Chapter-II

REVIEW OF RELATED LITERATURE

A review of literature relating to Physiological and Physical profile of soccer players, as well as on performance in various sports and games, as the scholar could glean from the library of the Lakshmibai National Institute of Physical Education, (Deemed University), Gwalior, (MP) is presented in abstracts to provide the variable background material for this study.

Chamari (2005) studied a new test to assess aerobic performance in soccer by means of a specific dribbling track: the Hoff test. They further determined whether improvement in maximal oxygen uptake was reflected in increased distance covered in the Hoff test. 18 male soccer players (14 years old) both were tested in the laboratory and using the Hoff test before and after 8 weeks of soccer training. The distance covered in the Hoff test correlated significantly with maximum oxygen uptake, and improved by 9.6% during the 8-week training period, while maximum oxygen uptake and running economy improved by 12 and 10%, respectively. Backward multiple
regressions showed maximum oxygen uptake to be the main explanatory variable for the distance covered in the Hoff test. The present study demonstrated a significant correlation between laboratory testing of VO\(_2\) (max) and performance in the Hoff test. Furthermore, training induced improvements in VO\(_2\) (max) were reflected in improved performance in the Hoff test. It was suggested that there should be a goal for active U-15 soccer players to cover more than 2100 meters in the Hoff test, as this required a VO\(_2\) (max) of above 200 ml.kg\(^{-0.75}\). min\(^{-1}\), which should serve as a minimum in modern soccer.

**Wisloff** (2004) determined whether maximal strength correlates with sprint and vertical jump height in elite male soccer players. Seventeen international male soccer players (mean (SD) age 25.8 (2.9) years, height 177.3 (4.1) cm, weight 76.5 (7.6) kg, and maximal oxygen uptake 65.7 (4.3) ml.kg\(^{-1}\).min\(^{-1}\)) were tested for maximal strength in half squats and sprinting ability (0-30 m and 10 m shuttle run sprint) and vertical jumping height. There was a strong correlation between maximal strength in half squats and sprint performance and jumping height. Maximal strength in half squats determines sprint performance and jumping height in high level soccer players. High squat strength did not imply reduced maximal oxygen consumption.
Elite soccer players should focus on maximal strength training, with emphasis on maximal mobilization of concentric movements, which may improve their sprinting and jumping performance.

Metaxas (2005) evaluated the maximal oxygen uptake (VO₂ (max)) values in soccer players as assessed by field and laboratory tests. Thirty-five elite young soccer players were studied (mean age 18.1 ± 1.0 years, training duration 8.3 ± 1.5 years) in the middle of the playing season. All subjects performed 2 maximal field tests: the Yo-Yo endurance test (T (1)) for the estimation of VO₂ max according to normogram values, and the Yo-Yo intermittent endurance test (T (2)) using portable telemetric ergospirometry; as well as 2 maximal exercise tests on the treadmill with continuous (T (3)) and intermittent (T (4)) protocols. The estimated VO₂ max values of the T (1) test (56.33 ml.kg⁻¹.min⁻¹) were 10.5%, 11.4%, and 13.3% (p < or = 0.05) lower than those of the T (2) (62.96 ml.kg⁻¹.min⁻¹), T (3) (63.59 ml.kg⁻¹.min⁻¹) and T (4) (64.98 ml.kg⁻¹.min⁻¹) tests, respectively. Significant differences were also found between the intermittent exercise protocols T (1) and T (3) (p < or = 0.001) and the continuous exercise protocols T (2) and T (4) (p < or = 0.001). There was a high degree of cross correlation between the VO₂ (max) values of the 3-ergospirometric tests.
(T (2) versus T (3), r = 0.47, p < or = 0.005; T (2) versus T (4), r = 0.59, p < or = 0.001; T (3) versus T (4) r = 0.79, p < or = 0.001). It is necessary to use ergospirometry to accurately estimate aerobic capacity in soccer players. Nevertheless, coaches should use the Yo-Yo field tests because they are easy and helpful tools in the training program setting and for player follow-up during the playing season.

McMillan (2005) studied physiological adaptations to a 10 week high intensity aerobic interval training program performed by professional youth soccer players, using a soccer specific ball dribbling track. Eleven youth soccer players with a mean (SD) age of 16.9 (0.4) years performed high intensity aerobic interval training sessions twice per week for 10 weeks in addition to normal soccer training. The specific aerobic training consisted of four sets of 4 min work periods dribbling a soccer ball around a specially designed track at 90-95% of maximal heart frequency, with a 3 min recovery jog at 70% of maximal heart frequency between intervals. Mean VO₂ max improved significantly from 63.4 (5.6) to 69.8 (6.6 ml.kg⁻¹.min⁻¹, or 183.3 (13.2) to 201.5 (16.2) ml.kg⁻¹.min⁻¹ (p<0.001). Squat jump and counter movement jump height increased significantly from 37.7 (6.2) to 40.3 (6.1) cm and 52.0 (4.0) to 53.4 (4.2) cm, respectively (p<0.05). No
significant changes in body mass, running economy, rate of force
development, or 10 m sprint times occurred. Performing high intensity
4 min intervals dribbling a soccer ball around a specially designed
track together with regular soccer training is effective for improving
the VO$_2$ max of soccer players, with no negative interference effects on
strength, jumping ability, and sprinting performance.

Kemi (2003) studied to evaluate maximal oxygen uptake in a
soccer specific field test, compared to treadmill running. Ten male
soccer players (age 21.9±3.0 years, body mass 73.3±9.5 kg, height
179.9±4.7 cm) participated in the study, and 5 endurance-trained men
(age 24.9±1.8 years, body mass 81.5±3.7 kg, height 185.6±3.1 cm)
took part in a comparison of the portable and the stationary metabolic
test systems. The soccer players accomplished a treadmill test and a
soccer specific field test containing dribbling, repetitive jumping,
accelerations, decelerations, turning and backwards running. Maximal
oxygen uptake was similar in field (5.0±0.5 L.min$^{-1}$) and laboratory
(5.1±0. L.min$^{-1}$) tests, as were maximal heart rate, maximal breathing
frequency, respiratory exchange ratio and oxygen pulse. Maximal
ventilation was 5.4% higher at maximal oxygen uptake during
treadmill running. These findings show that testing of maximal oxygen
uptake during soccer specific testing gives similar results as during treadmill running, and therefore serves as a valid test of maximal oxygen uptake in soccer players.

Edwards (2003) aimed to investigate whether a single soccer specific fitness test (SSFT) could differentiate between highly trained and recreationally active soccer players in selected test performance indicators. 13 Academy Scholars (AS) from a professional soccer club and 10 Recreational Players (RP) agreed to participate in this study. Test 1--VO$_2$ (max) was estimated from a progressive shuttle run test to exhaustion. Test 2--The SSFT was controlled by an automated procedure and alternated between walking, sprinting, jogging and cruise running speeds. Three activity blocks (1A, 2A and 3A) were separated by 3 min rest periods in which blood lactate samples were drawn. The 3 blocks of activity (Part A) were followed by 10 min of exercise at speeds alternating between jogging and cruise running (Part B). Estimated VO$_2$ (max) max did not significantly differ between groups, although a trend for a higher aerobic capacity was evident in AS (p<0.09). Exercising heart rates did not differ between AS and RP, however, recovery heart rates taken from the 3 min rest periods were significantly lower in AS compared with RP following blocks 1A
(124.65 beats.min\(^{-1}\)) ± 7.73 and 133.98 beats.min\(^{-1}\) ± 6.63), (p<0.05) and 3A (129.91 beats.min\(^{-1}\) ± 10.21 and 138.85 beats.min\(^{-1}\) ± 8.70), (p<0.01). Blood lactate concentrations were significantly elevated in AS in comparison to RP following blocks 2A (6.91 mmol.\(^{-1}\) ± 2.67 and 4.74 mmol.\(^{-1}\) ± 1.28) and 3A (7.18 mmol.\(^{-1}\) ± 2.97 and 4.88 mmol.\(^{-1}\) ± 1.50), (p<0.05). AS sustained significantly faster average sprint times in block 3A compared with RP (3.18 sec ± 0.12 and 3.31 sec ± 0.12), (p<0.05). The results of this study show that highly trained soccer players are able to sustain, and more quickly recover from, high intensity intermittent exercise.

**Esposito** (2004) studied to validate the use of heart rate (HR) in describing and monitoring physiological demands during soccer activities, the HR versus oxygen uptake (VO\(_2\)) relationship determined on the field during soccer-specific exercises was compared to that found in the laboratory during treadmill exercise. Seven male amateur soccer players [mean (SE), age 25.3 (1.2) years, body mass 72.9 (2.1) kg, stature 1.76 (0.03) m] performed three trials on the field (two laps of a purpose-made circuit including a variety of soccer activities) at different intensities (moderate, high and very high, according to their rate of perceived exertion) and an incremental test on a treadmill in the
laboratory. HR increased linearly with VO$_2$ during both field and laboratory tests according to exercise intensity (P<0.01). The mean correlation coefficients of the HR- VO$_2$ relationships obtained in the laboratory and on the field were 0.984 (0.012) and 0.991 (0.005) (P<0.001), respectively. The mean value of the HR- VO$_2$ regression equation slope and intercept obtained in laboratory [0.030 (0.002) and 79.6 (4.6), respectively] were not significantly different compared to those found on the field [0.032 (0.003) and 76.7 (9.7)]. The present study seems to confirm that HR measured during soccer exercises effectively reflects the metabolic expenditure of this activity. Thus, with the aid of laboratory reference tests, the physiological demands of soccer activities can be correctly estimated from HR measured on the field in amateur soccer players

**Helgerud** (2001) studied the effects of aerobic training on performance during soccer match and soccer specific tests. Nineteen male elite junior soccer players, age 18.1 ± 0.8 yr, randomly assigned to the training group (N = 9) and the control group (N = 10) participated in the study. The specific aerobic training consisted of interval training, four times 4 min at 90-95% of maximal heart rate, with a 3-min jog in between, twice per week for 8 wk. Pl---
monitored by video during two matches, one before and one after training. In the training group: a) maximal oxygen uptake (VO₂ max) increased from 58.1 ± 4.5 ml.kg⁻¹.min⁻¹ to 64.3 ± 3.9 ml.kg⁻¹.min⁻¹ (P < 0.01); b) lactate threshold improved from 47.8 ± 5.3 ml.kg⁻¹.min⁻¹ to 55.4 ± 4.1 ml.kg⁻¹.min⁻¹ (P < 0.01); c) running economy was also improved by 6.7% (P < 0.05); d) distance covered during a match increased by 20% in the training group (P < 0.01); e) number of sprints increased by 100% (P < 0.01); f) number of involvements with the ball increased by 24% (P < 0.05); g) the average work intensity during a soccer match, measured as percent of maximal heart rate, was enhanced from 82.7 ± 3.4% to 85.6 ± 3.1% (P < 0.05); and h) no changes were found in maximal vertical jumping height, strength, speed, kicking velocity, kicking precision, or quality of passes after the training period. The control group showed no changes in any of the tested parameters. Enhanced aerobic endurance in soccer players improved soccer performance by increasing the distance covered, enhancing work intensity, and increasing the number of sprints and involvements with the ball during a match.

Hoff (2002) determined whether ball dribbling and small group plays are appropriate activities for interval training, and whether heart
rate in soccer specific training is a valid measure of actual work intensity. Six well-trained first division soccer players took part in the study. To test whether soccer specific training was effective interval training, players ran in a specially designed dribbling track, as well as participating in small group play (five a side). Laboratory tests were carried out to establish the relation between heart rate and oxygen uptake while running on a treadmill. Corresponding measurements were made on the soccer field using a portable system for measuring oxygen uptake. Exercise intensity during small group play was 91.3% of maximal heart rate or 84.5% of maximal oxygen uptake. Corresponding values using a dribbling track were 93.5% and 91.7%. No higher heart rate was observed during soccer training. Soccer specific exercise using ball dribbling or small group play may be performed as aerobic interval training. Heart rate monitoring during soccer specific exercise is a valid indicator of actual exercise intensity.

**Wragg** (2000) assessed the reliability and validity of a soccer-specific field test of repeated sprint ability. Seven male games players performed the repeated sprint test on six separate occasions. The temporal pattern of the mean sprint time was analyzed by using coefficient of variation with confidence intervals (CI), and repeated
measures ANOVA. A within subject mean coefficient of variation of 1.8% (95% CI, 1.5-2.4) was found for performance in the repeated sprint test across all six trials. The mean coefficient of variation across trials 2-4 was found to be 1.9% (95% CI, 1.3-3.1), compared to trials 4-6, where it was 1.4% (95% CI, 1.0-2.3). The ANOVA showed that a significant difference was present between the trials (F6, 30 9.8. P<0.001). A Tukey post-hoc test showed that significant differences were present between trial I and trials 3-6, and trial 2 and trial 5. The learning effect was complete by trial 3. Performance in the repeated sprint test was compared to total running time averaged from two repeats of the maximal anaerobic running test laboratory protocol. Mean sprint time in the repeated sprint test and total running time in the laboratory protocol had a correlation coefficient of \( r = -0.298 \) (\( P = 0.516, n = 7 \)), suggesting that the energetic of the two tests are not closely related. In conclusion, this soccer-specific field test demonstrated high reliability.

