CHAPTER II

REVIEW OF RELATED LITERATURE

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

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

The purpose of this review of selected literature was to relate studies pertaining to the topic under study and to organise the collected review into meaningful sub sections as listed below:

a) Prediction studies on Handball playing ability

b) Prediction studies on playing ability from anthropometric variables

c) Prediction studies on playing ability from physical fitness variables

d) Prediction studies on playing ability from physiological variables

e) Prediction studies on playing ability and performance variables.
2.1 PREDICTION STUDIES ON HANDBALL PLAYING ABILITY

Anis Chaouachi et al. (2009) studied anthropometric, physiological, and performance characteristics of an elite international handball team. Twenty-one elite handball players were tested and categorized according to their playing positions (goalkeepers, backs, pivots, and wings). Testing consisted of anthropometric and physiological measures of height, body mass, percentage body fat and endurance (\(\dot{V}O_{2\text{max}}\)), performance measures of speed (5, 10, and 30 m), strength (bench press and squat), unilateral and bilateral horizontal jumping ability, and a 5-jump horizontal test. Significant differences were found between player positions for some anthropometric characteristics (height and percentage body fat) but not for the physiological or performance characteristics. Strong correlations were noted between single leg horizontal jumping distances with 5-, 10-, and 30-m sprint times (\(r = 0.51-0.80; P < 0.01\)). The best predictors of sprint times were single leg horizontal jumping with the dominant leg and the distance measured for the 5-jump test, which when combined accounted for 72% of the common variance associated with sprint ability. In conclusion, performance abilities between positions in elite team-handball players appear to be very similar. Single leg horizontal jumping distance could be a specific standardized test for predicting sprinting ability in elite handball players.

Oxyzoglou et al. (2008) documented that high performance in team sports depends to a great extent on the motor abilities of all players according to their
position in the team. Assessing the motor abilities of elite athletes according to their playing position in the team was the aim of the study. The sample consisted of 46 handballers aged 18-21 years (M=19.5, SD=.4.5), belonging to national teams from Greece and Serbia. Afterward, the sample was divided into subgroups, representing their unique position in the team. More specifically the subgroups consisted of eight goalkeepers, fourteen extreme players, sixteen peripheral players and eight pivotal players. The motor abilities of power, agility and flexibility were assessed. The Kruskal-Wallis and Mann-Whitney U analysis were used for the comparison among groups. The results revealed that the goalkeepers have a highly developed level of pelvis flexibility and a well developed level of explosive force. The peripheral players have high vertical jump and a high degree of wrist flexibility. Extreme players have a developed level of explosive force and big width of wrist movement. Finally, pivotal players are less flexible but very agile. Every playing position developed specific motor abilities which contribute to team performance.

Visnapuu et.al. (2007) reported that in handball and basketball the longer the finger length the better the accuracy of the shot or throw. All shots and throws are finished with the wrist and fingers. It can be proposed that athletes with longer fingers and greater hand surface parameters also probably have greater grip strength. The aim of this study was to investigate the influence of general body and hand-specific anthropometric dimensions on handgrip strength in boys participating in handball and basketball training. In total, 193 boys aged 10-17 years participated in
this study. They were divided into 6 groups: 10-, 11-, 12-, 13-, 14-15-, and 16-17-year-olds. The body height and body mass were measured and body mass index was calculated as general anthropometric parameters. The outlines of the hands of the boys were drawn on paper with a thin marker. Three groups of hand anthropometric parameters were measured: 5 finger spans, 5 finger lengths, and 5 perimeters of the hand. Handgrip strength was measured on the dominant hand with a Lafayette dynamometer. As a rule, general anthropometric parameters determined the maximal handgrip strength more accurately than did specific hand anthropometric parameters. From the specific hand anthropometric parameters, finger lengths and perimeters of the hand significantly correlated with the maximal handgrip strength. In summary, fingers are the smallest, lightest parts of the motor apparatus, and, therefore, they represent the parts most easily deflected by force from the ball, but at the same time, finger control is especially important for the accuracy of different shots, both in handball and basketball. Thus, it is especially necessary to measure finger length and perimeters of the hand for practical reasons.

Schorer et al. (2007) examined the movement patterns of 5 left-handed handball players (ranging from beginner to national level) who threw a handball to different sections of a goal as if a goalkeeper were present. The authors used time-continuous, 3-dimensional kinematic data to assess intraindividual movement patterns and considered participants’ intraindividual differences relative to different targets. Cluster analysis yielded the highest assignment rates for level of expertise; a
mean of 92% of trials was correctly assessed. The authors observed an interaction with expertise for the intraindividual movement patterns. Variability in the novice throwers was increased, whereas (a) advanced throwers experienced a period of stability, and (b) the expert thrower's variability was increased. The results indicate that random variability characterizes novice motor performance, whereas active functional variability may exemplify expert motor performance.

Vatromir et.al. (2006) assessed the basic motor abilities that determine top performance in women's handball, and to identify test panel for primary selection at handball school. The study included 155 female attendants of the Split Handball School, mean age 12.5 years. Differences in the basic motor abilities between the subjects that developed into elite handball players after 7-year training process and those that abandoned handball for being unable to meet the competition criteria were evaluated by use of discriminative analysis. The former were found to have also been superior initially in all variables analyzed, and in arm coordination, overall body coordination, throw and jump explosive strength, arm movement frequency and repetitive trunk strength in particular. Motor superiority based on the abilities of coordination, explosive strength and speed determines performance in women's handball, qualifying these abilities as reliable selection criteria. Based on this study results, a new model of selection in women's handball, with fine arm coordination as the major limiting factor of performance, has been proposed.
Ikeda Mariko et al. (2004) reported that it is well known that athletes participating in different sports vary in physique and physical fitness. Although several studies on the physique and physical fitness of athletes have been conducted on both sexes, research on physique and physical fitness of female handball player is lacking. The purpose of this study was to investigate the physical characteristics and motor performance of the college women handball players. For this purpose the physique and motor performances of the college women handball players to college women basketball players and college women volleyball players were compared. Basic anthropometric indices and physical fitness such as 20M shuttle-running, vertical jump, standing jump, handball-throw for distance, trunk flexion, side step, grip strength and back strength were determined for 6 handball players, 7 basketball players and 8 volleyball players aged from 19 to 22 years. All of these ball game teams were a top level of the university in Japan and all subjects were the regular players in each team. The difference in girth of upper arm, skinfold thickness of upper arm and percentage of body fat (%Fat) among 3 ball game teams were statistically significant. The girth of upper arm of the handball players was significantly higher than that of basketball players, and the skinfold thickness of upper arm and %Fat was significantly lower in handball players than in volleyball players. The handball throw for distance, side step and back strength were significantly higher in handball players than in basketball players and volleyball players. In handball game, the transition from defense to offense occurs in about every 25-30 sec. and the transition is very speedy and the considerable body contact
to the opponent is allowed, so that muscular strength, power, agility and aerobic power are strongly required for each player. When the handball game is compared with basketball game, the playing time is longer and the charged time-out is shorter, and the shooting motion is more dynamic. In comparison with volleyball, the considerable body contact to the opponent is allowed in handball game but that is not allowed in volleyball and the ball is very heavier. Therefore, it was concluded that the results of this study as stated above show the characteristics of female handball player.

