AN INVESTIGATION INTO THE

SPECIFICITY OF THE

GIESSENER SOCCER

FITNESS

TEST

by

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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DEDICATION

TO Dinah Atsenga and Abraham Asembo,

my parents

who

toiled on the farm tirelessly

to educate me.

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A B S T R A C T

The current trend in Sports Science is to develop sport specific fitness tests which can be used to monitor the conditioning and training regimen in competitive sports. The purpose is to avoid overtraining which is associated with pathophysiological effects that deter performance. The present study investigated whether the Giessener Soccer Fitness Test is specific to the game of Soccer.

Three teams' performance (Hockey, Rugby and Soccer) were compared. The Hockey team (n=25; age 24.48 ± 4.4. years; weight 69.2 ± 7.3 kg; and height. 173.8 ± 6.3 cm) participated in the Kenya Hockey National League; the Rugby team (n=30; age 21.96 ± 3.7 years; weight 73.33 ± 3.7kg ; and height 175.43 ± 5.17cm) took part in Kenya Cup Rugby League; while the Soccer team (age 23.88 ± 4.5 years; weight 66.1 ± 5.3 kg; height 172.9 ± 5.6cm) played in the Kenya Amateur Football National League. The three teams were randomly sampled. All the players were tested once during the mid season of their respective leagues on the Giessener Soccer Fitness Test instrument as described by Kruemmelbein et al. (1989). The dependent variables measured were the resting heart rate, exercise heart rate, recovery heart rate (monitored by auscultation using a stethoscope) and time (min) taken to perform the test. A one way analysis of variance was used to determine whether the dependent variables varied significantly across the independent variable (type of sport); the Scheffes' test was applied where necessary while a paired t-test was applied to compare the results of this study with those of Kruemmelbein et al.(ebd.).

The results showed no significant difference in the anthropometrical measures of age and height of the subject between the teams ($p>0.05$). However, a weak significant difference was established in the weight of the subjects between Soccer and Rugby as well as Hockey and Rugby teams ($p<0.05$). As pertains to the exercise heart rate, a strong significant difference was revealed in the resting heart rate between Soccer and Hockey groups ($p<0.01$), but no significant difference was established between Soccer and Rugby teams ($p>0.05$). For circuits one and two , no significant difference in exercise heart rate was revealed ($p>0.05$) between the teams. At circuits three, four, five, six, and average heart rate, a very strong significant difference was found between Soccer and each of Rugby and Hockey teams ($p<0.001$) but no significant difference was established between Rugby and Hockey for same circuits ($p>0.05$). There was no significant difference between the groups in the time taken to perform the test ($p>0.05$). As regards the recovery heart rate and recovery pulse sum a very strong significant difference was established between Soccer and each of Rugby and Hockey ($p<0.001$), but no significant difference between Rugby and Hockey ($p>0.05$).

The finding of this study suggest that the Giessener Soccer Fitness Test appears to be a specific test to the game of Soccer. However, more research ought to be done to establish its diagnostic usefulness in soccer.

CHAPTER ONE

INTRODUCTION

1.1. BACKGROUND TO THE PROBLEM

Soccer is a team sport which is normally played by eleven players per team (with five reserve players of which three can be fielded as substitutes). The game is played on a field maximally sixty eight metres wide and one hundred and five metres long with a surface of grass or gravel. Lately, artificial turf surfaces have been introduced (Ekblom, 1986). A normal game consists of two 45 minutes halves with a 15 minutes interval at half time.

The game appears to be the most popular sport in the world today (Stone and Kroll,1986). It is estimated that 150 countries are affiliated to the Federation Internationale de Football Association (FIFA) founded in 1904 (Ekblom, ebd.). "The number of licensed players in 1984 worldwide was about 60 million, but it had been estimated that there were another 60 million unlicensed ones" (Ekblom ebd., p.50).

Some researchers have argued that Soccer is the most fascinating of all games (Hatziharistos, 1991; Lisowiski, 1991; Sugden, 1991) because the game has demonstrated great potential in promoting friendship on and off the field of play, although hooliganism and violence are prevalent in this game (Dunning, 1991; Lisowiski, ebd). With this popularity, scientific studies in Soccer are increasingly becoming imperative.

A review of literature reveals that much research in the game of Soccer has investigated Soccer injuries and rehabilitation of injured athletes (Benezis, 1991; Ekstrand, 1991; Inklaar et al. 1991 ; Lisowiski, 1991); Spectators behaviour (Clarke & Madden, 1991; Dunning, 1991; Sugden, 1991;); training, coaching and strategy development (Balsom et al., 1991; Capranica, 1991); applied biomechanics (Brady et al., 1991; Kollath & Quade,1991); anthropometry and the Physical profile of Soccer players (Brewer & Davis 1991; Jacobs et al., 1982; Nagahama et al., 1991) and evaluation of training and match play analysis (Erdmann, 1991; Gerisch, 1991; Reilly & Thomas, 1980; Tumilty & Smith,1991). However, less emphasis has been placed on the development of field specific tests in this game (Baron et al., 1988; Kruemmelbein et al., 1989).

Some research findings indicate that Soccer is a high intensity, non-continuous intermittent form of exercise (Ekblom,1986). The exercise intensity increases with the increase in the tempo of the game. The distance covered during a game averages ten kilometres per player in a game (Ohashi et al., 1991; Reilly & Thomas, 1976; Withers et al., 1977). This is a demanding form of exercise which places high demands on the energy supplying mechanism of the musculature (Balsom et al., ebd; Ekblom ebd.; Reilly & Ball, 1984).

Other studies have shown that the player's average heart rate during a match ranges between 166 and 194 beats per minute (Bunc et al., 1991; Ohashi et al., Raven et al., 1976; Reilly & Thomas, ebd; Vanfraechen & Thomas, 1991). This represents approximately 85% of maximum oxygen uptake ($\dot{V}O2$ max) [Stone & Kroll, 1986]. Extensive studies have also demonstrated that nearly 90% of the movement in the game of Soccer is aerobic and that aerobic power of Soccer players is very high (among team sports) averaging 56-66 millimetres of oxygen per kilogram of weight in one minute (relative $\dot{V}O2$ max) [Jensen & Larson, 1991; Nowacki & Preuhs, 1991; Ogushi et al., 1991; Reilly & Thomas, 1976; 1980; Withers et al., 1977].

According to Comas et al. (1991), aerobic power, anaerobic power, muscle strength, agility and speed are important variables in high performance level of Soccer players. In fact explosive power and speed are emphasized as important physical fitness qualities for optimal performance in the game of Soccer (Balsom et al., 1991; Kollath & Quade, 1991; Lindquist & Bangsbo,1991; Muckle,1981; Stone & Kroll, 1986). About 10% of the time in the game, is spent on anaerobic bursts which include sprinting over short distances, jumping explosively and making sporadic movements which require much agility (Berger, 1982; Reilly & Thomas, ebd).

Kollath and Quade(ebd.) regard sprinting ability as one among many important criteria for a good Soccer player. This fact explains the use of sprint-tests to evaluate physical fitness of Soccer players (Balsom et al., ebd.; Brewer & Davis,1991). The other important factor in fitness is strength development in the legs and the neck. This is essential for jumping explosively, agility, kicking, quick starts and heading (Sarsaniya & Seluyanov, 1991; Stone & Kroll, ebd.).

In modern Soccer, the fight for the possession of the ball, running free, feinting, dribbling, tackling, counter attacks and running back to defend demand a high level of physical fitness in all players (strikers, mid fielders and defenders). This can be attributed to the transition from the old zonal and system play, which restricted players in particular positions to total Soccer. The latter demands that both players assume dual roles of striking and defending. This calls for physical fitness in all players in addition to skills and strategies (Stone & Kroll,1986).

Conditioning efforts in Soccer should be directed towards developing aerobic and anaerobic endurance, speed, agility, flexibility, muscular strength and endurance (Stone & Kroll, ebd). However, such efforts should be cautiously undertaken to avoid both undertraining and overtraining (Nisson,1987).

Many researchers are in agreement that monitoring physical fitness training of athletes by use of fitness tests could be used to:

1. prevent injury through pre-selection of fit players for a particular competition level (Cahill & Griffith, 1978; Jackson et al., 1978; Salokun, 1991);
2. indicate the strength and weakness of athletes (MacDougall et al., 1982);
3. indicate the feedback needed for evaluating the effectiveness of a given training regimen (MacDougall et al., ebd ; Winkler, 1991);
4. show the effects of training on the athletes'

physiological characteristics (Banister & Wenger,1982; MacDougall et al., 1982) ; and

5. control overtraining and undertraining which are associated with patho-physiological problems that lower performance of athletes (Appell,1986; Berg et al., 1989; MacDougall & Wenger , 1982 ; Kindermann et al., 1989; Liesen et al.,1989; Mader, 1990; Order et al., 1989).

Stone and Kroll (1986) strongly argue that any time an athlete starts a conditioning programme it is essential to establish the existing level of fitness and later, periodic testing enables the coach, physician and athletes to determine the effectiveness of that programme. This argument is supported by other researchers (Banister & Wenger, ebd; MacDougall et al., ebd). Physical fitness testing in competitive sports is usually done using either ergometric methods (cycle ergometry, treadmill, crank ergometry and rowing ergometry) or field tests. In some cases a combination of the two methods has been reported (Causarano et al., 1991; Kruemmelbein et al., 1989; Weiss et al., 1989).

Ergometry is preferable because its loading is more exact, reproducible and easily controlled. Its disadvantages lie in the fact that the results cannot be directly applied to the form of sport in question without modifications. Field tests on the other hand offer the advantage of being sport specific although they are difficult to standardise in accordance with established criteria for tests.

However, several researchers have successfully demonstrated comparable results between ergometry and field tests in track athletics (Dickhuth et al., 1989; Hageloch et al.,1988;Tegtbur et al., 1989), hockey (Schneider et al., 1988) and swimming (Jackson et al., 1979; Mader,1990; Weiss et al., 1989). These studies have shown that field tests when standardised can be used by the athletes, coaches and team physicians to improve training and conditioning programmes.

Most of the field tests in Soccer have been used to measure various components of physical fitness either separately or combined. For example, speed (Kollath & Quades, 1991 ; Malonsoki, 1991;) aerobic and anaerobic endurance (Balsom et al., 1991; Evangelista et al., 1991; Lindquist & Bangsbo 1991 , Raven et al ., 1976; Reilly & Ball, 1984; Reilly & Thomas, 1976; 1980) ; Strength (Reilly & Thomas, ebd); agility and co-ordination (Muckle, 1981 ; Starosta, 1984). It is however widely recognised that fitness for top class sport is multifaceted (Reilly and Thomas, ebd.). "This tends to complicate interpretations of individual differences when viewing a number of fitness variables separately" (Reilly & Thomas, ebd.; p.247). A multivariate test whose test items combine all of the important physical components, and which has been standardised in terms of the type of the game, workload, muscle mass, surface and which simulates the participants competitive activity is deemed vital (Thoden et al., 1982).

An attempt by some Austrian researchers to develop such a field test specific to Soccer were unsuccessful (Baron et al.,1988).

A recently developed multivariate Giessener Soccer Fitness Test (Kruemmelbein et al., 1989) meets some of these qualities.

1.2 STATEMENT OF THE PROBLEM

The current trend in sports science is on the development of sport specific field tests which combine the advantages of ergometry and field test while minimising their disadvantages (Dickhuth et al., 1989; Schneider et al., 1988; Tegtbur et al., 1989; Weiss et al., 1989).

In the game of Soccer, one of the few comprehensive field test that is comparable to spiro-ergometry is the Giessener Soccer Fitness Test (Kruemmelbein et al.,ebd). The items in this test are Soccer oriented and are arranged in five stations (see Appendix A). They involve sprinting with and without the ball, dribbling and heading a Soccer ball. They test co-ordination, explosive power, sprinting ability (speed), aerobic and anaerobic endurance.

A comparative study of the hemodynamic and metabolic characteristics (heart rate and lactacidosis) of Soccer players on this test as well as on a standardised spiroergomety revealed comparable results (Kruemmelbein et al., ebd). Hence the test is considered to bridge the gap between ergometry and field tests.

This study set out to establish whether this test is specific to the game of soccer or whether it is a general fitness test. This was done via a comparison of the hockey ,rugby and soccer players' performance on the test.

1.3 RESEARCH OBJECTIVES

The following were the objectives of the study:

1. To measure and compare the hemodynamic (heart rate) response of the Hockey , Rugby and Soccer players on the Giessener Soccer Fitness Test.
2. To measure and compare the time taken by Hockey, Rugby and Soccer players to complete the Giessener Soccer Fitness Test.
3. To evaluate the usefulness of the Giessener Soccer Fitness test in discriminating between Soccer players and those from other disciplines (Hockey and Rugby).

1.4 RESEARCH HYPOTHESES

HO_1 There is no significant difference in the anthropometric measurements of:

a) age,
b) weight, and
c) Height between Hockey ,Rugby and Soccer players.

HO_2 There is no significant difference in the heart rate between Hockey, Rugby and Soccer Players at:

a) Rest
b) Warm up
c) Round one
d) Round two
e) Round three
f) Round four
g) Round five
h) Round six.

HO_3 There is no significant difference in the average exercise heart rate between Hockey ,Rugby and Soccer Players.

HO_4 There is no significant difference in the time taken to perform the test between the teams at:

a) Warm up
b) Round one
c) Round two
d) Round three
e) Round four
f) Round five
g) Round six.

HO_5 There is no significant difference in the average time taken to perform the test between the teams (Hockey, Rugby and Soccer).

HO_6 There is no significant difference in the recovery heart rate between the teams at:

a) second recovery minute
b) fourth recovery minute
c) sixth recovery minute
d) eighth recovery minute
e) tenth recovery minute.

HO_7 There is no significant difference in the average recovery heart rate between Hockey, Rugby and Soccer players.

HO_8 There is no significant difference in the sum of recovery heart rate between the Hockey, Rugby and Soccer players.

1.5 ASSUMPTIONS OF THE STUDY

The following were the assumptions of this study:

1. All the subjects in the study had been trained and conditioned in their respective games by their coaches and had attained peak form.
2. All the subjects and research assistants were highly motivated throughout the study.

3. All the subjects were in a good health status and were free from symptomatic diseases or injury.

4. All research assistants were accurate in measuring the parameters (time and heart rate).

1.6 LIMITATIONS OF THE STUDY

1. There was no pre- and post-training administration of the test. Hence this study did not inquire into the diagnostic value of the test.

2. The sample size used in this study was relatively small (i.e. Hockey = 25, Rugby = 30 and Soccer = 26).

1.7 SIGNIFICANCE OF THE STUDY

A comprehensive physical fitness examination is mandatory either before or/and during an on-going conditioning programme. The need for a Soccer specific fitness test is of paramount importance for coaches, sports physicians, athletes and Physical Education teachers. This study is specifically intended to benefit:

1. Coaches and post-primary Physical Education teachers who can use the test to monitor the training and teaching methods used in conditioning and teaching Soccer players and students respectively.

2. Coaches and post-primary Physical Education teachers who can use the test to select elite Soccer players for purposes of including them in the national, school or college team.

3. Post-primary Physical Education teachers, coaches and sports physicians in the control of conditioning level of Soccer players to avoid overtraining.

4. Soccer players and post-primary students by providing them with some feedback about their physical condition in relation to the game of Soccer.

5. Soccer players and Post-primary Physical Education students by serving as a source of motivation towards playing and training in the game of Soccer.

1.8 DEFINITION OF TERMS

ATHLETES

These are participants in any form of sport where the goal is to compare performance (Bayer,1987).

AUXOTONIC CONTRACTION

This is the form of contraction in which the isotonic, isometric and isokinetic forms are combined (Krueger, ebd.).

COACH

A person who prepares athletes psychologically, technically, and physiologically for athletic performance and competition (Bayer,ebd.).

CONDITION

> die Summe aller leistungsbedingenden Faktoren in einer bestimmten Sportart (Hollmann and Hettinger, 1990, p. 138) [is the sum of all factors that determine performance in a given form of sport].

ENDURANCE

Ausdauer ist charakterisiert durch die Faehigkeit eine gegebene Leistung ueber einen moeglichst langen Zeitraum durchhalten zu koennen: Somit ist Ausdauer identisch mit Ermuedungs-Wiederstandsfaehigkeit (Hollmann & Hettinger 1990 ; P. 138) [Endurance is characterised by the ability to carry on a given task for over a relatively long period of time. Endurance is therefore identical with resistance to fatigue].

ERGOMETER

An apparatus for measuring the amount of work done by a human or animal subject (Thomas, 1981; p. 496).

EXHAUSTION

einen Extremgrad der Ermuedung, der eine Fortsetzung der Belastung ausschliesst (Hollmann & Hettinger, ebd.) [is an extreme degree of fatigue which prohibits the continuation of physical activity].

FATIGUE

die reversible Herabsetzung der Funktionsfaehigkeit infolge einer muskulaeren Taetigkeit (Hollmann & Hettinger, ebd.; p.138) [reversible reduction of the functional ability as a result of muscle activity].

FIELD HOCKEY

Also called Hockey. Refers to a game played by two teams of eleven players each (with five substitutions in each team on a roving manner) on a field, with sticks and a ball (Procter, 1978).

FIELD TESTS

A test which is conducted in an environment which attempts to simulate the actual competitive situation of a particular sport (Reed, 1982, P. 133).

FITNESS (PHYSICAL)

The ability to perform physical tasks with the minimal effort. This means that fitness is associated with efficiency of the body organs (Harre, 1982).

HEART RATE (HR)

Also referred to as pulse rate. It is the number of ventricular beats per minute as counted from records of the electrocardiogram or blood pressure curve. The heart rate can easily be determined by palpitation over the heart, femoral, temporal, carotid artery or brachial arteries both during rest and exercise (Åstrand & Rodahl, 1986).

ISOKINETIC CONTRACTION

In this form of contraction, the speed of movement remains constant. This form is very rare in normal practical situation and can only be simulated using isokinetic machines (Krueger,1986).

ISOMETRIC CONTRACTION

In this form of contraction the muscle length remains constant. Thus the muscles are neither pulled together nor stretched but rather have a higher tonus. The work done is equal to zero if work done is defined as distance multiplied by force (Krueger,ebd.).

ISOTONIC CONTRACTION

The muscle insertion and origin could either come together (concentric) or further from one another (eccentric). The speed of movement changes analogous to movement of force experienced (Krueger, 1986).

OVERTRAINING

Any situation in athletic training where the demands in training and all the other demands of daily life are above the athletes' capacity to perform and resist (Harre, 1982).

PRACTICE

> die systematische Wiederholung gezielter Bewegungssteigerung (Hollmann & Hettinger, 1990. p. 129) [is a systematic repetition of specific movement patterns aimed at improving performance without morphological changes].

RUGBY

A type of football played with an oval-like ball by two teams of fifteen men each on an outdoor field (Procter, 1978).

SOCCER

Also referred to as Association Football particularly in Britain. It is a game played between two teams of eleven players who kick or touch a round ball without using the arms or hands (with the exception of a throw-in for players). However, the goalkeeper is an exceptional case (Ekblom, 1986).