**Strudwick** (2002) aimed to describe anthropometric and performance characteristics of elite players in two footballs codes and explore the differences between them. Data were compared by means of "t"-tests. Subjects: subjects were 19 professional soccer players and
33 inter-county Gaelic football players. Measurements were made on members of a Premier League soccer team throughout their regular season, whilst the Gaelic footballers were members of the Mayo squad preparing for the 1999 All-Ireland championship. The variability in stature was significantly greater in the soccer players compared to the Gaelic footballers (p<0.01). Performances in the 10-m and 30-m sprints, and in vertical jump were superior in the soccer group compared to the Gaelic footballers (p<0.01). The intra-group variability on the anthropometric and performance measures of the soccer players is likely to be due to the specificity of positional roles. The combined groups could be described as lean and muscular with a reasonably high level of capacity in all areas of physical performance. Anaerobic characteristics of the professional soccer players were superior to those of Gaelic football players. It is concluded that anthropometric and performance assessment of elite footballers using mean values masks the heterogeneity evident within the football codes.

_Strover_ (2004) studied to examine aerobic demands and activity patterns during match play in young soccer players with respect to competition level, age, and biological maturity. Ten nonelite players (NbP) and nine elite players (EbP) in their early puberty (12 yr), and
seven elite players (EeP) in their late puberty (14 yr) were studied. Heart rate (HR) and activity pattern were recorded during match play, whereas corresponding VO\(_2\) (max) and HR values were obtained during sub maximal and maximal treadmill tests in the laboratory. The maturity status was assessed from testicular volume. No difference in VO\(_2\) (max) was observed between the nonelite and the elite players in the beginning of puberty (58.7 ± 5.3 vs 58.6 ± 5.0 ml. O\(_2\) kg\(^{-1}\).min\(^{-1}\)), whereas the elite players in the end of puberty were significantly more fit (63.7 ± 8.5 ml. O\(_2\) kg\(^{-1}\).min\(^{-1}\)). During match play, a higher HR was recorded in the elite players in the beginning of puberty than their nonelite counterparts, whereas the two elite groups showed the same HR responses (HR 1st half/2nd half-NbP: 162/157; EbP: 177/174; EeP: 178/173). The elite players in the end of puberty thus performed a higher absolute and relative VO\(_2\) (VO\(_2\).min\(^{-1}\) and ml. O\(_2\) kg\(^{-1}\).min\(^{-1}\)) compared with the nonelite players during both halves, corresponding to more time spent in standing/walking in the nonelite group. The elite players in the end of puberty showed higher absolute VO\(_2\) values during match play than the young elite players but identical relative aerobic loads. It seems that the midfield/attack group had the highest absolute VO\(_2\) (max) and was performing at the highest HR during the
matches. The present study showed that young soccer players are highly specialized both according to playing level and position on the field.

Reilly (Sep. 2000) studied to apply a comprehensive test battery to young players with a view to distinguishing between elite and sub-elite groups on the basis of performance on test items. Thirty-one (16 elite, 15 sub-elite) young players matched for chronological age (15-16 years) and body size were studied. Test items included anthropometric (n = 15), physiological (n = 8), psychological (n = 3) and soccer-specific skills (n = 2) tests. Variables were split into separate groups according to somatotype, body composition, body size, speed, endurance, performance measures, technical skill, anticipation, anxiety and task and ego orientation for purposes of univariate and multivariate analysis of variance and stepwise discriminant function analysis. The most discriminating of the measures were agility, sprint time, ego orientation and anticipation skill. The elite players were also significantly leaner, possessed more aerobic power (9.0 ± 1.7 vs 55.5 ± 3.8 ml.kg⁻¹.min⁻¹) and were more tolerant of fatigue (P < 0.05). They were also better at dribbling the ball, but not shooting. They concluded that the test battery used might be useful in establishing baseline
reference data for young players being selected onto specialized development programmes.

Bangsbo (1992) evaluated exercise procedures to test the endurance capacity during soccer, individual results in laboratory and field tests were compared to physical performance during the match and further to performance during long term, intermittent exercise. Twenty professional soccer players were videotaped during competitive soccer matches, and the longest total distance (match-distance) and high intensity distance were determined. Blood lactate and maximum oxygen uptake VO2 (max) were measured during treadmill running. The subjects also carried out a continuous and an interval field test. Furthermore, eight players performed a prolonged, soccer-specific, intermittent test to exhaustion. Muscle enzymes and morphological characteristics were determined in biopsy samples obtained from the gastronomies muscles. The distance covered during the prolonged, intermittent test (mean: 16.3 km; range: 14.8-18.5 km) was not related to match-distance (r = 0.16), however, its correlation coefficient with high intensity distance covered during the match was 0.70. The interval field test distance was strongly correlated (r = 0.83) with the distance covered during the prolonged, intermittent test
distance. \( \text{VO}_2 \ (\text{max}) \ (r = 0.64) \) and blood lactate concentrations during sub maximal running \( (r = 0.58) \) were related to match-distance, but not to the prolonged intermittent test distance \( (r = 0.18 \text{ and } r = 0.27, \text{ respectively}) \). The muscle enzyme activities and the morphological variables were not related to match activities or to prolong, intermittent exercise performance.

McMahon (1998) studied to establish a link between aerobic adaptation and both the recovery from maximal short duration exercise, and the ability to maintain power output in a subsequent bout. The question as to whether the aerobic adaptations facilitating recovery were centrally or peripherally located was also examined. Male university level rugby and soccer players \( (n=20) \) volunteered for the study. Mean (SD) age, mass and maximal oxygen uptake \( \text{VO}_2 \ (\text{max}) \) was 21.9 (1.8) years, 84.7 (12.7) kg and 52.7 (6.9) ml.kg\(^{-1}\).min\(^{-1}\) respectively. Subjects completed six 15s maximal intensity sprints (90s active recovery) on a Monark friction braked cycle ergometer. A significant relationship \( (r=-.49, P=0.03) \) was obtained between \( \text{VO}_2 \) (max) ml.kg\(^{-1}\).min\(^{-1}\) and the percent drop-off in mean power in bouts 5 and 6 compared with bout 1. A correlation of \( r=-.62 \) \( (P=0.002) \) was obtained between \( \text{VO}_2 \) (max) ml.kg\(^{-1}\).min\(^{-1}\) and the percent drop off in
peak power in bouts 5 and 6 compared with bout 1. A significant correlation was obtained between arterial venous oxygen difference and the drop in mean power \((r= -0.54, P=0.02)\) but not with the drop in peak power \((r= -0.22, P= 0.36)\). There was no significant relationship between cardiac output and the drop in mean power \((r= -0.16, P= 0.51)\) or the drop in peak power \((r= -0.02, P= 0.94)\). Percent drop-off in oxygen consumption, when compared with the first, in the second (R \(\text{VO}_2\) (30-60)), third (R \(\text{VO}_2\) (60-90)), fourth (R \(\text{VO}_2\) (90-120)) and fifth (R \(\text{VO}_2\) (120-150)) 30s time periods of recovery following the intermittent protocol was calculated. Correlations between \(\text{VO}_2\) max (ml.kg\(^{-1}\).min\(^{-1}\)) and these variables were \((r= 0.51, P= 0.03)\), \((r= 0.44, P= 0.06)\), \((r= 0.63, P= 0.003)\) and \((r= 0.6, P= 0.007)\) respectively. Consequently it was concluded that maximal oxygen uptake particularly the peripheral component, is an important determinant of the ability to perform intermittent exercise of this nature and to recover between bouts.

Chamari (Feb.2005) compared aerobic capacity of young and adult elite soccer players using appropriate scaling procedures. Twenty-four male adult (mean (SD) age 24 (2) years, weight 75.7 (7.2) kg, \(\text{VO}_2\) max 66.6 (5.2) ml.lbm\(^{-1}\).min\(^{-1}\), where lbm is lean body mass in kg) and 21 youth (14 (0.4) years, 60.2 (7.3) kg, 66.5 (5.9) ml.lbm\(^{-1}\)
1.min⁻¹) elite soccer players took part in the study. Allometric equations were used to determine the relation between maximal and sub maximal oxygen cost of running (running economy) and body mass. Maximal and sub maximal oxygen uptake increased in proportion to body mass raised to the power of 0.72 (0.04) and 0.60 (0.06) respectively. The VO₂ max of adult players was similar to that of the youth players when expressed in direct proportion to body mass—that is, ml.kg⁻¹.min⁻¹ but 5% higher (p<0.05) when expressed using appropriate procedures for scaling. Conversely, compared with seniors, youth players had 13% higher (p<0.001) energy cost of running—that is, poorer running economy—when expressed as ml.kg⁻¹.min⁻¹ but not when expressed according to the scaling procedures. Compared with the youth soccer players, VO₂ max in the seniors was underestimated and running economy overestimated when expressed traditionally as ml/lbm/min. The study clearly shows the pitfalls in previous studies when aerobic capacity was evaluated in subjects with different body mass. It further showed that the use of scaling procedures can affect the evaluation of, and the resultant training programme to improve, aerobic capacity

Reilly (2000) reviewed to focused on anthropometric and physiological characteristics of soccer players with a view to
establishing their roles within talent detection, identification and
development programmes. Top-class soccer players have to adapt to
the physical demands of the game, which are multifactorial. Players
may not need to have an extraordinary capacity within any of the areas
of physical performance but must possess a reasonably high level
within all areas. This explains why there are marked individual
differences in anthropometric and physiological characteristics among
top players. Various measurements have been used to evaluate specific
aspects of the physical performance of both youth and adult soccer
players. The positional role of a player is related to his or her
physiological capacity. Thus, midfield players and fullbacks have the
highest maximal oxygen intakes (> 60 ml.kg\(^{-1}\).min\(^{-1}\)) and perform best
in intermittent exercise tests. On the other hand, midfield players tend
to have the lowest muscle strength. Although these distinctions are
evident in adult and elite youth players, their existence must be
interpreted circumspectly in talent identification and development
programmes. A range of relevant anthropometric and physiological
factors can be considered which are subject to strong genetic
influences (e.g. stature and maximal oxygen intake) or are largely
environmentally determined and susceptible to training effects.
Consequently, fitness profiling can generate a useful database against which talented groups may be compared. No single method allows for a representative assessment of a player's physical capabilities for soccer. It was concluded that anthropometric and physiological criteria do have a role as part of a holistic monitoring of talented young players.

**Thatcher** (2004) studied to quantify the motion characteristics of professional youth soccer players and, to develop and validate a soccer-specific exercise protocol (SSEP). The motion characteristics of 12 first team members and 12 scholars (under 19s), signed to an English Premiership club were determined via motion analysis. Motion profiles from the analysis were then used to develop a SSEP for a non-motorized treadmill. Validity of the protocol was checked with 6, healthy, male soccer players who completed the SSEP and, on a separate occasion, a soccer match. Heart rates were recorded during both trials, in addition, capillary blood and expired air samples were taken, and RPE recorded, during the SSEP. Youth team players covered 10274±609 m, compared to 9741±882 m by the first team players (t=1.72, p>0.05; 95% CI for the difference = -1174 m to 109 m). The trend for greater mean distance covered by youth players
could be attributed to the distances covered while jogging and running. Mean heart rate response was 166±9 beats.min⁻¹ during match play and 166±12 beats.min⁻¹ during the SSEP (t=0.164, p>0.05). Mean \( \dot{V}O_2 \) during the SSEP was 70±3% of \( VO_2 \) (max). Blood lactate concentration fell from a mean value of 5.37±1.15 mmol. L⁻¹ during the first half to 4.74±1.25 mmol. L⁻¹ during the 2(nd) half (t=2.52, p<0.05). The findings of the study suggest that the protocol developed induced a similar physiological load to soccer match play and provide the opportunity to study the physiological demands of soccer.

