-square} = 0.69, p < 0.05]$.

Arnason and others investigated the relationship between physical fitness and team success in soccer, and differences in physical fitness between different player positions. The Participants were 306 male soccer players from 17 teams in the two highest divisions in Iceland. They were tested just before the start of the 1999 soccer season in the following variables: height and weight, body composition, flexibility, leg extension power, jump height, and peak oxygen uptake. Injuries and player participation in matches and training were recorded through the 4-month competitive season. Team average physical fitness was compared with team success (final league standing) using a linear regression model. Physical fitness was also compared between players in different playing positions. The results showed a significant relationship between team average jump height (countermovement jump and standing jump) and team success $P$ at 0.009 and $P = 0.012$, respectively. The same trend was also found for leg extension power $P$ at 0.097 and body fat percentage $P$ at 0.07, and the total number of injury days per team $p$ at 0.09. Goalkeepers demonstrated different fitness characteristics from outfield players. They were taller and heavier, more flexible in hip extension and knee flexion, and had higher leg extension power and a lower peak oxygen uptake. However, only minor differences were observed between defenders, midfield players, and

attackers. The study concluded that coaches and medical support teams should pay more attention to jump and power training, as well as preventive measures and adequate rehabilitation of previous injuries to increase team success.

Someren and Palmer\(^{88}\) examined the anthropometric and physiological profile of 200-m sprint kayakers and relationships with 200-m race performance. Twenty-six male kayakers who were categorised in two ability groups, international and national level, underwent a battery of anthropometric and physiological tests and a 200-m race. Race time was significantly lower in International than National (39.9 +/- 0.8 s and 42.6 +/- 0.9 s, respectively). International demonstrated significantly greater measures of mesomorphy, biepycondylar humeral breadth, circumferences of the upper arm, forearm and chest, peak power and total work in a modified Wingate test, total work in a 2-min ergometry test, peak isokinetic power, and peak isometric force. Significant relationships were found between 200-m time and a number of anthropometric variables and anaerobic and dynamometric parameters. Stepwise multiple regressions revealed that total work in the modified Wingate alone predicted 200-m race time (\(R^2 = 0.53\), \(SEE = 1.11\) s) for all 26 subjects, while biepycondylar humeral breadth alone predicted race time (\(R^2 = 0.54\), \(SEE = 0.52\) s) in International. These results demonstrate that superior upper body dimensions and anaerobic capacities distinguish international-level kayakers from national-level athletes and may be used to predict 200-m performance. This study highlights the fact that well developed upper body musculature; superior capacities for anaerobic energy metabolism, and expression of muscular power differentiate between international and national – level kayakers.

Jensen, Freedson and Hamill\cite{1} examined the relationship between power and gross efficiency during near-maximal rowing, and physiological measures of strength, power, aerobic and anaerobic capacities and United State Rowing Association (USRA) performance tests (independent variables) was investigated among collegiate male rowers. Criterion measures of rowing power and gross efficiency were measured in a moving-water rowing tank, using an oar instrumented with strain gauges to assess force and a potentiometer to assess oar position. Bivariate correlation analysis (n = 28) indicated no relationship between the independent variables and rowing gross efficiency (P > 0.05). Rowing power [mean (SD) 483.4 (34.75) W] was significantly related to inboard leg extension strength (IL strength, r = 0.63), outboard leg extension strength (r = 0.45), combined leg extension strength (r=0.45), and time to complete the USRA 2000-m simulated rowing race (r=-0.52; P <0.05). Stepwise regression using resampling cross-validation of 15 random samples (21 subjects per sample selected from a total group of 28 intercollegiate oarsmen) indicated that predictors of rowing power were inboard leg extension strength and blood lactate following a peak oxygen uptake rowing test with significant multiple correlations of R 0.61 to 0.86 (P <0.05). The standard error of estimate (SEM) ranged from 18.1 to 29.9 W, or 5.3 (0.77) percent of the criterion value. Cross-validation with a holdout group (seven subjects per sample) was performed for each equation and correlations ranged from R = 0.14 to 0.97 (SEM = 8.0 to 38.9 W). They concluded, data from the present study suggest that to increase rowing power, training should emphasize leg strength and anaerobic training to decrease the level of lactate accumulated during rowing.