SPORT SPECIFIC TEST

A test specific to a particular sport which simulates the actual competitive environment in relation to type of work, rate, resistance, muscle mass used, range of motion and intensity of the activity in the sport in question. (Reed, 1982, p. 133).

SUM OF THE RECOVERY HEART RATE (RPS)

The total pulse rate after work which lie above the resting value (Stegemann, 1981).

TEST BATTERY.

A scientific procedure to investigate one or more empirically definable personality, physical or motoric traits (Bayer,1987).

TRAINER

This applies to a specialist who is concerned with the care and prevention of injuries and conditioning of athletes in Anglo-American usage. In other languages it refers to a coach (Bayer, ebd.).

TRAINING

> die systematische Wiederholung gezielter ueberschwelliger Muskelanspannungen mit morphologischen und funktionellen Anpassungserscheinungen zum Zwecke der Leistungssteigerung (Hollmann & Hettinger, 1990 ; p. 124) [Training is a systematic repetition of specific muscle contractions above the threshold level with morphological and functional adaptations aimed at improving performance].

UNDERTRAINING

Training below an individuals' training threshold which results in no effect in physiological adaptation. The optimal level is defined as the highest exercise intensity that can be maintained without a progressive increase in the lactate concentration (Stegemann & Kindermann, 1982).

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 RATIONALE FOR PHYSICAL FITNESS TESTING

A lot of research has been done in the field of fitness testing in competitive sports. The rationale for testing has been equally presented. MacDougall and Wenger (1982) have identified four general benefits of exercise testing to both coaches and athletes as to:

1. indicate the athlete's strength and weakness relevant to his sport and provide baseline data for individual training programme prescription;
2. provide feedback for evaluating the effectiveness of a given training regimen
3. provide information as to the healthy status of an athlete;
4. educate the athlete about his body and the demands of his sport (P,1).

Research findings in this area have demonstrated that physical fitness testing could check the pathophysiological effects associated with overtraining in athletes (Appel, 1986; Burggraef et al., 1989; Hageloch et al.,1988; Jacobs et al., 1986; 1989; Kindermann et al., 1989; Lehmann et al., 1989; 1990; Liesen et al., 1989; Mader, 1990; Werle et al., 1989). Overtraining is characterised by negative physiological reactions and limits the capacity of performance and adaptation of the athletes (Harre, 1982).

Stone and Kroll (1986) argue that a fine line could exist between optimal or peak training and overtraining in competitive sports. The authors contend that although it is not easy to anticipate overtraining it's presence can be recognised through specific symptoms (see table 1). These symptoms of overtraining vary from one athlete to another. It causes a progressive worsening of fatigue (Harre,1982), which represents a major determent to ones' performance (Stegemann, 1981). Under conditions of fatigue, muscular strength is decreased, the reaction and movement time are prolonged, agility and neuromuscular conditions are reduced, the speed and total body movement is slowed while the level of concentration and alertness is reduced (Åstrand & Rodahl, 1986; Harre,ebd.; Wilmore,1982). In the game of Soccer the onset of fatigue is most noticeable in the loss of speed and a marked deterioration of co-ordination (Muckle 1981). Fatigue has also been associated with a marked reduction in cognitive function (Astrand & Rodahl, ebd.). Marriot et al.(1991) have however pointed out that the fatigue-induced adverse effects on decision making as sports participants approach a state of physiological fatigue is largely due to peripheral mechanism.

Trainers, coaches and athletes can easily monitor their training and performance in competitions by performing standardised tests repeatedly with a view of avoiding overtraining and undertraining. According to O'Brien (1988), the most reliable and simple physiological indicators of overtraining include an increased resting heart rate, blood pressure, exercise heart rate and a slowed recovery time after exercise. Any test that uses the heart rate to score can serve this purpose. In addition to avoiding the pathophysiological effects and performance determent associated with overtraining,

Table 1: Symptoms of overtraining.

Symptoms	Reference
1. Increased ammonia accumulation in muscles	Hageloch et al., 1988; Mader,1990; Schneider et al., 1989; Witt et al., 1989.
2. Decreased lymphocyte count and exercise induced immobilization of granulocytes and monocytes.	Kindermann et al., 1989; Liesen et al., 1985; 1989 Order et al., 1989; Werle et al., 1989.
3. Increased level of catecholamine secretion with a decrease in basal nocturnal catecholamine excretion.	Adlercreutz et al., 1986; Buggraeff et al., 1989; Jacobs et al., 1989; Jost et al., 1989; Kindermann et al., 1989; Lehmann et al., 1989.
4. Decreased enzymatic activity	Adlercreutz et al., ebd; Buggraeff et al., ebd.
5. Increased lactate accumulation in the muscles and blood	Åstrand & Rodahl,1986; Ekblom et al., 1968; Hollmann et al., 1981; Jacobs 1986; Kindermann et al., 1979; Londere & Ames, 1975; Stegemann, 1981; Stegemann and Kindermann, 1982.
6. Lowered endurance,speed and strength,loss of motivation,co-ordination and power of concentratio	Harre,1982; O'Brien,1988; Stone and Kroll,1986.

efforts to identify overstress are also designed to avoid injury (Stone & Kroll,1986). Many reports suggest that poor physical fitness and lack of practice lead to a high incidence of injuries (Cahill & Griffith,1978; Jackson et al., 1978; Lysen et al.,1984; Nicholas,1974; Salokun,1991). However, Jackson et al. (ebd.) did not find any relationships between an anthropometric data and physical fitness characteristics on one hand and injuries on the other.

The importance of testing for physical fitness in athletes can therefore be summarised as follows:

> Physiological tests measure physical capabilities and are usually used by the coach, athlete, and scientist to assist in the evaluation of a particular training regimen ; to assess the influence of a particular condition ... ; to prescribe or alter training regimens, to maintain strengths and / or to remedy weaknesses ; and to evaluate the reasons for success or failure at a particular time (Banister & Wenger 1982, p. 163).

2.2. METHODS USED IN PHYSICAL FITNESS TESTING

There are two forms of physical fitness testing which have been internationally acclaimed. These are ergometry and field tests.

2.2.1. ERGOMETRY

Ergometry is a form of measurement of physical or work performance. Physically, power is defined as the rate of transfered energy. Thus power is rate of work done. The unit of measurement of power is metre kilopond per second (mKp/s). However, the watt is more commonly used (1 watt = 10 mkp/s). Ergometry is used to:

1. establish the performance ability of the body i.e. to test the physical fitness;
2. diagnose cardiovascular and pulmonary disorders; and to
3. evaluate the success of therapeutic procedures related to exercise (Rost et al., 1987).

Forms of ergometry used include a stationary cycle, treadmill, rowing ergometer and crank ergometer. The variables (parameters) measured in ergometry include hemodynamic responses (heart rate, blood pressure); respiratory responses ($\dot{V}O_2$ max, CO_2, respiratory quotient); metabolic responses such as hormones; lactate, ammonia, catecholamines and physical working capacity (PWC) at various heart rates (Rost et al., ebd.).

According to Baumgartner and Jackson (1982), cardiorespiratory function depends on several factors namely the efficiency of the lungs; heart and blood vessels; the quality and quantity of blood and cellular components. Since an individual's ability to utilise oxygen during exhausting work itself depends on these factors, $\dot{V}O_2$ max is an accepted indicator of exercise ability (ACSM, 1979). In fact $\dot{V}O_2$ max is considered the best laboratory measure of a persons' physical fitness provided the definition of fitness is restricted to endurance (Åstrand & Rodahl, 1986; Hollmann & Hettinger, 1990; Wilmore, 1982).

Maximal oxygen uptake has been commonly used to evaluate the cardiorespiratory endurance on the treadmill ergometer

(Baumgartner & Jackson, 1982; Davis & Thompson, 1986; Harrison et al., 1982; Kelly et al., 1980; Kirgan & Reilly, 1991; Ogushi et al., 1991; Wilmore, 1982). The nature of work done on the treadmill is either walking, running or both. The tests use one of the three methods of increasing exercise intensity:

1. Increasing velocity with elevation kept constant;
2. Increasing elevation with velocity kept constant;
3. Increasing both elevation and velocity (Thoden et al.,1982)

This is done at a given interval (for example every 3 minutes) (Astrand & Rodahl, 1986). Also, work can be done at a fixed velocity and elevation for a given period of time (Oseid, 1983; Wekesa, 1989; Wekesa & Debelic, 1991; Wekesa et al., 1990a ; Wekesa et al, 1990b; Wekesa & Onsongo, 1992).

Other researchers have widely used the cycle ergometer to measure oxygen uptake (Åstrand & Rodahl,ebd.; Kirgan & Reilly, ebd.; Montgomery et al.,1978). Attainment of $\dot{V}O_2$ max is assumed when a plateau or a slight drop in the $\dot{V}O_2$ occurs as work is increased beyond the work intensity that first results in a maximum value. Other information which has been used as criteria to establish that valid $\dot{V}O_2$ max values have been attained includes exhaustion, or when a subject reaches the age predicted maximal heart rate. Since in the latter two methods, workload is increased at a constant rate, the person who can continue the test longer has a higher $\dot{V}O_2$ max (Åstrand & Rodahl,ebd; Clarke & Clarke,1987). In other studies , the use of arm ergometer, wheelchair, rowing ergometer, peddling ergometer, swimming tank or flume have been reported (Abel et al., 1989;

Åstrand & Rodahl, 1986; Bar-Or,1983; Froelicher, 1987; Glacer et al. 1977; Thoden et al. 1982; Weiler,1989; Wicks et al. 1977).

Although ergometer methods are favoured because their loading is exact, easily reproducible and can be controlled, the results from such tests cannot be applied directly to sports without modifications. Further, if the measurement of $\dot{V}O2$ max is to be of any practical value to the athlete, the mode of exercise must be controlled and be specific to the sport both in form and intensity. Consequently, $\dot{V}O2$ max measured on a treadmill and cycle ergometer does not represent a true practical situation unless it is related to the sport concerned (Reed,1982).

This is in agreement with Åstrand's observation that:

> every sport event is in a way unique in that it has a specific pattern in its demand on such factors as the energy-yielding systems(aerobic and / or anaerobic power),neuro-muscular function and locomotor organism (including strength and technique) and the psychological factors (e.g. motivation, tactics, perceived exertion ...(1984, p.1)

Sport scientists have developed predictive tests in the assessment of exercise capacity from sub-maximal exercise heart rate. These tests are based on the assumptions that a relationship exists between $\dot{V}O2$ max and other more easily measurable variables during submaximal work and that extrapolation to maximal work level can be made to predict the $\dot{V}O2$ max (Thoden et al., ebd.). Both heart rate and oxygen uptake increase linearly in response to increasing work

(Åstrand & Rodahl ,1986; Thoden at al.,1982) hence the use of working heart rate to predict $\dot{V}O_2$ max (Stegemann, 1981). When the heart rate reaches the predetermined value,(e.g. 170 beats/min), the work is terminated and $\dot{V}O_2$ read from the Astrand Rhyming Nomogram (1954) which is based on the linear relationship between HR and age (Thoden et al., ebd). However, though inexpensive and easily administered, predictive tests are subject to error, for group data they are excellent, with the error between predicted and measured $\dot{V}O_2$ max being less than 10%. The range can spread to 25% (MacDougall & Wenger,1982).

According to Åstrand and Rodahl (ebd.), "It is possible to estimate the workload from the heart rate recorded during a specific work situation in the field." (P.456). This is because there is a significant relationship between heart rate, stroke volume (SV), cardiac output ($\dot{Q}$) and $\dot{V}O_2$ max (Berger, 1982; Israel et al., 1974; Wilmore,1982). Furthermore, Israel et al., (ebd.) have pointed out that;

> sie ist einfach, billig und leicht zugaenglich , ihre Erfassung ist bequem , unschaedlich, unblutig und schmerzfrei. Sie ist sofort auswertbar, ihre fortlaufende oder kurzfristige wiederholte Registrierung ermoeglicht ... die feinere Beurteilung von Regulationen und damit eine dynamische Betrachtungsweise. Ihre Ermittlung ist nicht nur Sportaerzten vorbehalten, sondern sie kommt fuer Aktive und Trainer gleichermassen in Betracht, und sie ist uch bei grossen Kollektiven unkompliziert und im allgemeinen ohne grossen Aufwand einsetzbar. Die Submaximale HF ist zur Trainingssteuerung besonders fuer Sportformen von Bedeutung bei denen groessere Muskelgruppen eingesetzt werden (Israel et. al. 1974 pp. 297 - 298). [HR is simple , cheap and easy to obtain . It's recording is comfortable, not

dangerous, bloodless and without pain . It can be evaluated immediately, it's continuous or short term repeated registration enables ... a fine evaluation of regulations and with a dynamic approach. Its investigation is not only reserved for doctors , but it can also be done by the athletes and coaches alike , and it can be carried out on large samples without complications and without much costs. The use of the submaximal HR in controlling intensities is particularly useful in forms of sports that use very large muscle groups].

This simplicity has made the use of submaximal heart rate to control training (Israel et al.,1974; Mathews & Fox,1982; Rost et al., 1987) in forms of sports which use large muscle groups important. Another presumption for the assessment of physical fitness based on heart rate is the argument that the cardiac output at a given oxygen uptake varies only within reasonable limits (Åstrand & Rodahl,1986; Wilmore, 1982).

A very noticeable change associated with endurance training is a reduction in the resting heart rate (Åstrand & Rodahl ,ebd.; Goss, 1983; Rost et al., ebd; Stromme & Ingjer, 1982; Wilmore ebd). This exercise-induced bradycardia may result in resting values for the athlete as low as 35 to 40 beats per minute. However, endurance training superseding the optimal level would result in tachycardia at rest, work and with a delayed recovery (Harre, 1982; O'Brien,1988; Stone and Kroll, 1986).

At submaximal level of work, when the level of exercise is held constant, the heart rate increases fairly rapidly until it levels off at what is called a steady state level (Åstrand & Rodahl, ebd ; Stegemann, 1981; Wilmore, ebd). The more intense the level of exercise, the longer it takes to achieve this steady state. If the workload is greater than the threshold for prolonged work, then there is an initial rapid rise in heart rate, no steady state is reached and the heart rate increases until fatigue interrupts work (Stegemann,1981). Other measurable factors which increase linearly to HR and which have a direct bearing on physical fitness include cardiac output, systolic rate and maximum oxygen uptake (Åstrand & Rodahl,1986; Watson,1983).

Since the work performed by the heart has a high correlation with the resting and exercise heart rate, the reduced submaximal exercise heart rate indicates that the heart is working more efficiently (Åstrand & Rodahl, ebd; Israel et al., 1974; Morris,1983; Rost, 1987). Several researches have also illustrated that the HR recovers from an exercise at a much faster rate following endurance conditioning (Åstrand & Rodahl,ebd; Goss,1983 ; Rost,ebd. ; Rost et al. 1987; Stromme & Ingjer, 1982; Wilmore, 1982). This has led to the use of the sum of the recovery heart rate as a measure of physical fitness or work (Stegemann, ebd).

In other studies, maximal anaerobic power and capacity have been used as indicators of physical fitness. This has been measured on cycle ergometer in most sports laboratories over a long time (Berg & Ekblom, 1979; Nagahama et al., 1991). The subject is required to peddle on a cycle ergometer till exhaustion or for a specific time and at a certain workload, for instance 400 watts for males. Blood samples are then taken from a punctured earlobe or finger tip for lactic acid analysis (Thoden et al., 1982).

Other researchers have used treadmill ergometry to evaluate the anaerobic power and/or capacity of athletes (Evangelista et al., 1991) The subject runs on a motor driven treadmill at a 20% grade (or more) till exhaustion or for a specific time. Running time and blood lactate analysed from blood samples taken at certain intervals (e.g. 5th, 12th and post exercise) are used frequently to score. Lower values of each variable indicates superior fitness.

2.2.2 FIELD TESTS

Field tests are designed to measure specific motor components i.e. flexibility, strength, coordination, speed, and endurance in a field situation. Test batteries are capable of measuring a combination of these components (Baumgartner & Jackson,1982). Most of the test batteries on the market have been used to measure conditioning effects, co-ordination and for diagnostic purposes for school children, college men and women (Clarke & Clarke,1987). Some of these motor related tests have been adequately reviewed by Boes (1987) and Clarke and Clarke (ebd). The disadvantages of these tests is that they are general to all sports and less important in competitive sports where specificity of training is the goal.

The most popular field test in competitive sports has been the step test (Baumgartner & Jackson, ebd.). The original step test

(Harvard step test) was developed by Brauha in 1943. However, the test has subsequently been altered by various researchers (Baumgartner & Jackson, 1982).

Distance runs have also been commonly used. Factor analysis studies have indicated that distance runs normally measure two components. These include:

1. Speed which is represented by short sprints; and
2. Aerobic endurance which is measured by longer distances or for more than nine minutes (Baumgartner & Jackson, ebd.; Jackson & Colleman, 1976).

A study by Balke reported in Baumgartner and Jackson (ebd.) suggested that the distance covered during 15 minutes of running or walking is a more valid test of maximal oxygen uptake in a field situation. Later, Cooper whose study aimed at establishing the construct validity of distance runs, reported a correlation of r = 0.90 between $\dot{V}O2$ and distance covered in twelve minutes of run/walk test (reviewed by Baumgartner and Jackson,ebd.). Concurrent validity reported for the Cooper 12 minutes run/walk test range from as moderate as r = 0.54 to as high as r = 0.91 (Gurtin et al., 1976; Jackson & Colleman, ebd).

The 600 yard run (1.5 km) has been included in the AAHPERD Youth Fitness Battery (AAHPERD,1984) as a measure of aerobic endurance. However, this distance is not considered long enough to measure aerobic capacity (Baumgartner & Jackson; ebd.).

Some researchers have used stair-case run to measure anaerobic alactacid power (Kirgan & Reilly,1991). In recent years however, the use of sprints where time and lactate are used to score have been extensively reported (Balsom et al., 1991; Brewer & Davis,1991; Malonsoki,1991; Rhodes & Mosher,1991; Schlicht et al., 1988; Schneider et al., 1989).

There are multistage test batteries whose test items combine several single tests such as shuttle run for agility, co-ordination; and anaerobic capacity, dynamography for strength, sit and reach for flexibility; squatting jumps and vertical jump for explosive power; vertical lift for strength and broad jump for concentric dynamic muscle strength of lower extremities (Bell et al., 1991; Brady et al., 1991).

Some researchers have developed sport specific tests in swimming (Jackson et al., 1979; Mader,1990; Weiss et al., 1989); track and field athletics (Dickhuth et al., 1989; Kosten-Reck et al., 1989; Tegtbur et al., 1989), field Hockey (Schneider et al., ebd). These studies have demonstrated that sport specific field tests compare well with established standard tests.