Marko Sbila et al. (2004) identified the differences in the volume and intensity of large-scale cyclic movement activities performed by handball players in different playing positions - backcourt players, wings, pivots and goalkeepers. For this purpose six experimental model matches (2x20min), played by the Slovenian male handball teams (youth, juniors and seniors), were analysed. The sample consisted of 84 players of twelve teams (average age 20.26 ± 4.28yrs; average height 182.51 ± 6.59cm; average body mass 80.61 ± 10.37kg) and was divided into four sub-samples by playing position. The collection of data on the cyclic loading of players in a handball match was based on the computer-aided automatic tracking method with the SAGIT system, based on computer vision methods. The output data on the cyclic movements obtained by the SAGIT programme were processed by the selected descriptive statistics methods in Excel and SPSS programmes. Statistically significant differences were registered between the groups of players in different
playing positions in terms of average distances walked or run during matches (volume). The greatest total distance was covered by the wings (3,855m), followed by the backcourt players (3,432m) and pivots (3,234m), whereas goalkeepers ran the least (1,753m). Differences also appeared in the intensity of large-scale cyclic movements, that is in the percentage of time spent in all the speed classes. In the first speed class statistically significant differences occurred among all the groups - the goalkeepers spent the highest percentage of time (86%) here, followed by the pivots (62%) and wings (58%). There were no statistically significant differences in the second speed class between the groups of wings (23%), backcourt players (25%) and pivots (25%); however, all three groups differed from the goalkeepers (11%). The highest percentage of time spent in the third speed class was that of the wings (14%) and backcourt players (14%). Nevertheless, there were no statistically significant differences between them. Pivots (10%) and goalkeepers (2%) did not spend much time in the third speed class, so statistically significant differences were registered for the latter two and the groups mentioned before. In the fourth speed class statistically significant differences occurred between all the groups of players. In this speed class the wings spent the most time (4%), followed by the backcourt players (3%) and pivots (2%), whereas the lowest percentage of time in this speed class was that of the goalkeepers (0.5%). There were statistically significant differences between all the groups of players in terms of average speed of movement - the fastest were the wings (1.60m/s), followed by the backcourt players (1.43m/s), pivots (1.34m/s), and goalkeepers (0.73m/s)
Atkinson (1977) conducted a study on prediction of performance in handball, tennis and badminton from certain physical traits. Regression equations using physical traits and class commitment as predictors were developed for determining potential skill in beginning handball, tennis and badminton for college men. The physical traits used were: agility, power, hand eye coordination and visual ability. Skill level was determined by a round robin tournament in each sport. Subjects were 140 college men enrolled in beginning classes for each sport and taught by the whole past method. The controlled subjects included 138 subjects enrolled in at the beginning classes and taught by past method. Another purpose of the study was to determine if practice in the sport would significantly improve scores in physical traits. A paired standard deviation was used to co-compare experimental and control groups. Conclusions were class commitment is probably an integral part of skill attainment in the sports studied, students taught tennis and badminton by the whole part method experience greater gain in agility and hand eye coordination, students taught tennis by the past method experience greater gains in shoulder girdle power.

2.2 PREDICTION OF PLAYING ABILITY FROM ANTHROPOMETRIC VARIABLES

Sheppard et.al. (2008) examined the potential strength, power, and anthropometric contributors to vertical jump performances that are considered specific to volleyball success: the spike jump (SPJ) and counter-movement vertical jump (CMVJ). To assess the relationship among strength, power, and anthropometric variables with CMVJ and SPJ, a correlation and regression analysis was performed.
In addition, a comparison of strength, power, and anthropometric differences between the seven best subjects and the seven worst athletes on the CMVJ test and SPJ test was performed. When expressed as body mass relative measures, moderate correlations (0.53-0.65; \( p \leq 0.01 \)) were observed between the 1RM measures and both relative CMVJ and relative SPJ. Very strong correlations were observed between relative (absolute height-standing reach height) depth jump performance and relative SPJ (0.85; \( p \leq 0.01 \)) and relative CMVJ (0.93; \( p \leq 0.01 \)). The single best regression model component for relative CMVJ was the relative depth jump performance, explaining 84% of performance. The single best predictor for relative SPJ was also the relative depth jump performance (72% of performance), with the three-component models of relative depth jump, relative CMVJ, spike jump contribution (percent difference between SPJ and CMVJ), and relative CMVJ, spike jump contribution, and peak force, accounting for 96% and 97%, respectively. The results of this study clearly demonstrate that in an elite population of volleyball players, stretch-shortening cycle performance and the ability to tolerate high stretch loads, as in the depth jump, is critical to performance in the jumps associated with volleyball performance.

Pearson et al. (2004) investigated the physiological and anthropometric characteristics of junior volleyball players competing at the elite, semi-elite, and novice levels and to establish performance standards for these athletes. One hundred and fifty-three junior national (\( N = 14 \) males; \( N = 20 \) females), state (\( N = 16 \) males;
N = 42 females), and novice (N = 27 males; N = 34 females) volleyball players participated in this study. Subjects underwent measurements of standard anthropometry (body mass, height, standing reach height, and sum of 7 skinfolds), lower-body muscular power (vertical jump and spike jump), upper-body muscular power (overhead medicine ball throw), speed (5-m and 10-m sprint), agility (T-test), and estimated maximal aerobic power (multistage fitness test) during the competitive phase of the season, after obtaining a degree of match fitness. Significant differences (p < 0.05) were detected among junior national, state, and novice volleyball players for height, standing reach height, skinfold thickness, lower-body muscular power, agility, and estimated maximal aerobic power, with the physiological and anthropometric characteristics of players typically improving with increases in playing level. Male players were taller, heavier, leaner, and had greater standing reach height, speed, agility, muscular power, and estimated maximal aerobic power than female players. These findings provide normative data and performance standards for junior volleyball players competing at the elite, semi-elite, and novice levels. Given the improvements in lower-body muscular power, agility, and estimated maximal aerobic power with increased playing level, and given the importance of these qualities to competitive performances, conditioning coaches should train these qualities to improve the playing performances of junior volleyball players.
Justin et.al. (2003), developed an effective testing battery for female field hockey by using anthropometric, physiological, and skill-related tests to distinguish between regional representative (Rep, n = 35) and local club level (Club, n = 39) female field hockey players. Rep players were significantly leaner and recorded faster times for the 10m and 40-m sprints as well as the Illinois Agility Run (with and without dribbling a hockey ball). Rep players also had greater aerobic and lower body muscular power and were more accurate in the shooting accuracy test, p < 0.05. No significant differences between groups were evident for height, body mass, speed decrement in 6 x 40-m repeated sprints, handgrip strength, or pushing speed. These results indicate that, sprinting speed, agility, dribbling control, aerobic and muscular power, and shooting accuracy can distinguish between female field hockey players of varying standards. Therefore talent identification programs for female field hockey should include assessments of these physical parameters.

2.3 PREDICTION STUDIES ON PLAYING ABILITY FROM PHYSICAL FITNESS VARIABLES

In recent years researchers in education and related disciplines have begun to take a closer look at the relationship between perception and movement. The frequent appearance in the literature of the terms perceptual motor and sensory motor is indicative of the fact that the interactions of input to output are being scrutinized more and more by contemporary scholars. The studies in which the perceptual abilities of motor activities have been explored in motor skills, while other
information emanating from these investigations contributes to more basic understanding of how humans perceive, move and develop during the earliest months of life.

**Sheppard et.al. (2008)** examined the potential strength, power, and anthropometric contributors to vertical jump performances that are considered specific to volleyball success: the spike jump (SPJ) and counter-movement vertical jump (CMVJ). To assess the relationship among strength, power, and anthropometric variables with CMVJ and SPJ, a correlation and regression analysis was performed. In addition, a comparison of strength, power, and anthropometric differences between the seven best subjects and the seven worst athletes on the CMVJ test and SPJ test was performed. When expressed as body mass relative measures, moderate correlations (0.53-0.65; p <= 0.01) were observed between the 1RM measures and both relative CMVJ and relative SPJ. Very strong correlations were observed between relative (absolute height-standing reach height) depth jump performance and relative SPJ (0.85; p <= 0.01) and relative CMVJ (0.93; p <= 0.01). The single best regression model component for relative CMVJ was the relative depth jump performance, explaining 84% of performance. The single best predictor for relative SPJ was also the relative depth jump performance (72% of performance), with the three-component models of relative depth jump, relative CMVJ, spike jump contribution (percent difference between SPJ and CMVJ), and relative CMVJ, spike jump contribution, and peak force, accounting for 96% and 97%, respectively. The
results of this study clearly demonstrate that in an elite population of volleyball players, stretch-shortening cycle performance and the ability to tolerate high stretch loads, as in the depth jump, is critical to performance in the jumps associated with volleyball performance.