Michael\textsuperscript{90} and others in their study to test the accuracy of the 20 Meter Multi Stage Shuttle Run Test to predict the VO\textsubscript{2} max in youth adults quoted that that maximal rate of oxygen is considered the gold standard for measurement of aerobic fitness. As the direct measurement of VO\textsubscript{2} max demands sophisticated instrumentation, laboratory time, and trained personnel, and it may not be appropriate for some applications. For these reasons there is interest in predictive tests that can serve as convenient alternatives to direct VO\textsubscript{2} max measurement. The 20 Meter Multi Stage Shuttle Run Test, originally developed by Leger and Lambert (1882), has been used as a predictive test for VO\textsubscript{2} max. The Shuttle Run involves graded exercise to exhaustion with typical duration of 8-12 minutes. Paliczka et al. (1987) reasoned that this is an ideal test because using audio signals eliminates judgment about pace; the incremental test ensures a gradual rise in work rate and heart rate. The test is highly reliable (r=0.975); and large number of participants can be tested at a time. The purpose of this study was to test the accuracy of 20 m shuttle run test to predict VO\textsubscript{2} max in young adults. VO\textsubscript{2} max was measured during a graded treadmill test in 60 men and 62 women whose age was 25.3 years and 25.1 years respectively. Each subject was familiarised with shuttle run procedure and completed the shuttle run test to predict the VO\textsubscript{2} max on a separate day. The mean terminal shuttle run stage was 9.5 for men and 7.8 for women. The regression equation were developed from the present data to predict VO\textsubscript{2} max for males: $Y = 2.75x + 28.8$ (r$^2=0.77$ SEE=4.07 ml.kg$^{-1}$.min$^{-1}$): and for females $Y = 2.85x + 25.1$ (r$^2= 0.66$, SEE= 3.64 ml.kg$^{-1}$.min$^{-1}$) where X equals the last half of stage of shuttle run completed. They suggest that gender –distinct equations provide more accurate predictions of VO\textsubscript{2} max for the shuttle run.

Russell, Rossignol, and Sparrow\textsuperscript{91} attempted to analyse the relationship between anthropometric characteristics, metabolic parameters, strength variables and 2000-m rowing ergometer performance time in 19 elite school boys rowers. Body mass, VO$_2$\textsubscript{max} and knee extension correlated with 2000-m performance time ($r$=-0.41, -0.43 and -0.40, respectively; $P< 0.05$), while net efficiency and accumulated oxygen deficit did not. Multiple-regression analyses indicated that the prediction model using anthropometric variables alone best predicts performance ($R=0.82$), followed by the equation comprising body mass, VO$_2$\textsubscript{max} and skin folds ($R=0.80$). Although the regression equations increased the predictive power from that obtained using single variables, the hypothesis that a prediction model consisting of variables from different physiological categories would predict performance better than variables from one physiological category was not supported.

Hoare\textsuperscript{92} in his study measured anthropometric and physiological attributes of 125 male and 123 female junior basketball players competed at the Australian Under 16 championships in 1998. In addition, experienced coaches rated the performance of players during the championships. Performance profiles were compared across playing positions and by playing performance ('Best versus Rest'). Differences in anthropometric characteristics were present across some playing positions for both males and females. Speed and agility differences between some playing positions were also present. Best players differed to Rest players on a number of anthropometric and physiological variables for both males and females. Regression analyses indicated the test variables accounted for a significant proportion of variance in playing


performance for both females (41.3%) and males (38.3%). Z score analysis indicated good alignment between the test and coach ranking of the Best player in four out of five positions for females and two out of five positions for males. Anthropometric and physiological profiling can contribute to selection procedures in junior basketball, however determinants of success are multifactorial.