2.3 FITNESS TESTING IN SOCCER

Physical fitness testing for Soccer players is not a recent phenomenon (Muckle, 1981). Researchers have for a long time employed standard motor fitness test batteries dominated by motor performance variables. "Alternatively, investigators have concentrated on one or a few variables at a time with heavy emphasis placed on maximal oxygen uptake and anaerobic power" (Reilly & Thomas,1980, p. 247). It is however, widely recognised that fitness for top class sport is multifaceted. In soccer, for example, the demands of the game are to a large extent multifaceted. This however,

> tends to complicate interpretations of individual differences when viewing a number of fitness components separately. (Reilly & Thomas ebd .,p.247).

Ergometric methods have been used to evaluate aerobic power and capacity, alactacid anaerobic power and physical working capacity of Soccer players. The most frequently used form of ergometry has been the treadmill (Bunc et al., 1991; Evangelista et al., 1991; Heller et al., 1991; Jensen & Larson, 1991; Matkovik et al., 1991; Ohashi et al., 1991). A subject exercises on a treadmill while his heart rate is monitored or oxygen consumption is analysed from the expired air for $\dot{V}O2$ max. To measure anaerobic power and capacity, lactate accumulation is analysed from blood samples taken from a punctured earlobe or fingertip.

Other researchers have used cycle ergometry to measure both aerobic and anaerobic capacity of soccer players (Berg & Ekblom, 1979; Kirgan and Reilly,1991; Nagahama et al., 1991; Nowacki & Preuhs,1991; Raven et al., 1976; Reilly 1979; Tumilty & Smith, 1991). $\dot{V}O2$ max and lactate accumulation are used as indicators of fitness whereby high values of $\dot{V}O2$ max represents superior fitness while lower values of post exercise lactate shows that one is physically fit.

Modified treadmill ergometry suitable for Soccer players has been reported in the literature in the recent years (Kruemmelbein et al., 1989; Nowacki & Preuhs, 1991; Reilly & Ball,1984). The purpose of such tests has been to make them as sport specific as possible.

Reilly and Ball (ebd.) investigated the net physiological cost of dribbling a Soccer ball on a Soccer specific treadmill. Eight competent Soccer players volunteered to participate in the experiment. All the subjects (mean age 19.6 ± 1.2 years) first attended the laboratory for measurement of $\dot{V}O_2$ on a Quinton motor-driven treadmill. The experiment involved dribbling a Mikas 2000s Soccer ball for 5 minutes while running on the treadmill at speeds of 9, 10.5, 12 and 13.5 km per hour. The control condition involved running at these speeds without the ball. In a single experiment session, all 8 trials were performed. Measurement of $\dot{V}O_2$ were made for the third, fourth and fifth minute of each trial by means of the on-line system used for determining $\dot{V}O_2$ max. The results showed that the VO_2 max. of subjects ranged from 55.9 to 74.2 ml. kg. min These values compared favourably with those reported earlier for professional players (Raven, et al.,1976; Reilly, 1979; Withers, et al., 1977). ANOVA showed that there was no significant difference between the first and second set of tests for any of the measures ($P > 0.05$). However, further analysis indicated that there was a significant effect of time measured for $\dot{V}O_2$ ($F = 7.35$, $P < 0.001$). It was concluded that dribbling a ball does significantly increase the energy cost and perceived exertion of motion, as well as including disproportionate rises in heart rate when performed at high speeds.

Whereas these ergometry methods are standardised, controlled and their results accurate and reliable, they do not simulate a true game situation. Furthermore, the measurement of aerobic and anaerobic power under laboratory conditions does not allow direct application to the field situation (Thoden et al., 1982). Perfect fidelity of simulation would involve irregular changes in speed and swift changes in direction of motion as used in dribbling in match play to manoeuvre around opponents (Reilly and Ball, 1984). Such acyclical and dynamic changes in activity would affect the energy cost.

Some researchers have used field tests to measure aerobic power and capacity. Such tests include a shuttle run (Brewer & Davis,1991, Garganta et al., 1991; Davis & Brewer,1991). The values recorded after these tests range from 55-63 ml.kg.min of relative $\dot{V}O2$ max. In earlier studies researchers used the Cooper test and Harvard step test to measure both aerobic capacity and power in a field situation. The Harvard step test provides a fitness index based on the effect of a controlled workload on the post-exercise pulse rate and the recovery period. Muckle (1981) reported studies by Ishiko (1968) and Thomas (1975) Where Harvard index of 119.5 and 117 respectively were observed. "These values are classed as excellent according to the Harvard criterion, although they are considerably less than the 160.2 for Olympic marathon runners" (Muckle, ebd, p.32). Studies on the 12 minutes Cooper test in the USA have shown that average American professional Soccer players in the

1976 covered 1.86 miles (2.99 km) during the test. The values are much lower than those found in the English Soccer leagues where over 2 miles (3.218 km) was recorded. The Brazilian Pre-World cup final players who had undergone an aerobic type of conditioning programme in addition to their regular intensive Soccer training raised the average distance to 2.2 miles [3.54 km] (Muckle, 1981).

Tests in which $\dot{V}O_2$ max. and lactate are used to score whether in the laboratory or on the field assume the predominance of aerobic and anaerobic endurance in a game of Soccer with little emphasis on other physical fitness components. However, both laboratory and field tests have shown that the average relative maximum oxygen uptake in a Soccer player ranges from 45 - 71 ml. kg. min for both amateur and professional players. The maximal oxygen uptake is the capacity of the body tissue to consume oxygen during the period of activity and indicate the endurance capacity. It is obvious that the endurance capacity of Soccer players is fairly high. Whether or not an increase in the average maximal aerobic power would increase the quality of the game and improve performance of a team is still a matter of discussion.

A fairly recent study by Roi et al., (1991) investigated the relationship between maximal aerobic power and performance of a professional Soccer team. The study was conducted with a presumption that cross-sectional studies in different teams had showed that professional players have 56-71 ml. kg. min. of $\dot{V}O_2$

max and that other factors than this are decisive for success. 72 players of an International team participating in the 1st division of the National league between 1984 and 1990 took part in the study. $\dot{V}O2$ was measured during treadmill running (1% slope; 8km/h starting velocity with increments of 2 km/h every 3 minutes until exhaustion) with the standard open circuit method. The value of $\dot{V}O2$ measured in the last minute of each test was chosen as $\dot{V}O2$ max. The results showed no significant differences ($p > 0.05$) in $\dot{V}O2$ max. for the examined period. On the contrary, the performance of the team in 1989 season was far much better than in the 1986 - 87 season when the team was relegated from the second division. Thus the performance increased. It was then concluded that the performance of a team depends on other physical,technical and tactical factors than on $\dot{V}O2$ max. alone. This supports an earlier observation by Åstrand (1984) that :

> maximal aerobic power is not the only decisive factor in an excellent performance in heavy exercise; some sort of specificity in training also plays a part (p.1).

Other physical fitness components important in the game of Soccer include leg strength, agility and co-ordination. Several field tests in which these components have been measured are reported (Ekblom, 1986; Reilly, 1979 ; Sarsaniya & Seluyanov ,1991; Verstappen et al., 1991). These tests have used the vertical jump, broad jump, bench-press maximum, hand-grip and dynamography to measure strength, explosive power, and muscular endurance of Soccer players. However, some of the tests could not significantly discriminate between elite Soccer players from non-Soccer players. For example, the use of vertical jump test to evaluate the maximal dynamic concentric muscle strength in the lower extremities is highly questioned (Ekblom, 1986). On the basis that maximal dynamic concentric muscle strength is particularly important for Soccer players, several researchers measured it on a vertical jump test. Raven et al. (1976) and Reilly (1979) studying North American league professional Soccer players and British league Soccer players showed only an average of 50 - 55 cm in vertical jump which was not statistically different from untrained controls in separate studies. Similar values have been reported for the Australian World Cup squad (Muckle,1981) and Swedish teams (Ekblom, ebd; Oberg, 1984).

A study by Oberg et al. (1984) investigated knee extensor and flexor strength at 30° and 180° isometrically at 60°/sec in male Soccer players from the fourth division respectively. The results showed that there were differences in strength between players from different divisions, the national team players being the strongest. It can therefore be concluded that the vertical jump test is not a valid test when one intends to discriminate the lower extremity muscle strength of Soccer players from non-athletes.

Elsewhere, sprinting tests either on a Staircase (Withers et al., 1979) or on Soccer field (Balsom et al., 1991; Brewer & Davis,1991 Comas et al., 1991; David & Brewer,1991; Garganta et al., 1991; Kollath & Quade,1991; Lindquist & Bangsbo, 1991; Malonsoki, 1991; Tumilty & Smith, 1991; Verstappen et al.,

1991) have been extensively used. However, speed, power and anaerobic capacity are just but a few of the physical components required in the game of Soccer. Further, such tests are either not specific to Soccer (i.e. the staircase test) or are not comprehensive enough.

Other studies have compared Soccer field tests against standardised ergometry tests (Kruemmelbein et al., 1989; Reilly & Thomas, 1980; Rhodes & Mosher, 1991; Sarsaniya & Seluyanov,1991; Tumilty & Smith, 1991). Results from these tests indicate that field tests compare significantly well with ergometry, hence the rationale for their use.

Reilly and Thomas (ebd) undertook a study to identify discrete fitness factors in professional Soccer players at the beginning of the season and to investigate the replicability of such factors in the analysis of fitness data obtained at subsequent critical points throughout the season. It was hypothesised that solutions would show common factors related to body size, composition, strength, power endurance, lung function and blood pressure. Thirty one male professional players (mean age 22.4 years) from an English league first division club acted as subjects. They were tested on a battery of 35 test items which incorporated 13 anthropometric variables, 10 strength and cardiac function variables both in a laboratory and in the field. The test was applied at four points during the season. These were pre-season, start of competition, mid-season and end of season. The test administration took two days in each instance. The results indicated that anthropometric variables, cardiac variables and endurance showed 81% variance. It was concluded that general fitness factors do persist and that specific factors are to an extent subject to interseasonal influence. The items in this test though Soccer related, are not specific to the game of Soccer alone. Other researchers have used similar test items in other sports and have reported high performance comparable to what was found in this study. (Kirgan & Reilly,1991; Menchinelly et al., 1991). Furthermore, the measurement of these items is time consuming, painful and demanding on the part of the subjects in that unless he is adequately motivated, the results will be affected.

In another study, Sarsaniya and Seluyanov (1991) evaluated the strength abilities and anaerobic capacity of highly skilled Soccer players (n=50) on a 7 x 50 metre sprint test. The subjects were required to run without a ball at top speed without stopping seven times the distance whose length was 50 metres in the field. The results showed that the time of running the test was 64 seconds, which linearly correlated with the concentration of blood lactate on the fourth minute recovery. The researchers concluded that the 7 x 50 metres sprint test can be used to estimate strength and aerobic abilities of highly skilled Soccer players. Other studies which have used sprint test have arrived at similar conclusions (Balsom et al., 1991; Brewer & Davis 1991; Comas et al., 1991; Withers et al., 1977).

Rhodes and Mosher (1991) carried out some physiological investigations involving a comparison of certain factors in a laboratory and on the field on female soccer players. A strong negative correlation was found between the laboratory variables and the field test parameters. However,these authors did not endeavour to develop a field test as such.

Comas et al.(1991) have indicated that aerobic power, anaerobic power, muscle strength, agility are the other important variables in high performance level of Football players. Hence a valid test of physical fitness for Soccer players should incorporate these factors. Attempts by some Austrian researchers to develop a comprehensive multivariate Soccer specific field test were unsuccessful (Baron et al., 1988). In their study they analysed basic motoric characteristics in Soccer players of three different levels (National league level, lower level and regional level) on an incremental treadmill ergometry, Isokinetic strength testing of the quadriceps muscles and on a Soccer specific field test. The aerobic endurance index calculated from the treadmill did not correlate with corresponding performance index calculated on the field test.

Later a group of German researchers (Kruemmelbein et al., 1989) reported a Soccer field test - The Giessener Soccer Fitness Test. It measures explosive power, speed, aerobic, anaerobic power and co-ordination.

Comparable studies between the treadmill and the newly developed sport specific treadmill as well as Soccer specific field test were done . The results showed no significant difference ($P < 0.05$) in maximal average heart rate 196 ± 4 min (youth) and 186±5/min (league players) on the treadmill as compared to 196±5 beats/min (Youth) and 190±6 beats/min (league players) on the Giessener Soccer Fitness Test. The results of the cardiocirculatory recovery capacity as determined at the end of the fifth recovery minute were equally comparable:

ergometry:	Youth (113/min)	League (104/min)
field test:	" (107/min)	" (100/min)

Whether this test is specific to the game of Soccer alone was the focus of research in this study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter covers the research methodology used in the study. Specifically, the subjects and sampling method, the test instrument, procedures, and data analysis techniques are discussed.

3.2 METHODOLOGY

This study was a comparative analysis of the Soccer, Rugby and Field Hockey players' performance on the Giessener Soccer Fitness Test. The purpose was to establish the specificity of this test to the game of Soccer. Rugby and Field Hockey were chosen for comparison because these are forms of sport whose demands in terms of training, frequency and duration of each training session are similar to the game of Soccer (Berger, 1982).

3.2.1 SUBJECTS AND SAMPLING METHOD

The subjects for this study were sampled from clubs which participated in the highest leagues in Kenya in the year 1991. There were sixteen Soccer clubs in the Kenya Amateur Football super league, six teams in the Kenya Cup Rugby league and twelve teams in the Men's Shimba Tourist sponsored National Field Hockey league. Simple random sampling (Hinkle et al., 1979) was used to select one team from each category. All the players in each of the selected teams were tested.

3.2.2 THE TEST INSTRUMENT

The Giessener Soccer Fitness Test was used as the instrument for all the groups (Hockey, Rugby and Soccer). The test is an interval like circuit exercise whose items are arranged in five stations as follows:

Station one: Shuttle Slalom dribbling of a Soccer ball.

Station two: Heading a Soccer ball hung at 200 cm high.

Station three: Shuttle dribbling of Soccer ball.

Station four: Shuttle sprint.

Station five: Shuttle zigzag dribbling of a Soccer ball.

(See appendix A)

Each subject was required to perform the test at all the stations in the order of Warm-up(W), Round one(R1) to Round six(R6), thereby covering a total of seven circuits. A circuit consisted of a specific round (e.g. R1 at all the stations).

3.2.3 PROCEDURE

Prior to the experiments, a research permit number OP/13/001/21C113 was obtained from the Office of the President. After the teams were sampled and notified, the subjects were tested once during the mid season of their respective leagues. It was assumed that players had attained peak form. On the testing day, the researcher and his assistants visited the players at their training field, set up and administered the test. Prior to the performance of the test, each subject was assigned a research assistant who supervised him throughout the test and measured the pertinent variables. The following variables were recorded before the test performance; age (yrs), weight (kg), height (cm) and resting heart rate (beats/min). The research assistants had been trained adequately on how to measure the variables in question before hand.

On the research assistants' instructions 'ready go' each subject was required to do one circuit through the five stations without stopping. After each circuit, the subjects were allowed three minutes recovery period before the next circuit. To score the test, the exercise and recovery heart rate (beats/min) as well as time (minutes) taken to perform the test were measured. Time (minutes) taken to perform a circuit by each subject was measured by the research assistants using a CASIO stopwatch with six digits.

The total time taken on the test by each subject was obtained by summing up the time taken by each subject to perform each of the seven circuits. The heart rate (beats/min) was monitored by a stethoscope. Timing started on the research assistants instructions "ready go" and ended when the subjects completed each circuit. The figure read from the watch was taken as time for that circuit. The heart rate was monitored within the first 10 seconds immediately upon completion of each circuit. Recovery heart rate was monitored in a similar manner at the end of the second, fourth sixth, eighth and tenth recovery minute.

3.3 PILOT STUDY

The purpose of the pilot study was to assess the difficulties involved in the administration of this test and to train the research assistants. The test was administered to fifteen second year P.E. student majors who had undergone a Soccer course at Kenyatta University. From the results, the researcher further trained the assistants so as to get more accurate results. Further, any flaws in the test set up were identified and controlled.

3.4 DATA ANALYSIS TECHNIQUES

The data obtained from the field were summarised and presented using summary tables showing means , standard deviations, F - ratio and P-values of age, weight, working heart rate, recovery heart rate, and time taken to perform the test. Line graphs were used to show the response as well as means and standard deviations for each group. Bar charts were used to show the mean and standard deviation for working time (minutes), heart rate (beats/min), and recovery heart rate (beats/min) for each group.

Coded data were analysed by a computer type International Computer Limited ICL 75402 system. The Statistical Package for Social Sciences (SPSS) programme was used (Nie et al., 1975). The SPSS Anova programme was used to analyse data with and without repeated measures. The variables age, height, resting heart rate, sum of recovery heart rate, average time and total time were analysed without repeated measures while the exercise heart rate, recovery heart rate, and time taken to perform the test were analysed with repeated measures. The analysis was done in order to test the hypotheses formulated for this study in chapter one section four (1.4). A one way analysis of variance with and without repetitions on one factor (type of sport with three levels - Soccer, Rugby and Hockey groups) was used. All the null hypotheses were tested at the $P<0.05$ level of significance. The Scheffes' method, a post hoc multiple comparisons procedure was used to determine the combination of means that differed after rejecting the null hypotheses. A pocket calculator (CASIO Scientific calculator fx - 82c) was used to compute data for this method since the SPSS package used did not involve the Scheffes' method. A paired t-test was used to compare the results in the present study and those of Kruemmelbein et al. (1989).

3.4.1 ONE WAY ANALYSIS OF VARIANCE

The one-way analysis of variance (Hinkle et al., 1979) was used to assess whether the dependent variables (heart rate at rest, exercise, and at recovery ; RPS and time taken to perform the test) differed significantly across the independent variable (type of sport with three levels: Soccer, Rugby and Hockey groups). The preferred computational formula for a one way Anova is:

$$x_{ij} = \mu + \alpha_i + \varepsilon_{ij}$$

Where i = Subscript for a score
x_{ij} = the observed value
μ = the grand mean
α_i = the effect of the th population
ε_{ij} = the error of measurement
j = subscript for a subject

(Hinkle et al., ebd.; p.286).

3.4.2 SCHEFFES' METHOD

The Scheffes' method is recommended when there is a significant F - ratio in the Anova and when the group sample sizes are unequal. This method is advantageous as it can be used to test complex comparisons as well as pair used comparisons. With the use of this test, the experimental Type 1 error rate is maintained at the a prior alpha level.

The test statistic for the Scheffes' method is:

$$F = \frac{\sum cj = \bar{x} j^2}{Msw\,[\Sigma\,(j^2 / nj)]}$$

Where:
- c is the coefficient
- $\bar{x}$ is the mean
- Msw is Mean Square within
- n is number of observations within each group
- j is is subject for a subject.

3.4.3 **PAIRED T-TEST**

The two-sample t-test is a powerful tool for comparing population means when the following assumptions are met;

1. Both sampled populations have relative frequency distributions that are approximately normal;
2. The population variances are equal;
3. The samples are randomly and independently selected from the populations (McClave & Dietrich, 1988; p. 420).