Siegler (2003) evaluated changes in soccer-specific power endurance of 34 female high school soccer players throughout a season either with or without an intermittent, high-intensity exercise protocol. Thirty-four female high school soccer players were tested prior to the 2000 fall season and again 10 weeks later. The tests included an abridged 45-minute shuttle test (LIST), hydrostatic weighing, vertical jump, 20-m running-start sprint, and 30-second Wingate test. The experimental group (EG; n = 17, age 16.5 ± 0.9 years) completed a 10-week in-season plyometric, resistive training, and high-intensity anaerobic program. The control group (n = 17, age 16.3 ± 1.4 years) completed only traditional aerobic soccer conditioning. Statistical
significance was set at alpha < 0.05. The experimental group showed significant improvements in the LIST (EG = delta 394 seconds ± 124 seconds), 20-m sprint (EG = Delta-0.10 seconds ± 0.10 seconds), increase in fat-free mass (EG = delta 1.14 kg ± 1.22 kg), and decreases in fat mass (EG = Delta-1.40 kg ± 1.47 kg) comparing pre- to postseason. This study indicates that a strength and plyometric program improved power endurance and speed over aerobic training only. Soccer-specific power endurance training may improve match performance and decrease fatigue in young female soccer players.

**Cometti** (2001) assessed muscular strength and anaerobic power of elite, sub elite and amateur soccer players to clarify what parameters distinguish the top players from the less successful. Test was conducted on 95 soccer players from the French first division (elite), second division (sub elite), and amateurs and determined the isokinetic strength of the knee extensor and flexor muscles at angular velocities from -120 degrees sec\(^{-1}\) to 300 degrees sec\(^{-1}\). Vertical jump, 10 m sprint, 30 m sprint and maximum ball speed during shooting were also measured. The elite players had higher knee flexor torque than the amateurs at all angular velocities (p < 0.05), except at 300 degrees sec\(^{-1}\). The hamstring/quadriiceps ratios proposed with two different
methods were significantly lower in the amateur group than in the elite group (p < 0.05), except at 300 degrees sec\(^{-1}\). Maximum ball speed during shooting and speed over 30 m sprint were not different between elite, sub elite, and amateur players while speed over a 10 m sprint was significantly slower in amateur players and faster in the elite group (p < 0.05). Although performance in soccer is not determined only by measurable variables, professional players differ from amateurs in terms of knee flexor muscle strength and short-distance sprinting speed. Based on these findings they conclude that hamstring strength is extremely important in soccer players for joint stabilization during various tasks, notably in eccentric action. Further, short-sprinting performance may mirror actual game situations at high level and could be an important determinant of match-winning actions.

McIntyre (2005) evaluated and compared the mid-season physiological profiles of elite players. Physiological assessment was carried out on 29 inter-county Gaelic footballers, 30 inter-county hurlers, and 21 League of Ireland soccer players. Significant differences were reported for % body fat (p<0.05), aerobic capacity (p<0.05), flexibility (p<0.05), upper body strength (p<0.05), upper body strength endurance (p<0.05), abdominal endurance (p<0.05), and
speed endurance ($p<0.05$), while there were no differences recorded for height, weight, or speed levels. A relatively heterogeneous body size is evident for all three sports. Soccer players had lower body fat levels, greater aerobic capacity, greater strength endurance, and greater flexibility compared to both Gaelic footballers and hurlers, possibly due to specific training and conditioning programmes or physical adaptation to match play. The greater strength of both Gaelic footballers and hurlers and the superior speed endurance levels of Gaelic footballers also reflect the physical nature of the sports. Similar speed levels amongst all three sports reflect the importance of speed for performance. The various physiological attributes for Gaelic football, soccer, and hurling reflect the physical requirements for success and participation in each of these field games.

**Mohr** (2003) assessed physical fitness, match performance and development of fatigue during competitive matches at two high standards of professional soccer. Computerized time-motion analyses were performed 2-7 times during the competitive season on 18 top-class and 24 moderate professional soccer players. In addition, the players performed the Yo-Yo intermittent recovery test. The top-class players performed 28 and 58% more ($P < 0.05$) high-intensity running.
and sprinting, respectively, than the moderate players (2.43 ± 0.14 vs.
1.90 ± 0.12 km and 0.65 ± 0.06 vs 0.41 ± 0.03 km, respectively). The
top-class players were better (11%; P < 0.05) on the Yo-Yo
intermittent recovery test than the moderate players (2.26 ± 0.08 vs
2.04 ± 0.06 km, respectively). The amount of high-intensity running,
independent of competitive standard and playing position, was lower
(35-45%; P < 0.05) in the last than in the first 15 min of the game.
After the 5-min period during which the amount of high-intensity
running peaked, performance was reduced (P < 0.05) by 12% in the
following 5 min compared with the game average. Substitute players (n
= 13) covered 25% more (P < 0.05) ground during the final 15 min of
high-intensity running than the other players. The coefficient of
variation in high-intensity running was 9.2% between successive
matches, whereas it was 24.8% between different stages of the season.
Total distance covered and the distance covered in high-intensity
running was higher (P < 0.05) for midfield players, fullbacks and
attackers than for defenders. Attackers and fullbacks covered a greater
(P < 0.05) distance in sprinting than midfield players and defenders.
The midfield players and fullbacks covered a greater (P < 0.05)
distance than attackers and defenders in the Yo-Yo intermittent
recovery test ($2.23 \pm 0.10$ and $2.21 \pm 0.04$ vs $1.99 \pm 0.11$ and $1.91 \pm 0.12$ km, respectively). The results show that: (1) top-class soccer players performed more high-intensity running during a game and were better at the Yo-Yo test than moderate professional players; (2) fatigue occurred towards the end of matches as well as temporarily during the game, independently of competitive standard and of team position; (3) defenders covered a shorter distance in high-intensity running than players in other playing positions; (4) defenders and attackers had a poorer Yo-Yo intermittent recovery test performance than midfielders and full-backs; and (5) large seasonal changes were observed in physical performance during matches.

_Drust_ (2000) studied to devise a laboratory-based protocol for a motorized treadmill that was representative of work rates observed during soccer match play. Selected physiological responses to this soccer-specific intermittent exercise protocol were then compared with steady-rate exercise performed at the same average speed. Seven male university soccer players (mean ± s: age 24 ± 2 years, height 1.78 ± 0.1 m, mass 72.2 ± 5.0 kg, VO$_2$ max 57.8 ± 4 ml.kg$^{-1}$.min$^{-1}$) completed a 45-min soccer-specific intermittent exercise protocol on a motorized treadmill. A continuous steady-rate exercise session for an identical
period at the same average speed was also completed. The physiological responses to the laboratory-based soccer-specific protocol were similar to values previously observed for soccer match play (oxygen consumption approximately 68% of maximum, heart rate 168 ± 10 beats.min⁻¹). No significant differences were observed in oxygen consumption, heart rate, and rectal temperature or sweat production rate between the two conditions. Average minute ventilation was greater (P < 0.05) in intermittent exercise (81.3 ± 0.2 L.min⁻¹) than steady-rate exercise (72.4 ± 11.4 L.min⁻¹). The rating of perceived exertion for the session as a whole was 15 ± 2 during soccer-specific intermittent exercise and 12 ± 1 for continuous exercise (P < 0.05). The physiological strain associated with the laboratory-based soccer-specific intermittent protocol was similar to that associated with 45 min of soccer match play, based on the variables measured, indicating the relevance of the simulation as a model of match play work rates. Soccer-specific intermittent exercise did not increase the demands placed on the aerobic energy systems compared to continuous exercise performed at the same average speed, although the results indicate that anaerobic energy provision is more important during intermittent than during continuous exercise at the same average speed.
Francis (1989) a suitable ergometer that is generally favored for estimating maximal oxygen consumption (VO₂ max) under field conditions or in environments where testing equipment is limited is the step test. Recently a mathematical model was reported to standardize the height of stepping for individuals of various heights. They designed a study to validate this model using a three-minute single-stage step test for predicting VO₂ max in women. Seventeen women aged 19 to 33 performed each of three rate-specific step tests and a Bruce treadmill test. Direct measurements of VO₂ max obtained from the treadmill test were correlated with the 15 second recovery heart rates after three different step tests done at stepping frequencies of 22, 26, and 30 step-ups per minute. The correlation coefficients of prediction of VO₂ max from 15-second recovery pulse counts and directly measured oxygen consumption were 0.74 at 22 step-ups/min, 0.77 at 30 step-ups/min, and 0.8 at 26 step-ups/min. Each relationship was significant at the P less than .01 levels. It was be concluded that the single-stage step test described in this study provides an effective predictor of VO₂ max in young women and can be used when more complex methods of laboratory testing are unavailable or not feasible.
Fuso (1996) evaluated the inspiratory muscle strength in a group of professional soccer players in comparison with a group of sedentary subjects. Maximal Inspiratory Pressure (Plmax) was measured both at Functional Residual Capacity (FRC) and at Residual Volume (RV) in 130 subjects: 27 of these were elite soccer players (all males, aged 22 ± 3 years) and 103 were normal sedentary subjects (77 males and 26 females, aged 44 ± 19 years). Predictive linear models were produced by a stepwise regression analysis in the whole sample of subjects. Both PlmaxFRC and PlmaxRV models included female gender and ageing as negative predictors, and Body Mass Index (BMI) as positive predictor of the inspiratory pressures. The model predicting PlmaxFRC was slightly more accurate than the model predicting PlmaxRV (r-squared: 0.38 vs 0.36, respectively). After adjustment for the variables entered in these models, PlmaxFRC and PlmaxRV were respectively 1.54 KPa and 1.08 KPa higher in soccer players than in sedentary subjects but this result was statistically significant (p < 0.02) only for PlmaxFRC. It was conclude that the inspiratory muscle strength is increased in soccer players and Plmax measured at FRC seems more sensitive in order to discriminate between subjects with different level of physical activity.
Raven (1976) evaluated on cardio respiratory function, endurance performance, body composition, blood chemistry, and motor fitness measures near the end of their competitive season. The following means were observed: age, 26 yrs; height, 176 cm; weight 75.5 kg; resting heart rate, 50 beats/min; maximum heart rate (MHR), 188 beats.min⁻¹; maximum oxygen intake (VO₂ (max)), 58.4 ml.kg⁻¹.min⁻¹; maximum ventilation (VEmax BTPS), 154 L.min⁻¹; body fat, 9.59%; 12-min run, 1.86 miles; and Illinois agility run, 15.6 secs. Results on resting blood pressure, serum lipids, vital capacity, flexibility, upper body strength, and vertical jump tests were comparable to values found for the sedentary population. Comparing the results with previously collected data on professional American Football backs indicated that the soccer players were shorter; lighter in body weight; higher in VO₂ max (4 ml.kg⁻¹.min⁻¹) and body fat (1.8%); and similar in MHR, VE max, and VC. The 12-min run scores were similar to the initial values observed for the 1970 Brazilian World Cup Team. The agility run results was superior to data collected from other groups. Their endurance capabilities, agility, and low percent of body fat clearly differentiate them from the sedentary population and show them to be similar to that of professional American football backs.
Davis (1992) undertook an investigation in an effort to establish physiological characteristics of soccer players and to relate them to positional roles. A total of 135 footballers (age 24.4 ± 4.6 years) were assessed for body mass, % body fat, hemoglobin, maximal oxygen uptake (VO₂ max), leg power, anaerobic capacity and speed prior to an English league season. The sample included 13 goalkeepers, 22 fullbacks, 24 center backs, 35 midfield players and 41 forwards. The goalkeepers were significantly heavier (86.1 ± 5.5 kg; P < 0.01) than all groups except the backs-backs, had significantly higher estimated body fat percentages than backs-backs, forwards, midfield players (P < 0.01) or full-backs (P < 0.05), significantly lower estimated VO₂ max values (56.4 ± 3.9 ml.kg⁻¹.min⁻¹; P < 0.01) and were slowest over 60 m (12.71 ± 0.42 s). The midfield players had the highest predicted VO₂ max values (61.4 ± 3.4 ml.kg⁻¹.min⁻¹), this being significantly greater (P < 0.05) than for the backs-backs. The forwards were the fastest group over 60 m (12.19 ± 0.30 s), being significantly quicker than goalkeepers or backs-backs (P < 0.01) and fullbacks (P < 0.05). Anaerobic power, as well as knee extensor torques (corrected for body mass) and extensor-flexor ratios, was similar between groups. No difference in estimated body fat percentage was observed between any
of the outfield players, and hemoglobin concentrations were similar among players of all positions.