Williams AG, and Wilkinson M. (2007) reported that Box-lifting ability is an important characteristic of military personnel. The purpose of this paper was to determine the usefulness of the upright row free weight exercise and simple anthropometric tests to predict maximal box-lifting performance that simulates the loading of military supply vehicles. Two groups of adults performed maximal box lifts to 1.4 m (study 1) and 1.7 m (study 2), respectively. All subjects were also tested for upright row 1 repetition maximum (1RM) strength, body mass, height, and body composition. In study 1, a remarkably good prediction of maximal box-lift performance to 1.4 m (42 +/- 12 kg) was obtained from a regression equation including the variables body mass, body composition, and upright row 1RM. Approximately 95% of the variation in 1.4-m box-lifting performance could be accounted for. In contrast, in study 2, only 80% of the variation in 1.7-m box-lifting performance (51 +/- 15 kg) could be accounted for by the best predictor equation. Upright row 1RM strength appears to be a useful tool in the prediction of box-lifting ability to approximately chest height for most adults, probably due to a close match between the muscle groups and contraction modes required during both tasks. Military or other organizations could use the data reported here to substitute simple
anthropometry and a 1RM test of strength and for the direct assessment of 1.4-m
box-lifting performance.

Gamelin FX, et.al. (2006) reported that Critical velocity (CV) represents,
theoretically, the highest velocity that can be sustained without fatigue. The aim of
this study was to compare CV computed from 5 mathematical models in order to
determine which CV estimate is better correlated with 1-hour performance and
which model provides the most accurate prediction of performance. Twelve trained
middle- and long-distance male runners (29 +/- 5 years) performed 3 randomly
ordered constant duration tests (6, 9, and 12 minutes), a maximal running velocity
test for the estimation of CV, and a 1-hour track test (actual performance). Two
linear, 2 nonlinear, and 1 exponential mathematical models were used to estimate
CV and to predict the highest velocity that could be sustained during 1 hour
(predicted performance). Although all CV estimates were correlated with
performance (0.80 < r < 0.93, p < 0.01), it appeared that CV estimated from the
exponential model was more closely associated with performance than all other
models (r = 0.93; p < 0.01). Analysis of the bias +/- 95% interval of confidence
between actual and predicted performance revealed that none of the models provided
an accurate prediction of the 1-hour performance velocity. In conclusion, the
estimation of CV allows us to rank middle- and long-distance runners with regard to
their ability to perform well in long-distance running. However, no models provide
an accurate prediction of performance that could be used as a reference for coaches or athletes.

Lintunen T, et.al. (1999) studied physical activity intentions in 12- to 16-year-old Finnish girls (n= 186) and boys (n=215). Theoretical predictions were used to establish a model that was then tested separately for each sex using path analysis. Firstly, it was hypothesised that malleable conceptions of the nature of sport ability positively influence enjoyment in physical activity and intentions to participate in physical activity, mediated by a task-oriented achievement goal independent of variations in perceptions of competence. Secondly, it was hypothesised that fixed conceptions of the nature of ability decrease enjoyment in physical activity and intentions to participate, mediated by an ego-oriented achievement goal and by perceived competence. The modified models were shown to fit the data. Overall, the results showed that 63% (boys) and 45% (girls) of the variance in intentions was explained by the model. The motivational importance of task orientation and, among the boys, perceived physical competence was confirmed with their direct prediction of intentions.

Biddle SJ, et.al. (1999) predicted physical activity intentions in 12 to 16-year-old Hungarian adolescents with two samples. Theoretical predictions established a model that was tested through path analysis. Beliefs thought to underpin goal orientations were hypothesised to predict ego orientation (general and gift beliefs) and task orientation (learning and incremental beliefs). Task orientation
was hypothesised to predict intentions directly, while ego orientation was hypothesised to predict intentions indirectly through perceived competence. Results from the first sample (n=301) suggested that the model could be improved by adding paths between general beliefs and perceived competence and between task orientation and perceived competence. This modified model was shown to fit data from a second sample (n=422) very well. Multi-group analysis confirmed a good fit and so the two samples were combined. The model fitted the data well for the total sample (n=723). Overall, results showed that 20.8% of the variance in intentions was explained by the model, and that sport ability beliefs were moderately associated with task orientation but only weakly associated with ego orientation. The motivational importance of a task orientation was confirmed with its direct prediction of intentions.

Hoffman et.al. (1983) studied the throwing and prediction performance of first, third and fifth grade boys and girls were analysed within the frame work of a four part taxonomy originally conceived by Fitts (1963). Throwing performance was assessed under task conditions which varied the motion states of the throwers body and the target (stationary and moving) by use of a dual pendulum apparatus. Accuracy scores were highest in a condition where body and target were stationary, and lowest where both body and target were moving. Task conditions requiring motion of only target or of body were of intermediate difficulty, and scores for these tasks were not significantly different from each other. There was evidence of
learning across trial blocks for all tasks, but no indication that rates of acquisition differed for the task types. Likewise, significant main effects were observed for age levels but no age x task type interactions was disclosed. Boys were more accurate than girls across task conditions, most noticeably on the two most difficult tasks. Comparison of subjects ability to predict from a stationary body position, the coincidence of moving target with a standard reference point and their ability to predict the coincidence of their moving body with the same reference point revealed lower error scores on the former prediction task.

2.4 PREDICTION OF PLAYING ABILITY FROM PHYSIOLOGICAL VARIABLES

Korhonen MT, et.al. (2009) reported that aging diminishes the ability to run fast, but the specific mechanisms responsible for this deterioration remain largely unknown. In the present study, we investigated the age-related decline in sprint running ability through a cross-sectional examination of biomechanical and skeletal muscle characteristics in 77 competitive male sprinters aged 17-82 yr. METHODS: Ground reaction force (GRF) and kinematic stride cycle parameters were measured during the maximum-velocity phase using a 9.4-m-long force platform. Knee extensor (KE) and ankle plantar flexor (PF) structural characteristics were investigated using ultrasonography and muscle biopsies (vastus lateralis). Force production characteristics of leg extensor muscles were determined by dynamic and isometric contractions. RESULTS: The main findings were as follows: 1) the
progressive age-related decline in maximum running velocity (Vmax) was mainly related to a reduction in stride length (Lstr) and an increase in ground contact time (tc), whereas stride frequency showed a minor decline and swing time remained unaffected; 2) the magnitude of average braking and push-off resultant GRFs declined with age and associated with Lstr, tc, and Vmax; 3) there was an age-related decline in muscle thickness, Type II fiber area and maximal and rapid force-generating capacity of the lower limb muscles; and 4) muscle thickness (KE + PF) was a significant predictor of braking GRF, whereas the countermovement jump height explained most of the variance in push-off GRF in stepwise regression analysis. CONCLUSIONS: Age-related slowing of maximum running speed was characterized by a decline in stride length and an increase in contact time along with a lower magnitude of GRFs. The sprint-trained athletes demonstrated an age-related selective muscular atrophy and reduced force capacity that contributed to the deterioration in sprint running ability with age.

**Papadimitriou ID, et.al. (2008)**, studied genetic influence in the making of an Olympic champion is still in its nascence, but recent work has provided findings regarding the association of the ACTN3 gene on athletic performance. The aim of this study was to examine genetic differences among elite Greek track and field athletes by analysing a mononucleotide polymorphism in exon 15 of the ACTN3 gene. Results showed that ACTN3 genotype and allele frequencies in the top power-oriented athletes were statistically significantly different from those in a
representative random sample of the Greek population: the frequency of the RR ACTN3 genotype in power-oriented athletes vs. the general population was 47.94 % vs. 25.97 %. This result was even more prominent for comparison of the subgroup of sprinters to controls. The results suggest an overall strong association between the presence of the RR genotype and elite power performance.

Nolan L, and Lees A. (2007) investigated the adjustments to posture, kinematic and temporal characteristics of performance made by lower limb amputees during the last few strides in preparation for long jump take-off. Six male unilateral trans-femoral and seven male unilateral trans-tibial amputees competing in a World Championships final were filmed in the sagittal plane using a 100-Hz digital video camera positioned so that the last three strides to take-off were visible. After digitizing using a nine-segment model, a range of kinematic variables were computed to define technique characteristics. Both the trans-femoral and trans-tibial athletes appeared to achieve their reduction in centre of mass during the flight phase between strides, and did so mainly by extending the flight time by increasing stride length, achieved by a greater flexion of the hip joint of the touch-down leg. The trans-tibial athletes appeared to adopt a technique similar to that previously reported for able-bodied athletes. They lowered their centre of mass most on their second last stride (-1.6% of body height compared with -1.4% on the last stride) and used a flexed knee at take-off on the last stride, but they were less able to control their downward velocity at touch-down (-0.4 m x s(-1)). Both this and their restricted
approach speed (8.9 m x s\(^{-1}\) at touch-down), rather than technique limitations, influenced their jump performance. The trans-femoral athletes lowered their centre of mass most on the last stride (-2.3% of body height compared with -1.6% on the second last stride) and, as they were unable to flex their prosthetic knee sufficiently, achieved this by abducting their prosthetic leg during the support phase, which led to a large downward velocity at touch-down (-0.6 m x s\(^{-1}\)). This, combined with their slower approach velocity (7.1 m x s\(^{-1}\) at touch-down), restricted their performance.