The test statistic for this test is ;

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - D}{S^2 p \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}$$

where: subscript 1 represents measurement for sample 1
subscript 2 represents measurement for sample 2

and $S^2 p = \frac{\sum (x_1 - \bar{x}_1) + \sum (x_2 - \bar{x}_2)}{n_1 + n_2 - 2}$

CHAPTER FOUR

THE RESULTS

4.1 INTRODUCTION

The findings of this study are presented in the following order:

a) the anthropometric measurements of the subjects;

b) exercise heart rate;

c) exercise time;

d) recovery heart rate;

4.2 ANTHROPOMETRIC MEASUREMENTS

A total of eighty one (81) elite players (age: 23.36 ± 4.40 yrs; weight: 69.20 ± 7.33 kg; height 173.78 ± 6.32 cm) from three top clubs in Kenya (Hockey, Rugby and Soccer) participated in this study. The Hockey team (n=25) participated in the Kenya Hockey league, the Rugby team (n=30) took part in the Kenya cup National league, while the Soccer team (n=26) played in the Kenya Amateur Football National league.

Table two (2) shows the results of age, weight and height for the subjects. The Rugby players were the youngest group (21.91 ± 3.71 yrs) followed by Soccer players (23.88 ± 4.84 yrs), while the Hockey players were the oldest group (24.48 ± 4.39 yrs). The findings from Anova indicate no significant difference in the age between the three groups ($F=2.59$; $p = 0.0808$).

Table 2: The analysis of variance for anthropometric measurements of the Hockey (n=25), Rugby (n=30) and Soccer (n=26) players who performed the Giessener Soccer Fitness Test.

Dependent Variable	Independent Variable	$\bar{X} \pm SD$	F-Ratio	P-Value	Comment
Age (yrs)	Hockey	24.48 ± 4.39			
	Rugby	21.96 ± 3.71			
	Soccer	23.85 ± 4.48	2.59	0.0808	Not Significant
Weight (kg)	Hockey	67.48 ± 7.47			
	Rugby	73.33 ± 6.48			
	Soccer	66.07 ± 5.27	9.48	0.0002	Highly Significant
Height (cm)	Hockey	172.68 ± 7.15			
	Rugby	175.43 ± 5.17			
	Soccer	172.92 ± 5.65	1.65	0.1944	Not Significant

The Soccer players were the lightest group (66.07 ± 5.27 kg) as compared to the Hockey players (67.48 ± 7.47 kg). The Rugby players were the heaviest group among all (73.33 ± 6.93 kg.) Analysis of variance showed a significant difference between the three teams ($F = 9.48$; $p = 0.0002$). Further analysis using the Scheffes' post hoc method revealed no significant difference in the weight of the subjects between Soccer and Hockey ($F = 1.30$, $p > 0.05$). However, there was a high significant difference between Soccer and Rugby ($F = 16.57$; $p < 0.01$) as well as Rugby and Hockey players ($F = 10.57$; $p < 0.01$).

The shortest group was that of Hockey players (172.68 ± 7.15 cm) followed by Soccer players (172.92 ± 5.65 cm) while the Rugby players were tallest (175.42 ± 5.97 cm). However, this difference was small and not statistically significant as indicated by the Anova test ($F = 1.67$; $p = 0.194$).

4.3 EXERCISE HEART RATE

Findings of the heart rate at rest (RO), warm up (W), round one to six (R1-R6) are summarized in figure 1, figure 2 and table 3. Generally the Soccer players had the lowest heart rates all through followed by Hockey players while the Rugby players had the highest values with the exception of the resting heart rate where the Hockey players exhibited the highest values. The heart rates of all groups rose sharply from resting values to warm up. Thereafter the increase was gradual in all groups (see figure 1)

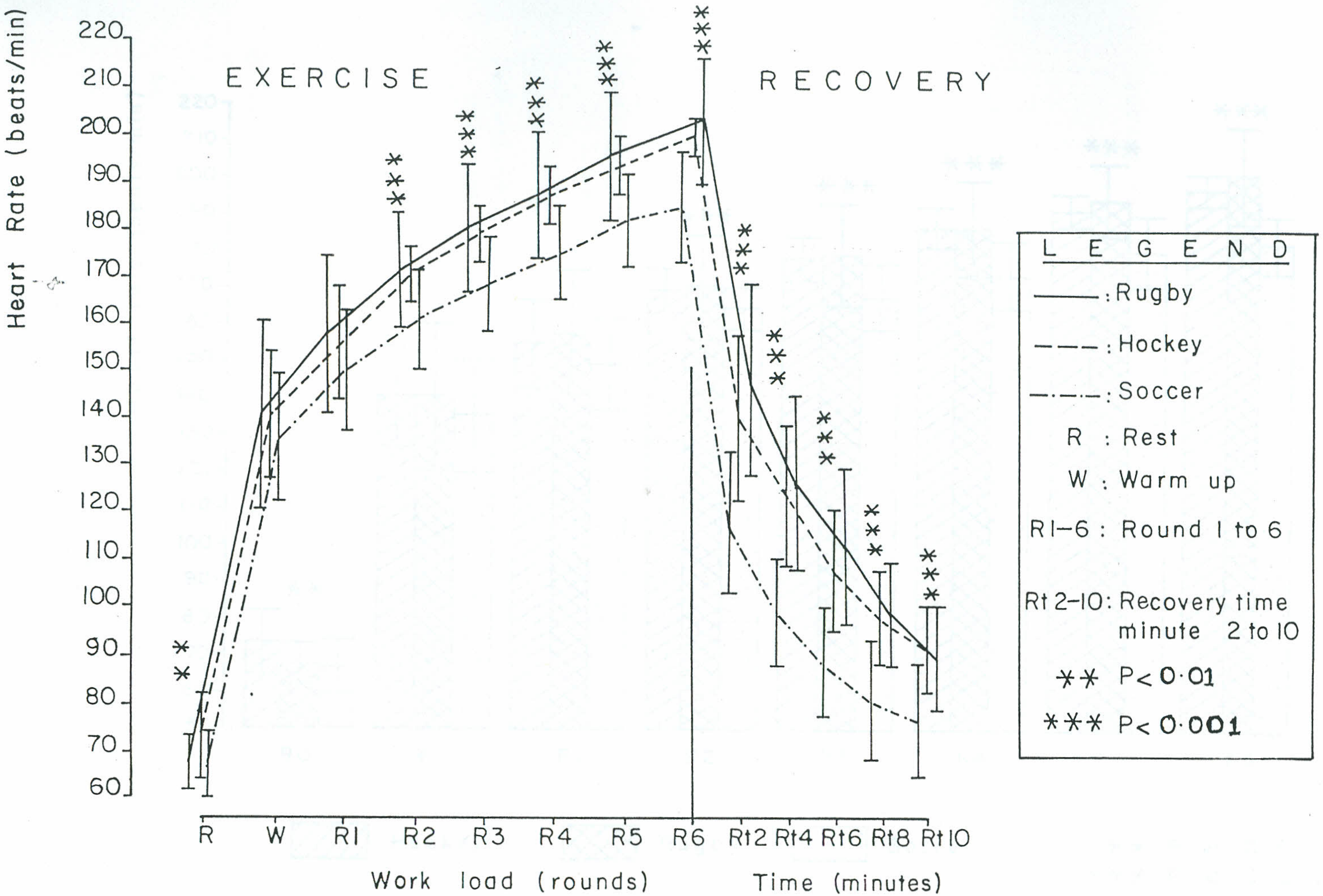


FIG. 1: The Heart Rate (HR) Response of Hockey (n=25), Rugby (n=30) and Soccer (n=26) players to the Giessener Soccer Test ($\overline{X} \pm SD$).

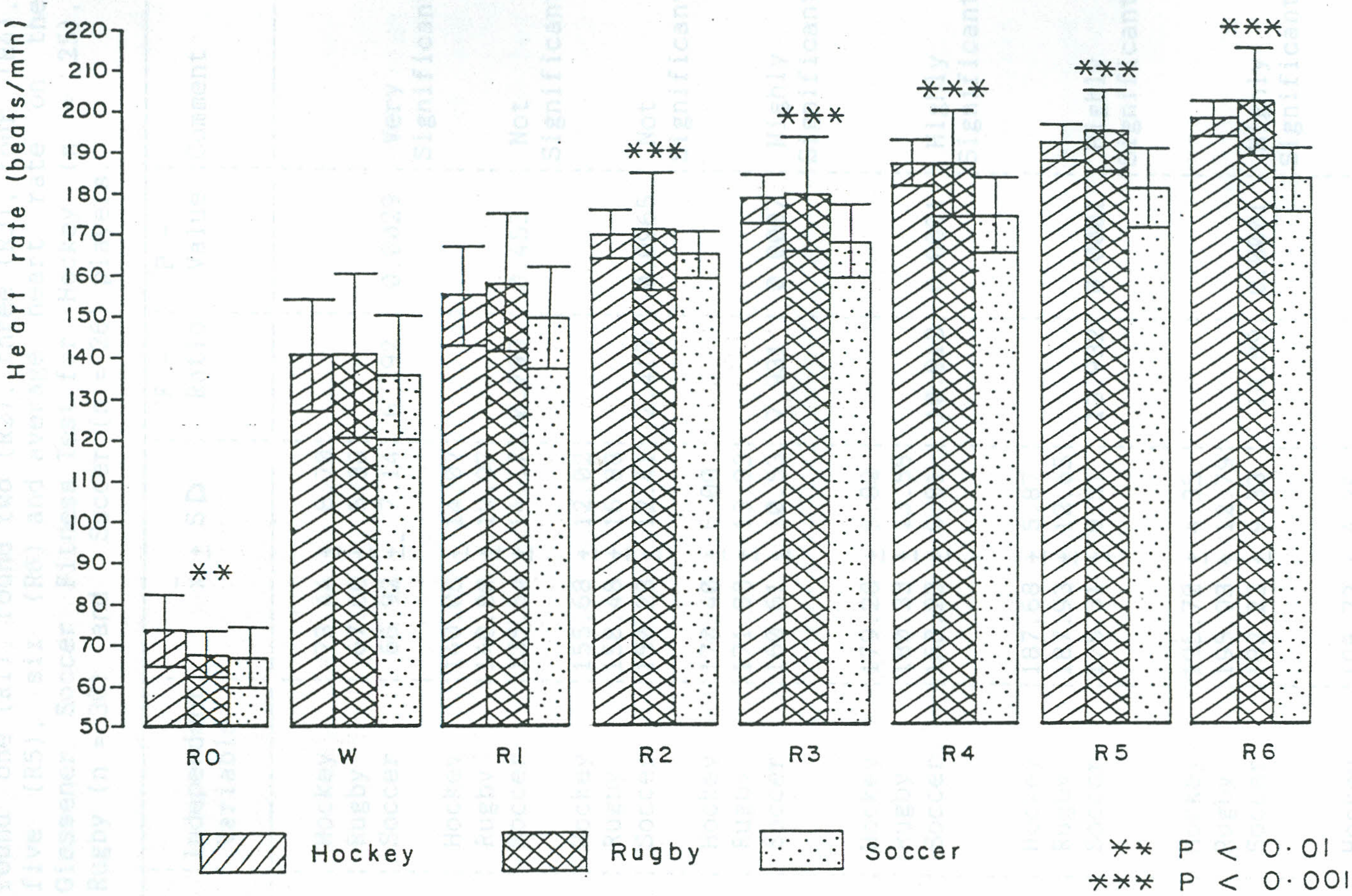


FIG. 2: Heart rate response to exercise at rest (RO), warm up (W), round 1 (R1), round 2 (R2), round 3 (R3), round 4 (R4), round 5 (R5), round 6 (R6) on the Giessener Soccer Fitness Test for Hockey n = 25 Rugby n = 30 and Soccer n = 26 players ($\bar{X} \pm SD$)

TABLE 3: The heart rate (beats/min) [dependent variable] response to exercise at rest (R0), Warm up (W), round one (R1), round two (R2), three (R3), four (R4), five (R5), six (R6) and average heart rate on the Giessener Soccer Fitness Test for Hockey (n = 25), Rugby (n = 30) and Soccer (n = 26) players.

Treat-ment	Independent Variable	$\bar{x} \pm SD$	F - Ratio	P - Value	Comment
R0	Hockey	73.44 ± 8.70			
	Rugby	67.60 ± 5.88			
	Soccer	66.92 ± 7.14	6.292	0.0029	Very Significant
W	Hockey	140.08 ± 14.07			
	Rugby	140.80 ± 19.97			
	Soccer	135.54 ± 14.17	0.793	0.453	Not Significant
R1	Hockey	155.68 ± 12.02			
	Rugby	158.48 ± 16.88			
	Soccer	150.23 ± 12.41	2.410	0.0965	Not Significant
R2	Hockey	170.40 ± 6.00			
	Rugby	171.33 ± 13.93			
	Soccer	160.61 ± 10.53	7.931	0.0007	Highly Significant
R3	Hockey	179.28 ± 5.82			
	Rugby	180.33 ± 13.58			
	Soccer	168.23 ± 9.81	10.913	0.0001	Highly Significant
R4	Hockey	187.68 ± 5.87			
	Rugby	187.93 ± 12.65			
	Soccer	175.31 ± 9.51	13.932	0.0001	Highly Significant
R5	Hockey	195.72 ± 4.35			
	Rugby	195.93 ± 12.79			
	Soccer	182.23 ± 9.33	14.89	0.0001	Highly Significant
R6	Hockey	198.72 ± 4.35			
	Rugby	203.00 ± 13.09			
	Soccer	184.53 ± 7.51	28.876	0.0001	Highly Significant
Averag	Hockey	175.07 ± 4.00			
	Rugby	176.82 ± 12.81			
	Soccer	165.24 ± 9.35	11.15	0.0001	Highly Significant

The Soccer players had the lowest resting heart rate (66.92 ± 7.13 beats/min) as compared to the Rugby (66.60 ± 5.83 beats/min) and Hockey players (73.44 ± 8.70 beats/min). The average difference between Soccer players and Rugby players was minimal. However, the average differences between Rugby and Hockey as well as Soccer and Rugby were 5.48 beats/min and 6.52 beats/min respectively. A significant difference was found between the teams ($F = 6.292$; $p = 0.0029$). When further analysed by the Scheffes' Post hoc test, a very high significant difference was established between Soccer and Hockey players ($F = 10.31$; $p<0.01$) as well as Rugby and Hockey players ($F = 9.27$; $p<0.01$). However, no significant difference was revealed between Rugby and Soccer players ($F = 0.12$; $p>0.05$).

At the warm up circuit, the findings indicated that the Soccer players' heart rate (beats/min) was the lowest (135.54 ± 14.77) followed by Hockey players (140.08 ± 14.07) while the Rugby players registered the highest (140.80 ± 14.07). The analysis of variance showed no significant difference between the groups ($F = 0.798$; $p = 0.453$).

The findings for round one (figure 2 and table 3) show that the Rugby players had the highest heart rate (158.48 ± 16.88 beats/min), while the Soccer players had the lowest (150.23 ± 12.41 beats/min). The Hockey players' mean heart rate (beats/min) was (155.68 ± 12.02). The average difference was 5.48 beats/min between the Soccer and Hockey while 8.25 beats/min between the former and Rugby players with an insignificant difference between Rugby and Hockey players (2.80 beats/min). However, these differences were not statistically significant when tested by the anova test (F = 2.410; p>0.05).

At round two, the findings indicated that Soccer players had the lowest heart rate (160.64 ± 10.53 beats/min), Hockey players had an average of 170.40 ± 6 beats/min, while the Rugby players had the highest values (171.33 ± 13.93 beats/min). The average difference between Soccer and Hockey players was 9.97 beats/min while 10.72 beats/min between Soccer and Rugby players. The difference between Hockey and Rugby players was insignificant. The analysis of variance showed a high significant difference between the teams (F=7.931; p<0.001). When analysed by the Sheffes' post hoc test, a very high significant difference was established between Soccer and Hockey F = 10.28; p<0.01) as well as Soccer and Rugby players (F = 13.37; p<0.01). But the difference between Hockey and Rugby was not significant (F = 0.09; p>0.05).

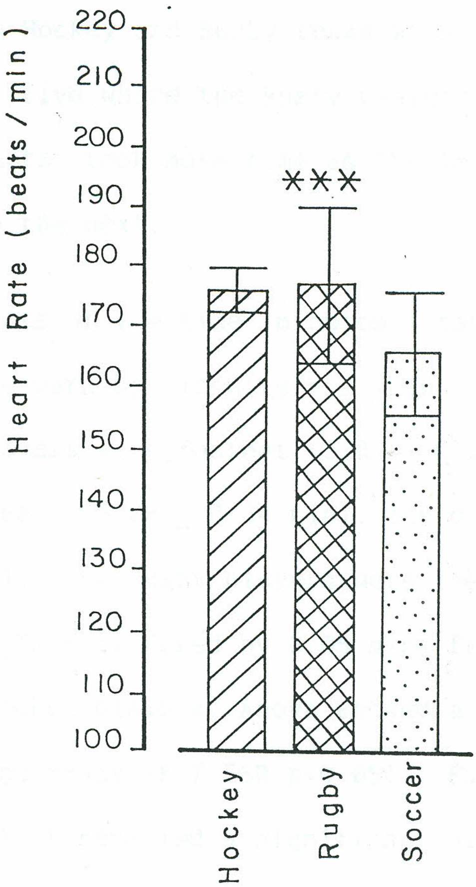
Figure 2 and table 3 show the results of the exercise heart rate (beats/min) at circuit three. The findings show that the heart rate attained by the Rugby players was the highest (180.33 ± 13.58) while the lowest was attained by Soccer players (168.23 ± 9.31). The Hockey players' heart rate was 170.40 ± 6. beats/min. The one factor analysis of variance showed a highly significant difference between the three teams (F = 10.913; p<0.001). Further analysis by Scheffes' test showed a very significant difference between Soccer and Rugby (F = 19.54; p<0.001) while the difference between Soccer and Hockey was ($F = 22.66$; $p < 0.001$). But no significant difference was established between Rugby and Hockey players ($F = 0.008$; $p > 0.05$).

The findings of the exercise heart rate (beats/min) for Hockey, Soccer and Rugby players at round four show that the Soccer players had the lowest heart rate (175.31 ± 9.51 beats/min) followed by Hockey (187.68 ± 5.82 beats/min) and the Rugby players (187.93 ± 12.79 beats/min). The average difference between Hockey and Rugby was 0.25 beats/min, while 12.37 beats/min and 12.62 beats/min between Soccer and Hockey as well as Soccer and Rugby respectively. These differences were statistically significant ($F = 13.932$; $p < 0.0001$). When analysed further by the Scheffes' test a very high significant difference was established in Soccer and Hockey ($F = 22.90$; $p < 0.001$) as well as Soccer and Rugby players ($F = 28.81$; $p < 0.001$). However, no significant difference was revealed between Hockey and Rugby players ($F = 0.06$; $p > 0.05$).