Reviews on Positional play

Gabbett in his study on 159 junior under the age group of 16, 15, 14, and 13, numbering 88 and senior under the age group of 19 numbering 71 rugby league players (forwards, n = 80, backs, n = 79), competing at a sub elite level, underwent measurements of body mass, muscular power (vertical jump), speed (10 m, 20 m, and 40 m sprint), agility (Illinois agility run), and estimated maximal aerobic power (multistage fitness test). Data were also collected on match and training frequency and playing experience. There was a significant effect (p<0.05) of age and playing level on playing experience, body mass, muscular power, speed, agility, and estimated maximal aerobic power, with the physiological capacities of players increasing as the playing level increased. Forwards were heavier than backs for all junior and senior teams. Forwards and backs had similar estimated maximal aerobic power, except for fewer than 16 players, for whom significant (p<0.05) differences were detected (mean (95% confidence intervals) 42.9 (40.1 to 45.7) v 49.5 (46.4 to 52.6) ml/kg/min for forwards and backs respectively). Scores for speed, muscular power, and agility were not significantly different between forwards and backs for any of the junior or senior teams. The results show that there is a progressive improvement in the physiological capacities of rugby league players as the playing level increases. These findings provide normative data and performance

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standards for sub elite junior and senior rugby league players. Further studies on the sociological, physical, psychological, and personal predictors of talent in rugby league are warranted.

Williford\textsuperscript{94} and others investigated the performance and physiologic characteristics of a "successful" American high school football team, and to compare the present values with values reported for other groups of high school, college, and professional players. For descriptive purposes, players were divided into two groups: backs (N = 8) and linemen (N = 10). Maximal aerobic power (VO2max) was determined from a maximal treadmill test, and body composition was evaluated by hydrostatic weighing. Maximal strength values were evaluated by one-repetition maximum bench press and squat test; the sit-and-reach test was used to measure flexibility. Speed and power were evaluated by a vertical jump and a 36.6-meter sprint. Results indicate that compared with other groups of college and professional players, as the level of competition increases so do height, weight, and fat-free weight of the players. Similar maximum oxygen consumption values were found for the present group when compared with other groups of these players. From the strength and power standpoint, football players at all levels are becoming stronger. Incorporation of strength training programs has greatly improved strength and performance profiles of football players at all levels of competition.

Schmid\textsuperscript{95} with an aim to examine strength and physiological parameters of NCAA Division III American football players conducted a study on 78


players who reported for the 1994 and 1995 preseason football training camp at a National Collegiate Athletic Association III Division College. The athletes were each tested one time for explosive power, upper-body strength, lower body strength, muscular endurance, speed endurance, lower body flexibility and body composition. The performance data were analyzed according to position and playing status (starter & non starter). Significant (p<0.05) differences were observed between positions for all but the sit and reach test. For measures of muscular and speed endurance and lower body explosive power, defensive backs scored the highest, where as for measures of upper- and lower body strength and upper body explosive power, defensive line men scored the highest. Starter performed better than nonstarters for the seated medicine ball put, bench press, and hip sled. The results reported in this study will allow football coaches and players in Division III programme to see how specific test performances compare with those of other players competing at the same level. The information will also be useful for determining what position may offer athletes the best chance for success based on performances.

Arnason\textsuperscript{96} examined the relationship between physical fitness and team success in soccer, and differences in physical fitness between different player positions. The Participants were 306 male soccer players from 17 teams in the two highest divisions in Iceland. They were tested just before the start of the 1999 soccer season in the following variables: height and weight, body composition, flexibility, leg extension power, jump height, and peak O2 uptake. Injuries and player participation in matches and training were recorded through the 4-month competitive season. Team average physical fitness was compared with team success (final league standing) using a linear regression

\textsuperscript{96} A.Arnason and others, “R. Physical Fitness, Injuries, and Team Performance in Soccer,” Medicine and Science and Sports Exercise, 36, 2, (February, 2004), 278-85
model. Physical fitness was also compared between players in different playing positions. The results showed a significant relationship between team average jump height (countermovement jump and standing jump) and team success $P$ at 0.009 and $P = 0.012$, respectively. The same trend was also found for leg extension power $P$ at 0.097 and body fat percentage $P$ at 0.07, and the total number of injury days per team $p$ at 0.09. Goalkeepers demonstrated different fitness characteristics from outfield players. They were taller and heavier, more flexible in hip extension and knee flexion, and had higher leg extension power and a lower peak O2 uptake. However, only minor differences were observed between defenders, midfield players, and attackers. The study concluded that coaches and medical support teams should pay more attention to jump and power training, as well as preventive measures and adequate rehabilitation of previous injuries to increase team success.