**Pearson DT, et.al. (2006)** found that Entrepreneurial marketing of sport increases demands on sport development officers to identify talented individuals for specialist development at the youngest possible age. Talent identification results in the streamlining of resources to produce optimal returns from a sports investment. However, the process of talent identification for team sports is complex and success prediction is imperfect. The aim of this review is to describe existing practices in physiological tests used for talent identification in team sports and discuss the impact of maturity-related differences on the long term outcomes particularly for male participants. Maturation is a major confounding variable in talent identification during adolescence. A myriad of hormonal changes during puberty results in physical and physiological characteristics important for sporting performance. Significant changes during puberty make the prediction of adult performance difficult from adolescent data. Furthermore, for talent identification programs to succeed, valid and reliable testing procedures must be accepted and implemented in a
range of performance-related categories. Limited success in scientifically based talent identification is evident in a range of team sports. Genetic advances challenge the ethics of talent identification in adolescent sport. However, the environment remains a significant component of success prediction in sport. Considerations for supporting talented young male athletes are discussed.

**Bosquet L, et.al. (2006)** evaluated the validity of maximal velocity (Vmax) estimated from three-parameter systems models, and to compare the predictive value of two- and three-parameter models for the 800 m. Seventeen trained male subjects (VO2max=66.54+/-7.29 ml min(-1) kg(-1)) performed five randomly ordered constant velocity tests (CVT), a maximal velocity test (mean velocity over the last 10 m portion of a 40 m sprint) and a 800 m time trial (V 800 m). Five systems models (two three-parameter and three two-parameter) were used to compute V max (three-parameter models), critical velocity (CV), anaerobic running capacity (ARC) and V800m from times to exhaustion during CVT. Vmax estimates were significantly lower than (0.19<Bias<0.24 m s(-1)) and poorly associated (0.44<r<0.49) with actual Vmax (8.43+/-0.33 m s(-1)). Critical velocity (CV) alone explained 40-62% of the variance in V800m. Combining CV with other parameters of each model to produce a calculated V800m resulted in a clear improvement of this relationship (0.83<r<0.94). Three-parameter models had a better association (0.93<r<0.94) and a lower bias (0.00<Bias<0.04 m s(-1)) with actual V800 m (5.87+/-0.49 m s(-1)) than two-parameter models (0.83<r<0.91,
0.06 < Bias < 0.20). If three-parameter models appear to have a better predictive value for short duration events such as the 800 m, the fact the Vmax is not associated with the ability it is supposed to reflect suggests that they are more empirical than systems models.

Naughton et al. (2005) estimated the values of blood pressure and heart rate in professional handball and water polo players before and after training and submaximal exercise test and to analyze the lipid state in these professional athletes in comparison with people who have never been in sports. The investigation included 30 professional handball players, 30 professional water polo players and 15 men who have never been in sports (control group). All groups were matched for age, smoking habits, family predisposition to arterial hypertension and dyslipidemia. Between these groups there were statistically significant differences of blood pressure values and heart rate in the state of rest, after exercise test and after the training. There were also statistically significant differences of total cholesterol values, LDL cholesterol, triglycerides, HDL cholesterol, LDL cholesterol/HDL cholesterol ratio and total cholesterol/HDL ratio between these groups. Differences between these groups can be explained by various values of body mass index, by activity of lipoprotein lipase in athletes, by body position during the sports activity, by thermoregulatory vasoconstriction in the water, and by effects of hydrostatic pressure and reflex mechanisms during swimming.
Van Someren KA, and Palmer GS. (2003) determined the anthropometric and physiological profile of 200-m sprint kayakers and to examine relationships with 200-m race performance. Twenty-six male kayakers who were categorised in two ability groups, international (Int) and national (Nat) level, underwent a battery of anthropometric and physiological tests and a 200-m race. Race time was significantly lower in Int than Nat (39.9 +/- 0.8 s and 42.6 +/- 0.9 s, respectively). Int 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 regression 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 Int. 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.

Olivier Hue (2003) determined which physiological variables accurately predict the race time of an Olympic-distance International Triathlon undertaken in drafted conditions, 8 elite triathletes underwent both maximal and submaximal laboratory and field physiological testing: a 400-m maximal swim test; an
incremental treadmill test; an incremental cycling test; 30 min of cycling followed by 20 min of running (C-R); and 20 min of control running (R) at the exact same speed variations as in running in C-R. Blood samples were drawn to measure venous lactate concentration after the 400-m swim and the cycle and run segments of C-R. During the maximal cycling and running exercises, data were collected using an automated breath-by-breath system. Results: The only parameters correlated with the overall drafted-triathlon time were lactate concentration noted at the end of the cycle segment (r = 0.83, p < 0.05) and the distance covered during the running part of the submaximal C-R test (r = -0.92, p < 0.01). Stepwise multiple regression analysis revealed a highly significant (r = 0.96, p < 0.02) relationship between predicted race time (from laboratory measures) and actual race time, using the following calculation: Predicted Triathlon Time (s) = -1.128 (distance covered during R of C-R [m]) 38.8 ([lactate] at the end of C in C-R) 13,338. The high [R.sup.2] value of 0.93 indicated that, taken together, these two laboratory measures could account for 93% of the variance in race times during a drafted triathlon. Conclusion: Complementing previous studies, this study demonstrates that different parameters seem to be reliable for predicting performance in drafted vs. nondrafted Olympic-triathlon races. It also demonstrates that, for elite triathletes competing in a drafted Olympic-distance triathlon, performance is accurately predicted from the results of submaximal laboratory measures.
Schabort EJ, et.al. (2000) conducted a study on prediction of triathlon race time from laboratory testing in national triathlons. The purpose of the study was to compare four days after competing in an Olympic-distance National Triathlon Championship (1500-m swim, 40-km cycle, 10-km run), five male and five female triathletes underwent comprehensive physiological testing in an attempt to determine which physiological variables accurately predict triathlon race time. METHODS: All triathletes underwent maximal swimming tests over 25 and 400 m, the determination of peak sustained power output (PPO) and peak oxygen uptake (VO2peak) during an incremental cycle test to exhaustion, and a maximal treadmill running test to assess peak running velocity and VO2peak. In addition, submaximal steady-state measures of oxygen uptake (VO2), blood [lactate], and heart rate (HR) were determined during the cycling and running tests. The five most significant (P < 0.01) predictors of triathlon performance were blood lactate measured during steady-state cycling at a workload of 4 W x kg(-1) body mass (BM) (r = 0.92), blood lactate while running at 15 km x h(-1) (r = 0.89), PPO (r = 0.86), peak treadmill running velocity (r = 0.85), and VO2peak during cycling (r = 0.85). Stepwise multiple regression analysis revealed a highly significant (r = 0.90, P < 0.001) relationship between predicted race time (from laboratory measures) and actual race time, from the following calculation: race time (s) = - 129 (peak treadmill velocity [km x h(-1)]) + 122 ([lactate] at 4 W x kg(-1) BM) + 9456. The results of this study show that race time for top triathletes competing over the Olympic distance can be accurately predicted from the results of maximal and submaximal laboratory measures.
**Stanforth et al. (1999)** made a study on "Accuracy of prediction equation to estimate submaximal VO$_2$ during cycle ergometry: the Heritage Family study". It was hypothesised that more accurate equations for estimating submaximal VO$_2$ during cycle ergometry could be developed if more independent variables were used in the equation. Subjects (715 men and women, ages 16-65 yr from the heritage family study, completed a maximal cycle ergometry test, two submaximal trials at 50 W and 60% of VO$_2$ max, hydrostatic weighting and stature and body mass measures before and after 20 wk of cycle ergometry training. Regression analysis generated prediction equation using pretraining data from the 60% trials. The results showed no equation with more independent variables was better than an equation that used only power output. This equation, Heritage –1 with only power output was cross validated using the jackknife technique. Paired t tests, mean differences, SEEs and Es were used to compare the VO$_2$ estimated by Heritage –1 and those previously published equations with the measures VO$_2$ at 60% of VO$_2$ max. The study concluded finding Heritage –1 was slightly better than the equations of ACSM, Lang et al., and Latin and Berg using pretraining data but was not better when using post-training data. All four of these equations were superior to the equations of Berry et al and Londeree et al.