At round five the Soccer players exhibited the lowest heart rate (182.23 ± 7.51 beats/min) while the Rugby players had the highest (195.93 ± 12.79 beats/min). The Hockey players attained a heart rate of 193.63 ± 5.34 beats/min. The average differences between Soccer players and both Hockey and Rugby players were 11.40 beats/min and and 13.70 beats/min respectively. These differences were statistically significant at $p < 0.001$ ($F = 17.13$ and 27.08 respectively). But the average difference between Rugby and Hockey players was minimal (2.30 beats/min). This was not significant ($F = 1.28$; $p > 0.05$).

As table 3 and figure 2 indicate, the exercise heart rate for Hockey, Rugby and Soccer players at round six (end of work) reveals that the Rugby players had the highest heart rate (beats/min) [203.0 $\pm$ 13.09]. The Hockey players' heart rate was 193.63 $\pm$ 5.34 beats/min while the Soccer players had the lowest (184.53 $\pm$ 7.51 beats/min). The Anova results showed a highly significant difference between the groups ($F = 28.88$; $p<0.001$). The Scheffes' test established a very significant difference between Soccer and Hockey ($F = 29.28$; $p<0.001$) as well as between Soccer and Rugby ($F=49.61$; $p<0.001$). However, no significant difference was established between Rugby and Hockey players ($F = 2.84$; $p>0.05$).

Figure 3 presents the average exercise heart rate for Hockey, Rugby, and Soccer players. The findings reveal that Soccer players had the lowest heart rate (165.24 $\pm$ 9.35 beats/min) followed by Hockey players (175.07 $\pm$ 4 beats/min), while the Rugby players had the highest heart rate (176.82 $\pm$ 12.81 beats/min). The difference between Soccer and Rugby players was 11.58 beats/min while 9.83 beats/min between Soccer and Hockey. The average difference between Rugby and Hockey was the lowest (11.75 beats/min). The analysis of variance showed a high significant difference between the teams ($F = 11.15$; $p<0.001$). Further analysis by the Scheffe's test showed a significant difference between Hockey and Soccer ($F = 13.02$; $p<0.01$) as well as Rugby and Soccer players ($F = 20.20$; $p<0.01$). But no significant difference between Rugby and Hockey players ($F = 0.46$; $p>0.05$) was revealed.



*** P < 0·001

FIG. 3: Average exercise Heart Rate (HR) of Hockey (n = 25), Rugby (n = 30) and Soccer (n = 26) players in Response to the Giessener Soccer Test ($\overline{X} \pm$ SD).

4.4. PERFORMANCE TIME

Table 4 and figure 4 show a summary of the findings of the time (minutes) taken by the Hockey, Rugby and Soccer players to perform the test. The Soccer players were faster on the test than both Hockey and Rugby teams with the exception of rounds four and five where the Rugby players were faster. Generally, the subjects took more time as the test progressed from one circuit to the next.

The results of the time (minutes) taken by the subjects to perform the warm up circuits are shown in Table 4 and figure 4. Hockey players were fastest (3:07 ± 0.28 minutes) followed by Soccer players (3:08 ± 0:34 min), the difference being minimal (0.01 min). The Rugby players were the slowest group (3:23 ± 0:47 min). This differed by 0.05 min. from the Soccer and 0.06 min.from Hockey players. Anova showed a significant difference between the teams ($F=7.560$ $p=0.05$). Further analysis by the Scheffe's test revealed a significant difference between Soccer and Rugby ($F = 15.27$; $p<0.01$). However no significant difference was established between Hockey and Rugby ($F = 2.74$; $p > 0.05$) as well as between Hockey and Soccer ($F = 4.48$; $p > 0.05$) groups.

At round one, the findings showed that the Soccer players were faster (3:04 ±0.30 min) than both Hockey (3:09 ±0.26 min) and Rugby (3:25 ± 0.43 min). The average difference was 0:21 minutes between Soccer and Rugby, 0:05 minutes between Hockey and Soccer, while 0.16 minutes between Rugby and Hockey teams. However, these differences were not statistically significant.

Table 4: Time taken (minutes) [dependent variable] to perform the exercise at warm up (W), rounds one(R1), two (R2), three (R3), four (R4), five (R5) and six (R6) as well as average time taken on the Giessener Soccer Fitness Test for Hockey (n=25), Rugby (n = 30) and Soccer (n = 26) players.

Treat-ment	Independent Variable	$\bar{x} \pm SD$	F-Ratio	P-Value	Comment
W	Hockey	3:07 ± 0:28			
	Rugby	3:23 ± 0:47			
	Soccer	3:08 ± 0:34	7.560	0.001	Highly Significant
R1	Hockey	3:09 ± 0:26			
	Rugby	3:25 ± 0:43			
	Soccer	3:04 ± 0:30	2.942	0.586	Not Significant
R2	Hockey	3:17 ± 0:18			
	Rugby	3:26 ± 0:35			
	Soccer	3:10 ± 0:31	1.660	0.196	Not Significant
R3	Hockey	3:42 ± 0:29			
	Rugby	3:39 ± 0:37			
	Soccer	3:31 ± 0.28	0.474	0.623	Not Significant
R4	Hockey	3:46 ± 0:32			
	Rugby	3:39 ± 0:37			
	Soccer	3:50 ± 0:40	0.152	0.859	Not Significant
R5	Hockey	3:56 ± 0:32			
	Rugby	3:59 ± 0:29			
	Soccer	4:03 ± 0:37	0.239	0.795	Not Significant
R6	Hockey	4.08 ± 0:39			
	Rugby	4:03 ± 0:30			
	Soccer	4:04 ± 0:35	0.227	0.804	Not Significant
Average	Hockey	3:34 ± 0:25			
	Rugby	3:42 ± 0.23			
	Soccer	3:30 ± 0.27	1.303	0.277	Not Significant

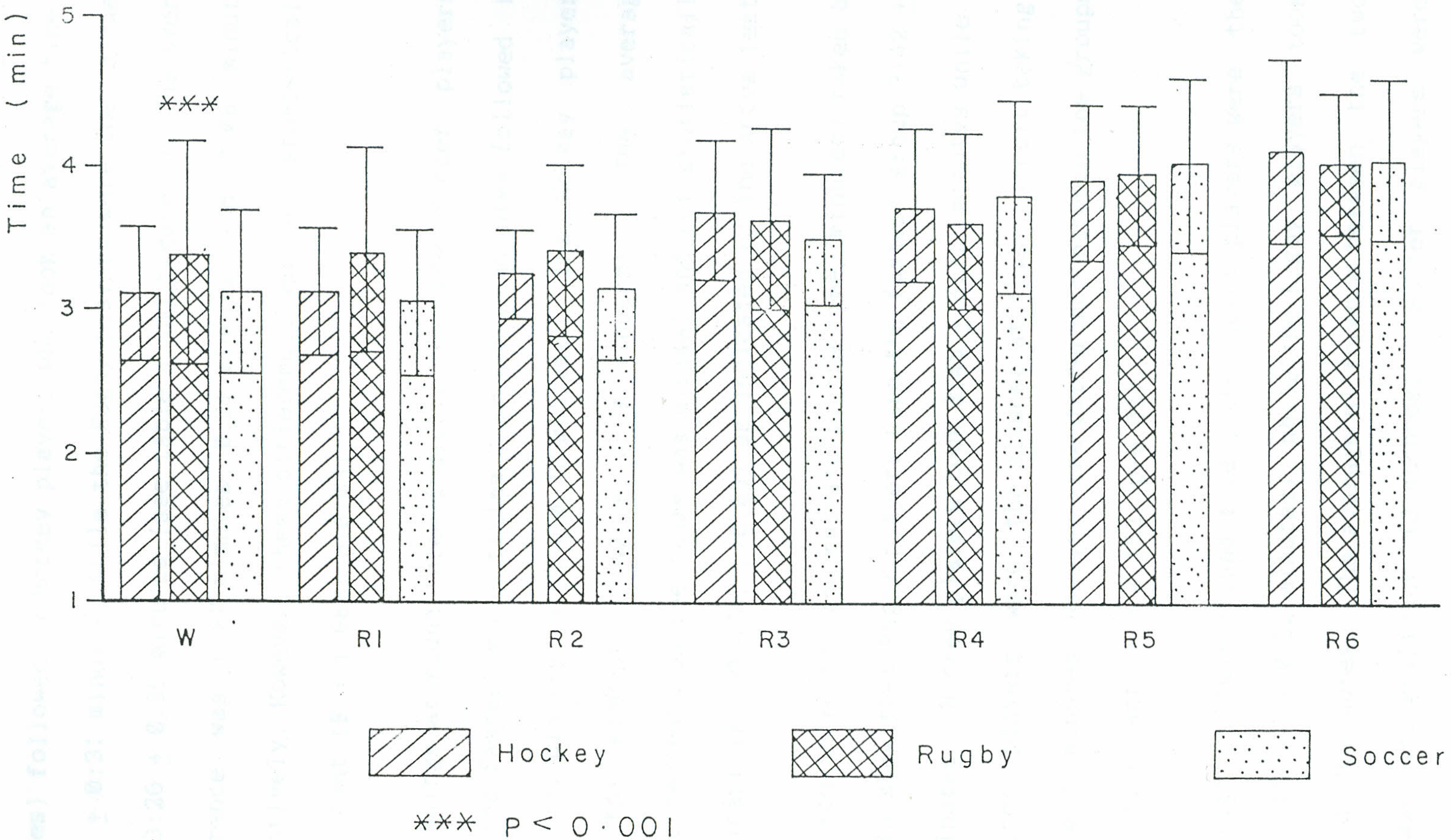


FIG. 4 : Time (min) taken to perform exercise at warm up (W), round 1 (R1), round 2 (R2), round 3 (R3), round 4 (R4), round 5 (R5) and round 6 (R6) of the Giessener Soccer Fitness Test by Hockey (n = 25) Rugby (n = 30) and Soccer (n = 26) players ($\bar{X} \pm SD$)

At round two Soccer players were the fastest (3:10 ± 0.31 minutes) followed by Hockey players who took an average time of 3:17 ± 0:31 minutes, while the Rugby players were the slowest with 3:26 ± 0.35 minutes (see table 4 and figure 4). The average difference was 0:67 minutes, 0:21 minutes and 0:08 minutes respectively. However, these differences were not statistically significant ($F = 1.660$; $p > 0.05$).

The findings at round three indicate that the Soccer players were the fastest group taking 3:31 ± 0:28 minutes followed by the Rugby players (3:39 ± 0.37 minutes). The Hockey players were the slowest (3:42 ± 0.29 minutes). The average differences between the teams was minimal and not statistically significant ($F = 0.474$; $p > 0.05$) as indicated by the Anova test.

At the fourth round, the results of the time (minutes) taken by subjects show that Rugby players were the fastest group 3:42 ± 0:35 minutes. Hockey players took 3:45 ± 0:32 minutes while the Soccer players were the slowest at this circuit taking 3:45 ± 0:32 minutes. However, the difference between the groups was insignificant ($F = 0.152$; $p > 0.05$).

At the fifth circuit (round five), the Hockey players were the fastest (3.56 ± 0:32 minutes) while the Rugby players took 3:59 + 0:32 minutes. The average difference between the two teams was insignificant (3 seconds). Soccer players were slowest in round five taking 3 min and 03 seconds ± 0.37 minutes. An analysis of Variance showed no significant difference between the groups ($F = 1.303$; $p = 0.0277$).

The results of the time taken by the Hockey, Rugby and Soccer players to perform round six reveal that the Rugby players were the fastest with 4:03 $\pm$ 0:30 minutes, followed by Soccer players (4:04 + 0:35 minutes). The Hockey players were the slowest (4:08 $\pm$ 0:39 minutes). The Anova test revealed no significant difference between the teams ($F = 0.227$; $p>0.05$).

On the average, the Soccer players were fastest (3:30 $\pm$ 0.27 minutes) as compared to Hockey (3:34 $\pm$ 0:25 minutes) and Rugby players (3:42 $\pm$ 0:23 minutes) who were the slowest group (see fig. 5). Soccer players were faster by 12 seconds and 4 seconds than Rugby and Hockey players respectively. The Rugby players were slower by 8 seconds than Hockey. However, the Anova test showed no significant difference between the groups ($F = 1.303$; $p>0.05$).

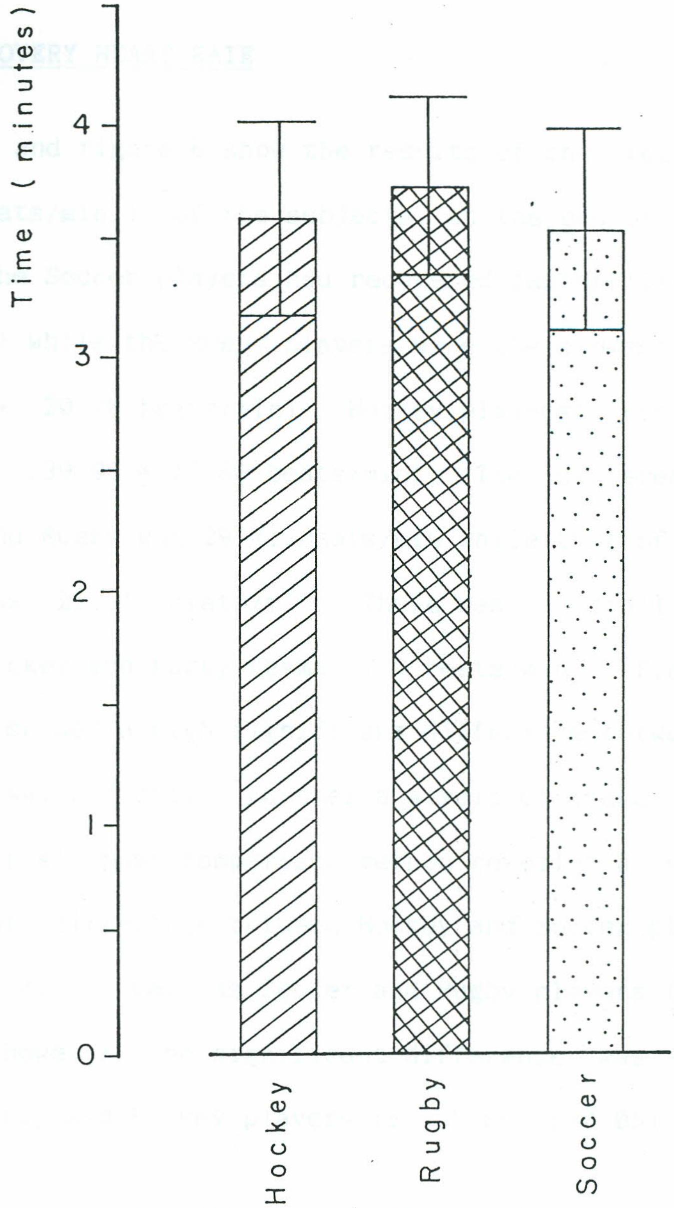


FIG. 5 : Average Time (min) taken by Hockey (n = 25), Rugby (n = 30) and Soccer (n = 26) players to perform the Giessener Soccer Test ($\overline{X} \pm$ SD).

4.5 RECOVERY HEART RATE

Table 5 and figure 6 show the results of the recovery heart rate (beats/min.) of the subjects. At the end of the second minute, the Soccer players had recovered faster (118.15 ± 14.28 beats/min) while the Rugby players were the slowest in recovery (147.86 ± 20.70 beats/min). Hockey players' recovery heart rate was 139.96 ± 17.60 beats/min. The difference between Soccer and Rugby was 29.71 beats/min while that of Hockey and Soccer was 21.81 beats/min. There was a small difference between Hockey and Rugby teams (7.9 beats/min). Findings from the Anova showed a high significant difference between the teams ($F = 20.144$; $p<0.001$). Further analysis of these results by the Scheffes' post comparison method revealed a very strong significant difference between Hockey and Soccer players ($F = 18.95$; $p<0.01$) as well as Soccer and Rugby players ($F = 33.83$; $p<0.01$). However, no significant difference was established between Rugby and Hockey players ($F = 2.66$; $p>0.05$).

After the fourth recovery minute, the findings showed that the soccer players had recovered faster (99.46±10.20 beats/min) as compared to the Hockey players who had 123.60 ±14.38 beats/min. The difference between Hockey and Soccer players was small (2.6 beats/min) as compared to that between soccer and Rugby (26.74 beats/min) as well as Hockey and Soccer players (19.4 beats/ min). Analysis of variance showed a highly significant difference between the teams ($F = 25.117$; $p<0.001$). When analysed further using the Scheffes' post hoc test, a very high significant difference was established between Soccer and

Table 5: Recovery heart rate (beats/min) after the second (Rt2), fourth (Rt4), sixth (Rt6), eighth (Rt8) and the tenth (Rt10) recovery minute as well as the average and the Recovery Pulse Sum (RPS) in response to the Giessener Soccer Fitness Test for Hockey (n = 25), Rugby (n = 30) and Soccer (n = 26) Players.

