The performance of today's athletes is due to a complex blend of many factors including genetic endowment, training and the health/nutritional status of the athlete (MacDougall, Wenger and Green 1991). There is an increasing trend towards a more scientific approach to training as athletes and coaches attempt to maximise performance whilst minimising the effects of overtraining (such as overtraining syndrome and overuse injuries). According to MacDougall, Wenger and Green (1991) physiological testing of athletes is beneficial in four ways:

- It indicates the athlete's strengths and weaknesses in relation to their sport, whilst providing baseline data for individual training program prescriptions.

- It gives the athlete and coach feedback, whilst assessing the effectiveness of training programs.

- It provides information on the health status of the athlete.

- It acts as an educational process by which the athlete learns to better understand their body and the demands of the sport.
A study of relevant literature is essential to get a full picture of what has been done and said, with regard to the problem under study. The review of literature before and after the selection of the problem developed deep understanding of the subject in which an investigator intended to investigate and explore new areas. Recorded knowledge of the past, revealed the problem and also developed understanding of various techniques available for such a study. These purposes can only be accomplished by a systematic and thorough study of the available literature. Sincere efforts have been made by the investigator to locate literature related to this study. The reviews of the relevant studies found from various sources are enumerated below.

In order for exercise physiologists to construct and implement specific training programs, they must have access to the fundamental information concerning the qualities that contribute to successful athletic performance. This may include the development of a functional training model to determine the relative contributions and kinetics of metabolism and other physiological factors that contribute to performance. Sport specificity is also important when testing aerobic capacity and trying to get an accurate picture of the aerobic demands of the sport being completed (Bergh et al., 2007).
The athletes in a particular sport must possess such typical characteristics which are of advantage to their performance. Body composition also makes an important contribution to an individual’s level of physical fitness for performance, particularly in such sports that require one to carry one’s body weight over a distance, which is facilitated by a large proportion of active tissue (muscle) in relation to a small proportion of fat tissue.

**STUDIES RELATED TO CYCLING (ENDURANCE SPORTS)**

Bicycle racing demands a wide range of physiological capabilities, from being able to ride at race pace for hours and then finish with a sprint at full speed, to be able to climb long and short hills, to accelerated anaerobically several times per mile in a criterium. Unlike cycling, many endurance sports do not require the extremes in physiological capabilities (e.g. marathoners don’t need a fast sprint). Because cycling requires such a wide range of capabilities, it is a challenge to develop a training plan that prepares a cyclist for all aspects adequately.
Competitive cycling is a varied and challenging sport. Therefore it is not surprising that one of the best determinants for success in road cycling is maximal oxygen consumption (\(\text{VO}_{2\text{ max}}\)). However explosive anaerobic power plays a significant role in breakaway attempts, hill climbing and sprints towards the finish line. Thus, anaerobic testing of a road cyclist is equally as important as determining aerobic ability.

Saltin and Astrand (1967) stated that the maximum aerobic capacity (\(\text{VO}_{2\text{ max}}\)) is a determining factor in endurance events. Shepherd et al, (1968) states that maximum aerobic capacity as a result of endurance training, distance runners acquire a high relative \(\text{VO}_{2\text{ max}}\).

Kenney & Hodgson (1985) and Bunc et al, (1987) in a studied the maximum oxygen consumption of elite international cyclists (74.4 and 74.8 ml.kg\(^{-1}\).min\(^{-1}\)). Ghosh et al (1988) reported that the relative \(\text{VO}_{2\text{ max}}\) of Indian long distance runners (68.1 ml.kg\(^{-1}\).min\(^{-1}\)).

Foley et al (1989) conducted upon 36 competitive male cyclists (mean age 23.4 years) who had been competing on average for 8.2 years. Cyclists were allocated to one of four groups; sprint, pursuit, road and time trial according to their competitive strengths. The sprint cyclists were significantly shorter and more mesomorphic than the other three groups (p less than 0.05). The time trialists were the tallest, most ectomorphic group, having the
longest legs (p less than 0.01), the highest leg length/height ratio (p less than 0.05) and the greatest bitrochanteric width (p less than 0.05). The pursuit and road cyclists were found to have similar physiques, which were located between those of the sprinters and time trialists. The biomechanical implications of these differences in physique may be related to the high rate of pedal revolutions required by sprinters and the higher gear ratios used by time trialists.

Ekblom,(1969); Pollock, (1973), and Daniels et al, (1978) stated since VO$_2$ max is a test for assessing the running endurance, the distance runners who acquire a high VO$_2$ max, will obviously be at an advantage. VO$_2$ max improves with training but reaches a plateau at a certain time, whereas, continuous improvement of distance running performance has been observed.