**Mannion, Adams, Cooper and Dolan (1999)** made a study on Prediction of maximal back muscle strength from indices of body mass and fat-free body mass. For this purpose, the maximal voluntary isometric back extensor strength of 456
volunteers, age 18-42 yr and with no history of low back pain, was measured in a standing, slightly flexed forward posture. This was then correlated with two indices of body size; body mass and fat-free body mass. Significant linear relationships were observed between back muscle strength and each of the two indices of body size. There was a gender difference in both the slope and the intercept of the regression equations describing the relationships. There was no independent influence of age within the range studied. It was concluded that it was possible to establish predictive equations for back extensor strength based on body size which could be used to quantify strength ‘deficits’, for instance in patients with low back pain, and to prescribe submaximal target forces for use in endurance training and testing.

**Hooper SL, Mackinnon LT, Howard A (1999)** conducted a study on physiological and psychometric variables for monitoring recovery during tapering for major competition. The purpose of study was to identify variables that are useful in monitoring recovery during tapering. Changes in physiological variables, tethered swimming force, mood states, and self-ratings of well-being were measured in 10 elite swimmers from before to after 2 wk of tapering for national championships. Physiological measures included resting heart rate (HR); blood pressure (BP); blood lactate concentration; red blood cell, white blood cell, and differential counts; and plasma cortisol, free testosterone, and catecholamine concentrations. Measures taken after 100-m maximal and 200-m standardized submaximal swims included HR, BP, and blood lactate concentration. The results were: Step-down regression analysis
showed that changes in plasma norepinephrine concentration, heart rate after maximal effort swimming and confusion as measured by the Profile of Mood States (POMS) predicted the change in swimming time with tapering \( r^2 = 0.98 \); the change in plasma norepinephrine concentration predicted the change in swim time with tapering \( r^2 = 0.82 \) by itself. These data suggest that recovery after intense training can be monitored during tapering and that an accurate prediction of performance changes may be possible if the changes in a range of physiological and psychological variables are measured.

Stanish, (1994) investigation was to identify the best predictors of performance on the Physical Ability Requirement Evaluation (PARE) using field measures of physical fitness thought to be important in law enforcement. The objective was to provide RCMP recruits and officers with information regarding the physical demands of the test for training and preparation purposes. Twenty seven females and twenty one males between 19 and 31 years of age participated in the study. All of the subjects completed 10 field tests of fitness which included measures of muscular strength, muscular endurance, agility, anaerobic power, and body composition. Performance scores (total time) on the PARE were found to be significantly \( P<0.05 \) and positively correlated to agility \( r= 0.73 \), anaerobic capacity (sprint) \( r=0.70 \), and aerobic capacity \( r=0.66 \), and negatively correlated to upper body muscular endurance \( r=0.71 \), anaerobic power (jump) \( r = 0.71 \), and upper body muscular strength \( r=0.63 \). Backward selection, stepwise, multiple
linear regression analysis indicated that 66% of the variance in PARE performance time was accounted for by agility and upper body muscular endurance. Multiple regression analyses were conducted on the male and female subject groups separately. The analyses demonstrated that 78% of variance in performance time was accounted for by upper body muscular endurance, agility, and anaerobic power for the males, and 49% of variance in performance time was accounted for by aerobic power and upper body muscular endurance in females. Cross-validation was conducted to determine which variables were important in predicting PARE performance. The model was constructed on 19 subjects and validated on the remaining 29 and identified the best prediction variables for the data included sex, upper body muscular endurance, and agility.

**Kramer, Leger, Paterson and Marrow (1994)** made a study on rowing performance and selected descriptive, field and laboratory variable. The purpose of this study was to determine the relationship among measures of rowing performance and selected descriptive, field and laboratory variables. Rowing performance of 20 inter collegiate women was assessed using 2,500m time test on a concept of rowing ergometer. The rowers competitive experience and the coach's ranking of the rowers. The women also undersent standard, descriptive tests including anthropometric measurements, field tests including gas rowing ergometer distance and weight lifting tests, and laboratory tests including VO₂ max and isokinetic knee extensor strength tests. Rowing ergometer time were highly related to competitive
experience and coach’s ranking VO\(_2\)max was the only other variable to produce correlations greater than 0.71 with rowing performance. Although most of the correlations observed in the present study were poor to modestly high they do document and quantify relationships, and suggest that training and testing techniques should be modified to be more rowing specific and that their usefulness with respect to positive transfer and prediction should be examined.

Sleivert and Wenger (1993) conducted a study on physiological prediction of short course performance. The purpose of this study was to investigate if selected physiological variables were related to triathlon performance. Eighteen male and seven female triathletes competed in a short-course triathlon (1-km swim, 30-km cycle, 9-km run) and underwent physiological testing within 14 d. VO\(_2\)max and ventilatory threshold (VT) were measured on a cycle ergometer, treadmill, and tethered swim apparatus. Leg flexion and extension strength were measured on a Cybex II isokinetic dynamometer. Multiple linear regression did not improve the prediction of triathlon performance over that provided by simple correlations. Swim performance was related to relative swim VO\(_2\)max in both males (r = -0.48) and females (r = -0.93) as well as the resistance pulled at swim VT (r = -0.81) and absolute leg flexion strength (r = -0.77) in females. No physiological variables were significantly related to cycling time in either gender. Running time was related to relative VO\(_2\)max (r = -0.88) in females and velocity at run VT in both females (r = -0.88) and males (r = -0.73). Relative swim VO\(_2\)max (r = -0.98), velocity at run VT (r
= -0.89), and absolute leg flexion strength (r = -0.80) were related to overall performance in female triathletes. The only significant predictor of overall triathlon time for males was velocity at run VT (r = -0.78). It therefore appears that in short-course triathletes physiological variables in swimming and running are important to overall performance. Differences in sample size, group variability, and level of performance between males and females may account for the reported differences in the physiological predictors of performance between genders.

Obert P, Falgairette G, Bedu M, Coudert J (1992) conducted a study on Bioenergetic characteristics of swimmers determined during an arm-ergometer test and during swimming. In this study the maximal oxygen uptake (VO2max) of 13 swimmers was determined by an arm-ergometer test (direct method) and estimated from a maximal multistage swimming test (indirect method) (23). A test-retest of the progressive swimming exercise showed that there were no significant differences from one test to the other and that there were significant correlations between the principal parameters: arm stroke index: 0.73, maximal aerobic swimming velocity: 0.94, VO2max: 0.95, p less than .01. Therefore, for swimmers of average ability, the reproducibility of this test has been proved. A significant difference (p less than 0.001) was observed between the two tests for VO2max: arm-ergometer test (VO2max arms): 2.4 +/- 0.5 l.min-1, swimming test (VO2max ST): 3.2 +/- 0.7 l.min-1, p less than 0.01. This difference appeared to be linked to the use of a greater muscle mass (arms and legs) during swimming. A significant correlation (r = 0.73, p
less than 0.01) was obtained between VO2max (l/min-1) by using both the direct and indirect exercises as methods of measurement. However, the level of r did not permit the prediction of one parameter from the other. Significant correlations were obtained between VO2max and performances over 200 and 400 m free style regardless of the methodology used (VO2max arm, VO2max ST). Moreover, only VO2max (arm, ST) emerged as a variable accounting for swimming performance from a step-wise multiple regression analysis, in which biometric and bioenergetic parameters were taken into account.