Treatment	Independent Variable	$\bar{x} \pm SD$	F - Ratio	P - Value	Comment
Rt2	Hockey	139.96 ± 17.60			
	Rugby	147.86 ± 20.70			
	Soccer	118.15 ± 14.28	20.144	0.0001	Highly Significant
Rt4	Hockey	123.60 ± 14.38			
	Rugby	126.20 ± 19.00			
	Soccer	99.46 ± 10.20	25.117	0.0001	Highly Significant
Rt6	Hockey	106.80 ± 13.52			
	Rugby	112.80 ± 16.55			
	Soccer	88.61 ± 11.16	21.74	0.0001	Highly Significant
Rt8	Hockey	99.44 ± 9.68			
	Rugby	98.66 ± 10.52			
	Soccer	80.53 ± 12.45	22.78	0.0001	Highly Significant
Rt10	Hockey	90.72 ± 9.53			
	Rugby	89.80 ± 10.62			
	Soccer	76.61 ± 11.79	14.30	0.0001	Highly Significant
Average	Hockey	111.70 ± 9.53			
	Rugby	115.05 ± 13.22			
	Soccer	92.67 ± 9.33	29.20	0.0001	Highly Significant
RPS	Hockey	558.52 ± 57.96			
	Rugby	575.33 ± 66.08			
	Soccer	534.20 ± 75.63	29.20	0.0001	Highly Significant

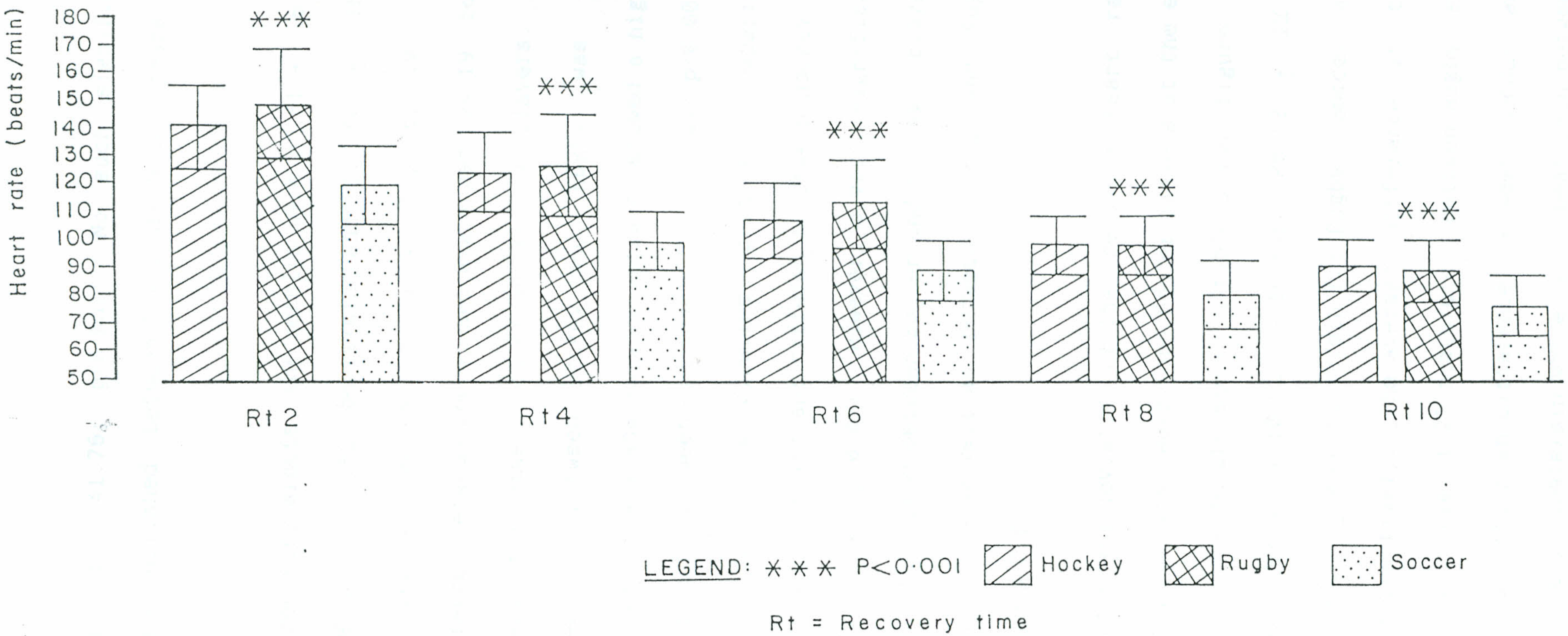


FIG. 6: Recovery Heart rate after the second (Rt2), fourth (Rt4), sixth (Rt6), eighth (Rt8) and tenth (Rt10) resting minute for Hockey (n=25) Rugby (n=30) and Soccer (n=26) players in response to the Giessener Soccer Fitness Test ($\bar{X} \pm SD$).

Rugby players F = 41.76; $p<0.001$). No such significant difference was established between Rugby and Hockey teams (F = 0.39; $p>0.05$).

At the sixth recovery minute, the results were 88.61 $\pm$ 16.16 beats/min, 106.80 $\pm$ 13.52 beats/min and 112.80 $\pm$ 16.55 beats/min for Soccer, Hockey and Rugby respectively. The average difference between Soccer and Rugby was 24.19 beats while 18.19 beats/min between Soccer and Hockey players. The average difference between Hockey and Rugby was 6.0 beats/minute. The one way analysis of variance showed a highly significant difference between the teams (F = 21.744; $p<0.001$). Further analysis using the Scheffes' post hoc comparison procedure revealed no significant difference between Hockey and Rugby players (F = 2.47; $p>0.05$). However, a very significant difference was established between Soccer and Hockey players (f = 21.29; $p<0.001$) as well as between Soccer and Rugby players (F = 13.9 $p<0.001$).

The mean and standard deviation of the recovery heart rate (beats/min) for the Hockey, Rugby and Soccer players at the end of eighth recovery minute are shown in table 5 and figure 7. The results were 98.66 $\pm$ 10.52 beats/min, 80.53 $\pm$ 12.43 beats/min, and 97.44 $\pm$ 9.68 beats/min for Rugby, Soccer and Hockey groups respectively. The average difference in the heart rate was negligible (1.22 beats/min) between Rugby and Hockey groups. But the mean difference between Soccer and Rugby players was 18.13 beats/min while 16.93 beats/min between Soccer and Rugby players. Statistically there was a highly significant difference between the groups ($F = 22.789$; $p<0.001$). To find out which pair of means differed, the Scheffes' post hoc test was done. The findings revealed a very significant difference between Soccer and Rugby groups ($F = 38.58$; $p<0.001$) as well as between Soccer and Hockey ($F = 30.39$; $p<0.001$). But the difference between Hockey and Rugby was insignificant ($F = 0.17$; $p>0.05$).

At the end of the tenth recovery minute, the subjects' heart rate was 76.61 $\pm$ 11.79 beats/min, 89.80 $\pm$ 11.62 beats/min and 90.72 $\pm$ 9.53 beats/min for Soccer, Hockey and Rugby groups respectively. The average difference between Hockey and Rugby was insignificant (0.92 beats/min). However, the average difference between Soccer and Hockey players was 14.11 beats/min while it was 13.19 beats/min between Rugby and Soccer players. The analysis of variance showed a highly significant difference between the teams ($F = 14.307$; $p<0.001$). Further analysis of these results using the Scheffes' post hoc test revealed a very significant difference between Soccer and Hockey players ($F = 22.17$; $p<0.001$) as well as Soccer and Rugby players ($F = 21.40$; $p<0.001$). But the difference between Hockey and Rugby was not statistically significant ($F = 0.10$; $p>0.05$) (see table 5 and figure 6).

The average recovery heart rate (beats/min) for the Hockey, Rugby and Soccer team players ($x \pm SD$) is shown in table 5 and figure 7. The findings indicate that on the average, the Soccer players recovered faster (92.67 $\pm$ 9.32 beats/min) as compared to both Hockey (111.70 $\pm$ 11.59) and Rugby players

(115.07 $\pm$ 13.22 beats/min). The difference was 19.03 beats/min between Hockey and Soccer players while 22.4 beats/min between Soccer and Rugby players. The difference between Hockey and Rugby players was 3.37 beats/min. The findings of the Anova test are shown in table 5. The results indicate a highly significant difference between the teams ($F = 29.200$; $p < 0.001$). Further analysis using the Scheffe's post hoc comparison showed a very significant difference between Soccer and Hockey players ($F = 41.34$; $p < 0.001$) as well as Rugby and Soccer players ($F = 52.60$; $p < 0.001$). No significant difference was established between Hockey and Rugby players ($F = 1.15$; $p > 0.05$).

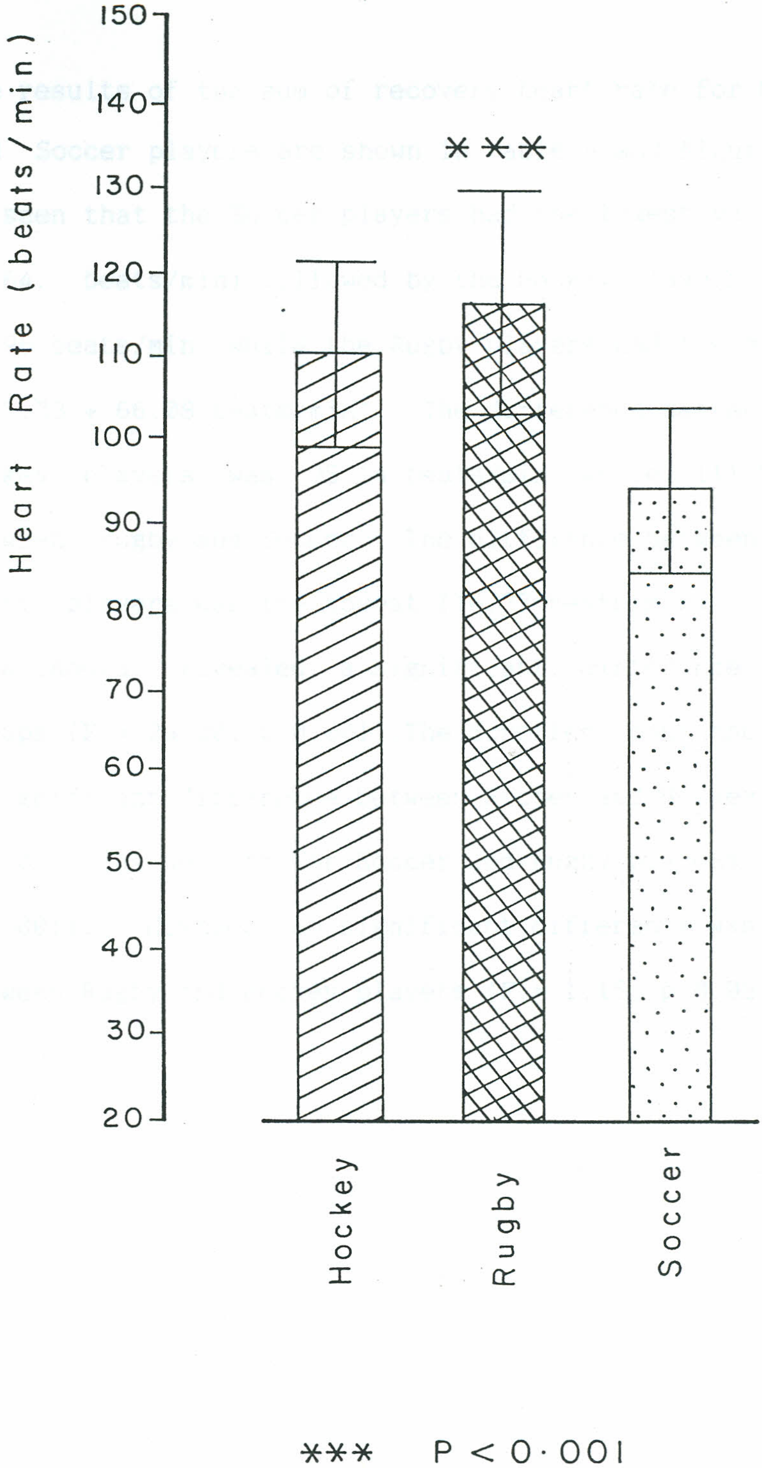
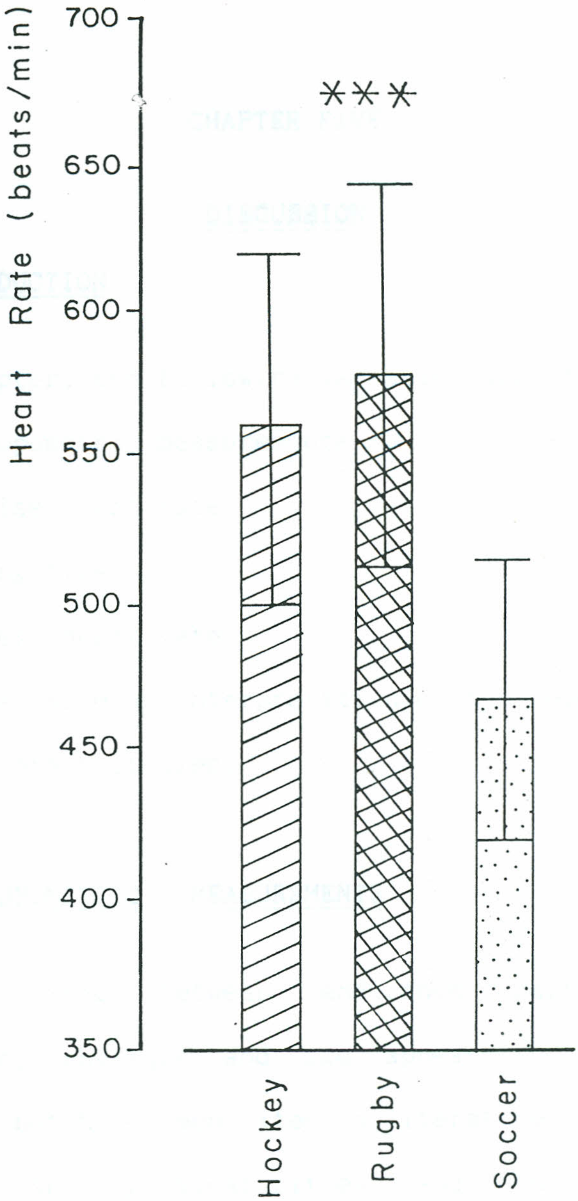


FIG. 7: Average recovery Heart Rate (HR) of Hockey (n=25), Rugby (n=30) and Soccer (n=26) players in Response to the Giessener Soccer Test ($\overline{X} \pm SD$).

The results of the sum of recovery heart rate for Hockey, Rugby and Soccer players are shown in table 5 and figure 8. It can be seen that the Soccer players had the lowest values (463.38 $\pm$ 46.64. beats/min) followed by the Hockey players with 558.56 $\pm$ 57.96 beats/min, while the Rugby players had the highest values (575.33 $\pm$ 66.08 beats/min). The difference between Soccer and Hockey players was 95.14 beats/min while 111.92 beats/min between Rugby and Soccer. The difference between Hockey and Rugby players was the lowest (16.77 beats/min). The results from Anova revealed a significant difference between the groups ($F = 29.20$; $p<0.001$).The Scheffes' post hoc test showed a significant difference between Soccer and Hockey ($F = 34.41$; $p<0.001$) as well as for Soccer and Rugby players ($F = 52.61$; $p<0.001$). However, no significant difference was established between Rugby and Hockey players ($F = 1.15$; $p>0.05$).



*** P < 0·001

FIG. 8 : Sum of recovery pulse Rate of the Hockey (n = 25), Rugby (n = 30) and Soccer (n = 26) players who performed the Giessener Soccer Test ($\overline{X} \pm SD$).

CHAPTER FIVE

DISCUSSION

5.1 INTRODUCTION

In this chapter, the following variables are discussed:

(a) Anthropometric measurements.

(b) Exercise heart rate.

(c) Working time.

(d) Recovery Heart rate.

For each variable, an interpretation of the results is made in relation to other studies.

5.2 ANTHROPOMETRIC MEASUREMENTS

The relationship between endurance performance, body measurements, physique and age appear to be of moderate importance but have been cited in literature as contributory factors to one's physical fitness and athletic performance (Bouchard & Lortie, 1984). In the game of Soccer body size within normal range is of minor importance for physical performance (Ekblom, 1986; Muckle, 1981).

5.2.1 AGE

A subjects' age is of prime importance as ones' maximal, perceived or working heart rate declines with an increase in age after twenty years (Åstrand & Rodahl, 1986; Bar-Or, 1983; Froelicher, 1987; Goss, 1983; Rost, 1987; Rost et al., 1987; Wilmore, 1982). The subject's average age in the present study was 23.35 $\pm$ 4.39 years . No significant difference existed between the three groups as indicated by the Anova test ($F = 2.29$; $p > 0.05$).

The Soccer players' age in this study (23.85 + 4.48), compared favourably with players of international level: 24.8$\pm$ 3.4 yrs (Bunc et al., 1991), 23.5$\pm$ 3.9 yrs (Heller et al ., 1991), 25.6 $\pm$ 3.3 yrs (Raven et al., 1976), 25.4 $\pm$ 3.3 yrs (Savvas et al., 1991) and 25.0 $\pm$ 4 yrs (Vanfraechen and Thomas 1991).

The results in this study also compare well with the results reported by Kruemmelbein et al., (1989) whose players' age was 24.3 $\pm$ 4.2 years compared to that in the present study. A comparative analysis between the players' age in the present study and that in Kruemmelbein et al. (ebd.) study [t-test] showed no significant difference ($t = -0.318$; $p > 0.05$)

5.2.2 HEIGHT

One of the attractive features of Soccer is that discrepancies in height are nullified by speed, jumping ability and ball control (Muckle, 1981). This is in contrast to other sports, for instance , American footfall, basketball, track and field athletics where taller athletes are advantaged (Åstrand & Rodahl, 1986; Bouchard & Lortie ,1984; Watson, 1983).

The present study revealed no significant difference in the subjects' height between the three teams - Hockey, Rugby and

Soccer (F = 1.65; p>0.05). This suggests that height did not influence the performance of the subjects.

The height of the subjects in this study was similar to that reported in other studies (Muckle,1981; Raven et al., 1976). But our subjects were relatively shorter compared to the height of Soccer players reported in fairly recent studies by Bunc et al., 1991 (182.6 ± 5.6 cm); Heller et al., 1991 (183 ± 3.5 cm), as compared to 172.92 found in this study.

The Soccer players in the present study were relatively shorter as compared to the Soccer players in the study by Kruemmelbein et al.(1989) [180 ± 8 cm]. However, the t-test showed no significant difference between the two groups (t = -1.812; p>0.05).

5.2.3 WEIGHT

Physiological studies have indicated that weight significantly affects the strength, working heart rate, $\dot{V}O_2$ max and speed of an individual (Åstrand & Rodahl, 1986; Berger, 1982; Watson, 1982).

A strong significant difference was noted in the weight between Soccer and Rugby (F = 16.57; p>0.01) as well as Hockey and Rugby (F = 10.57; p>0.01). But no significant difference was noted between Soccer and Hockey players. The Rugby players were thus heavier than both Hockey and Soccer players. The subjects in this study were relatively lighter as compared to other players of similar level of competition reported in other studies for example, 78.7 ± 6.2 kg (Bunc et al., 1991), 76.6 ± 3.4 kg (Heller et al.,1991); 76.5 ± 4.0 kg (Reilly & Ball,1984), 74.5 ± 5.5 kg (Savvas et al., 1991); 77.6 ± 6.6 kg (Vanfraechen et al., 1991).

The subjects in this study were lighter (66.07 ± 5.25 kg) than those in the study by Kruemmelbein et al., (1989) [76.9 ± 8.3 kg]. Comparative analysis of the difference between this study and that by Kruemmelbein et al. (ebd.) showed a a weak significant difference in the weight of the subjects ($p < 0.05$).

5.3 HEART RATE RESPONSE

5.3.1 RESTING HEART RATE

"One of the striking phenomenon of an increased state of training is a lowered resting heart rate" (Stegemann, 1981, p.293). This exercise-induced bradycardia may result in resting values for the athlete as low as 35 to 40 beats/min (Åstrand & Rodahl, 1986; Falch & Shormme,1979; Keul et al., 1982; Stegemann, ebd.; Wilmore, 1982). Longitudinal studies have shown unambiguously that the bradycardia is a result of regular physical training and especially endurance training (Åstrand & Rodahl,ebd. ; Goss,1983; Rost 1987; Stegemann, ebd ; Stromme & Ingjer, 1982).