Farrel et al (1979) studied on marathon runners. He found that VO$_2$ max is positively correlated with high level marathon.Butts et al (1991) studied the VO$_2$ on the triathlon found the positive correlation with the performance.
Daniels, 1985, Sjodin and Svedenhag, (1985) studied a wide range of performance among different population, displaying a similar VO₂ max or alternatively, equivalent performances from populations with dissimilar VO₂ max values.

Londeree et al (1986) stated that appropriate tests can be used to accurately estimate: an individual's potential for success in long distance running; his current level of conditioning; his appropriate training and racing paces; and his ideal bodyweight. The proposed tests include the study of VO₂max, running efficiency, maximal steady-state, and body composition. Based on a review of the literature it was determined that VO₂max, running efficiency, and body composition provide the information about long distance running potential, including specific paces for various events. Maximal steady-state running pace (pace that elicits 2 mmol/L lactate) identifies appropriate running paces for various events. Relative maximal steady-state oxygen consumption (% VO₂max) identifies the current level of conditioning. A comparison of maximal steady-state, running efficiency, and body composition by assessing current status with optimums, provide guidelines for appropriate changes.

Ryschon (1994) studied the metabolic demands of cycling. He stated that the body size, state of conditioning and health, biomechanical factors
and technologic innovations in bicycle design can each have dramatic effects on energy expenditure.

Coyle et. al. (1990), Tanaka et. al. (1993) and Lucia et. al. (1998) in a study observed that maximum oxygen consumption in cyclists have been reported in the recent literature to be in the range of approximately 4.9 l.min\(^{-1}\) to 5.09 l.min\(^{-1}\).

Research has shown that demonstrating a high aerobic capacity is important for success in track cycling events (Craig et al., 1993). The ability to rapidly reach and sustain high maximal oxygen uptake enables a large, rapid and sustained aerobic energy release that reduces the reliance upon a large proportion of the finite oxygen deficit. VO2 max values above 90 ml/kg/min have been found to exist in many world class track cyclists. As high aerobic power is strongly associated with track cycling success, peak VO2 max values in excess of 80 ml/kg/min for males and 70 ml/kg/min for females are considered prerequisites for successful world-class cyclists. Because VO2 max and its response to training are under strong genetic control, it becomes obvious that a high aerobic power base is mandatory for successful track cycling performance (Craig et al., 1993). This became apparent in a study conducted by Jeupendrup et al.(2000), who reported, that during the off season, a male track cyclist recorded VO2 max values of 74.3 ml/kg/min; however, in preparation for the National Championships less...
than a year later, the same cyclist’s VO2 max values increased to 84.8 ml/kg/min. Variations in VO2 max values have been shown throughout a training season as a result of alterations in the amount of training volume and training intensity. Sjogaard et al. (1985) reported changes of up to 22% in the relative VO2 max values of track cyclists over a 12 month training period.

In addition, Jeukendrup et al.(2000) reported longitudinal changes in aerobic indices over a six year period for elite male 4000m pursuit track cyclists. In terms of performance, Olds et al. (1993) predicted that a 15% improvement in VO2 max (5.24 to 5.91 l/min) would enable a track cyclist to compete in the 4000m pursuit 15.5 seconds faster. Further, it has been demonstrated that elite cyclists exhibited physiological adaptations such as the ability to perform near 90% of VO2 max over long periods of time. Therefore, the kinetics of VO2 max among track cyclists has become a topic for research with regards to training protocols.

**STUDIES RELATED HOCKEY (INTERMITENT SPORTS)**

Field hockey is played on gravel, natural grass, sand-based or water-based artificial turfs, with a small and hard ball. The game is
popular among both males and females in many continents of the world, particularly in Europe, Asia, Australasia, and South Africa. A field hockey game consists of two halves of 35 minutes each in men's play and 30 minutes in women's play with an intermission of 5-10 minutes.

Paterson (1979) observed in a studied that as ice hockey shifts in a typical hockey game last approximately 90 seconds, these short bouts of high intensity exercise draw upon anaerobic metabolism, including the depletion of phosphocreatine stores, which are depleted in six to 10 seconds.

Ghosh et al., 1991; Reilly and Borrie, 1992 observed in the study that field hockey is a high intensity non-continuous game in which the physiological demands are considerable, placing it in the category of heavy exercise during the match analyses.

Reilly and Seaton (1990) stated that the unique requirements of field hockey including dribbling the ball and moving quickly in a semi-crouched posture superimpose the work-load demanded by the game.