Doren, E. Brown (1991) reported that the activity level, the fitness level (VO2 max & PWC: Physical work capacity) and the body composition (BMI : Body mass index, LBM : lean body mass, fat weight, and percent fat ) relative to blood pressure were examined in 40 elderly (69+/- 6yr ) borderline hypertensive subjects. Resting systolic (DBP) blood pressure were measured with a random zero sphygmomanometer. Activity was assessed by the Stanford Physical Activity Questionnaire. Fitness was assessed by graded bicycle testing. Body composition was assessed by bio-impedance and mathematical equations. Multiple regression analysis was used to analyze the data. Form this investigation, regression determined the variance (r2%) in SBP (143=-23) and DBP (75+/-12) was explained by activity (2936 +/-794 Kcal/wk), fitness (VO2MAX = 22+/-7 ml/kg/min & PWC + 326 +/-172 kgm/min) and BMI (26.7/-4.1 kg/m2). The combination of PWC and BMI Significantly improved the multiple correlations r.
These were $R = .41$ (16.8%) for SBP AND $r = .37$ (13.7%) for DBP. These results suggest both SBP and DBP are influenced independently by fitness (PWC) and BMI in an elderly population.

Hudson, J.L. (1985) examined the use of selected biomechanical variables in the prediction of basketball skill. The subjects were college women in three mutually exclusive groups of basketball skill: an elite group of six competitors on the United States team in the World University Games, a good group of seven players on a varsity team, and a poor group of nine members of an instructional class. An accuracy test and digitized film records provided the data for 12 variables related to the process or product of free throw shooting. Discriminant analysis was employed to predict the categorical variable of skill. The most discrimination came from variables of accuracy, stability, and height of release rather than from variables of projection. Poor shooters were distinguished by instability; elite shooters were characterized by a high point of release and accuracy under pressure. Depending on the method of prediction, rates for correct classification of subjects ranged from 76-100%. Thus, it appears that discriminant analysis using biomechanical variables can be a successful tool in the prediction of basketball skill.

2.5 PREDICTION OF PLAYING ABILITIES AND PERFORMANCE VARIABLES

Abrahamsen FE, et.al. (2008) examines the relationship between motivation, social support and performance anxiety with team handball players
(n=143) from 10 elite teams. Based on these theories and previous findings, the study has three purposes. First, it was predicted that the female athletes (n=69) would report more performance worries and more social support use than males (n=74). The findings support the hypothesis for anxiety, but not for social support use. However, females report that they felt social support was more available than males. Second, we predicted and found a positive relationship between the interaction of ego orientation and perceptions of a performance climate on performance anxiety, but only for females. As predicted, perceived ability mediated this relationship. Finally, we predicted that perceptions of a performance climate were related to the view that social support was less available especially for the male athletes. Simple correlation supports this prediction, but the regression analyses did not reach significance. Thus, we could not test for mediation of social support between motivational variables and anxiety. The results illustrate that fostering a mastery climate helps elite athletes tackle competitive pressure.

Stafilidis S, and Arampatzis A. (2007), study was to test the hypothesis that sprint performance (time over a given distance) would be affected by track compliance, with better performances on the more compliant surface. Ten sprinters participated in the study. The athletes performed maximal sprints (60 m) on three different track configurations (hard, 5500 kN m(-1); soft, 2200 kN m(-1); spring, 550 kN m(-1)). A 60-m single-lane running surface was constructed. Plywood boards (1.2 cm thick) were placed on a 60 x 0.6 m wooden chipboard frame serving as the
base surface. All participants ran two times on each track configuration in a randomized order. The athletes' kinematics were recorded using the Vicon 624 system with 12 cameras operating at 250 Hz. Four Kistler force plates (1250 Hz) were used to record ground reaction forces. Sprint performance (time over 60 m) was unaffected by the different track compliances ($P= 0.57$). In addition, there was no effect of track ($P> 0.05$) on the sprinting kinematics and kinetics of the ankle or knee joint. The hypothesis that sprint performance is affected by track compliance can be rejected because the sprinters recorded similar performances while sprinting over 60 m on all three track configurations. We conclude that: (1) the possible deformation of the track while sprinting is minor enough not to cause a specific adjustment in the leg mechanics affecting the effectiveness of the stretch-shortening cycle of the sprinters; and (2) the energy exchange between sprinters and tracks has only a marginal effect on sprint performance due to its small magnitude. More research on tracks with lower stiffness is required.

Stafilidis S, and Arampatzis A. (2007) determined whether sprint performance is related to the mechanical (elongation - force relationship of the tendon and aponeurosis, muscle strength) and morphological (fascicle length, pennation angle, muscle thickness) properties of the quadriceps femoris and triceps surae muscle - tendon units. Two groups of sprinters (slow, $n = 11$; fast, $n = 17$) performed maximal isometric knee extension and plantar flexion contractions on a dynamometer at 11 different muscle - tendon unit lengths. Elongation of the tendon
and aponeurosis of the gastrocnemius medialis and the vastus lateralis was measured using ultrasonography. We observed no significant differences in maximal joint moments at the ankle and knee joints or morphological properties of the gastrocnemius medialis and vastus lateralis between groups (P > 0.05). The fast group exhibited greater elongation of the vastus lateralis tendon and aponeurosis at a given tendon force, and greater maximal elongation of the vastus lateralis tendon and aponeurosis during maximum voluntary contraction (P < 0.05). Furthermore, maximal elongation of the vastus lateralis tendon and aponeurosis showed a significant correlation with 100-m sprint times (r = -0.567, P = 0.003). For the elongation-force relationship at the gastrocnemius medialis tendon and aponeurosis, the two groups recorded similar values. It is suggested that the greater elongation of the vastus lateralis tendon and aponeurosis of the fast group benefits energy storage and return as well as the shortening velocity of the muscle-tendon unit.

Arampatzis A, et.al. (2007), investigated whether the mechanical properties (i.e. force strain relationship) of the triceps surae tendon and aponeurosis relate to the performed sport activity in an intensity-dependent manner. This was done by comparing sprinters with endurance runners and subjects not active in sports. Sixty-six young male subjects (26+/−5 yr; 183+/−6 cm; 77.6+/−6.7 kg) participated in the study. Ten of these subjects were adults not active in sports, 28 were endurance runners and 28 sprinters. All subjects performed isometric maximal voluntary plantar flexion contractions (MVC) on a dynamometer. The distal
aponeuroses of the gastrocnemius medialis (GM) was visualised by ultrasound during the MVC. The results showed that only the sprinters had higher normalised stiffness (relationship between tendon force and tendon strain) of the triceps surae tendon and aponeurosis and maximal calculated tendon forces than the endurance runners and the subjects not active in sports. Furthermore, including the data of all 66 examined participants tendon stiffness correlated significantly \((r=0.817, P<0.001)\) with the maximal tendon force achieved during the MVC. It has been concluded that the mechanical properties of the triceps surae tendon and aponeurosis do not show a graded response to the intensity of the performed sport activity but rather remain at control level in a wide range of applied strains and that strain amplitude and/or frequency should exceed a given threshold in order to trigger additional adaptation effects. The results further indicate that subjects with higher muscle strength possibly increase the margin of tolerated mechanical loading of the tendon due to the greater stiffness of their triceps surae tendon and aponeurosis.

**Mero A, et.al. (2006)** examined the effects of muscle-tendon length on joint moment and power during maximal sprint starts. Nine male sprinters performed maximal sprint starts from the blocks that were adjusted either to 40 degrees or 65 degrees to the horizontal. Ground reaction forces were recorded at 833 Hz using a force platform and kinematic data were recorded at 200 Hz with a film camera. Joint moments and powers were analysed using kinematic and kinetic data. Muscle - tendon lengths of the medial gastrocnemius, soleus, vastus medialis, rectus femoris
and biceps femoris were calculated from the set position to the end of the first single leg contact. The results indicated that block velocity (the horizontal velocity of centre of mass at the end of the block phase) was greater (P < 0.01) in the 40 degrees than in the 65 degrees block angle condition (3.39 +/- 0.23 vs. 3.30 +/- 0.21 m . s(-1)). Similarly, the initial lengths of the gastrocnemius and soleus of the front leg in the block at the beginning of force production until half way through the block phase were longer (P < 0.001) in the 40 degrees than in the 65 degrees block angle condition. The initial length and the length in the middle of the block phase were also longer in the 40 degrees than in the 65 degrees block angle condition both for both the gastrocnemius (P < 0.01) and soleus (P < 0.01-0.05) of the rear leg. In contrast, the initial lengths of the rectus femoris and vastus medialis of the front leg were longer (P < 0.05) in the 65 degrees than in the 40 degrees block angle condition. All differences gradually disappeared during the later block phase. The peak ankle joint moment (P < 0.01) and power (P < 0.05) during the block phase were greater in the 40 degrees than in the 65 degrees block angle condition for the rear leg. The peak ankle joint moment during the block phase was greater (P < 0.05) in the 40 degrees block angle for the front leg, whereas the peak knee joint moment of the rear leg was greater (P < 0.01) in the 65 degrees block angle condition. The results suggest that the longer initial muscle-tendon lengths of the gastrocnemius and soleus in the block phase at the beginning of force production contribute to the greater peak ankle joint moment and power and consequently the greater block velocity during the sprint start.
Sudheer (2004) conducted a study to predict badminton playing ability from selected skills physical, anthropometrical and psychological variables of university men. Fifty subjects of University Men Badminton players in the age group of 17 to 25 years who studied in the Universities of Kerala, Calicut, Mahatma Gandhi and Kerala agricultural during the year 1999-2000, 2000-2001, 2001-2002, 2002-2003 were selected as subjects for this study.