Bale and Naught\textsuperscript{97} studied the body build, explosive strength and cardio-respiratory fitness of group of forty-three top class female hockey players and the findings were compared with similar investigations of female Hockey players and sports women. The Hockey players were then divided into four groups according to their respective playing positions on the field and the morphology. Strength and fitness variables were examined in relation to this field position. The somato types and body compositions of the forwards and half backs were found similar but both these groups were lighter, had lower percentage of fat and lean body weights than the backs and goal keepers. The halfbacks were fittest both on the tests of explosive strength and cardio respiratory fitness.

Lamba\textsuperscript{98} compared the physical fitness components and physiological variables of offensive and defensive Hockey players at college level. The subjects were sixty male students of four colleges of Gwalior who participated in 1979 intercollegiate tournaments. Data were analysed statistical by using “t” ratio. It was concluded that (1) The offensive players are faster and have less resting pulse rate and they have more cardiovascular endurance than defensive players. (2) The defensive players have more leg strength than offensive players. (3) There is no difference between offensive and defensive Hockey players in agility, blood pressure and breath holding capacity.

Dureha\textsuperscript{99} compared the offensive and defensive hockey player on the basis of selected motor abilities and selected anthropometric measurements. Fifty male players studying in college during the 1983-84 academic years were the subjects. The selected motor components included agility, speed, explosive strength, endurance and selected anthropometric variables included height, weight, leg length, arm length, thigh girth and wrist diameter. It was concluded that the test result in motor abilities and anthropometric variables of offensive and defensive hockey players showed no significant differences.

Mohr, Krstrup and Bangsbo\textsuperscript{100} assessed physical fitness, match performance and development of fatigue during competitive matches at two

\textsuperscript{98} Manmohan Kumar Lamba, “Comparative Study of Selected Physical Fitness Components and Physiological Parameters of Offensive and Defensive Hockey Players of College Level” (Unpublished PhD Thesis, Jiwaji University, Gwalior, 1979).


high standards of professional soccer. Computerized time-motion analyses were performed 2-7 times during the competitive season on 18 top-class and 24 moderate professional soccer players. In addition, the players performed the Yo-Yo intermittent recovery test. The top-class players performed 28 and 58% more (P < 0.05) high-intensity running and sprinting, respectively, than the moderate players (2.43 +/- 0.14 vs 1.90 +/- 0.12 km and 0.65 +/- 0.06 vs 0.41 +/- 0.03 km, respectively). The top-class players were better (11%; P < 0.05) on the Yo-Yo intermittent recovery test than the moderate players (2.26 +/- 0.08 vs 2.04 +/- 0.06 km, respectively). The amount of high-intensity running, independent of competitive standard and playing position, was lower (35-45%; P < 0.05) in the last than in the first 15 min of the game. After the 5-min period during which the amount of high-intensity running peaked, performance was reduced (P < 0.05) by 12% in the following 5 min compared with the game average. Substitute players (n = 13) covered 25% more (P < 0.05) ground during the final 15 min of high-intensity running than the other players. The coefficient of variation in high-intensity running was 9.2% between successive matches, whereas it was 24.8% between different stages of the season. Total distance covered and the distance covered in high-intensity running were higher (P < 0.05) for midfield players, full-backs and attackers than for defenders. Attackers and fullbacks covered a greater (P < 0.05) distance in sprinting than midfield players and defenders. The midfield players and fullbacks covered a greater (P < 0.05) distance than attackers and defenders in the Yo-Yo intermittent recovery test (2.23 +/- 0.10 and 2.21 +/- 0.04 vs 1.99 +/- 0.11 and 1.91 +/- 0.12 km, respectively). The results show that: (1) top-class soccer players performed more high-intensity running during a game and were better at the Yo-Yo test than moderate professional players; (2) fatigue occurred towards the end of matches as well as temporarily during the game, independently of competitive standard and of team position; (3) defenders covered a shorter distance in high-intensity running than players in other playing positions; (4) defenders and attackers had a poorer Yo-Yo intermittent
recovery test performance than midfielders and full-backs; and (5) large seasonal changes were observed in physical performance during matches.