Thus, the execution of tactical skills in field hockey is always related to the physiological and technical limitations of the individual player, his or her teammates and his or her opponents. To obtain expert status in field hockey, players must excel in four domains, i.e. physiological, technical, tactical, and psychological.
Bhanot and Sidhu,(1983), Boyle et al.,(1994); Lothian and Farrally, (1994) stated that although great anaerobic capacity is needed during the many brief bursts of high-energy release, aerobic capacity is also needed for efficient recovery during the short rest periods in the field hockey players.

Paliazka et al (1987), Ramsbottom et al (1988) and Grant et al (1995) have investigated the correlation between VO$_2$ max as measured on a treadmill with gas analysis and the predicted value from performance in the 20m shuttle Run test. Highly significant correlations have been reported (0.93, 0.92 and 0.86).

Maud and Shultz (1986) compared the anaerobic power and anaerobic capacity between young active men and women. Three performance measures of anaerobic power and two of anaerobic capacity were administered. They observed the significant differences between men and women in body height, weight and percent fat, in fat free mass (FFM), anaerobic power, and anaerobic capacity when recorded as gross work completed and relative to body weight. The study found no significant differences between men and women in either anaerobic power or anaerobic capacity when values were given relative to FFM.
Cibich (1991) observed as critical components of game performance are both the aerobic and anaerobic capacity of the hockey player. They stated that the duration and the pace of hockey requires a high aerobic fitness level for players.

Dawson et al (1991) and Fitzsimons et al (1993), stated that hockey involves multiple sprint repetitions throughout a game and as such there is a large anaerobic component of the sport. They also explained that hockey requires multiple repeated sprint efforts with short recovery time within the period of a game. Higher sports performance would be anticipated with the ability to repeat sprint efforts at or near maximal intensity.

Dawson et al. (1991) stated that in team sports including hockey involve multiple short sprint efforts of five to ten seconds duration. Reilly and Borrie (1992) studied the physiological profiling of female hockey players. They have shown that the percentage body fat in female players ranged from 16 to 26%.

Reilly and Borrie,(1992) observed that competitive field hockey matches place heavy aerobic demands on players and require them to expend energy at relatively high levels.
Boyle et al (1994) reported that somatotypes of male hockey players have shown considerable variation but there was a trend away from ectomorphy towards mesomorphy.

Rechichi (1998) stated that back line players require power and may therefore tend towards a heavier weight in comparison to a midfield player who is required to perform frequent repeated sprint efforts. However, these characteristics are not indicators of hockey skill potential and as such the physical profile of elite hockey players varies between individuals.

Wilmore & Costill (1999) stated the in terms of energy requirements, the aerobic capacity is very important during matches at the elite level.

Aziz et al (2000) stated that the Field hockey match requires high level of aerobic fitness, and it is a prerequisite for a superior anaerobic performance during sustained intermittent activities.

Keough 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.
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. They concluded that %BF, sprinting speed, agility, dribbling control, aerobic and muscular power, and shooting accuracy can distinguish between female field hockey players of varying standards. Therefore talent identification programs for female field hockey should include assessments of these physical parameters.

Spencer et al., (2005) stated the Hockey game involves intermittent running the alternation of accelerating and decelerating, and changes of direction while sprinting.

Carey et al (2007) stated that hockey is widely considered an aerobic activity through the accumulation of several repeated bouts of anaerobic exercise.

Carey et al., (2007) stated in his study depletion in phosphocreatine in hockey players results in the inability to generate more ATP, thus activating the glycolytic system. There is also a corresponding increase in inorganic phosphates, lactate formation, H+ ions, and a decrease in pH.

Quinney et. al. (2008) examined the physiological profile of a National Hockey League (NHL) team over a period of 26 years. Most anthropometric (height, mass, and BMI) and physiological parameters (absolute and relative VO2 peak, relative peak 5 s power output, abdominal
endurance, and combined grip strength) showed a gradual increase over the 26 year period. Defensemen were taller and heavier, had higher absolute VO2 peak, and had greater combined grip strength than forwards and goaltenders. Forwards were younger and had higher values for relative VO2 peak. Goaltenders were shorter, had less body mass, a higher sum of skinfolds, lower VO2 peak, and better flexibility. The overall pre-season fitness profile was not related to team success.

Potteiger et. al. (2010) examined relationships between laboratory tests and on-ice skating performance in division I men's hockey athletes. Twenty-one men (age 20.7 +/- 1.6 years) were assessed for body composition, isokinetic force production in the quadriceps and hamstring muscles, and anaerobic muscle power via the Wingate 30-second cycle ergometer test. They concluded that laboratory testing of select variables can predict skating performance in ice hockey athletes. This information can be used to develop targeted and effective strength and conditioning programs that will improve on-ice skating speed.