*Chamari* (2004) determined to correlate between the physical fitness of young soccer players assessed by field and laboratory testing. Thirty-four male soccer players took part in the study (mean (SD) age 17.5 (1.1) years, height 177.8 (6.7) cm, weight 70.5 (6.4) kg). Maximal oxygen uptake $\text{VO}_2\text{ (max)}$ during treadmill running and vertical jump height on a force platform was measured in the laboratory. Field tests consisted of a soccer specific endurance test (Bangsbo test) and 30 m sprint with 10 m lap times. The Bangsbo test correlated with the lowest velocity associated with $\text{VO}_2\text{ max}$ ($v\text{ VO}_2\text{ max}; R (2) = 0.55, p<0.001$), but not with $\text{VO}_2\text{ (max)}$. Sprint times at 30 m and 20 m were related to peak extension velocity and peak extension force measured during vertical jumping, but not to vertical jump height per se. The jumping force and velocity could explain 46% of the 30 m sprint performance ($R (2) = 0.46, p<0.001$). The Bangsbo test and 30 m sprint test correlate with $v\text{ VO}_2\text{ (max)}$ and vertical jump force and velocity respectively. The Bangsbo test does not give a good estimate of $\text{VO}_2\text{ (max)}$ in young soccer players.
Vanderford (2004) conducted a study on physiological and sport specific skill response of Olympic youth soccer athletes. Although many studies have been focused on soccer athletes, no comprehensive studies have been conducted on adolescent soccer athletes in the United States. Therefore, the purpose of this study was to quantify the physiological and sport-specific skill characteristics of Olympic Development Program (ODP) soccer athletes by age group and game experience. Following written, informed consent, 59 male athletes (age=14.6±2.0 years; wt=60.5±1.4kg; ht=172.4±1.2 cm) completed a battery of test to determine aerobic power (VO$_2$ max), heart rate (HR$_{max}$), ventilation (VE$_{max}$), respiratory exchange ratio (RER), anaerobic threshold (AT), blood pressure (BP$_{rest,max}$), anaerobic power/capacity [peak power (PP), mean power (MP), total work output (TWO), fatigue index (FI)], leg power [Vertical squat jump (VSJ), countermovement jump (VJC)], body composition [percent body fat (%BF), lean body mass (LBM)], joint range of motion (trunk, back, hip, knee, and ankle, and agility/sport-specific skills (T-test, line drill test, juggling test, Johnson wall volley, and modified-Zelenka circuit). Factor analyses with subsequent multivariate analyses of variance (MANOVAs) indicated significant main effects across age (p=0.0001)
but not by game experience (p=0.82). Older athletes exhibited greater height, weight, LBM, \(VE_{\text{max}}\), \(\text{Time}_{\text{max}}\), PP, TWO, and VSJ values than younger athletes. Although not significant, there were differences with increasing age in the agility tests (T-test, wall volley, and juggling test). In conclusion, improvements in anaerobic power, agility, and sport specific skill should be addressed at this developmental level of competition.

Aziz (2000) examined the relationship between maximal oxygen uptake and repeated sprint performance in field hockey and soccer players. A descriptive study on the aerobic-anaerobic performance of intermittent team game players was set as experimental design. The study was conducted at the Sports Medicine and Research Center. Forty male national team game players (22.6±4.2 years; 1.73±0.07 m and 63.7±6.2 kg) were involved in the study. All subjects completed a treadmill run test to exhaustion to determine maximal oxygen uptake and 8x40 m sprints either on the field or running track to determine repeated sprint ability performance. Body mass normalized maximal oxygen uptake of 58.0±4.9 ml.kg\(^{-1}\).min\(^{-1}\) of the group is comparable to values reported in the literature for team game players. No significant correlations were established between the fastest 40 m sprint time and
maximal oxygen uptake \((r=-0.21\) and \(-0.08, \ p>0.05)\). Moderate correlations were established between maximal oxygen uptake and total time for the eight sprints \((r=-0.346\) and \(-0.323; \ p<0.05)\). Maximal oxygen uptake was not correlated with the fastest 40 m sprint time but was moderately correlated with total sprint time. Since the shared variance between maximal oxygen uptake and total sprint time was only 12%, improving aerobic fitness further will only be expected to contribute marginally to improving repeated sprint performance of the team game players. It remains possible that a high level of aerobic fitness enhances other aspects of match play in games like soccer and hockey.

Mukherjee (2004), stated that physiological studies on children, involved in various active sports disciplines, especially in football, are scanty in world Literature. An attempt to investigate the same, in the age group of 10-112 years with especial reference to \(\text{VO}_2\text{max}\) and Pulmonary Capacities. The study was conducted on 23 children in the age group of 10-11 years who have been selected in a Football Academy at Chindigarh. At the time of evaluation, these children had training age of one year. The aerobic capacity or maximum oxygen uptake capacity \((\text{VO}_2\text{max})\) was estimated with the help of a COSMED
K4 portable telemetric analyzer (COSMED, Italy), following a graded protocol of exercise on a bicycle ergometer, till exhaustion. The initial load was 1 watt/kg and was increased at the rate of 0.5 watt/kg after every 2 min, till exhaustion. The physiological variables were recorded every 30 sec interval. The anaerobic threshold level of the subjects were determined by gas exchange method from the deviation point of $V_E - VCO_2$, $V_E-VO_2$ relationship and breathing equivalent. The respiratory profiles, like, Forced vital capacity, FEV-1, and peak expiratory flow rate were estimated using a computerized spirometer. The mean relative $VO_{2max}$ of these child footballers was 56.6± 3.9 ml.kg⁻¹.min⁻¹ and the AT $VO_2$ was 79.5±7.3 % $VO_{2max}$. These were comparable to those of adult players. The static and dynamic lung volumes depended more on the corporal data than the training status. The study highlights that training can improve aerobic adaptation in the child footballers like adults and thus the $VO_{2max}$ and anaerobic threshold level of the child players reach a comparable status to the adult footballers. The lung capacities of the child footballers depend more on age, height and weight than the training adaptation and for this reason the lung capacities of the child players are lower than their adult counterparts.
Garstrecki (2004) studied the comparison of selected physical fitness and performance variables between NCAA Division I and II football players. The purpose of the study was to compare selected physical fitness and performance variables between National Collegiate Athletic Association (NCAA) Division I and II football players. The subjects included offensive and defensive starters, excluding kickers and punters from 26 NCAA Division 23 and I Division II teams. Offensive players were grouped and compared by the following position: quarterback, running back, wide receiver, tight ended, and line. Defensive players were grouped and compared by the following position: line, linebackers, and back, Division I players were better in 58 of 117 comparisons \((p<0.01)\). Division II players were not found to be better in any of the variables studied.

Secora (2004) conducted a study to compare physical and performance characteristics of NCAA Division I football players: 1987 and 2000. The purpose of the study was to compare normative data from present Division I National Collegiate Athletic Association football teams to those from 1987. Players were divided into 8 positions for comparisons: quarterback (QB), running back (RB), receivers (WR), tight ends (TE), offensive linemen (OL), defensive
linemen (DL), linebackers (LB), and defensive back (DB). Comparison included height; body mass, bench press and squat strength, vertical jump, vertical jump power, 40-yd dash speed, and body composition. Independent ‘t’ test were used to analyze the data with level of significance set at $p<0.01$. Significant differences ($p \leq 0.01$) were found in 50 of 88 comparisons. From 1987 until 2000, Division I college football players in general have become bigger, stronger, faster, and more powerful.

**Thomas** (2004) studied on cheerleading which traditionally considered as a non-athletic activity, which require high level of fitness. Despite the trend of cheerleaders performing increasingly difficult and athletic skills, very little is known about their fitness levels. The purpose of the study was to provide a physiological profile of the fitness status of a squad of collegiate cheerleaders. Eighteen cheerleaders (11 men and 7 women) participated in this study. Each subject completed a Bruce protocol maximal treadmill test, underwater weighing repetition maximum bench press, sit and reach test, pushups, curl ups, and isokinetic strength testing. The mean and SD were calculated to provide the physical fitness profile for each parameter.
Comparison to normative data demonstrated that cheerleaders have a high level of fitness and scores similar to other collegiate athletes.

**Vanheest** (2004) studied the characteristics of elite open-water swimmers. Open water swimming (5, 10, and 25 km) has many unique challenges that separate it from other endurance sports, like marathon running and cycling. The characteristics of a successful open-water swimming are unclear. The purpose of the study was to determine the physical and metabolic characteristics of a group of elite level open water swimmers. The open water swimmers were participating in a 1-week training camp. Anthropometric, metabolic, and blood chemistry assessments were performed on the athletes. The swimmers had a VO\(_2\) peak of 5.51±0.96 and 5.06±0.57 ml.kg\(^{-1}\).min\(^{-1}\) for males and females respectively. Their lactate threshold (LT) occurred at a pace equal to 88.75% of peak pace for males and 93.75% for females. These elite open water swimmers were smaller and lighter than competitive pool swimmers. They possess aerobic metabolic alterations that resulted in enhanced performance in distance swimming. Trainers and coaches should develop dry-land programs that will improve the athlete’s muscular endurance. Furthermore, programs should be designed to increase the LT velocity as a percentage of peak swimming velocity.
Ostojic (2003) examined the effects of training and competition on body fat content and sprint performance in elite professional soccer players. Thirty professional male soccer players (1st National league) participated in the study. Anthropometric measurements were collected at the start of the first conditioning period, at the start of season, in the mid-season, end-season and at the start of the second conditioning period. Body composition was assessed by skinfold measurement. Estimated body fat percentage at the end of the season was significantly lower than levels at the start of the first conditioning period, mid-season, second conditioning period and at the start of the season (9.6±2.5% vs. 11.5±2.1, 10.2±2.9, 12.6±3.3 and 10.9±2.4% respectively; p<0.05; values are mean (s.d.). There were no significant differences in fat-free mass between measurements performed during the season. Better 50 m sprint times were achieved at the end of season as compared to the start of the first conditioning period, at the beginning of the season and at the start of the second conditioning period (7.1±0.5 s vs. 7.5±0.6, 7.3±0.6, 7.6±0.5 s, respectively; p < 0.05). The main finding of the present study was that body fat content of professional soccer players significantly dropped during the
conditioning and competitive periods and increased during the off-
season.

**Bunc** (2001) studied the physiological profiles of 22 young soccer players (mean age = 8.0±0.3 years, body mass = 28.2±3.2 kg, body height = 132.4±4.3 cm and body fat = 19.4±1.6 percent) were measured by the incremental exercise protocol on the treadmill with 5 percent inclination. All boys systematically trained at least 2 years with a minimum of two training units per week. During preseason, they trained two times per week, and during the competitive season they trained at least three times and competed in one or two games per week. Mean $\text{VO}_2 \text{ max}$ kg$^{-1}$ was 56.7±4.9 ml.kg$^{-1}$.min$^{-1}$. Mean value of maximal running speed on a treadmill with 5 percent of inclination was 12.0±0.9 km.h$^{-1}$. Mean values of Rmax = 1.11±0.07. The selected functional variables at the ventilatory threshold (VT) level corresponded to $\text{VO}_2$. Kg$^{-1}$ = 42.9±5.0 ml.kg$^{-1}$.min$^{-1}$, mean values of percent $\text{VO}_2 \text{ max}$ Kg$^{-1}$ at VT level were 76.5±1.3 percent, mean speed of running was 10.5±1.2 km.h$^{-1}$, mean values of percent Vmax at VT level were 87.5±1.9 percent. The mean of energy cost of running was 4.28±0.19 J.kg$^{-1}$.m$^{-1}$. According to our results, we can conclude that the physiological characteristics of young soccer players about 8 years old
should be as follows: VO$_2$ max. Kg$^{-1}$ higher than 55 ml.kg$^{-1}$.min$^{-1}$ in defenders, and higher than 60 ml.kg$^{-1}$.min$^{-1}$, in midfielders and forwards. Maximal speed of running on the treadmill with 5 percent of inclination should be higher than 12 km.h$^{-1}$ in all players, the running speed at anaerobic threshold (5 percent) higher than 10.5 km.h$^{-1}$, percent VO$_2$ (max) at anaerobic threshold level higher than 77.0 percent, and the energy cost of running lower than 4.20 J.kg$^{-1}$.m$^{-1}$. As in other sports where skills play a decisive role, the physiological data cannot be the sole predictor of competitive success.

Kraemer (2001) conducted a study and investigated the physiological and performance responses to a simulated freestyle wrestling tournament after typical weight loss techniques used by amateur wrestlers. Twelve Division I collegiate wrestler (mean ± SD; 19.33±1.16 years) lost 6 % of total body weight during the week before a simulated, 2-d freestyle wrestling tournament. A battery of tests was performed at baseline and before and immediately after each individual match of the tournament. The test battery included assessment for body composition, reaction/movement time, lower and upper body power and isokinetic strength, and a venous blood sample. Lower body power and upper body isometric strength were significantly reduced as the
tournament progressed ($P \leq 0.05$). Significant elevations in testosterone, cortisol, and lactate were observed after each match ($P \leq 0.05$). However there was significant reduction ($P \leq 0.05$) in resting testosterone value in the later match. Norepinephrine increased significantly ($P \leq 0.05$) after each match whereas epinephrine increased significantly ($P \leq 0.05$) after each match except the last match of each day. Plasma osmolality was consistently higher than normal values at all times including baseline, with significant increases observed after each match ($P \leq 0.05$). Tournament wrestling augments the physiological and performance decrements of weight loss and its impact is progressive over 2 d of competition. The combined effects of these stresses may ultimately be reflected in a wrestler’s ability to maintain physical performance throughout a tournament.