Exercise-induced bradycardia is associated with many factors. Some of them are: an increase in stroke volume , blood volume increases, hypertrophy of the myocardium, increased mitochondrial activity and changes in the functional ability of the autonomic nervous system (Åstrand & Rodahl, 1986; Froelicher, 1987; Rost, 1987 ; Rost et al., 1987; Stegemann, 1981; Wilmore, 1982). According to Stegemann (ebd), "the adjustments of the circulatory system to work is characterised by a quantified elevation in sympathetic tone" (p.293). An increase in parasympathetic activity and a reduction in sympathetic activity can partly explain this exercise-induced bradycardia (Goss, 1983; Stromme & Ingjer, 1982). The resting heart rate of Soccer players in our study was in agreement with that reported in some other studies (Reilly,1979; Reilly & Thomas,1980). Both studies reported a resting heart rate of 63 beats/min and 60 beats/min respectively, but was higher than what has been quoted by Muckle (1981) where a heart rate of 48 beats/min was reported for the English first division teams. Further , a high significant difference was established between Hockey and Soccer ($F = 10.31$; $p < 0.01$) as well as Hockey and Rugby players ($F = 9.27$; $p < 0.05$). But no significant difference was found between Soccer and Rugby players resting heart rate ($F = 0.12$; $p > 0.05$).

The discrepancies in the subjects' resting heart rate could be due to the method used in measuring the heart rate. In our study the heart rate was measured while subjects were standing as compared to sitting as reported in earlier studies (Reilly, ebd; Reilly & Thomas, 1976). It is argued that a person's lowest resting heart rate is found in the supine position measured in the morning (Wilmore, 1982). It will be elevated slightly with sitting and further with standing. Several studies have also shown that endurance training below and above an individual's optimal training level could result in an increased resting heart rate (Harre, 1982; O'Brien,1988; Stegemann,1981; Stone & Kroll, 1986).

5.3.2 EXERCISE HEART RATE

The exercise heart rate of players from all the groups rose sharply from rest to warm up (see fig 1) in response to acute exercise. This is in agreement with the argument that during an acute bout of exercise, the heart rate will increase in direct proportion to the intensity of the exercise. (Astrand & Rodahl, 1986; Berger,1982; Kuhlemier & Muller,1978; Lewes et al., 1983; Stegemann, ebd.; Wilmore, 1982).

The Rugby and Hockey players' heart rate increased more steeply after warm up as compared to Soccer players. This could imply that the Rugby and Hockey players worked at a higher exercise intensity than Soccer players. As Astrand and Rodahl (ebd.) have pointed out, it is possible to "estimate the workload from the heart rate recorded during a specific work situation in the field" (p.456). This is due to a significant relationship between heart rate and stroke volume, cardiac output and $\dot{V}O2$ max (Berger,ebd.; Wilmore ebd).

The Anova test revealed no significant difference in the working heart rate at warm-up and round one between Hockey, Rugby and Soccer teams ($p>0.05$). This is possibly due to the fact that Rugby and Hockey players were working at lower intensity hence the reason for lower heart rate. The warm up circuit was particularly intended for orientation.

For rounds two, three, four, five and six, the Soccer players had the lowest exercise heart rate . Further, a highly significant difference between each of the Hockey and Rugby players was established ($p<0.001$). However, no significant difference in exercise heart rate for the same rounds was found between Rugby and Hockey players ($p>0.05$).

The average exercise heart rate of Soccer players was lower than that of Rugby and Hockey players (fig 2 and table 1). The Scheffes' test established a very significant difference between Soccer and each of Hockey and Rugby players ($p<0.001$). But no significant difference was established between Rugby and Hockey players ($p>0.05$). The fact that Hockey and Rugby players had the highest exercise heart rate could suggest that the Soccer players were more fit. This could also be an indicator of the specificity of this test.

The average exercise heart rate of Soccer players in the present study was 165.24 $\pm$ 9.35 beats/min. This is in agreement with the average exercise heart rate during a game in international matches as reported by Marriot et al., 1991 (162 beats/min) ; Miles et al., 1991 (168-176 beats/min) and Ogushi et al.,1991 (160 beats/min.).

5.3.3 THE END EXERCISE HEART RATE

The Scheffes' test showed a significant difference in the end heart rate between Soccer and each of Hockey and Rugby teams ($p < 0.001$). The Soccer players had the lowest heart rate of 184 beats/min as compared to Hockey (198 beats/min) and Rugby players (203 beats/min).

Studies by Åstrand and Rodahl (1986) as well as Stegemann (1981) have shown that the intensity of exercise is reflected in the heart rate attained during the exercise. The fact that the test instrument was Soccer oriented might have made it coo-rdinatively easier and less intense for Soccer players, but int ense and fatiguing for Rugby and Hockey players. The test items which possibly contributed to the difference in performance were dribbling and heading of a ball. Soccer players were adv antaged in these as compared to Hockey and Rugby ones. Other-wise the pattern of movement in the test is similar in the three sports. Furthermore, the physical fitness components which are crucial in performance in the three sports are similar (Berger, 1982) hence the choice of Hockey and Rugby for comparison purposes.

The end exercise heart rate attained by Soccer players was lower than what was found by Raven et al.,(1975) and Lindquist & Bangsbo (1991), who reported a heart rate of 195 and 191 beats / min respectively in their field tests as compared to 184 beats/min found in the present study. However, it compared favourably with 185 beats/min as reported by Reilly and Ball (1984) on a modified treadmill ergometer.

When compared with the findings of Kruemmelbein et al. (1989), players in the present study had a lower end heart rate (184 beats/min) as compared to the response of the former on the ergometer test (190 beats/min). However, their results on the Giessener Soccer Fitness Test (186 beats/min) was in agreement with the findings of this study. The difference of two beats/min was probably brought about by the fact that our subjects were slower (3.30 minutes) than the subjects in the study in question (3:00 minutes). This implies that their subjects worked at a higher exercise intensity.

5.4 WORKING TIME

The test time was recorded for each of the seven circuits i.e warm up, round one, two, three, four, five, and six. The Soccer players were faster in nearly all circuits. At the warm-up circuit (W), a significant difference was established between the teams ($p<0.01$). The Scheffes' test however did not reveal a significant difference in the time taken to perform the test between Soccer and Hockey players ($p>0.05$) as well as Rugby and Hockey players, but a highly significant difference between Soccer and Rugby players was noted ($p<0.001$). These findings are inconsistent with the findings for time taken to perform round one, two, three, four, five, and six circuits. At rounds one, two, three, four, five, and six, the findings of the time taken to perform the test revealed no significant difference ($p>0.05$). However, slight differences which were not statistically significant were observed. These differences favoured the Soccer players for round one, two, and three. But at rounds four and six the difference favoured Rugby players. On the average, Soccer players were faster on this test than both Rugby and Hockey players though this was not statistically significant.

The reasons for lack of a significant difference in their time taken to perform the test can be explained by the fact that Hockey and Rugby players were unable to control the ball while dribbling, hence they tended to "chase the ball" unlike Soccer players who actually dribbled the ball at a controlled distance. By chasing the ball, the Hockey and Rugby players ran faster than Soccer players in some cases (e.g. round four, five and six). This can also be reflected in the high heart rates attained by Hockey and Rugby at the mentioned rounds. For the time taken to perform the test at the warm up circuit to round six , no other studies with similar test protocol were available for comparison.

Analysis of variance showed no significant difference in the average time taken to perform the test between the three groups ($p>0.05$). However, the Soccer players were faster than Rugby and Hockey players by 12 and 04 seconds respectively. The Soccer players were slower than the those in the study by Kruemmelbein et al., (1989) in which an average time of three minutes (compared to three minutes and thirty seconds reported in the present study) was reported. One of the striking points to note in this study is that despite lack of a significant difference in test time, a strong significant difference in the exercise heart rate was observed.

5.5 RECOVERY HEART RATE

The sum of the recovery heart rate which is "the sum of beats after exercise which still exceed the resting value" (Stegemann,1981, p. 125), is a good measure of fitness and muscular fatigue (Lewis et al., 1983; Stegemann,ebd.; Wilmore 1982). This is because;

> A thorough analysis has shown that during bicycle ergometer exercise, the magnitude of the sum of recovery heart rate is proportional to the product of the amount of work .... performed (Stegemann, ebd.; p.125).

The recovery heart rate for each group (Rugby, Hockey and Soccer) exhibited a negative exponential function (an inverted e- function). There was a sharp drop in the exercise heart rate from round six to the recovery heart rate at the second recovery minute. After which the Soccer players displayed a more gradual decline in heart rate as compared to Hockey and Rugby players.

Several studies indicate that under both submaximal and maximal work, there is a faster return of the heart rate to the pre-exercise level. The recovery is faster following endurance conditioning (Åstrand & Rodahl,1986 ; Bar-Or,1983 ; Froelicher, 1987; Goss,1983; Rost,1987; Stromme & Ingjer,1882). These results are in agreement with the observation by Stegemann (ebd.) on the characteristic appearance of the curve for the recovery heart rate. The fact that, the Sheffes' post hoc test established a significant difference between Soccer players and each of the Rugby and Hockey players at the second, fourth, sixth, eighth, and tenth recovery heart rate implies that the test was very strenuous for Rugby and Hockey players but less test was very strenuous for Rugby and Hockey players but less intense for Soccer players. Further , the recovery capacity of Soccer players at the end of the fourth minute compared well with that reported by Kruemmelbein et al.(1989) at the end of the fifth minute (100 beats / min.) on the same test.

The above finding is also supported by results of the recovery pulse sum (RPS). A very significant difference in the RPS between Soccer and Rugby players was established ($p<0.001$) as well as between Soccer and Hockey players ($p<0.001$). But no such difference was noted between Hockey and Rugby players ($p>0.05$). The Soccer players thus recovered faster than both Rugby and Hockey players indicating that they were more fit (Åstrand & Rodahl,1986; Bar-Or,1983; Froelicher, 1987; Goss,1983; Stegemann, 1981; Wilmore, 1982). The results of the recovery heart rate also point out that this test (Giessener Soccer Fitness Test) could be specific to the game of Soccer.

In Summary, the Soccer players'performance on the Giessener Soccer Fitness Test was superior to that of both Rugby and Hockey players. The difference in both exercise and recovery heart rate was statistically significant between Soccer and each of Rugby and Hockey groups ($p<0.001$). But the difference between the latter two was insignificant ($p>0.05$). With regard to the time taken to perform the test, the Soccer players were faster than both Rugby and Hockey players. However, this difference was not statistically significant ($p>0.05$). As pertains to the anthropometrical measurements, there was no statistical significant difference ($p>0.05$) in the age and height between the three groups. However, there was a high statistical significant difference in weight between Rugby and each of Soccer and Hockey groups ($p<0.01$), with no significant difference between Soccer and Hockey groups. Although the Rugby players were significantly heavier than both the Soccer and Hockey players, this did not affect their performance on this test significantly.

Based on the findings of this study, it is concluded that the Giessener Soccer Fitness Test is one that tests the cardio-respiratory fitness of Soccer players and cannot be effectively applied to other forms of sport. It therefore appears to be specific to soccer and not a general fitness test.

5.6 RECOMMENDATIONS FOR FURTHER RESEARCH

The following are the recommendations for further study which can be drawn from the present study:

1. More research using larger samples and in which the test is administered during pre-season, mid-season and towards the end of season is needed for a better comparison.
2. There is need to modify the test for other forms of sports such as hockey and rugby.
3. There is need to develop the test norms for school, college and club player at various categories.
4. The diagnostic use of the test should be investigated.
5. More research ought to be done to shed more light on its objectivity , reliability , validity and the economy of this test .

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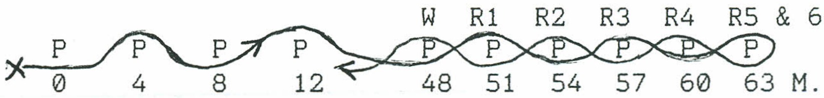
A P P E N D I C E S

APPENDIX A

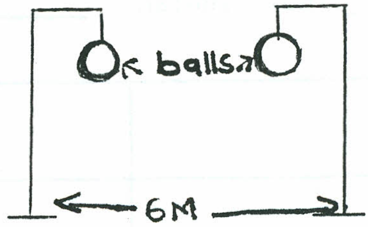
THE GIESSENER SOCCER FITNESS TEST INSTRUMENT

STATION I
t = 40s



STATION II

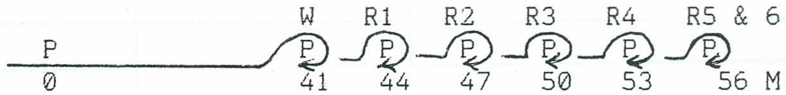
t = 30s



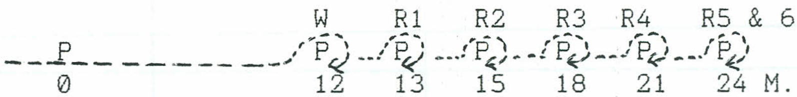
Number of Headings

W = 6, R2 = 8, R3 = 9,
R4 = 10, R5 and R6 =11.

STATION III
t = 20s

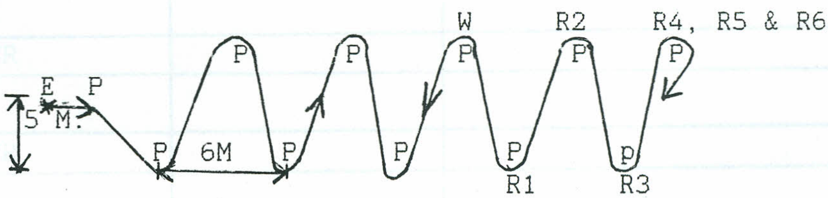


STATION IV
t = 20s



STATION V

t = 50s



L E G E N D

P : A marking,
W : Warm - up,
R1-6 : Round one to six,
——— : Dribbling the ball,
---- : Free sprint,
E : Ending point,
t : Time,
M : Metres,
X : starting point,
s : Seconds.

A P P E N D I X B

TEST PROTOCAL SHEET

THE GIESSENER FOOTBALL FITNESS TEST

NAME : ______________________________

AGE (yrs) : _____ HEIGHT (cm): ________ WEIGHT (kg): ________

PARAMETERS			REMARKS
REST	HR		
W	HR		
	t		
R1	HR		
	t		
R2	HR		
	t		
R3	HR		
	t		
R4	HR		
	t		
R5	HR		
	t		
R6	HR		
	t		
Rt2	HR		
Rt4	HR		
Rt6	HR		
Rt8	HR		
Rt10	HR		
RPS	HR		

Date : ____________________

Name and signature of tester : ______________________________

A P P E N D I X C 1

WORKING AND RECOVERY HEART RATE OF SOCCER PLAYERS IN RESPONSE TO THE GIESSENER SOCCER TEST (Ro = Rest; W = Warm up; R = Round; RPS = Recovery Pulse sum; Rt=Recovery time; S = Subject).

				WORKING HEART RATE (Beats/min)								RECOVERY HEART RATE (Beats/min.)					
S	AGE (Yrs)	WEIGHT (Kg)	HEIGHT (cm)	Ro	W	R1	R2	R3	R4	R5	R6	Rt2	Rt4	Rt6	Rt8	Rt10	RPS
1	19	68	175	66	156	162	174	180	186	192	192	144	090	072	066	066	438
2	25	69	177	84	126	138	156	174	180	186	192	144	108	096	084	084	516
3	22	63	176	84	120	144	150	156	162	168	174	120	108	102	084	084	498
4	22	69	172	72	138	144	162	174	180	186	186	120	102	102	102	102	528
5	26	70	167	54	144	150	156	162	168	174	180	108	090	078	066	060	402
6	30	75	189	60	144	150	156	168	174	180	180	132	120	108	076	084	520
7	36	67	168	66	164	174	174	180	186	192	192	114	096	078	066	066	420
8	23	65	167	60	138	144	150	156	162	174	180	120	108	102	090	078	498
9	26	64	171	72	132	144	150	156	174	174	180	102	090	084	084	084	444
10	27	67	173	66	156	168	174	180	186	192	192	120	102	078	078	078	456
11	21	76	172	60	150	174	180	186	192	198	198	138	114	084	072	066	474
12	22	77	181	66	138	150	162	168	174	180	180	126	108	090	084	078	486
13	22	71	181	72	132	150	168	174	180	186	186	120	108	108	102	096	534
14	22	53	162	66	120	144	156	162	162	174	174	132	120	102	102	090	546
15	16	69	176	72	144	156	168	174	180	186	186	102	090	090	084	084	450
16	22	61	168	60	144	150	156	162	174	180	186	120	102	090	084	078	474
17	23	62	165	60	120	144	156	162	168	174	174	102	090	078	072	072	414
18	21	67	177	78	132	144	156	162	178	174	174	114	102	102	096	096	510
19	19	66	177	66	120	162	174	180	192	198	198	120	096	084	084	078	462
20	18	60	172	60	150	162	168	174	180	186	186	102	096	084	066	066	414
21	19	62	174	66	114	138	150	162	168	174	180	102	090	078	072	072	414
22	30	62	171	66	144	156	174	180	186	198	198	114	084	078	078	072	426
23	24	65	169	66	144	162	168	174	180	186	186	102	084	078	066	066	396
24	27	62	163	66	120	138	144	156	168	180	180	114	102	096	078	072	462
25	31	63	169	66	120	138	144	150	156	162	180	096	090	072	066	066	390
26	18	65	176	66	114	120	150	162	168	180	186	144	096	084	072	072	468

APPENDIX C 2

RAW DATA OF TIME TAKEN BY SOCCER PLAYERS TO PERFORM THE GIESSENER SOCCER TEST (W=WARM UP: R1-R6 =ROUND ONE TO ROUND SIX; S = Subject; NOTE: Time in Seconds).