Salvo and Pigozzi\(^{101}\) was to evaluate the relative effectiveness of an individualized training programme for football players according to their positions in the team, by comparing it with a programme, which did not differentiate roles, but utilized the same means for training. METHODS: Forty-four young top-level football players divided equally into an experimental and a control group was submitted to two different training programmes for an 8-month period. Each group consisted of 5 forwards, 6 midfielders, 4 fullbacks, 4 centerbacks and 3 goalkeepers. The two groups had almost the same average age (17.8 +/- 0.6 and 17.7 +/- 0.6 yrs respectively), weight (72.6 +/- 4.7 and 72.8 +/- 3.7 kg) and height (181.3 +/- 4.4 and 180.3 +/- 4.0 cm). The following measurements were taken before and after the training period in order to evaluate the aerobic and anaerobic (lactacid and alactacid) power as well as explosive and elastic power which are related to football performance: running tests of 30, 50, 300 and 1,000 meters, squat jump (SJ), counter movement jump (CMJ) and repetition counter movement jump (test 15"). RESULTS: A percent improvement observed for forwards and centerbacks was significant, in comparison with the control group, in all tests but the 30 and 1,000 meters run, on the contrary fullbacks and midfielders demonstrated a significant improvement only in the 1000 m run test (p < 0.01). In addition, a significant increase (14%, p < 0.01) was observed in CMJ of goalkeepers in the experimental group, in comparison with the control group. It was concluded that individualized training developed in accordance with the real model of football performance and the different mechanisms of bioenergetic processes,

is a superior method of training and can optimise the performance of all player in the team.

Gowda\textsuperscript{102} undertook a comparative study of selected physical fitness variables among Kabaddi players based on positional play. Following physical fitness variables were taken up for study and tests was conducted on 120 college players, they are: Flexed arm hang, sit-up, shuttle run, standing broad jump, 50 yards dash, burpee test, chin up half squat jump, push-up. It was found that offensive group was found to be more consistent in its performance in half squat jump, sit up and shuttle run tests; the defensive group was more consistent in its performance in broad jump, chin ups, and flexed arm hang tests; and that the alround group was more consistent in its performance in push up, burpee, squat thrust and 50 yards dash tests. It was concluded, under assumption of equal work and practical loads for the Kabaddi players of all three specialised groups playing different positions, that there were no significant differences among the offensive, defensive and all-round Kabaddi groups in their mean performance in push ups, squat thrust, standing broad jump, sit-ups, flexed arm hang and 50 yards dash.

**Reviews on Kabaddi**

In a study conducted by Kaur\textsuperscript{103} and others on national level Kabaddi players during national coaching camp, identified that testing of physical fitness variables have indicated that overall improvement in their fitness and

\textsuperscript{102} Shivalinga Gowda, “A Comparative Study of Selected Physical Fitness Variables Among Kabaddi Players Based on Positional Play” (Unpublished Master’s Thesis, Mysore University, Mysore, 1989).

significant improvement has been noticed in pull-ups, 2.4 km run, and 6x10 m run at the end of the training camp with an exception of speed during the camp, as a result of training.

Bose\textsuperscript{104} conducted a study on anthropometrical, physical measures to predict the performance in Kabaddi. The performance of this study was to investigate, interpret and ascertain the factors that help to predict the performance level of Kabaddi player of both men and women who participated in the university Kabaddi tournament during 1991-92. The performance levels of player depend on anthropometrical, physical, physiological and playing ability. The subjects were administered with the help of battery of tests. One-way analysis of variances was carried out for both the sexes to see the significant variation on selected variables among the successful and unsuccessful group. Pearson product moment correlation was carried out to find out the relationship of selected variables with playing ability. In addition, multiple analyses were applied to find out the combined association of selected variables on playing ability.