Warrington (2001), conducted a study to determine the aerobic power $\text{VO}_2\text{max}$, body composition, strength muscular power, flexibility, and biochemical profile of an elite international squad of tug of war athletes. Sixteen male competitors (mean (SEM) age 34 (2) years) were evaluated in a laboratory. For comparative purposes, data were analyzed relative to normative data for their center and to a group of 20 rugby forwards from the Irish international squad. The tug of war
participants were lighter (83.6 (3.0) v 10.4.4 (1.8) kg, p<0.0001) and had less lean body mass (69.4 (2.1) v 86.2 (1.2) kg), than the rugby players and had lower than normal body fat (16.7 (0.9))%; all values are mean (SEM). Aerobic power measured during a treadmill test was 55.8 (1.6) ml/kg/min for the tug of war participants compared with 51.1 (1.4) ml.kg^{-1}.min^{-1} for the rugby forwards (P<0.03). A composite measure of strength derived from (sum of dominant and non-dominant grip strength and back strength) / lean body mass yielded a strength/mass ratio than that was 32% greater (p<0.0001) for the tug of war group than the rugby group. Dynamic leg power was lower for the tug of war group than the rugby forwards (4659.8 (151.6) v 6198.2 (105) W respectively; p<0.0001). Leg flexibility was 25.4 (2.0) cm for the tug of war group. Back flexibility was 28.6 (1.4) cm which was lower (p<0.02) than the rugby forwards 24.2 (1.5) cm. Whereas blood chemistry and hematology were normal, packed cell volume, hemoglobin concentration, and erythrocyte volume were lower in the tug of war group than in the rugby player (p<0.05). All three hematological measures correlated with muscles mass (packed cell volume, r^2=0.37, p<0.0001; hemoglobin concentration, r^2 =0.13, p<0.05; erythrocyte volume, r^2=0.21, p<0.01). The data indicate that
international level tug of war participants have excellent strength and above average endurance relative to body size, but have relatively low explosive leg power and back flexibility. The data provide reference standards for the sport and may be useful for monitoring and evaluating current and future participants.

Ostojić (2000) described structural and functional characteristics of elite Serbian soccer players and to make comparisons with non-elite counterparts. One of the teams in the study (Squad A; nA = 16) competed in the professional First National League while the other team (Squad B; nB = 16) played in the amateur Third Division. Physiological measurements were made in 32 players, during the final week of the preparatory training period. Subjects from Squad A were older (23.8 ± 3.4 vs. 21.5 ± 3.2 years, P < 0.05) and more experienced (7.5 ± 3.1 vs. 4.8 ± 2.8 years, P < 0.05) as compared to players in Squad B. Players from Squad B had significantly lower estimated VO$_{2}$ max values compared with elite subjects in Squad A (42.9 ± 6.6 vs. 53.5 ± 8.6 ml·kg$^{-1}$·min$^{-1}$, P < 0.05). In addition, the highest heart rate frequencies during the last minute of the 20-m shuttle run test were lower in elite players (183.1 ± 6.1 vs. 189.9 ± 8.1 beats·min$^{-1}$, P < 0.05). Vertical jump height was significantly higher in Squad A (47.6 ±
5.7 vs. 46.2 ± 5.5 cm, P < 0.05) and estimated percentage of fast muscle fibers (fast twitches) was higher in Squad A as compared to Squad B (62.8 ± 7.7 vs. 57.4 ± 8.1%, P < 0.05). The results of the present study supported previous investigations indicating a strong relationship between aerobic fitness, anaerobic power and performance results in elite soccer.

**Hedelin** (2000), investigated nine elite canoeists concerning changes in performance, heart rate variability (HRV) and blood chemical parameters over a 6-d training camp. The training regimen consisted of cross-country skiing and strength training, in total 13.0±1.6 h. corresponding to a 50% increase in training load. Time to exhausting (RunT) decreased from 19.1±1.0 to 18.0±1.2 min (P<0.05). \( VO_2_{\text{max}} \) and max lactate \( (L_a_{\text{max}}) \) both decreased significantly \( (P<0.05) \) over the training period \( (4.99±0.97 \text{ to } 4.74±0.98 \text{ L.min}^{-1} \) and from \( 10.08±1.25 \text{ to } 8.98±1.03 \text{ mmol. L}^{-1} \) respectively). Heart rate (HR) decreased significantly at all workloads. Plasma volume increased by 7±7% \( (P<0.05) \). Resting cortisol, decreased from 677±244 to 492±222 mmol. L\(^{-1} \) \( (P<0.05) \), whereas resting levels of adrenaline and noradrenalin remained unchanged. The change between tests in RunT correlated significantly with the change in \( HR_{\text{max}} \) \( (r=0.79; P=0.01) \).
There were no group changes in high or low frequency HRV, neither at arrest nor following a tilt. The reduced maximal performance indicates a state of fatigue/overreaching and peripheral factors are suggested to limit performance even though $HR_{\text{max}}$ and $La_{\text{max}}$ both were reduced. The reduced sub maximal heart rates are probably a result of increased plasma volume. HRV in this group didn’t seem to be affected by short term over training.

Wisloff (1998) examined whether there exists a relationship between preseason physiological test and performance results in the soccer league. Further, they investigated maximal oxygen uptake and maximal strength in proportion to body mass for soccer players. A secondary aim was to establish some normative data of Norwegian elite soccer players. Two teams from the Norwegian elite soccer league participated in the study. The present study supports previous investigation indicating a positive relationship between maximal aerobic capacities, physical strength and performance result in the elite soccer league. It is concluded that for soccer players, maximal oxygen uptake should be expressed in relation to body mass raised to the power of 0.75 and maximal strength in relation to body mass raised to the power of 0.67, where the aim is to evaluate maximal aerobic
capacity when running and strength capacity among players with different body mass. Midfield players had significantly higher maximal oxygen uptake compared with defense players using the traditional expression mL.kg\(^{-1}\).min\(^{-1}\), while no significant were found expressing maximal oxygen uptake either absolutely (L.min\(^{-1}\)) or in relation to body mass raised to the power of 0.75 (mL.kg\(^{-0.75}\).min\(^{-1}\)) among players grouped by position. There was a significant correlation (r=0.61, P<0.01) between squat I RM and vertical jump height. Vertical jump heights for defense and forward player were significantly higher compared with midfield players. Mean results from the laboratory test were 63.7 mL.kg\(^{-1}\).min\(^{-1}\) or 188.6 mL.kg\(^{-0.75}\).min\(^{-1}\) for maximal oxygen uptake, 150 kg or 8.0 kg.m\(^{-0.67}\) for 90\(^{\circ}\) squat , 79.9 kg or 4.4 kg.m\(^{-0.67}\) for bench press . Mean values of vertical jump height were 54.9 cm.

**Wilber (1997),** conducted a study on elite female (N=10) and male (N=10) athletes representing the United States National off-Road Bicycle Association (NORBA). Cross Country Team were compared with elite female (N=10) and male (N=10) athletes representing the United States Cycling Federation (USCF) National Road Team. Sub-maximal and maximal exercise responses were evaluated during the “championship” phase of the training year when athletes were in peak
condition. All physiological tests were conducted at 1860 m. Among the female athletes, physiological responses at lactate threshold (LT) and during maximal exercise (MAX) were similar between NORBA and USCF cyclists with two exceptions: 1. USCF cyclists demonstrated a significantly greater (p<0.05) absolute (16%) and relative (10%) maximal aerobic power, and 2) MAX heart rate was significantly higher (P<0.05) for the USCF athletes (6%). Among the male athletes, physiological responses at LT and MAX were similar between NORBA and USCF cyclists with two exceptions: 1) USCF cyclists produced significantly greater (P<0.05) absolute (18%) and relative (16%) power at LT, and 2) USCF cyclists produced significantly greater (P<0.05) absolute (12%) and relative (10%) power at MAX. These data suggested that, in general, elite off-road cyclists possess physiological profiles that are similar to elite road cyclist.

Griffin (1997) summarizes research dealing with the validity of commonly used methods for measuring systematic blood pressure during exercise. Arterial blood pressure measured from within peripheral arteries exaggerates systolic blood pressure because of waveform reflection but provide representative mean and diastolic pressures of the central arterial circulation. Manual and automated
sphygmonametry are the best noninvasive indirect methods of blood
pressure measurement to estimate ascending aorta systolic pressure;
however, both methods significantly underestimate diastolic pressures
at rest and during exercise. The error in diastolic pressure measurement
increases with increasing exercise intensity. The accuracy of many
indirect noninvasive devices for blood pressure measurement at rest
and during exercise can be questioned because of the use of unsuitable
criterion methods. Ascending aorta pressures should ideally be used as
a gold standard or criterion method for blood pressure method during
exercise and instrument/method validation. However, given the
constraints of varied criterion standards and current recommendations
for blood pressure measurement, the following units were found to be
acceptable devices for measuring systolic blood pressure during
Critikon 1165, and possibly the Paramed 9350.

Terbizan (1996) compared the physiological characteristics of
young wrestlers grouped by age. Three hundred and twenty eight
wrestlers (mean age 15.99±1.08 years and mean weight
65.94±11.01kg) attending a wrestling training camp between 1990 and
1994 were tested to determine their physiological capacities. The
physiological profile included body weight, body composition measured by hydrostatic weighing, sum of skinfolds, aerobic power, grip strength, absolute and relative endurance, sit-ups, pushups, fatigue, and flexibility measures. Wrestlers were divided into three age categories: G1: ≤ 15 years of age; G2: 16 years of age; and G3 ≥ 17 years of age. Analysis of variance with Tukey post hoc test revealed statistically significant (p<0.05) differences in body weight (G1<G2, G3), fat free weight (G1<G2, G3), grip strength (G1<G2, G3), absolute (G1<G2, G3; G2<G3) and relative endurance (G1<G3; G2<G3), pushups (G1<G3; G2<G3), sit and reach (G1<G3), Margaria-Kalamen power (G1<G2, G3), and Wingate arm and leg mean powers (G1<G2, G3). When covaried for body weight and fat free weight, there were no significant differences in grip strength and margaria-Kalamen power. Significant differences in arm mean power when covaried for body weight and fat free weight (G1<G3) and for leg mean power when covaried for body weight (G1<G3) were noted. These wrestlers were similar to young wrestler in published research, with low body fat, excellent aerobic capacity and flexibility. When separated by age, the younger wrestlers possess less body weight, fat free weight, grip strength, and power measures, possibly due to lower muscle mass.
Bunc (1996) characterized the physiological profile of top young triathletes, 13 top female (mean age = 17.1 ±1.4 years, body mass = 58.8±4.7 kg, body height =168.4±2.0 cm and body fat=10.4±2.6%) and 23 top male triathletes age =17.7±2.2 years, mass =66.7±7.1 kg, height=176.5±5.1 cm and fat 8.2±2.3%) were evaluated by means of an incremental exercise (increment was 1 km/h, and exercise starting at 11 km/h in females and 13 km/h in males) on a treadmill with 5% inclination. Mean VO$_2$$_{max}$ was 67.9 ± 5.9 ml/kg/min in boys and 56.12.4 ml/kg/min in girls. Mean value of maximal running speed was 18.6±1.2 km/h in mean and 15.4±0.6 km/h in females and L$A_{max}$ was 12.5±2.3 mmol/l in boys and 12.6±1.2 mmol/l in girls. The selected functional variables at ventilatory threshold (VT) level in boys and girls corresponded to VO$_2$$_{max}$ kg$^{-1}$ 56.0±5.4 and 46.2±2.6 ml/kg/min, respectively, % VO$_2$$_{max}$ kg$^{-1}$ at VT 82.4±2.1 and 83.1±1.7%, respectively speed of running 15.2±1.4 and 12.7±0.7 km/h, respectively, % V$_{max}$ at VT 81.8±2.6 and 82.3±1.6%, respectively and the coefficient of energy cost of running c was 3.74±0.42 and 3.71±0.39 J/kg/m, respectively. A comparison of the functional profiles of these triathletes with elite young athletes from the sports of swimming (age 17.5±2.0 and 172.2±1.7 years, respectively, VO$_2$$_{max}$
61.6±3.6 and 52.1±3.6 ml/kg/min, respectively, V\text{max} 17.5±0.8 and 15.0±0.9 km/h respectively, L\text{A}_{\text{max}} 11.1±3.2 and 11.8±3.3 mmol/l, respectively) cycling (17.7±1.8-17.0±1.7 years; 65.4±5.1-55.1±2.4 ml/kg/min, 18.2±0.7-15.2±0.8 km/h; 13.3±3.5-12.9±3.7 mmol/l) and middle distance running (17.8±1.9-17.2±2.1 years; 66.8±4.7-57.3±2.6 ml/kg/min, 19.1±0.9-16.1±0.9 km/h; 13.1±2.6-13.7±3.0 mmol/l) showed the physiological characteristics of tri-athletes to be similar to those of middle distance runners. According to our results and according to the data from the Literature we can conclude that physiological predispositions for success in international triathlon may be as follows in boys and girls: VO$_2$\text{max}/kg higher than 65 and 60 ml.kg$^{-1}$min$^{-1}$, respectively, V$_{\text{max}}$ (5%) higher than 18 and 16 Km/h, respectively, L\text{A}_{\text{max}} higher than 12 and 11 mmol/l, respectively, running speed at ‘anaerobic threshold’ higher than 15.0 and 13 km/h, respectively, % VO$_2$\text{max} at ‘anaerobic threshold’ level higher than 82.5% in both sex, and the coefficient of energy cost of running lower than 3.75 and 3.73 J/Kg/m, respectively. As in other sports events of endurance native, these data are not the sole predictor of racing success. Nevertheless these standards are necessary but not sufficient
conditions for success in triathlon. These data play a decisive role in the selection of talent for the triathlon.