S	W	R1	R2	R3	R4	R5	R6	$\bar{X} \pm$ SD	TOTAL TIME
1	160	165	176	203	205	238	246	199.00 + 34.1	1393
2	122	136	156	186	336	338	242	216.57 ± 91.0	1516
3	142	145	151	175	175	180	246	173.42 ± 35.6	1214
4	214	214	216	218	245	250	269	232.28 ± 22.2	1626
5	173	176	180	216	225	233	240	206.14 ± 28.9	1443
6	149	210	215	218	230	238	225	212.14 ± 29.4	1485
7	210	215	220	226	247	270	292	240.00 ± 31.0	1680
8	210	230	235	250	285	285	287	254.57 ± 31.3	1782
9	135	150	150	180	180	240	240	182.57 ± 42.8	1275
10	180	240	240	251	254	260	266	241.14 ± 28.8	1691
11	131	160	165	174	185	198	200	173.28 ± 24.1	1213
12	184	200	205	208	220	227	168	201.71 ± 20.3	1412
13	193	202	209	212	270	221	225	218.86 ± 25.0	1532
14	183	186	222	265	260	285	287	241.14 ± 44.2	1688
15	168	219	223	230	170	280	287	225.28 ± 46.9	1577
16	141	150	150	165	200	195	200	171.57 ± 26.1	1201
17	138	144	148	169	245	206	242	184.51 ± 46.2	1292
18	180	198	204	225	275	253	261	228.00 ± 35.8	1596
19	190	200	225	265	286	275	280	245.86 ± 40.1	1721
20	131	193	200	180	220	295	300	217.00 ± 61.4	1519
21	173	180	180	232	280	180	180	200.71 ± 40.3	1405
22	195	205	229	200	234	236	236	219.28 ± 18.4	1535
23	160	185	188	208	208	223	231	200.43 ± 24.4	1403
24	180	184	187	201	213	218	226	201.28 ± 18.2	1409
25	122	127	135	201	210	225	226	178.00 ± 47.7	1246
26	135	190	200	220	228	260	265	214.00 ± 44.6	1498

APPENDIX D1

WORKING AND RECOVERY HEART RATE OF HOCKEY PLAYERS IN RESPONSE TO THE GIESSENER SOCCER TEST
(Ro = Rest; W = Warm up;R = Round; RPS = Recovery Pulse sum ; Rt = Recovery time;S=Subject)

S	AGE (Yrs)	WEIGHT (Kg)	HEIGHT (cm)	WORKING HEART RATE (Beats/min.)								RECOVERY HEART RATE (Beats/min.)					RPS
				Ro	W	R1	R2	R3	R4	R5	R6	Rt2	Rt4	Rt6	Rt8	Rt10	
1	22	63	171	66	144	162	168	180	186	192	198	132	114	102	096	096	540
2	18	64	165	60	120	132	180	186	192	198	198	138	114	090	090	084	504
3	19	62	180	72	114	162	174	180	192	198	198	138	114	102	096	084	534
4	20	70	175	66	120	132	174	192	198	204	204	132	114	102	090	078	516
5	20	62	171	84	144	162	174	180	186	192	198	114	102	096	096	084	492
6	20	59	165	90	120	132	180	186	192	198	204	126	114	090	090	084	504
7	24	79	180	78	150	162	174	180	186	192	198	138	144	102	096	084	564
8	26	68	175	84	156	168	174	180	186	192	198	132	120	108	096	084	540
9	22	70	174	66	126	162	168	174	180	186	192	126	114	108	102	096	546
10	24	66	184	78	138	156	162	168	174	186	198	114	120	096	084	084	498
11	27	64	163	90	144	156	168	174	180	186	198	132	120	108	096	096	552
12	21	62	174	78	150	168	174	180	192	198	198	126	120	108	108	102	564
13	23	63	160	78	154	162	168	174	180	186	192	150	132	114	102	096	594
14	26	67	175	72	144	150	168	180	186	192	198	162	150	114	108	096	630
15	26	71	174	78	156	162	174	180	186	192	198	174	150	132	108	102	666
16	32	74	174	60	150	162	168	174	180	186	198	126	120	102	090	090	528
17	28	84	184	66	156	168	174	186	192	198	204	114	102	096	090	084	486
18	27	82	163	72	126	132	156	174	186	192	198	144	120	096	084	078	522
19	32	74	174	78	138	162	174	186	192	198	198	132	114	090	084	084	504
20	31	62	160	78	114	156	168	174	192	192	198	126	120	090	084	078	498
21	18	58	175	66	150	144	156	174	186	192	192	150	138	114	102	096	600
22	22	60	174	66	156	168	174	186	192	192	192	162	144	126	102	102	636
23	24	59	182	60	150	162	168	174	186	198	198	162	114	126	114	102	618
24	28	65	165	78	114	150	174	186	192	198	204	174	150	138	114	108	684
25	32	79	180	72	138	162	168	174	198	204	210	132	126	120	114	102	594

APPENDIX D2

RAW DATA OF THE TIME TAKEN (SECONDS) BY HOCKEY PLAYERS (n=25) TO PERFORM THE GIESSENER SOCCER TEST (LEGEND: W=Warm up: R1-R6 =Round one to Round Six ; S = Subject) NOTE: Time In Seconds.

S	W	R1	R2	R3	R4	R5	R6	$\bar{X} \pm$ SD	TOTAL TIME
1	210	225	225	278	290	300	350	268.29 ± 50.7	1878
2	200	210	200	230	240	369	253	243.14 ± 59.1	1702
3	212	216	221	247	253	357	290	256.57 ± 51.9	1796
4	210	286	290	200	210	240	260	242.28 ± 37.4	1696
5	180	225	225	278	285	300	350	263.00 ± 57.0	1843
6	170	161	194	202	269	253	255	214.86 ± 43.8	1504
7	212	206	221	247	253	257	288	240.57 ± 29.2	1684
8	150	165	180	180	195	244	244	194.00 ± 36.9	1358
9	230	169	185	211	203	203	210	201.57 ± 19.6	1411
10	120	135	165	180	195	225	140	165.71 ± 37.1	1160
11	180	188	186	245	270	290	290	235.57 ± 50.0	1649
12	180	180	180	200	228	246	227	205.86 ± 27.6	1441
13	230	175	180	183	240	240	240	214.00 ± 31.4	1488
14	152	191	200	220	228	229	235	207.86 ± 29.4	1455
15	135	148	182	165	169	182	187	166.86 ± 20.4	1168
16	230	169	155	211	230	238	240	214.71 ± 34.6	1473
17	180	184	186	187	188	190	198	187.57 ± 05.6	1313
18	186	184	189	190	200	242	248	205.57 ± 27.5	1439
19	190	194	200	210	230	240	248	216.00 ± 23.3	1512
20	200	250	210	211	213	219	225	218.29 ± 16.0	1528
21	180	186	190	198	210	216	230	201.43 ± 18.0	1410
22	170	180	186	190	194	199	210	189.86 ± 13.0	1329
23	200	220	230	230	235	240	245	228.57 ± 14.9	1600
24	200	220	230	230	235	240	245	228.57 ± 14.9	1600
25	170	180	186	190	194	199	210	189.86 ± 13.0	1329

APPENDIX E1

RAW DATA OF WORKING AND RECOVERY HEART RATE OF RUGBY PLAYERS IN RESPONSE TO THE GIESSENER SOCCER TEST (Legend : Ro = REST; W = WARM UP; R = ROUND; RPS = Recovery PULSE SUM ; Rt=Recovery minute ; S =Subject).

				WORKING HEART RATE (Beats/min.)								RECOVERY HEART RATE (Beats/min.)					
S	AGE (Yrs)	WEIGHT (Kg)	HEIGHT (cm)	Ro	W	R1	R2	R3	R4	R5	R6	Rt2	Rt4	Rt6	Rt8	Rt10	RPS
1	19	83	183	60	150	180	196	208	216	222	228	132	102	090	084	078	486
2	27	64	164	66	138	156	174	186	192	202	216	108	102	096	090	084	480
3	23	75	180	78	132	168	180	192	202	216	222	144	102	096	096	090	538
4	20	72	181	66	156	174	180	186	192	198	198	120	108	102	090	090	510
5	19	69	168	60	144	156	168	174	180	186	192	132	120	102	084	084	522
6	19	64	178	60	132	150	162	180	186	192	192	126	108	102	096	084	516
7	33	81	175	72	126	138	162	192	204	216	222	144	114	096	090	084	528
8	21	64	170	78	150	156	162	174	180	186	192	150	120	096	084	072	522
9	26	78	179	72	132	162	174	180	186	192	198	120	108	102	096	096	522
10	21	81	177	60	162	174	192	198	204	216	222	150	114	108	096	084	552
11	18	70	172	72	138	144	150	156	162	168	174	126	120	114	102	096	558
12	21	70	180	72	156	168	174	180	186	192	198	126	114	102	102	102	546
13	19	78	178	72	150	168	186	192	198	204	210	138	120	108	096	090	552
14	20	70	174	60	174	186	192	198	204	210	216	162	132	114	102	096	606
15	19	77	172	66	162	174	180	186	192	198	204	180	144	120	114	108	666
16	32	77	172	78	138	156	162	168	174	180	186	156	126	102	096	090	570
17	21	74	178	66	156	162	168	174	180	186	198	174	144	120	108	102	648
18	20	64	168	72	144	156	174	186	192	198	204	174	150	132	108	102	666
19	24	90	189	66	144	162	174	180	186	192	192	150	144	132	114	102	642
20	18	58	169	60	138	156	168	180	186	192	198	162	156	138	108	102	666
21	26	73	167	72	120	144	156	162	186	198	210	180	156	138	126	108	708
22	25	67	168	66	156	174	180	186	192	204	216	180	168	156	120	102	726
23	21	74	182	60	156	174	186	192	198	204	210	174	156	144	090	066	630
24	21	71	170	66	144	156	168	174	180	186	192	150	108	102	090	084	534
25	21	70	178	66	138	150	156	168	174	186	192	120	114	108	102	090	534
26	19	76	172	66	150	162	174	180	186	192	210	132	114	108	090	084	528
27	21	80	182	66	126	138	150	162	174	180	196	156	138	108	096	078	576
28	23	84	184	66	168	186	192	198	204	210	216	168	144	132	096	078	618
29	21	76	176	66	144	162	174	186	192	198	204	144	120	108	102	084	558
30	21	72	177	78	126	144	150	156	168	186	192	156	120	108	090	084	558

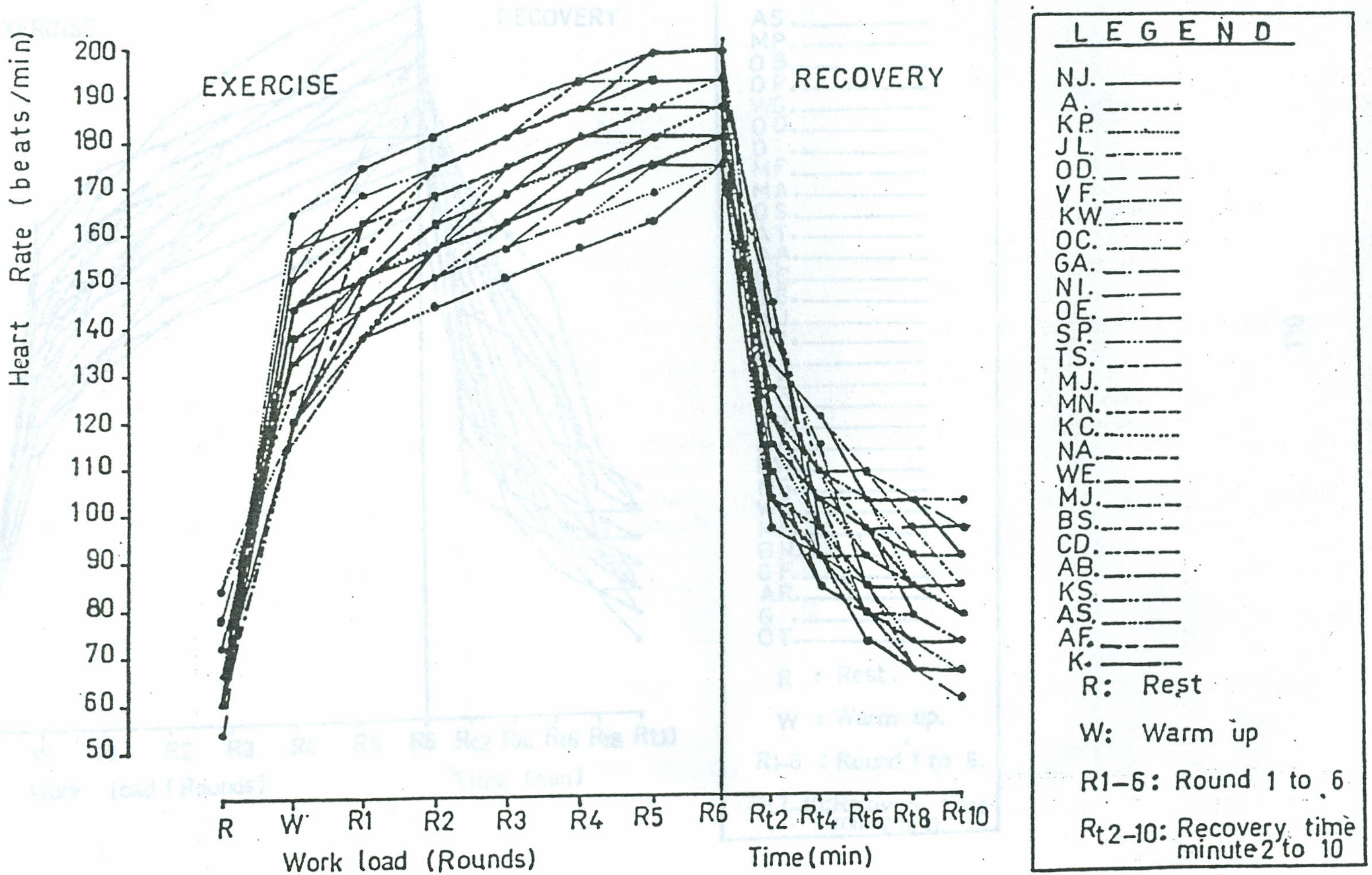
A P P E N D I X E 2

RAW DATA OF TIME TAKEN (Seconds) BY RUGBY PLAYERS (n = 25) TO PERFORM THE GLESSENER SOCCER TEST (Legend:W = Warm Up; R1-R6 =Round one to six; S = Subject)

S	W	R1	R2	R3	R4	R5	R6	$\bar{X} \pm SD$	TOTAL TIME
1	230	253	160	183	195	225	187	204.71 ± 32.3	1433
2	173	175	192	214	238	249	264	215.00 ± 36.5	1505
3	226	228	245	299	268	280	282	261.14 ± 28.5	1828
4	245	260	205	270	193	189	241	229.00 ± 32.9	1603
5	280	285	280	204	180	225	225	239.87 ± 42.0	1679
6	252	234	225	257	278	280	276	257.43 ± 22.0	1802
7	222	220	200	280	200	203	204	218.42 ± 28.7	1529
8	222	200	215	235	250	290	290	243.14 ± 35.6	1702
9	243	254	257	281	202	234	243	244.57 ± 24.1	1714
10	270	245	270	282	195	230	240	247.43 ± 29.8	1732
11	280	280	280	280	280	280	280	280.00 ± 00.0	1960
12	170	245	245	170	185	195	230	205.71 ± 33.6	1440
13	195	220	225	230	248	214	204	219.42 ± 17.4	1536
14	180	180	180	207	225	240	207	202.71 ± 24.1	1419
15	157	204	224	238	252	228	241	220.57 ± 31.9	1544
16	230	147	171	126	231	239	272	202.28 ± 54.2	1416
17	130	143	150	197	190	230	215	179.28 ± 38.5	1255
18	150	155	185	200	220	230	230	195.71 ± 33.7	1370
19	180	185	185	185	190	214	215	193.43 ± 14.7	1354
20	180	180	195	225	225	266	266	219.57 ± 36.8	1537
21	144	179	201	210	285	290	290	228.42 ± 59.8	1599
22	180	190	190	210	225	240	240	210.71 ± 24.9	1475
23	170	175	189	183	211	232	232	199.00 ± 26.1	1392
24	165	262	180	173	194	190	208	195.57 ± 32.4	1372
25	160	200	168	208	148	250	268	200.28 ± 45.7	1402
26	153	169	185	205	242	226	221	200.71 ± 32.4	1401
27	271	240	182	214	231	240	247	232.14 ± 28.0	1625
28	164	180	185	240	300	200	305	224.86 ± 58.1	1574
29	173	159	201	216	231	222	218	202.86 ± 27.0	1420
30	300	240	240	240	240	240	240	248.57 ± 22.7	1740

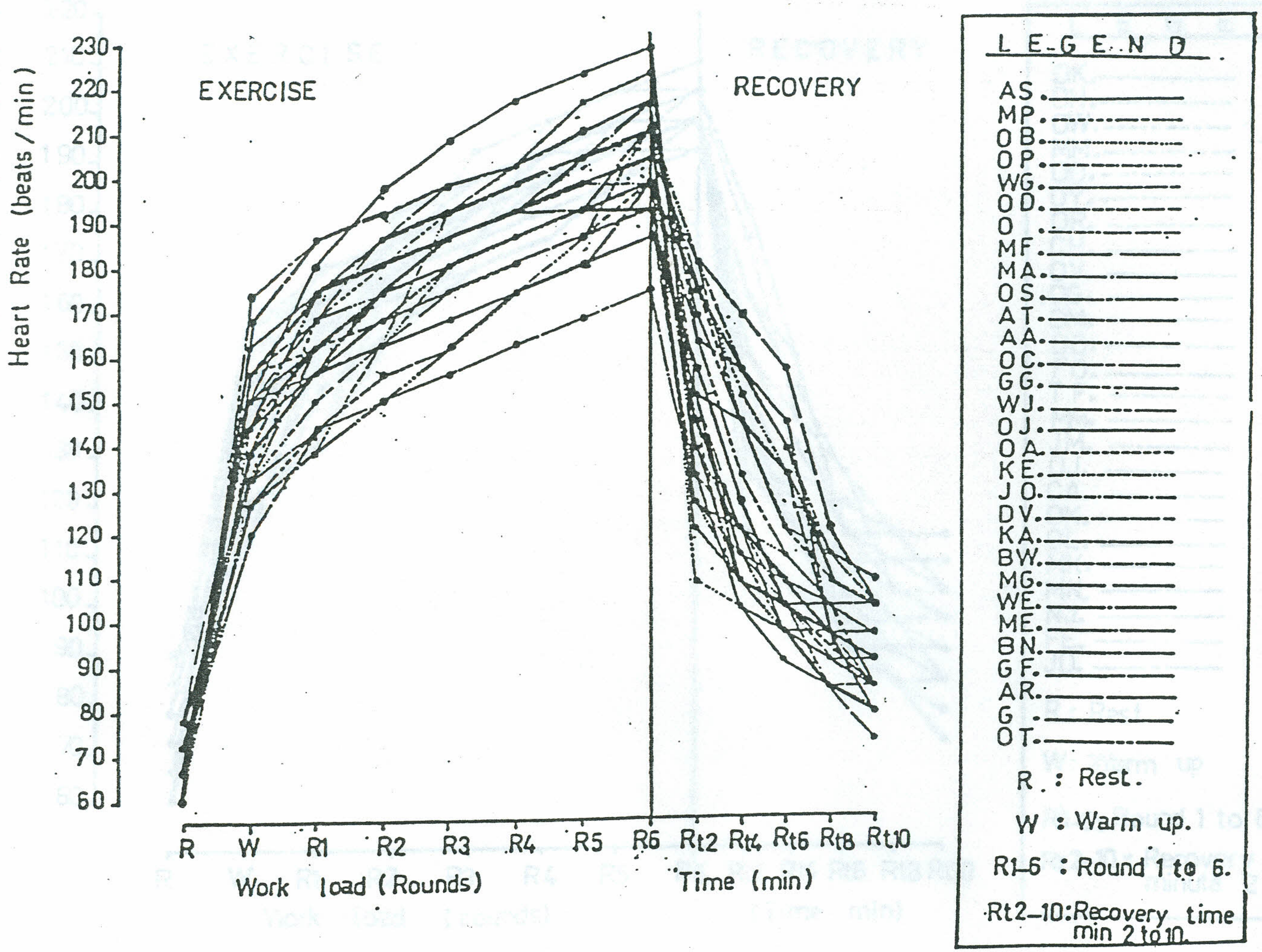
APPENDIX F

Hockey Players' Heart Rate (HR) Response to the Giessener Soccer Test



APPENDIX G

Rugby Players' Heart Rate (HR) Response to the Giessener Soccer Test



APPENDIX H

Soccer Players' Heart Rate (HR) Response to the Giessener Soccer Test