Wilson (2010) studied reliability of a repeated anaerobic power cycling test designed to mimic the repeated sprinting nature of the sport of hockey. There was no significant difference between the peak 5-second power output (PO), mean PO, or the fatigue index (%) among the 3 different trials. This study reports the methodology of a repeated anaerobic power
cycling test that was reliable for the measurement of PO and calculated fatigue index in varsity women ice hockey players and can be used as a laboratory-based assessment of repeated anaerobic fitness.

STUDIES ON JUDOKAS (COMBAT SPORTS)

Judo is Japanese art and Olympic sport in which, besides technical skill and tactical strategies, conditional characteristics are also indispensable for success in competition and for training (Franchini et al, 2005). Competitive judo can be described as a combative, high intensity sport in which the athlete attempts to throw the opponent onto his back or to control him during groundwork combat. Both attempts depend on specific techniques and tactical skills with the support of good physical fitness (Thomas et al, 1989).

Since 2003 the format of international judo competition has been one continuous 5-min period, which can be complemented by extra time until one athlete scores or to the end of the new 5-min period. The typical time structure is 30 s of activity with a 10 s interval (Castarlenas et al, 1997; Sikorski et al, 1987). The anaerobic system provides the short, quick, all-out bursts of maximal power during the match, while the aerobic system contributes to the athlete’s ability to sustain effort for the duration of the combat and to recover during the brief periods of rest or reduced effort.
Physiological testing is commonly used to assess the overall fitness level of the athletes and to set guidelines for individualized training. Some physical fitness and anthropometrical variables are considered requisites for high performance in judo competition (Sikorski et al, 1987; Thomas et al, 1989).

Mayers and Gutin (1979) studied the physiological characteristics of elite prepubertal crosscountry runners and it has been reported that the above said runners had significantly higher VO$_2$ max (56.6 ml.kg$^{-1}$.min$^{-1}$) than non-runners (46.0 ml.kg$^{-1}$.min$^{-1}$).

In a study Paterson et. al. (1979), pre-training VO2 was not measured, and causality of the training cannot be determined. Since on-ice shifts in a typical hockey game last approximately 90 seconds (Paterson, 1979), these short bouts of high intensity exercise draw upon anaerobic metabolism, including the depletion of phosphocreatine stores, which are depleted in six to 10 seconds.

Patterson (1979) examined the cardiovascular demands of intermittent exercise as it relates to ice hockey, and observed that the intermittent exercise represented a greater demand on both central circulation and oxidative metabolism in the muscle cell. Results stated that the training...
programs to increase aerobic capacity would be beneficial to intermittent exercisers such as ice hockey players.

According to Burke et al (1980), cyclists are said to be taller and heavier than distance runners, ice hockey players and speed skaters. The mean height and weight of 40 male road cyclists studied at the 1969 world championships was 175cm and 70 kg respectively.

Burke et al., (1980) observed a similar decline in percentage body fat has been found in female road cyclists, with 15.4% reported by Wilmore and co-authors in 1977 but Randall et al 1997 only 11.9% reported.

Tesch (1983) reported that recovery from high intensity exercise was related to capillary density and the increase in oxygen supply to the fatigued muscles, a study of highly trained athletes by Tomlin and Wenger (2001) concluded that recovery from high intensity.

Astrand and Rodahl, (1986) stated in a study that long-term changes may involve a conversion from type IIA fibres to type IIB. The application to judo performance essentially involves developing the athlete's corresponding tolerance to muscular fatigue (due to increases in metabolic buffers and larger stores of PrC). In addition to this, the athlete will be able to generate higher power outputs for a longer period of time. Astrand and Rodhal (1986) in a comparative study on judo, explained the lactic energy
system can be defined as anaerobic glycolysis, which is essentially the incomplete breakdown of glycogen in the absence of oxygen. This occurs during periods of maximal exercise lasting approximately 90 seconds in duration.


Findings by Taylor et al. (1955) revealed that lower body anaerobic peak power and capacity of male Canadian athletes were evaluated at a mean of 13.7 W.kg and 320 J.kg respectively. Furthermore, mean values for upper body anaerobic peak power and capacity were determined at 11.3 W.kg and 260 J.kg respectively.

Astrand and Rodahl, (1986) stated that the most important benefit of aerobic conditioning for judo involves improvements in the lactate threshold. The lactate threshold has been defined as the point at which lactate production exceeds lactate removal. The physical nature of competitive judo requires the athlete to sustain power at a high percentage of their individual VO₂ throughout the course of the match.
Astrand and Rodahl, (1986) examined the anaerobic power and capacity of elite judo athletes. Anaerobic capacity is determined by the mean power output throughout a 30 second test. This reflects combined alactic and lactic energy systems. Peak power is determined by the highest power output achieved at any five second period of the test. This is specific to the alactic energy system, and reflects the availability of creatine phosphate stores.