Kala\textsuperscript{105} conducted a study to compare physical, physiological and psychological variables of Kabaddi, Kho-Kho and wrestlers on a total of 158 male players drawn from different universities, 54 each in Kabaddi, Kho-Kho and Wrestling in the age group between 18 to 25 years. The following tests were administered and data was collected. Standing broad jump. Zig-Zag Run, 6lb medicine ball put, 50 yards run, Kraus Weber Floor Touch Test, 12 minute


Run Walk Test and different psychological and Physiological variables. Mean, standard deviation and t test was used to see the significance of difference between the Kabaddi, Kho-Kho and Wrestlers. It was concluded that Kabaddi players found to be better in arm strength, lung function and aggression than Kho-Kho players. Similarly when compared to wrestlers, Kabaddi players were better than wrestlers in leg power, agility, arm strength, speed, heart rate.

Joseph\textsuperscript{106} undertook a study to investigate the relationship of selected physical, anthropometrical and fundamental skills to the Kabaddi playing ability. The subjects were 35 high-school players in boy section who had participated in inter district tournament during the year 1996-97 at Thriuvallur district in Tamilnadu state. Motor abilities- speed and endurance, flexibility and anthropometrics measurements- height, arm length and trunk length and the playing ability was determined by taking the average of subjective grading by three experts who have gave their judgments on a 10 point rating scale. Among the motor abilities speed was measured by 50 yard dash, endurance was measured by 1000 meters run and flexibility was measured sit and reach test. Anthropometric measurements were taken by a steel tape and the data were analyzed using the Pearson product moment correlation coefficient and multiple correlation. The following conclusions were drawn.

1. Speed is significantly related to the kabaddi playing, the R value was 0.394
2. Endurance showed insignificant with the kabaddi playing ability
3. Flexibility also showed insignificant with the kabaddi playing ability
4. Height and Arm length showed significant relationship with the kabaddi playing ability.

\textsuperscript{106} Joseph, “Physical and Anthropometrical Parameters and Fundamental Skills as Determinants to the Kabaddi performance” (Unpublished Master's Thesis, Department of Physical Education and Health Science, Alagappa University, Karikudi, 1996).
5. Trunk length showed insignificant relationship with the kabaddi playing ability,

Balaji\textsuperscript{107} conducted a study with a purpose to determine relationship of sport competition anxiety, aggression, self-confidence, strength and flexibility to competition performance in kabaddi. Twenty Tamilnadu kabaddi players were the subjects who participated in senior national kabaddi championship held at Thirpur Tamilnadu. The collected questionnaires were assessed through the scoring system relevant to the concerned questionnaire and performance were assessed subjective rating by three experts of 10 point rating scale statistical procedure were used to analyzed the data by applying product moment correlation procedure were used and the following conclusion were drawn,

1. Aggression and self-confidence is significant to kabaddi performance.
2. Anxiety and flexibility were showed insignificant to kabaddi performance.

Reddy\textsuperscript{108} conducted an analytical study of Kabaddi playing ability from selected Physical, Anthropometrical and physiological variables to Kabaddi performance for state level players. For this study 75 male Kabaddi players in the age group of 18 to 30 years from different district of Andrapradesh were selected. Speed was measured by 50 meters dash, agility was measured 6-x10 meters shuttle run and endurance was measured by1500 meters run. Height,

\textsuperscript{107} Balaji, “An Analysis of selected Physical, Phychological Variables to Performance in Kabaddi State Level Male Kabaddi Players” (Unpublished Master’s Thesis, Department of Physical Education and Health Sciences, Alagappa University, Karaikudi, 1996).

\textsuperscript{108} J.Venkata Reddy,"A Analytical study of Kabaddi Playing Ability from Selected Physical Anthropometrical and Physiological Variables to Kabaddi Performance for State Level Players" (Unpublished Master’s Thesis, Department of Physical Education and Health Sciences Alagappa University, Karikudi, July 1998).
arm length and leg length was measured by using a steel tap. Physiological variable such as vital capacity and resting pulse rate and breath holding time were measured. The performance ability of the subjects was determined by a subjective rating of 3 expert coaches in the game. The obtained data was analysed by using Multiple Correlation and Step-wise Regression. Following conclusions were drawn.