**James** (1995) assessed match-lay demands of Gaelic football and fitness profiles at club competitive level. English Gaelic football club championship players (n=11) were assessed for anthropometry, leg strength and time to exhaustion on a treadmill run. A similar test battery was administered to a reference group of University competitive soccer players (n=12). Heart rate was recorded during match-play using radio telemetry and blood lactate concentrations were determined at half time and after full-time. No differences (p>0.05) were observed between the Gaelic and soccer players in: body mass (70.7±10.3 vs 76.6±10.3 kg); height (176±5.9 vs 177.7±6.4 cm); leg to trunk ratio (0.53±0.01 vs 0.54±0.03); adiposity (12.2±2.1 vs 13.5±3.2% body fat); mean somatotype (2.8- 4.3 - 2.0 vs 2.4 - 4.2 - 2.4); leg strength measures; and performance on the treadmill. The percentage muscle mass values were lower for the Gaelic players compared to the soccer players (41.9 ±5.4 vs 47.3 ± 5.2 %; p>0.005). For the Gaelic and soccer players, respectively, mean heart rate recorded during each half of match-play were (157±10 and 158±12 beats/min) and (164±10 and 157±11 beats/min), whilst blood lactates
measured at the end of each half, were (4.3 ±1 and 3.4±1.6 mmol/l) and (4.4±1.2 and 4.5±2.1 mmol/l). Gaelic footballers at English club championship level seem to exhibit similar fitness profiles, and are subject to broadly similar physiological demands as university-level competitive soccer players.

**Watson** (1995), observed the Anthropometric and fitness on 32 members of a top level Gaelic football squad that reached the Al Ireland final in the year in which these measurements were taken. The subjects were found to be large and well muscled with a mean somatotype of 2.6: 5.6: 3.1 (endomorhy: mesomorphy: ectomorphy). Body fat content of the whole squad averaged 15.0% but the most successful group of player’s averaged 12.4%. The body mass index (BMI) of the group was high and averaged 24.7 kg/m². This group of Gaelic footballers was found to be taller and heavier than top-level soccer players but smaller than Australian rules and American footballers. At 58.6 ml/min/kg maximum oxygen uptake (VO₂ max) was higher than the reported for rugby players and American footballers and is probably similar to that of professional soccer players. Scores on three lung function test: 1) forced vital capacity (FVC), 2) forced expiratory volume during 1 s (FEV), and 3) peak
expiratory flow rate PEFR) were between 11.2% and 115% of the values predicted from height and age. There were wide variations in flexibility among the members of the group, the best individual being as flexible as elite track and field athletes while the worst were less flexible than untrained subjects. Vertical jump score were high and averaged 503 mm. The fitness observations made on this group of elite Gaelic footballers showed that they were not only fitter but more homogenously fit than rugby players and American footballers and their fitness was generally similar to that reported for professional soccer players.

Singh (1995) determined the maximal oxygen consumption (VO₂ max) and maximal world load attained (WL max) on 28 Malaysian dragon boat rowers who were exercised to exhaustion on an arm ergometer. Mean VO₂ max was 2.75 l/m at a mean WL max of 195.5 W. Anaerobic endurance power of the arms, determined by cranking at 100 RPM at a world load of 400 W and the time taken to maintain the cadence until it fell to 75 RPM, was 34.9 (±2.3) s. Leg performance, as determined by standing long jump and vertical jump, was 140.0 (±4.5) kg m and 100.3(±3.1) kgm/s respectively. Right hand grip strength was significantly (p<0.001) greater than the left hand. Percentage body fat
of the rowers was 11.8(±0.6)%. These values represent the first measurements of their kind performed on dragon boat rowers in Malaysia.

Chin (1995) evaluated the physiological profile and sports specific fitness of Hong Kong elite squash players. It was conducted before the selection of the Hong Kong national squash team for the 1992 Asian Squash Championship. Ten elite squash players were selected as subjects for the study. Maximum oxygen uptake was measured using continuous treadmill running test. A sports specific field test was performed in a squash court. The following means (s.d.) were observed: height 172.6(4.3) cm; weight 67.7 (6.9) kg; body fat 7.4(3.4%); forced vital capacity (FVC) 5.13 (0.26) liters; maximum oxygen uptake (VO$_2$ max) 61.7 (3.4) ml/kg/min; anaerobic threshold (AT) 80.2 (3.3)% of VO$_2$ max; alactic power index 15.5 (1.8) W/Kg; lactic work index 323.5 (29.4) J/kg, peak isokinetic dominant knee extensor and flexor strengths 3.11 (0.29) Nm/kg and 1.87 (0.18) Nm/kg. The results show that the Hong Kong squash players have relatively high Cardio respiratory sports specific fitness and muscle strength, which may be one of the key factors that contributed to the success of the Hong Kong team in the Asian Championship.
Graetzer (1995), assessed ten male, competitive, open class handball players (40.22±5.85 years, 182.19±7.89 cm, 83.12±6.95 kg, 1.0654±. 0147 gm./mL, 14.70±6.48 percent body fat) for aerobic and anaerobic power and capacity, muscular strength, flexibility, balance, and blood chemistry status. Peak treadmill oxygen uptake and heart rate average 44.69±6.47 (range, 57.30-33.69) ml/kg/min and 177.50±8.26 (193-168) bpm with the ventilatory threshold occurring at 87.45±6.34 (97.01-76.03) percent of aerobic max. Leg Wingate peak anaerobic power was 728.24±94.87 (847.1-582.4) W, 9.22±. 95 (10.7-7.8) W/kg, and 10.87±1.43 (12.9-9.0) W.kgFF/W. Leg Wingate mean anaerobic power was 619.71±52.28 (670.6-506.9) W, 7.55±. 57 (8.4-6.8) W/kg and 8.89±. 84 (10.2-7.7) W.kgFF/W and power decline was 34.25±8.24 (50.0-22.2)%. Arm Wingate peak anaerobic power was 450.59±56.03 (517.7-376.5) W, 5.48±. 52 (6.2-4.8) W/kg, and 6.45±. 74 (7.5-5.3) W.kgFF/W. Arm Wingate mean anaerobic power was 368.24±26.82 (400.0-329.4) W, 4.49±. 32 (4.6-4.1) W/kg, and 5.28±. 40 (5.8-4.7) W.kgFF/W, and power decline was 34.49±6.59 (45.5-25.0)%). Standing vertical jump height was 50.93±7.27 (58.4-33.0) cm and right and left grip strength was 52.90±4.95 (62.47) kg and 52.70±4.72 (60-460 kg, respectively. Flexibility measures included: sit
and reach, 29.95±9.95 (43-13) CM; shoulder rotation, 89.15±11.36 (106.7-71.1) CM; and bridge-up trunk extension, 47.69±13.78 (73.7-29.2) cm. Sagittal stabilometer time in balance (average of six 20 second trials at 3 degree error setting) was 7.41±2.16 (10.53-4.94) sec whereas timeout of balance right and left were 7.11±1.58 sec (9.58-3.66) and 5.48±1.30 sec (7.17-2.93), respectively. Blood lipids were: total cholesterol, 197.80±26.78 (234-161) mg.d/L; triglycerides, 107.10±60.59 (264-55) mg.d/L; HDL-C, 47.40±10.64 (72-31) mg.d/L; LDL-C, 128.90±16.47 (155-111) mg.d/L; VLDL-C, 21.50±12.12 (53-11) mg.d/L, and total cholesterol /HDL-C ratio, 4.29±.77 (5.78-3.25).

Red blood cell and iron status revealed: hemoglobin, 16.00±.60 (16.9-14.9) g.d/L; serum iron, 173.00±37.85 (192-70) mcg.d/L; TIBC 347.40±46.32 (429-279) mcg.d/L; transferring saturation, 32.50±10.12 (58-22)%; serum ferritin, 117.50±55.28 (219-27) ng/ml; hematocrit, 47.33±1.71 (50.1-44.2) %; total RBC count, 5.25±.29 (5.80-4.81) K/mcl; MCV, 90.28±2.01 (92.4-85.6) fl; MPV, 8.69±.58 (9.6-7.8) fkl; MCH, 30.52±.66 (31.2-29.1) pg; MCHC, 33.79±.41 (34.4-33.1) g.d/L; and RDW, 12.67±.47 (13.8-12.2)%. Sports profiling, an important recent development in sports physiology, had not previously been reported for handball player’s although handball has been rated as
the top fitness developing activity by the President's Council for Physical Fitness. Sports specific physiological data is useful to predict performance success, compare athletic groups, assess improvements throughout phases of conditioning, provide baseline measures to monitor rehabilitation following injury, prevent over training, and as a pathological screening tool.

Chin (1994) studied the physiological characteristics of elite Asian Junior soccer players. The purpose of the study was to evaluate the Cardio respiratory fitness and isokinetic muscle strength of elite junior soccer players in Hong Kong. It was conducted in conjunction with the selection of the Hong Kong team to the 1989 Gothia Cup held in Sweden. Twenty-one top junior soccer players were selected as subjects for the study. The following means (±SD) were observed: age 17.3±1.1 years; height 172.5±6.2 cm; weight 62.8±7.0 kg; body fat 5.2±1.8%; forced vital capacity (FVC) 4.6±0.6L; maximum oxygen uptake (VO$_{2\text{max}}$) 58.6±2.9 ml.kg$^{-1}$m$^{-1}$; anaerobic threshold (AT) 76.7±10.2 %; of VO$_{2\text{max}}$; peak isokinetic dominant knee extensor and flexor strengths 3.28±0.37 Nm.kg$^{-1}$ and 1.84±0.24 Nm.kg$^{-1}$; hamstring to quadriceps peak torque ratio (H/Q) 56±0.6% measured at 60°s$^{-1}$. Hong Kong players appeared to have comparable anaerobic power,
light body weight, and poor flexibility and above average isokinetic muscle strength compared to other international junior soccer players. Training programs to improve the controalateral knee muscle imbalance and to increase the fast speed movement capability of the non-dominant knee flexors are recommended.

Kravitz (1994) determined the physiological characteristics of female step aerobics instructors who had been continuously teaching step aerobics for over one year, a minimum of two or more times per week. Analysis of the physiological profiles of the step instructors (N=24; average age=31 years) indicated good Cardio respiratory fitness (VO₂ max = 43.75 ml O₂/kg/min), excellent body fat levels (%BF=19.0%), above average strength for six different muscle groups, excellent low/back/hamstring flexibility (90th percentile), good flexibility of the ankle dorsiflexors but poor flexibility for the ankle plantar flexors. The VO₂ max, %BF and teaching experiences for step aerobics instructors compared favorably to data previously reported for aerobic dance instructors. The average VO₂ of step aerobic instructors was 5.4 ml O₂/kg/min less than that of aerobic dance instructors. Possible explanations for this difference include test specificity and the intermittent nature of step aerobics instruction. Instructors reported that
they move around the room as they teach, providing individual attention and encouragement to the participants. The step aerobics instructors VE (95.17 L/min) was significantly greater than that reported for the aerobic dance instructors (76.22 L/min). A possible explanation for this finding is the effect of high altitude on ventilation due to decreased atmospheric pressure. This study was conducted at an altitude of 1,524 meters; whereas, the aerobic dance instructors were tested at an altitude of 100 meters. The physiological profile of step aerobic trainers suggests that step aerobics is an excellent mode of exercise for maintaining low body fat levels, good cardio respiratory endurance, above average levels of muscular strength, and excellent low back/hamstring flexibility.