Astrand & Rohdal, (1986) investigated in a study that the anaerobic system has a tremendous ability to completely replenish stores after depletion within 2-3 minutes in judokas.

Coast et al., (1986); Hagberg et al., (1981); Ryschon & Stray-Gunderson, (1991) stated that based on studies using competitive cyclists riding at 80% to 85% of VO2 max in which VO2 was used as a measure of energy expenditure, optimal cadence (the pedal speed associated with the lowest VO2) ranged from 60 to 91 rpm.

Astrand and Rodahl, (1986) stated that the alactic system uses creatine phosphate (PCr) to generate intense bursts of action. It is characterized by maximal (100% VO2) exercise lasting 10 to 15 seconds in duration. The value of this system is its tremendous ability to completely replenish stores after depletion within a period of 2 to 3 minutes of rest.
Telford and Minikin (1987) formulated the Tri-level test to provide a profile of the athlete that was not skill based and as such could be applied to a variety of athletes.

However, Telford and Minikin (1987) concede that specificity is essential for the elite athlete and, as cycling is not sports specific to a running sport such as hockey, a cycle ergometer test is not optimal (Fitzsimons et al 1993).

Sharp and Koutedakis (1987) did conclude that body weight related resistance may constitute a greater proportion of their absolute muscular strength. This may be in part to the wide fluctuation in body mass of the subjects. These sources both emphasize the importance of developing anaerobic power and capacity in judo athletes.

Rowland et al (1988) studied the submaximal aerobic running economy and treadmill performance in prepubertal boys and the findings suggested that among older prepubertal boys, greater running economy was associated with superior treadmill training endurance performance and that stride frequency may influence submaximal VO$_2$ expenditure in children.
Thomas et al, (1989) stated that this energy system involves both the ATP-CP (Alactic) and Lactate (anaerobic glycolysis) systems. As mentioned previously, judo primarily involves the anaerobic system, therefore training specificity is crucial in the adaptation of this system.

Thomas et al, (1989) stated that the VO$_2$max of Canadian Judoka was found to be 59.2 mL.kg$^{-1}$.min$^{-1}$, but relative VO$_2$ max decreased with increasing body mass and elite judoka of other Nations (Australia, 53.2 mL.kg$^{-1}$.min$^{-1}$; Poland, 59.0 mL.kg$^{-1}$.min$^{-1}$; Norway, 58.5 mL.kg$^{-1}$.min$^{-1}$) had comparable aerobic fitness.

Thomas et al, (1989) stated that selected physiological and anthropometrical variables are considered requisites in high level judo. Reilly, (1990) noted that back line hockey players require power and may therefore tend to have heavier weight in comparison to midfield players who are required to perform frequent repeated sprint efforts.

According to Wenger and Green, (1991) when designing a physiological testing program for any athlete a number of factors must be considered. This review will describe the physical characteristics of a successful 40-km time trial cyclist and elaborate on three of the most useful tests to monitor their physiological performance.
According to Bouchard (1991), the peak power that was achieved was approximately 13.86 W/kg with a % fatigue index of 34.25, this compares favourably to the anaerobic data reported on sedentary young males, who demonstrated a peak power of 9.3 W/kg and a % fatigue index of 40.

Scott, (1991) has established a data base of physical norms for elite male field hockey players. Their results showed that with a stature of 176.3 cm and mass of 75.2 kg, the hockey players were identified as ecto-mesomorphic and the lean build of the subjects was evident with a fairly low percentage body fat (11.1%).

According to Ghosh & Goswami (1991), the aerobic demand of playing hockey on Astroturf was 2.26 l/min or 47.3 kJ/min which was 18% higher than the demand of playing on the grassy field. This showed that the players need to possess a high aerobic capacity on AstroTurf.

Cibich (1991) found that in game situations, hockey mid field players performed at or above their anaerobic threshold for 70% of the game time on average. Sustained high intensity is necessary with recovery time being only 12.25% of total game time (including warm up and half time) for Centre Half and Inside Forward players and 20% for Backs.
Thoden (1991) observed that aerobic power is the rate at which energy is provided for aerobic metabolism. Theoretically this commences after the third minute, once the alactic and anaerobic glycolytic pathways have been depleted. The rate at which aerobic metabolism supplies energy to the aerobic machinery of muscle is dependent on two mechanisms.

Sjodin and Svedenhag (1992) reported that changes in the oxygen cost of running and VO$_2$ max (ml.kg$^{-1}$.min$^{-1}$) during growth may mainly be due to an overestimation of the body mass dependency of oxygen consumption during running.

Cipriano, (1993) stated in a study that judokas has ability to recover quickly from anaerobic work is essential for competition success, since the total number of matches performed during a tournament may range as high as 6 to 8 bouts.