Falk B, et.al. (2004) reported that The processes of talent detection and early development are critical in any sport programme. However, not much is known about the appropriate strategies to be implemented during these processes, and little scientific inquiry has been conducted in this area. The aim of this study was to identify variables of swimming, ball handling and physical ability, as well as game intelligence, which could assist in the selection process of young water-polo players. Twenty-four players aged 14-15 years underwent a battery of tests three times during a 2-year period, before selection to the junior national team. The tests included: freestyle swim for 50, 100, 200 and 400 m, 100-m breast-stroke, 100-m 'butterfly' (with breast-stroke leg motion), 50-m dribbling, throwing at the goal, throw for distance in the water, vertical 'jump' from the water, and evaluation of game intelligence by two coaches. A comparison of those players eventually selected to the team and those not selected demonstrated that, 2 years before selection, selected players were already superior on most of the swim tasks (with the exception of breast-stroke and 50-m freestyle), as well as dribbling and game intelligence. This
superiority was maintained throughout the 2 years. Two-way tabulation revealed that, based on baseline scores, the prediction for 67% of the players was in agreement with the final selection to the junior national team. We recommend that fewer swim events be used in the process of selecting young water-polo players, and that greater emphasis should be placed on evaluation of game intelligence.

Chauhan (2004) predicted the performance of University throwers by developing the regression equation for the prediction of performance of university throwers in relation to their anthropometric measurements. To achieve the objectives of the study, thirty throwers were selected as subjects from the University Athletic Meet of Kurukshetra University, Kurukshetra. Thirty-two body measurements were taken with the help of anthropometer, steel tape, vernier caliper and skin fold caliper according to the instructions of Weiner and Lourie (1969). The throwing performance of the subjects was measured in terms of performance in putting the shot. Product moment method for inter-correlation and Wherry Do Little Method for calculating multiple correlation and development of regression equation for the prediction of performance were applied. The linear measurements, i.e., height, leg length, fore-leg length, total arm length, upper and fore arm length, circumferences i.e. shoulder, chest, abdomen, hip and arm, body diameters i.e. biacromial, bicristal and elbow diameters, and skin fold measurements, i.e. biceps, sub scapular, suprailiac and calf skin folds have been found to possess positive and significant correlations with throwing performances at 1% and 5% levels
respectively. Among body composition variables i.e., fat percentage, fat weight and lean body mass have positive and significant correlations but body density has negative and significant correlation with throwing performance at 5% level. The multiple correlation of body weight, height and total arm length with throwing performance is positive and highly significant (R=.935). The size of the multiple correlation is quite sufficient and hence the regression equation developed can be used for the prediction of throwing performance of the athletes.

**Korhonen MT, et.al. (2003)** study was undertaken to investigate age-related differences in the velocity and selected stride parameters in male and female master sprinters and to determine which stride characteristics were related to the overall decline in the performance of the 100 m with age. METHODS: The performances of 70 finalists (males 40-88 yr, females 35-87 yr) at the European Veterans Athletics Championships were recorded using two high-speed cameras (200 Hz) with a panning video technique and distance markers at 10-m intervals. Velocity, stride length (SL), stride rate (SR), ground contact time (CT), and flight time (FT) during the acceleration, peak velocity, and deceleration phases of the 100-m race were determined from the video records with the aid of the Peak Performance analysis system. RESULTS: There was a general decline in sprint performances with age, the decrease becoming more evident around 65-70 yr of age. The velocity during the different phases of the run declined on average from 5 to 6% per decade in males and from 5 to 7% per decade in females. Similarly, SL showed clear reductions with
increasing age, whereas SR remained unchanged until the oldest age groups in both genders. Furthermore, the CT, which correlated with velocity, was significantly longer, and FT, which correlated with both velocity and SL, was shorter in older age groups. CONCLUSION: Our findings indicated that age-associated differences in velocity in elite master sprinters were similar in each phase of the 100-m run. The deterioration of the overall performance with age was primarily related to reduction in SL and increase in CT.

Delecluse C, et.al. (2003) examined the impact of short-term (7-day), high-dose (0.35 g·kg(-1)·d(-1)) oral creatine monohydrate supplementation (CrS) on single sprint running performance (40 m, <6 seconds) and on intermittent sprint performance in highly trained sprinters. Nine subjects completed the double-blind cross-over design with 2 supplementation periods (placebo and creatine) and a 7-week wash-out period. A test protocol consisting of 40-m sprint runs was performed, and running velocity was continuously recorded over the total distance. The maximal sprint performance, the relative degree of fatigue at the end of intermittent sprint exercise (6 x 40 m, 30-second rest interval), as well as the degree of recovery (120-second passive rest) remained unchanged following CrS. There were no significant changes related to CrS in absolute running velocity at any distance between start and finish (40 m). It was concluded that no ergogenic effect on single or repeated 40-m sprint times with varying rest periods was observed in highly trained athletes.
The strength required for being quick off the mark and jumping to head the ball as well as the powerful header itself, the strength required for the shot and the supporting strength of the standing leg, as well as strength of the arms required to break a player's fall gently in the case of diving headers represent a number of the main occasions when the soccer player must deploy strength (Hermiston, et.al. 1979, Mayhew, et.al. 1995, Feliu Rovira, et.al. 1991, Bork, et.al. 1985, Kramer, et.al. 1994 and Mannium, et.al.1999).

Padilla, Mjuka, Evesta, and Gorriena, (1999) conducted a study on level ground and uphill cycling ability in professional road cycling. The purpose of the study was to evaluate the physiological capacities and performance of professional road cyclist in relation to their morphotype dependent specialty. The methodology of this was 24 world class cyclists, classified as flat terrain (N=5), time trial (N=4), all terrain (N=6) and uphill (N=9) specialists, completes an incremental laboratory cycling test to assess maximal power outfit (w max) maximal oxygen uptake (VO2 max), lactate threshold (LT), and onset of blood lactate accumulation (OBLA). The results was to UH had a higher front area, body max (BM) ratio (5.23 +/- 0.07 M x Kg (-1) > 10 (.3) then FT and TT (p < 0.05). FT showed the highest absolute W max and UH the highest W max relative to BM and W (OBCA) values were significantly higher in Ft and TT and then in UH. FT andTT had the highest w max per FA unit and whereas TT had the highest absolute w kg (-0.32) and w Kg (-0.79), as well as w Kg (-0.32) w Kg (-0.79) and w m2 at the LT and OBLA. The conclusion was
scaling of the maximal and submaximal physiological values showed a performance advantage of 77 over FT, AT and UH in all cycling terrain's and conditions and mass exponents of 0.32 and one week the most appropriate to evaluate level and uphill cycling ability, respectively, whereas absolute $V_{max}$ values are recommended for perform an prediction is short events on level terrain and $w_{LT}$ and $W_{OBCA}$ in longer time trials and uphill cycling.

**Kioumourtzoglou, Kourtessis, Michalopoulou, Derri (1998)** conducted a study on the differences in several perceptual abilities between experts and novice players in basketball, volleyball and water polo. The aim of this study was to examine differences between experts and novices in a number of perceptual abilities. Three groups of elite athletes, 44 members of Greek national teams in basketball ($n = 12$), volleyball ($n = 13$), and water-polo ($n = 19$) were selected. Two groups of physical education students ($n_s = 18$ 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 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.