Tumilty (1993) suggested that soccer is one of the most popular sports in the world. There is still much uncertainty and debate surrounding its physiological requirements because emphasis is on skills to the neglect of fitness, conservative training methods and the difficulty of studying the sport scientifically. The frequently found values for total distance covered in game of about 10 km and an above average, though not outstanding, maximum oxygen uptake 60 ml/kg/min suggest a moderate overall aerobic demand. A comparison
of top teams and players with less able participants indicates that the components of anaerobic fitness—speed, power, strength and the capacity of the lactic acid system may differentiate better between the 2 groups. Generally, there is a reduction in the level of activity in the second half of games compares with the first. There is some evidence that increased aerobic fitness may help counteract this. Progressively lower muscle glycogen stores are one likely cause of reduction in activity, and nutrition also appears to be key factor in minimizing performance deterioration, both in terms of overall diet and, more particularly, the ingestion of carbohydrates immediately before, during and after a game. There are evolutionary trends in the sport such as greater frequency of games, changes in the role of players, and new strategies and tactics, which are placing increasing demands on the all, round fitness of players. Many studies indicate scope for improvement in player fitness.

**Hakkinen** (1993) experimented on nine members of a female volleyball team served as experimental subjects in order to examine changes in a physical fitness profiles during the competitive season consisting of a first season (I) for 10 weeks followed by season II for 11 weeks. The entire season was characterized by 4-5 weekly sessions
for playing drills and competitive games and by 2-3 weekly sessions for physical conditioning mostly for strength and explosive strength training. The control group consisted of eight other female volleyball players who trained for physical conditioning during the competitive season 1-2 times per week. The present findings showed that the entire competitive season in experimental subjects led to no changes (from 47.3±1.7 to 48.1 ± 3.4 ml.kg⁻¹.min⁻¹) (ns) in VO₂ but a significant (p<0.05) decreased took place in average power in a 30s anaerobic jumping test. Significant increases took place in the maximal vertical jumping heights in the squat (from 30.3±1.7 to 31.6±1.3 cm) (p<0.05) and in the counter movement jump (from 32.8±1.6 to 34.3±1.3 cm) (p<0.05) as well as in the spike and block jumps (p<0.05) during competitive season I. When strength training was terminated at the middle of season II for 5 weeks, significant decreased took place both in maximal isometric leg extension strength (from 2944±578 to 2766±318 N) (p<0.05), in the squat (to 30.3±1.3 cm) (p<0.05)) in the counter movement jump (to 32.2±1.5 cm) (p<0.05) and in the maximal explosive strength capacity of the upper body extremity (and trunk) muscles (p<0.01). The changes in maximal strength were correlated (r=. 90; p<0.01) with changes in the maximal vertical jump
performances. The control group demonstrated only slight changes in physical performance characteristics during the entire season. The present findings suggest that in order to maintain the level of explosive strength performance characteristics in female volleyball players the magnitude of both strength and explosive strength training stimuli should be given careful attention during the entire course of the competitive season.

Chatterjee (1993) conducted a cross sectional study of physical and motor fitness measurements was undertaken on 629 healthy India (Bengalee) school going boys of 9-18 years. The study brought to light gradual increase in physical motor fitness measurements with the advancement of age except physical fitness score. Major increments were recorded between 13 and 15 years of age. All the fitness test scores showed significant positive correlations with age, height and weight but Dash, shuttle run and PFI showed significantly negative relationship. Indian boys of the present study were superior in Sit and Reach and inferior in Vertical Jump to the Belgian boys of comparable ages. These boys showed higher values in Vertical Jump than American boys after the age of 13. Dash and Shuttle run test scores of Indian boys fall between 15th to 25th and 30th to 45th percentiles of
American boys are superior in Grip strength to India boys. Percentile values of physical and motor fitness test scores of India (Bengali) boys are, therefore, useful for determining their present fitness status and potentiality in that particular community for specific sports activity.

Grant (1993) examined the physiological and psychological responses to a university fitness session entitled ‘popmobility’. A popmobility session consists of 20 minute of aerobic activities, 5 minute of local muscular endurance exercise and 5 minute of flexibility exercises. Ten regular participants of these sessions, women of mean (s.d.) age 21.2 (1.5) years, took part in the study. A maximal oxygen uptake (VO₂ max) treadmill test was performed by each subject to obtain VO₂ max and maximum heart rate values. In a laboratory, heart rate and Vo₂ were measured throughout a popmobility session for each subject. Rate of perceived exertion (RPE) was measured every 5 min throughout the session. The mean intensity of the aerobic part of the session ranged from 67.7-82.6% of the subject’s VO₂ max (mean of 76.4% VO₂ bmax). The mean heart rate reserve for the aerobic section was 75.6%. While the relative oxygen consumption remained fairly static during the aerobic section, the RPE score rose. The mean (s.d) total energy expenditure was 236.6 (28.4) kcal (range 203-288). The
popmobility session is of adequate intensity to improve the aerobic fitness of its participant. Heart rate, as used as a measure of intensity during a popmobility session, would appear to be a fairly accurate indicator of intensity. However, the use of RPE for exercise prescription in popmobility sessions is inappropriate. Popmobility could also be useful in a weight reduction programme.

Chin (1992) studied the physiological profiles of elite soccer players originate from Western Europe and North America. Unfortunately, there is a scarcity of descriptive data on the physical characteristics of Asian soccer players. Therefore, the purpose of this study was to evaluate the physiological profiles of elite soccer players in Hong Kong. It was conducted in conjunction with the selection of the Hong Kong team before the 1990 Beijing Asian Games. In all, 24 professional soccer players were selected from a pool of 180 players as subjects for the study. The following means (s.d.) were observed: height 173.4(4.6) cm; weight 67.7(5.0) kg; body fat 7.3(3.0)%; forced vital capacity (FVC) 5.1(0.6) l; maximum oxygen uptake (VO$_2$ max) 59.1(4.9) ml kg$^{-1}$ min$^{-1}$; anaerobic threshold (AT) 80.0(7.2)% of VO$_2$ max; alactic power index 13.5(2.4) W kg$^{-1}$; lactic work index 298(27) J kg$^{-1}$; peak isokinetic dominant knee extensor and flexor strengths
2.72(0.36) Nm kg⁻¹ and 1.65(0.20) Nm kg⁻¹. On average the physique of Hong Kong soccer players appeared to be smaller and lighter than those found in Europe, which may be one of the key factors that contribute to the lack of success of Hong Kong soccer teams in international competition.

Delistraty (1992) studied to develop a physiological and nutritional profile of 1 female figure skaters, aged 9-17 years. Compared with previous published data, skaters in this study were younger and smaller with a higher percentage body fat. Skaters in this study were less experienced and trained less than skaters in other studies but attained similar levels of maximal oxygen uptake (VO₂ max), handgrip strength, and vertical jump power. Relative VO₂ max (ml/kg/min) was significantly negatively correlated (p<0.0033) with body weight and percent body fat, while body weight was significantly positively correlated (p<0.0003) with handgrip strength and vertical jump power. In terms of nutritional recommendations, skaters in this study consumed comparatively high amounts of fat and protein with low amounts of carbohydrate, calcium, and iron. Despite sub optimal nutrition and a relatively low training volume, skaters in this study
exhibited physiological characteristics similar to those reported for female figure skaters in the literature.

Hakkinen (1991) studied on nine bandy players from an elite team as subjects in order to examine effects of the competitive season on a physical fitness profile. The present findings demonstrated that the competitive seasoned to a minor change in maximum oxygen uptake (from 63.2±6.0 to 60.8±3.7 ml/kg/min) but a significant (p<0.05) decreased occurred in oxygen uptake at the anaerobic threshold from 48.6±6.8 to 43.4±2.3 ml/kg/min. Average anaerobic power output during a 60s maximal work period remained statistically unaltered during the season. Statistically non-significant changes (from 3233±493 to 3185±543 N) took place in maximal strength of the leg extensor muscles. A considerable change occurred during the competitive season in the shape of the isometric force time curve so that the times of force production lengthened significantly (p<0.05) at all positions of the curve. The individual changes during the season in each of the characteristics of the physical fitness profile correlated (p<0.05-0.01) with the initial level recorded before the season. The present findings suggest that a competitive season in elite bandy players may lead to considerable decreases in selected characteristics
of the physical fitness profile. The findings suggest that the magnitude and/or the frequency of physical training stimuli might be given more attention also during the competitive seasons and the individual needs of the players should be taken properly into consideration in the full training program.

**Gool** (1988) suggested that the physiological load imposed on soccer players when playing a real match, seems to be high. The study of the relations between the parameters showed that the total distance covered does not reflect the extent that players were using their maximal aerobic capacity. Nevertheless, the total distance in combination with the running distance in each of the discrete movement categories (expressed as a percent of the total distance covered) can help to explain the extent that each player taxes his maximal aerobic power when playing a game. The relation varied between the individual players and so no general outline was found. The physiological measurements suggest that the mean training intensity should be high (approximately 75% if $V_O_2$ max) to prepare the players for real match-play conditions.

**Apor** (1988) suggested that soccer player’s profiles have anaerobic power, muscle fiber and enzyme activity characteristics-
particularly the key aerobic and key anaerobic enzymes- that suggests a moderately trained status. They have to be good at repeated short runs (high repetitive speed endurance); they obviously have to be skilled with the ball. These abilities coincide with large visual field and quick response for movements in the peripheral (colour) visual field. They do not need exceptional lactacid capacity, but they have to have a high alactic acid power. Repeated involvement of high an aerobic power in very quick motions, combined with large visual field and quick-witted perception of the game situation is the measurable basis of good results. To meet these requirements players should train their aerobic power to 3200-3000 m 12 min run score (above 65 ml/kg/min VO₂ max); they have to develop a musculature similar to sprinters in interspersed with stretching and technical exercises because quick recovery is required in the short pauses between the maximal loads without lactic acid accumulation. The so-called ‘mini-interval’ exercise regimen is suggested for soccer players: 4-6 s maximal speed runs with maximally explosive starts and 20-30 s pauses (with stretching or ball exercises or jogging in this interval) seem to be a good’ sports specific’ training practice. Muscle, ligaments and ankles require very careful strength and soft tissue maintenance during the season (stretching,
massage, baths, electrotherapy and so on) and proper healing of the lesions. Special dietary regimes are needed for the proper restoration of muscle glycogen after training and competition. Care must be taken in maintaining the basic physiological performance capacity, with regards to aerobic power, muscle power and muscle elasticity during the whole season.

**Horswill** (1988) characterized the body fat, maximum aerobic power and maximum anaerobic power of elite junior wrestler. The study was conducted in conjunction with an elite wrestler training camp. Wrestler (N=39) from ages 14 to 18 qualified for the camp and volunteered as subjects. Measurements were made for body composition (skinfold thickness), maximal aerobic power treadmill run), and maximal anaerobic power of the arms and legs (Wingate test). Body fat averaged (±SD) 7.2% (±2.4), whereas the means (±SD) for maximal aerobic power, arm power; and leg power were 51.2 (±9.3) ml/kg/min, 390.7 (±92) volts, and 549.1±101 watts, respectively. Elite junior wrestler appears to have a similar percentage of body fat, lower maximum aerobic power and higher relative anaerobic power compared to elite collegiate and senior wrestler.
Ramadan (1987) studied certain structural and functional characteristics of 18 members of the 1982 Kuwaiti World Cup Soccer Team and made comparison by position, with other groups of athlete, and with other data on soccer players. Data were collected just before, during and after the competition. Percentage body fat, estimated from skinfold, indicated that this group of athletes was lean (8.9% fat) and that goalkeepers were less lean and midfielders more lean than players of other position. The Health Carter somatotype method yielded a balanced mesomorphic configuration (2.06 – 4.50 – 2.08), about in the center of the distribution of elite athletes. Aerobic power ($VO_2\text{max} = 51.9 \text{ ml/kg/min}$) and anaerobic power (110.6 kgm/sec), determined by open circuit spirometry and the vertical jump, respectively, were both intermediate in comparison with other groups of elite athletes. By position, goalkeepers had lower aerobic power and higher anaerobic power than the players of other positions. All findings were in general agreement with previous research on soccer players, with previous research on soccer players, with those data on higher-level competitors usually revealing higher levels of fitness for sport. In summary, elite soccer players fall about the mean of outstanding athletes from other sports in terms of leanness, somatotype, and metabolic potential.
Soccer appears to be sports most suited for the masses, those without capacities for extremes of aerobic or anaerobic power.