Tanaka et al, (1993) explained that It is by no means exhaustive and deliberately ignores other factors for success in road cycling such as team work, aerodynamics, biomechanical skill, tactics and experience acquired in years of road racing.

Tanaka et al (1993) performed a Wingate anaerobic test on 9 elite male cyclists. They calculated peak power, mean power and fatigue index.
(difference between the peak power and the lowest 5-s power output divided by peak power) for the 30-second maximal test.

Horswill et al (1992) observed that Olympic wrestlers have been shown to have peak anaerobic power at 6.1 to 7.5 watts kg\(^{-1}\) (Horswill et al, 1992). Studies by Sharp and Koutedakis (1987) examined anaerobic power and capacity in elite gymnasts, rowers and judo athletes. Resistance was set at 8% of the athlete's body weight. Mean weight values (n=7) for the judoists were 85.0 kg. Upper body mean Wingate values of British judo athletes were found to be 8.5 W.kg for capacity, and 10.6 W.kg for peak power. These values of capacity and peak power were lower than those of gymnasts (9.5 W.kg, 11.0 W.kg) and rowers (10.0 W.kg, 11.5 W.kg) respectively.

Several studies by Cipriano, (1993); Wolach, et al, (2000); Degoutte et al, (2003); have looked at the physiological responses to a single judo contest but in reality, to become a successful judo athlete, several judo contests must be fought in succession.

Cipriano, 1993 done the time motion analysis of Judo Players. Time-motion analysis has shown that judo contests are characterised by maximal (100% VO\(_2\)) efforts of 10-15s interspersed with recovery periods of sub-maximal efforts that include pushing, pulling and lifting movements.
Pulkkinen (2001) postulates that the ATP-CP system and the anaerobic system are the primary sources of energy during a judo contest.

In comparative study Cipriano, (1993), the lactate system can be defined as anaerobic glycolysis, which is essentially the incomplete breakdown of glycogen in the absence of oxygen. This occurs during periods of maximal exercise lasting approximately 90 seconds in duration. Lactate is produced and transforms to lactic acid from pyruvate.

According to Ryschon, T., (1994), Cycling, like all modes of human locomotion, requires the conversion of metabolic energy into mechanical power. Mechanical power applied to the pedals of the bicycle is transferred through the bicycle drive train to overcome the physical forces that resist bicycle motion.

Morgan and Danniel s (1994) reported that among similarly performing elite distance runners, a positive relationship exists between VO$_2$ max and the aerobic demand of running.

Boyle, et al, (1994) also reported that the mean estimated oxygen uptake among nine Ireland international hockey players during competition was $48.2 \pm 5.2$ ml/kg/min.

Cox et al.,(1995) stated that Lactate removal usually depends on fitness level, state of training, active muscle mass, muscle fiber composition, nutrition, blood flow, and fatigue in judokas.
Saltin et al (1995) found that Kenyan runners in active training had VO2max of 68.0±1.4 ml.kg-1.min-1 at altitude and 79.9±1.4 ml.kg-1.min-1 at sea level, with individuals reaching 85 ml.kg-1.min-1.

However, Grant et al (1995) reported a systematic underestimation of VO2 max as predicted by the Shuttle Run test and therefore extrapolation of the shuttle sore to estimate VO2 max may be inappropriate.

Takahashi et al. (1995) also reported a strong relationship between increased aerobic capacity and faster anaerobic recovery, showing that trained runners have faster rates of phosphocreatine (PCr) re-synthesis. Due to the difficulty in obtaining blood samples during an actual hockey game, few reports exist documenting lactate accumulation between shifts and following games.

According to Ghosh et al, (1995), the sports persons acquire the capacity through training. But when the movements become fast, for example, repeated sprints in football, hockey, and basketball or in repeated fast punching in boxing, the dominating energy source is anaerobic. A high aerobic capacity (VO2max) is an advantage in endurance sports. Similarly, a high anaerobic capacity is an advantage in sprint or power events but success in any type of activity requires technique, tactic and skill perfection. Almost all the sports activities have aerobic and anaerobic components; the dominance depends on the
intensity and duration of the game or activity.

Cox et al, (1995) using primarily non-athlete populations, have shown optimal workloads for lactate removal during active recovery ranging from 28 to 68% VO2max, with results depending on the individual and the type of active recovery employed.

Gariod et al.,(1995) observed from video analysis of judoist in competition ,two strategies have been observed: (a) an aerobic profile judoist, who wins the fight in the end; (b) an anaerobic profile judoist, who wins at the very beginning of the fight. Therefore, endurance performance became extremely important in judo fight, above all with the introduction of the golden score.