Kioumourtzoglou, Derri, Tzetis and Theodorakis (1998) conducted a study on cognitive, perceptual and motor ability in skilled basketball performance. The purpose of this study was to find identification and selection of the best athletes in a specific sport. For the purpose of this study, a group of 13 men on the elite male national team of basketball players, 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.

Identifying and developing rugby talent among 10 year old boys was conducted by Prenaer, Spamer and Steyn (1998). The physical, motor and anthropometric variables of 173 ten year old boys with no rugby experience from a cross section of the population were selected at random and subjected to 14 physical and motor tests and 14 anthropometric measurements. The three top teams (n=45
individual from school level under 11 rugby league were selected and also tested. The results from these three teams were used as the criteria for rugby talent among 10 year old boys. To establish the best predictors of talent, a stepwise discriminate analysis was conducted, this indicate that eight variables (four motor and four anthropometric) discriminated maximally between the talented and the rest of the players of this age. With classification of functions based on these eight variables, 93.5% of all the subjects were classified correctly, indicating good validity. An analysis, based on the selected variables, was then conducted on all the under 11 teams that played in the league in the region (n=330) and they were ranked according to the scores of the first canonical variable from the most to the least talented. By comparing these results with the players who were chosen for the region's primary schools team, a success rate of 88% in prediction of talent was established. It was concluded that this is a successful and practical method to aid the teacher and the coach in selecting and developing talent among 10 year old rugby players in South Africa.

**Grubbs, Nelson, Bandy(1997)** conducted a study of predictive validity on a injury score among high school basketball players. The purpose of this study was to investigate the predictive value of the injury score among high school basketball players. Following the establishment of reliability of measures, injury scores were calculated for 62 high school basketball players (34 females, 28 males) before the start of the season. Lower extremity injuries sustained while playing basketball were
recorded throughout the season. The predictive value of the injury score equation was determined by calculating sensitivity, specificity, and positive and negative predictive values. The sensitivity and specificity were calculated to be 16.7% and 66.1%, respectively. The positive and negative predictive values were calculated to be 5.90% and 88.1%, respectively. These results indicate that the injury prediction score investigated was not a valid means of predicting injury in high school basketball players.

**Mayhew, Prinster, Ware, Zimmer, Arabas, Bemben (1995)** conducted a study on Muscular endurance repetitions to predict bench press strength in men of different training levels. The purpose of this study was to determine the accuracy of predicting maximal bench press (BP) strength (1-RM) from relative endurance performance in various groups of men. The subjects included untrained students (n = 35), resistance trained students (n = 28), college wrestlers (n = 21), soccer players (n = 22), football players (n = 51), high school students (n = 35), and resistance-trained middle-aged men (n = 24). Each subject performed a 1-RM test according to the same standard procedure. Within 4-10 days, the subject selected a weight to perform as many repetitions as possible to failure. Six relative endurance prediction equations produced validity coefficients of $r = 0.86$ to 0.98 in each group and $r = 0.82$ to 0.98 in the composite group (n = 220). In subjects completing $< 10$ repetitions-to-failure, three equations significantly overpredicted and two significantly underpredicted 1-RM scores. The Brzycki equation was the most accurate. In
subjects completing > 10 repetitions to failure, three equations significantly overpredicted and three significantly underpredicted 1-RM scores. While caution should be used when employing relative muscular endurance performance to estimate 1-RM strength in the bench press, the average of two equations may reduce the error.

Mayhew, Piper. Ware(1993) conducted a study on Anthropometric correlates with strength performance among resistance trained athletes. The relationship between selected anthropometric dimensions and strength performance in resistance trained athletes for fifty-eight college football players were measured. A 10-week resistance training program was conducted. The one-repetition maximum (1-RM) lifts in the bench press, squat, and dead lift and for 11 anthropometric dimensions were measured. Results indicated that the highest relationships existed between estimates of regional muscle mass (arm circumference, arm muscle cross-sectional area, and thigh circumference) and lifting performance. Multiple regression analysis selected arm size and %fat as variables common to the prediction of all three lifts. The fewer joints and muscle groups involved in a lift, the greater the predictive accuracy from structural dimensions. It was concluded that body structure and conformation make significant contributions to maximum strength performance in highly trained strength athletes.

The literature reviewed on perceptual and motor ability have shown that the elite players better than the intermediate players and individual differences in rate of
visual information process were interpreted as reflecting the operation of attentional factors (Kioumourtoglou et.al. 1998 and Adum et.al. 1992).

Adam and Wilberg (1992) conducted a study on the individual differences in visual information processing rate and prediction of performance difference in team sports. The purpose of the study was to use backward masking paradigm to examine individual differences in rate of visual information processing among university basketball, ice hockey and football players. Displays containing four letters were presented for stimulus durations ranging from 25 to 300 ms. Following stimulus offset, a masking stimulus was presented for 200 ms. The subjects were instructed to write down as many letters as possible from the briefly presented stimulus display on a specially prepared response grid. The results indicated consistent individual differences in rate of visual information processing. More importantly, it was found that rate of visual information processing as indexed by the backward-masking technique, has promising validity for predicting general performance excellence in university ice hockey and basketball players. Individual differences in rate of visual information processing were interpreted as reflecting the operation of attentional factors.

A study was made by Feliu Rovira et.al. (1991) on Prediction of physical endurance in athletes during puberty: analysis of high performance soccer players. Pubescent maturity is an essential element in obtaining physical capacity. Having described the anthropometric characteristics, such as body structure and results in the
physical and functional tests, of a group of football players in relation to their pubescent level, the results showed which tests has a higher predictive level on the physical capacity. Age can predict 54% of the variation of results in 500 m. run and 59% in the 60 m. dash. If pubescent maturity and the measurement of the tricipital skin-fold are also taken into consideration the prediction level goes up to 72% in 500 m. run and 75% in the 60 m. dash.

Buckolz, Prapavesis and Fairs (1988) conducted a study on "advance Cues and their use in predicting tennis passing shots". The investigators delimited the specific advance cues that tennis players might employ as a basis for predicting the passing shots or their opponents and as well to evaluate the predictive accuracy of any such cues identified. (i.e. forehand, and backhand; down-the-line, cross-court, or lob). In addition, an effort has been made to determine whether individuals judged to possess advanced tennis skills make more an intermediate level of overall tennis proficiency. The results obtained indicate that advance body language cues do exist that accurately forecast passing shot location, and this is particularly true for forehand shots. Generally, advanced players predicted passing – shot type more accurately than did their intermediate counterparts. In some instances, this difference in accuracy can be attributed to the fact that the intermediate players were unaware of what the telegraphic cues were while, in other situations, the difference in prediction ability is primarily due to the intermediate player's more frequent failure to detect the presence of known telegraphic cues, that is, forehand shots.
Meeuwisse and Fowler (1988) conducted a study on the frequency of predictability of sports injuries in intercollegiate athletes. The purpose of the study was to analyze injury frequency and predictability in 712 intercollegiate athletes in 24 different male and female sports over the 1984-85 season. The injury rate was 38% for males and 32% for females, with the males suffering more acute injuries. While the men's hockey team had the highest player injury rate, the football team had the greatest absolute number of injuries. Overall, the anatomic location with the highest injury rate was the knee, while sprains were the most common type of injury. Further elaboration of these results are provided in graphic form. By comparing injury occurrence to past history and preparticipation physical findings, this study assesses the predictability of injury. With one exception, no significant relationship was found. It would appear that the preseason exam may play a role in identification, rather than prediction of sports injuries.

2.6 SUMMARY OF RELATED LITERATURE

The investigator has reviewed several journals, research articles and presented the above related studies in three broad areas, namely, prediction studies on handball players’ athletic abilities of the sportmen from anthropometric, physical fitness variables, prediction of playing abilities of the sportmen from physiological variables and prediction of playing abilities from performance variables. From the reviewed studies it was inferred that there was scope for further research in
determining inter university level handball players’ playing ability from selected anthropometric, physical, physiological, psychological and performance variables.

Based on the experience the investigator gained, the investigator selected suitable methodology to be followed in this research, which was presented in Chapter III.