1. Among the Physical variables the agility has showed significantly related to the Kabaddi performance of State level players
2. The Anthropometrical variables namely standing arm length, leg length is significantly related to the Kabaddi performance.
3. The physiological variables namely breath-holding time are significantly relating to the Kabaddi performance.

Chandrashekar\textsuperscript{109} studied to determine the relationship of power, agility, flexibility, muscular endurance and cardio-respiratory endurance to playing ability in ‘Kabaddi.’ Thirty Kabaddi players of the Lakshmi Bai National College of physical education, Gwalior, acted as subjects. Leg power was measured by Sargent jump and agility was measured by side step test, flexibility by trunk flexion test, muscular endurance by pull-ups and bent knee sit-ups and cardio- respiratory endurance by one-minute lateral jump test. The playing ability was assessed by the subjective judgment of a panel of three experts for each subject. Product moment correlation was used to statistically analyse the data. On the basis of the finding of the study the following conclusions were drawn.

1. Leg power was the most significant motor fitness component underlying performance in the game of Kabaddi

\textsuperscript{109} Chandrashekar, “Relationship of Selected Motor Fitness Components to Playing Ability in Kabaddi players” (Unpublished Master's Thesis, Jiwaji University, Gwalior, 1984).
2. Muscular endurance, cardio-respiratory endurance and flexibility also contributed to the Kabaddi playing ability

3. Agility and muscular endurance of arm showed an insignificant relationship to playing ability in Kabaddi.

Chauhan with a view to construct a test battery of motor fitness for Kabaddi players selected forty male Kabaddi players of Uttar Pradesh who attended the state level Kabaddi camp. He selected the following fitness components such as, speed, agility, and explosive strength, strength endurance. The kabaddi playing ability was evaluated by computing the average of the three experts in a game situation. Pearson’s Product moment correlation was used to assess the relationship of criterion with each of the test items. Further wherry-do-little method of multiple correlations was computed to find out the combined contribution of all the test items. The multiple regression was worked out to assess the relative contribution of different selected test items to specific motor fitness of Kabaddi players. The analysis of the data disclosed significant relationship between three independent variable and criterion. The highest value of correlation for different components, namely sit-ups (r=0.52) chin ups (r=0.49) and shuttle run (r=0.39) found with the criterion. The multiple correlation (wherry-do-little method) was used to know the combined contribution of all the test items to Kabaddi performance. The result of the study shows that sit –ups (abdominal strength endurance), standing broad jump (explosive strength) and shuttle run (agility) contribute significantly to playing ability (c) Rc.432=. 79 among motor fitness tests. The multiple regression resulted in the following equation.

\[ Zc = 0.753 Z4 - 0.541 Z3 + 0.364 Z2 \]

\( Zc = \) proposed specific motor fitness test scores.

Z4=Sit-ups
Z3= standing Broad Jump.
Z2=Shuttle run

The result reveals that the specific fitness of Kabaddi player depends upon sit-ups abdominal (strength endurance) to a greater degree followed by standing broad jump (explosive strength) and shuttle run (agility) in diminishing order.

Ismail\textsuperscript{111} attempted to know the status of physique and fitness of Indian team Kabaddi players based on some selected anthropometric measures and physical fitness tests. To achieve this purpose 29 Indian Kabaddi players who were in the national coaching were selected as subjects for this study. The data on selected anthropometric variables as, age, height, body fat, and length of upper and lower limbs chest depth and circumference. Like wise data was collected on eight different fitness variables such as 30 m dash, 20 seconds side steps, standing broad jump, shuttle run, push up 10 seconds, pull ups, 100 m. sprint and 1500 m run. It was concluded that all the selected anthropometric variables and eight physical fitness variables were highly significant between offensive, defensive and all round groups at p at 5 %.