According to Tanaka 1993 there are fewer reports in the literature of elite female cyclists, however VO2\textsubscript{max} values have been reported to be in the range of 3.05 l.min\textsuperscript{-1} to 3.52 l.min\textsuperscript{-1}

Randall et al, (1997) studied 10 elite male road cyclists were studied and a mean height of 182cm and weight of 72.6kg was found in 1997. This demonstrates an increase in both variables of approximately 3.6%, which may be attributable to any number of factors.
According to Randell et al, (1997), the added weight will increase inertia and thus slow the rate of acceleration, secondly it will limit hill climbing ability, thirdly it will increase the rolling resistance on the tyres and lastly it will have a significant impact on the cyclist's frontal area.

Pregiffer (1997) observed that VO2 max demonstrated to be a strong predictor of cycling performance in a 14 day stage race among trained female cyclists.

Randall (1997) stated that there has been less emphasis on heart rate responses of elite cyclists in the literature, with maximal values reported by one group of authors as 188 bpm.

Wadley and LeRossignol (1998) reported 20 meter sprints with 20 second recovery and found no significant difference between the recovery of those athletes with high aerobic capacity and those with lower aerobic capacity; however, this was not comparable to an on-ice hockey shift.

Heller et al. (1998) studied the baseline physiological and kinanthropometric parameters of male and female taekwon-do. Both male and female taekwon-do black belts demonstrated low adiposity (8.2 and 15.4% fat, BMI 21.9 and 22.0 kg m(-2), respectively), normal reactivity and pulmonary function, above average muscular strength, PWC-170 (3.4 vs 2.7
W kg(-1)) and aerobic power (54 vs 42 ml min(-1) kg(-1)), and a high flexibility (37 and 38 cm) and anaerobic performance (peak power output from a 30 s Wingate test=14.7 and 10.1 W kg(-1); anaerobic capacity=334 and 242 J kg(-1), in males and females, respectively). In male athletes, competitive performance was significantly related to maximum power output and upper limb reaction time only, whereas in females, performance was related to maximum power output and ventilatory threshold level.

Quinney (2001) tried developing a hockey-specific skating treadmill protocol to measure VO2max. The subjects in this investigation completed VO2max tests on a skating treadmill and a cycle ergometer. They concluded that even though the physiological responses were similar for both protocols, the skating treadmill replicated the hockey skating stride, which could provide more accurate and applicable information for the development of training protocols.

Sbriccoli et al, (2007) studied on elite judo players. In their study the VO$_2$ max of elite judo competitor has been reported to be varying from 50 to 60 ml · kg–1 min–1.

Callan et al (2000) stated that the anaerobic system provides the short, quick bursts of maximal power during the match while the aerobic system
contributes to the wrestler’s ability to sustain effort for the duration of the match.

Tomlin & Wenger (2001) stated in his study that the aerobic involvement can be considered as another factor for leveraging the performance of the judoist. Obert et al (2003) studied cardiorespiratory responses to endurance training in children of 10-11 years old and found that whatever gender, aerobic training increases VO$_2$max in children.

Studies by Pulkkien, (2001) have shown that Olympic wrestling and judo are physiologically similar. Studies of Nilsson, et al, (2002); Pulkkinen, (2001); stated that judo and wrestling have shown a high anaerobic contribution to both sports.

According to Hausswirth & Lehenaff (2001), oxygen uptake (VO$_2$) appears to be a vital indicator of an athlete’s ability to generate locomotive efforts of middle to long duration (triathlon, marathon, duathlon). More specifically, the performance achieved during prolonged exercise, is dependent upon the relative contribution of a number of physiological factors, actively involved in the continued execution of the movement.

McMurray et al (2002) reported that although absolute VO$_2$ max (l.min$^{-1}$) increases from age 8 to 16 yr, relative VO$_2$ max (ml.kg$^{-1}$.min$^{-1}$) declines. McArdle et al (2000) stated that physiological tests are
necessary to assess the physical condition of the athletes and should be used as guidelines to determinate the intensity of training in judokas.

Nobes, et al., (2003), stated that at submaximal workloads, VO2 and heart rate were significantly higher on the skating treadmill which can probably be attributed to the fact that skating on a treadmill is not quite comparable to skating on open ice.

Nobes et al. (2003) compared skating economy between on-ice and skating treadmill protocols. Using male varsity hockey players with an average age of 21 years, the investigators found that the greatest differences in values between on-ice and skating treadmill occurred at flow workloads (Nobes et al., 2003).

Spencer et al. (2004) state that the hockey player is required to have a large aerobic and anaerobic capacity in addition to ball and stick skills. Time-motion analysis is one of the ways used to document the movement patterns during an international field hockey game. As repeated-sprint ability is considered an important fitness component of team-sport performance including field hockey, the movement patterns of repeated-sprint activity in a previous study were investigated.