Ekblom (1986) suggested that soccer is characterized as high intensity, intermittent non-continuous exercise. Players cover approximately 10 km of ground per game, of which 8 to 18% is at the higher individual speed. In higher levels of competition there is a greater number of tackles and headings plus a greater percentage of the game is performed at maximum speed. The average aerobic energy yield during a national level game is around 80% of the individual maximum. Blood lactate concentration during a game average 7 to 8 mmol/L. Because of a high-energy yield mot players have empty muscle glycogen stores at the end of the game, were hypo hydrated and also have an increased body temperature. Soccer players of national and international standard have a maximal aerobic power of around 60 to 65 ml/kg/min, an above average anaerobic alactacid power, and a greater buffer capacity and muscle strength compared with untrained controls, yet seem to be less flexible.

- Berg (Dec.1985) studied physiological training effects of playing youth soccer. The purpose of this investigation was to determine if a 9-week youth soccer program had any effect on Cardio
respiratory fitness ($VO_2_{max}$ and $VO_2_{submax}$), peak knee torque, and flexibility. Subjects were 20 sixth grade boys, 11 of whom were members of a YMCA soccer team: 9 were normally active boys who were not participating in any organized sport during the study that served as a control group. Mean ages ($\pm SD$) were 11.8 $\pm$ 0.34 and 11.5 $\pm$ 0.60 years for the soccer and control group, respectively. Initial $VO_2_{max}$ value of 49.83 and 47.42 ml.kg$^{-1}$.m$^{-1}$ for the soccer and the control group, respectively, are similar to those reported in the literature for untrained normal boys of this age. Results indicated that playing soccer three times weekly increased $VE_{max}$ and reduced $VO_2_{max}$ ml.kg$^{-1}$.m$^{-1}$ and l.min$^{-1}$) at a sub maximal running speed (all P’s < 0.05), while no change in $VO_2_{max}$ was noted. No significant training effect was observed in peak knee torque or flexibility subsequent to soccer training. It is concluded that the effects of playing soccer in these subjects resulted in no change in cardio respiratory fitness, peak knee torque, or flexibility.

Burke (1985) studied the anthropometric measurement and personal data from 119 Australian Rules footballers from Victoria. The teams represented three levels of professionalism and standard of play; the top level professional league (Team 1), a second level association
(Team 2) and the A-grade amateur association (Team 3). Within the present group, a gradation in body size was observed between teams. The top-level team players were slightly taller and heavier than the other teams. They had less body fat as shown by lesser skinfold thickness, a smaller percentage body fat as determined from prediction equations, and a greater fat free mass. The intermediate level team showed an intermediate level of body fat and the lower level team the highest proportion of fat. It would be interest to continue such a study to document changes in anthropometry and body composition during the season and also to attempt an analysis of characteristics specific to field position. The determination of specific to field position. The determination of specific regression equations to predict body fat in this population would also be advantageous.

Berg (1985) measured a broad spectrum of physiological and biochemical variables in six healthy males during submaximal exercise to assess sequential changes in these biochemical and hormonal variables and their relationship to cardiovascular reactivity. Blood pressure, heart rate, and oxygen consumption was measured continuously during exercise on a bicycle ergometer. Intravenous blood samples were drawn at various intervals throughout the exercise
and assayed for plasma catecholamines, cortisol, thromboxane B₂ plasma and RBC electrolytes and lipids. Oxygen uptake was related to heart rate, blood pressure, and catecholamine response during exercise, but was not related to cortisol changes. Plasma potassium increased and plasma magnesium decreased during the sub maximum exercise. However, all the electrolyte values returned to pre-exercise levels within 30 minutes of exercise termination. It is concluded that the physiological basis for the cardiovascular response during sub maximal exercise appears to be related to complex interactions of hormonal changes and electrolytes.

Reilly (1984) conducted a study to establish the net energy cost of dribbling a soccer ball. Eight male footballers ran for 5 min on a treadmill at speed of 9, 10.5,12 and 13.5 km/h while dribbling a football against a rebound box; running at each of these speeds without the ball constituted control. Oxygen uptake (VO₂), perceived exertion (RPE) and blood lactate levels were measured and compared between the two conditions. The energy expended increased linearly with speed for body exercise mode, the mean increment of 1.24 kcal/min caused by dribbling being independent of the speed of motion. Individual differences inefficiency of dribbling could not be explained by
considering different patterns of stride characteristics. Similarly, RPE showed a constant elevation for dribbling over running at each speed, and a linear increase with speed of motion for both modes. Blood lactate increased disproportionately with speed for dribbling, onset of metabolic acidosis benign attained at a lower speed for the experimental task. It was concluded that dribbling a ball does significantly increase the energy cost and perceived exertion of motion, as well as inducing disproportionate rise in blood lactate when performed at high speeds.

Sady (1984) compared the physiological responses to exercise, the anaerobic fitness, and the body composition of high ability prepubescent wrestlers and normally active boys. The wrestlers (N=15, mean age ± S.D. =11.3 ± 0.30 years) were recruited to participate in a summer wrestling camp. Their wrestling experience averaged 3.0 ± 1.63 years, during which time they won 78±10.5% of the matches. The comparison boys (N=13, 10.7±0.36 years) were volunteers from a local boys club. Each subject performed a graded treadmill exercise test (Bruce protocol) and an anaerobic cycle ergometer test. Additionally, body composition was assessed using densitometry and skinfold. There were no difference (p>0.05) between the wrestlers and the comparison
subjects for age or height. The wrestlers exercised for 1.5 minute longer on the treadmill and obtained a higher $\text{VO}_2\text{max}$ (54.0±1.15 ml/min/kg, $P<0.05$) than the comparison subjects (45.6±2.10 ml/kg/min). Also, the wrestlers had higher anaerobic test scores, greater body densities, and lower subcutaneous fat totals at all sites than the normally active boys. These data indicate that the favorable fitness and body composition scores found previously for more mature wrestlers are already presenting prepubescent wrestlers.

_Schantz_ (1984) The aerobic and anaerobic energy yield during professional training sessions (classes) of classical ballet as well as during rehearsed and performed ballets has been studied by means of oxygen uptake, heart rate, and blood lactate concentration determinations on professional ballet dancers from the Royal Swedish Ballet in Stockholm. The measured oxygen uptake during six different normal classes at the theatre averaged about 35-45% of the maximal oxygen up takes, and the blood lactate concentration averaged 3 mM (N=6). During 10 different solo parts of choreographed dance (median length=1.8 min) representative for moderately to very strenuous dance, an average oxygen uptake (measured during the last minute) of 80% of maximum and blood lactate concentration of 10 mM was measured
In addition, heart rate registrations from soloists in different ballets during performance and final rehearsals frequently indicated a high oxygen uptake relative to maximum and an average blood lactate concentration of 11 mM (N=5). Maximal oxygen uptake, determined in 1971 (N=11) and 1983 (N=13) in two different groups of dancers, amounted to on the average 51 and 56 ml/min/kg for the females and males, respectively. In conclusion, classical ballet is a predominantly intermittent type of exercise. In choreographed dance each exercise period usually lasts only a few minutes, but can be very demanding energetically, while during the dancer’s basic training sessions, the energy yield is low.

Vrijens (1983) established age norms for the physiological profile of Belgian cyclists, and to compare high level competitive cyclists with the average group. A total of 406 cyclists were tested, subdivided in distinct age categories and including 17 cyclists selected to participate in the World championship for amateurs, and 40 professional cyclists. Physiological profile was evaluated from measurements of body dimensions, muscle strength, and from the response to a maximal exercise test on the bicycle ergometer. The profile of competitive cyclists was characterized by high values for
vital capacity, heart volume, isometric strength of the leg extensors, PWC_{170} and VO_2_{max}, and these characteristics were already present in adolescent cyclists. When high level of cyclists is compared to the average group, they found no difference in body dimensions or in muscle strength, a small difference in VO_2_{max}, and a very marked difference in PWC_{170}. During growth, endurance capacity as evaluated by the PWC_{170} and by the anaerobic threshold, increased more than the VO_2_{max}. It was concluded that the physiological profile of adolescent cyclists is basically similar to the pattern observed in adult cyclists, and that endurance capacity is the most important physiological parameter in competitive cyclists.

Dwyer (1983), studied to assess physiologic characteristics on three marathon swimmers who train 15-40 km per day in the ocean (15-20° C) and compete over distance up to 78 km were. Anthropometric, pulmonary, and exercise studies were done and echocardiography imaging was used to determine internal cardiac dimensions. By immersion densitometry, relative fat was 21.9% in the male (Wt=57.3 kg) and 29.3% in the female (Wt=70.4 kg). (Three male approximated the relative fat of English Channel swimmers), No comparable data are available for female marathon swimmers. Static pulmonary function
data in the male were 110-180% of normal with the greatest deviations in RV and closing volume. Pulmonary studies done with one female gave normal results. Dynamic pulmonary studies revealed no outstanding features in any swimmer except high maximal voluntary ventilation (110% of normal). VO_{2\text{max}} \text{ (treadmill walking)} was 2.28L/min (4.5ml/kg/min) in the male and 2.65L/min (37.5 ml/kg/min) in one female. These data are in contrast to the high VO_{2\text{max}} of collegiate swimmers and suggest no outstanding cardio respiratory development. HR max-approached 200 bpm and V_E \text{ max. The estimated anaerobic threshold, from blood lactate, was 76% (male) and 60% (one female) of VO_{2\text{max}}. These unremarkable responses to exhausting exercise, together with the exceptional speed and endurance of the swimmers suggest that the treadmill test did not reveal their true VO_{2\text{max}}. However, the possibility that VO_{2\text{max}} is not a primary determinant to performance in 16 to 24 hr race in considered. Echocardiography revealed deviations from normal in left ventricular internal dimension and wall thickness.

Vaccaro (1979), assessed fifteen members of the University of Maryland women’s basketball team for body composition, somatotype, muscular strength and endurance; pulmonary function,
and aerobic capacity during the 1976-77 basketball season. Results of the analyses indicated that: (1) means for height and weight established here were greater than those of the average female and most other women athletes; (2) mean % fat was less than those values reported for female non-athletes, but somewhat higher than those reported for women distance runners; (3) mean somatotype was similar to those reported for normal younger women; (4) the average strength was greater than that of the normal women; (5) VC, FEV and MVV exceeded normal capacities and were similar to those values reported for female gymnasts and swimmers; and (6) mean VO₂ max was higher than those reported for women basketball players in the past and may indicate a trend toward an increase in the intensity of training and conditioning programs for women basketball players.

Hagberg (1979), evaluated nine of the best road-racing cyclists in the United States to selected psychological characteristics using the Eysenck Personality Inventory (EPI) and the Profile of Mood State (POMS). Their VO₂ max and other factors possibly involved in high level cycling performance were measured and compared to similar data on East German cyclists in an attempt to determine the performance factors affecting the success of American cyclists in international
events. The cyclists were more introverted than normal adults. This is in contrast to what has been found for elite marathon runners but agrees with the trait of introversion found in marathon runners at other competitive levels. The POMS profile of the cyclists was similar to those of elite marathoners, oarsmen, and wrestlers. The POMS scales reveal cyclists to be less tense, confused, depressed, and angry than college age normal. They also scored higher than normal on the vigor scale. The cyclists were able to average 52.8±4.9 (mean ± SE) seconds at a load in excess of 3780 kpm/min on the bicycle ergometer indicating that in addition to highly developed aerobic systems, these cyclists also possess the capacity for extremely high power outputs for short period of time. The VO₂ max for the group averaged 70.3±2.0 ml/kg/min, which is very similar to a number of previous reports on European cyclists, their age, height, weight, and years in training, were also virtually the same. Therefore, it is suggested that other factors, including tactics and technique, must contribute to the performance differences seen between American and European cyclists.

Crews (1978) studied the relationship between body composition measures, reaction time (RT), and run times at 5, 15 and 40 yards were investigated for 48 candidates for the 1976 Western
Kentucky University football squad. In addition, each player's optimal playing weight was predicted and the effect of being above or below one's predicted optimal playing weight (POPW) in RT and run times was evaluated. RT and run times were obtained during a 40-yard run. A multiple timing system was designed to measure the times at the designated distance. Body composition was assessed for all subjects using prediction equations. POPW was determined using body composition data of professional football players as guidelines. Negative correlations between percent fat and run times were found to increase as the distance increased. The players who weighed more than their POPW were found to have slower RT and significantly slower run times when compared to those players who weighted less than their POPW.

Costill (1968) investigated a technique for measuring the maximal work output and estimating maximal anaerobic power in man. Seventy-two college football players were tested to determine the differences among ability and playing position-grouped players as measured by anaerobic power. Significant differences were found in vertical speed and anaerobic power among ability grouped players and players grouped by playing position.
References