Khanna\textsuperscript{112} and others undertook a study to determine the physical and physiological profile of kabaddi players and the physiological demands of playing a kabaddi match. Maximum aerobic capacity (VO2max), maximum ventilation (VEmax), O2 pulse, respiratory equivalent (RE), maximum heart rate, and O2 debt were assessed on 16 players Kabaddi. The somatotype of the players was

\textsuperscript{111} L.Mohammed Ismail, “Study on Selected Anthropometric Variables and Physical Fitness of Kabaddi Players at National level performance” (Unpublished Master’s Thesis, Mysore University, Mysore, 1994).

calculated by the Health and Carter method. Heart rate was monitored during a selection trial match on eight players who represented India in the Asian Games, 1994. From the playing heart rate, oxygen consumption (VO2) was computed through a heart rate v VO2 regression equation. Maximum lactate was evaluated from the blood samples collected at the end of the match. The average heart rate and oxygen consumption during the match were 146.5 (SD 9.25) beats min\(^{-1}\) and 2.25(0.59) litre min\(^{-1}\) respectively. During raiding the maximum heart rate attained varied from 162.4(11.3) to 177.4(4.2) beats min\(^{-1}\). Out of 40 min of match play a raider raided on average on 8.13(2.03) occasions. The average time per raid was 20.8(6.26) s. The match heart rate and oxygen consumption was 72.3-83.3% of the maximum heart rate, and 43.5-70.5% of VO2max respectively. Maximum lactate at the end of the match was 6.13 (2.53) mmol litre\(^{-1}\). Kabaddi players had the somatotype of 2.68-4.71-1.83, with absolute back strength of 175.0 kg. VO2max and O2 debt were 3.59 (0.36) litre min\(^{-1}\) [47.82(3.68) ml kg\(^{-1}\) min\(^{-1}\)] and 5.3(1.85) litres (70 ml kg\(^{-1}\)) respectively. It was concluded that Kabaddi is an intermittent sport. The rest pause during the game is sufficient for recovery. During raiding the main source of energy is anaerobic.

Dey, Khanna and Batra\(^{113}\) attempted to know morphological and physiological status of Indian National Kabaddi Players. Twenty-five national kabaddi players, of mean age 27.91 years, who attended a national camp at the Sports Authority of India, Bangalore before the Beijing Asian Games in 1990, were investigated for their physical characteristics, body fat, lean body mass and somatotype. The physiological characteristics assessed included back strength, maximum oxygen uptake capacity and anaerobic capacity (oxygen debt) and related cardiorespiratory parameters (oxygen pulse, breathing equivalent, maximum pulmonary ventilation, maximum heart rate). Body fat was calculated

from skinfold thickness taken at four different sites, using Harpenden skinfold calipers. An exercise test (graded protocol) was performed on a bicycle ergometer (ER-900) using a computerized EOS Sprint (Jaeger, West Germany). The mean (SD.) percentage body fat (17.56(3.48)) of kabaddi players was found to be higher than normal sedentary people. Their physique was found to be endomorphic mesomorph (3.8-5.2-1.7). Mean (SD) back strength, maximum oxygen uptake capacity (VO_2max) and oxygen debt were found to be 162.6(18.08) kg, 42.6(4.91) ml kg⁻¹ min⁻¹ and 5.02(1.29) litre respectively. Physical characteristics, percentage body fat, somatotype, maximum oxygen uptake capacity and anaerobic capacity (oxygen debt) and other cardiorespiratory parameters were compared with other national counterparts. Present data are comparable with data for judo, wrestling and weightlifting. Since no such study has been conducted on international counterparts, these data could not be compared. These data may act as a guideline in the selection of future kabaddi players and to attain the physiological status comparable to the present gold medallists.

They opined that Kabaddi is a game that combines the actions of Wrestling, Judo, Rugby and gymnastics. The important body movements involved in this game are catching, holding, locking and jumping, thus the possession of desirable anthropometric and physiological characteristics will have a greater advantage in executing a better performance in competition. Kabaddi requires tremendous stamina, agility, individual proficiency, neuromuscular coordination, lung capacity, quick reflexes, intelligence and presence of mind on the part of the both attackers and defenders.

Further they concluded that a mesomorphic endomorphic physique would suit Kabaddi. The back strength of Kabaddi players was found to be good when compared to other sports persons. Kabaddi is an intermittent game. The aerobic and anaerobic capacity measured in their study was not satisfactory when compared to other sports persons.