Franchini et al, (2005) compared between national-level judoists and lower competitive level found that high-level judoists had large
circumferences (contracted arm, forearm, wrist and leg) and bone diameters (femur and humerus epicondyles).

Spencer, et al (2005) studied on 14 players of the Australian men's field-hockey team found that the mean VO$_{2\text{max}}$ of the players were 57.9 + 3.6 ml/kg/min during an international game.

Kubo et al (2006) observed in their study that Judo is a weight-category sport; so it has been supposed that high level judoists should have low adipose tissue. They observed that Judo athletes who participated in the Olympic Games or Asian Games had significantly higher fat-free mass (FFM) than university judo athletes who didn't participate in intercollegiate competitions.

Green et al. (2006) conducted a study of an NCAA Division I hockey team and how their physiological profiles, including VO2max, blood lactate, and percent body fat, related to their performance. Aerobic fitness (VO2max) accounted for 17% of the variance in performance, which was based on overall scoring chances while a particular player was on the ice. It was concluded that only VO2max significantly predicted performance.

Montgomery (2006) studied the physiological data, including size, strength, and aerobic fitness, of the Montreal Canadiens of the NHL, beginning in 1917. Compared to players from the 1920’s and 1930’s, current
players were an average of 17 kg heavier and 10 cm taller, for an average 
BMI increase of 2.3 kg·m⁻¹. However, percent body fat remained 
unchanged. He has seen in his study that aerobic fitness (VO2max) has also 
shown an increase from 54.6 to 59.2 ml·kg⁻¹·min⁻¹ between 1992 and 2003.

Franke et al. (2007) found that VO2max values were different 
according to the players’ position. The mean VO2max of the goalkeepers 
was 47.0 ± 1.9 ml/kg/min, 49.8 ± 7.0 ml/kg/min in defenders, 48.9 ± 7.3 
ml/kg/min in forward, and midfielder was 47.1 ± 0.3 ml/kg/min in 
midfielders.

A study by Carey et al. (2007) suggested hockey players need not 
train aerobically. This study consisted of five, one-lap intervals around a 
hockey rink, with 30 seconds rest between trials. A VO2max test was 
performed on a motor-driven treadmill using a Bruce protocol.

Carey (2007) concluded that the ability to recover from high intensity 
intermittent exercise was not related to aerobic capacity, due to the 
correlation coefficient (-0.422) not being significant (p>0.05) between the 
fatigue index and VO2.

Carey et. Al. (2007) concluded that coaches and trainers need not to 
include an aerobic component to their training, because the high intensity
intermittent training improves VO2. Carey et al. (2007) in his study explained that depletion results in the inability to generate more ATP, thus activating the glycolytic system. There is also a corresponding increase in inorganic phosphates, lactate formation, H+ ions, and a decrease in pH.

Carey et al. (2007) also suggested that aerobic metabolism plays an important role in the restoration of these metabolites used during anaerobic exercise, such as the regeneration of phosphocreatine (PCr) stores.

Azevedo et al (2007) stated in a study analysis of blood lactate concentration ([La]) in specific condition of judo has been studied in order to provide information on the metabolic requirements for the monitoring and the resiontion of work intensity.

A study by Popadic (2009) investigated the values of anaerobic energetic capacity variables in athletes engaged in different sport disciplines and to compare them in relation to specific demands of each sport. but there was no significant difference in values between volleyball players and wrestlers, between boxers and wrestlers, between boxers and basketball players, and between volleyball and hockey players (p > 0.05).
Frachini et al. (2011) observed in their study that, in international competitions, judo athletes must achieve an excellent level of physical fitness and physical condition during training. They studied the physiological profiles of elite judo athletes from different sex, age and weight categories. Body fat is generally low for these athletes, except for the heavyweight competitors. In general, elite judo athletes presented higher upper body anaerobic power and capacity than non-elite athletes. Lower body dynamic strength seems to provide a distinction between elite and recreational judo players, but not high-level judo players competing for a spot on national teams. Even maximal isometric strength is not a discriminant variable among judo players. However, more studies focusing on isometric strength endurance are warranted. Although aerobic power and capacity are considered relevant to judo performance, the available data do not present differences among judo athletes from different competitive levels. Typical maximal oxygen uptake values are around 50-55 mL/kg/min for male and 40-45 mL/kg/min for female judo athletes. As for other variables, heavyweight competitors presented lower aerobic power values. The typical differences commonly observed between males and females in the general population are also seen in judo athletes when analysing anaerobic power and capacity, aerobic power, and maximal strength and power.