INDEX

SECTION I
INTRODUCTION
- I.I – BASICS OF RUGBY
- I.II – OPTIMAL PERFORMANCE
- I.III – BACKGROUND INFORMATION
- I.V – EXPERIMENTAL PROPOSITION

SECTION 2
THEORY AND LITERATURE REVIEW
- II.I – THE BODY'S ENERGY RESOURCES
- II.II – THE LOSS AND REPLACEMENT OF FLUIDS AND ELECTROLYTES
- II.III – CHO DRINKS AND SUPPLEMENTATIONS

SECTION 3
STUDY DESIGN

SECTION 4
METHODOLOGY

SECTION 5
RESULTS

SECTION 6
ANALYSIS

BIBLIOGRAPHY

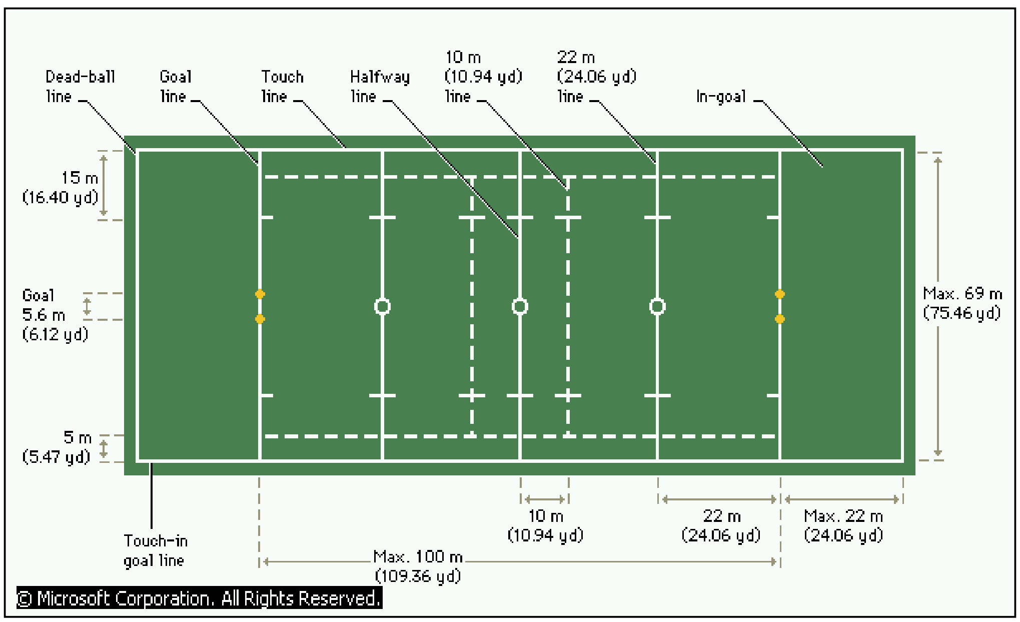
SECTION I
INTRODUCTION

1.1 – BASICS OF RUGBY

Rugby Football is a general name for a variety of football. It was said to have originated when a boy at Rugby School in Rugby, England, picked up and carried the ball during a game of football in 1823. Previously, the rules had only allowed the ball to be kicked. The modern game of rugby dates from the 1860s, when it was adopted and modified by other English schools and universities. In 1871 the English Rugby Union was formed to standardize the rules. The game is played with an oval ball, blunter in shape than the American football so that it may easily be bounced and dropkicked - that is, kicked on the rebound.

The form of rugby officially designated as Rugby Union Football played in more than 100 countries, including Australia, New Zealand, Japan, England, France, Italy, Fiji, and South Africa. The sport's international governing body is the International Rugby Football Board (IRFB), located in Dublin, Ireland. In the United States there are more than 1400 rugby clubs and more than 100,000 players, governed by USA Rugby, located in Colorado Springs, Colorado. Rugby was only played as an amateur sport until 1995, when the IRFB passed a resolution allowing national governing bodies and local rugby clubs to pay their players.

A rugby team consists of 15 players, generally divided into 8 forwards and 7 backs. Seven substitutions of players are permitted during a match in addition to injury replacements. Injured players, once having left the game, may not return. A game usually lasts for 80 minutes and is divided into two 40-minute halves with no time-outs.
A rugby field is not more than 100m in length and 69m in width, and is divided transversely by two lines 22m from each goal and a halfway line. Not more than 22m behind each goal line is the dead-ball line, beyond which the ball is out of play. The uprights of the goal are 5.6m



apart. A horizontal crossbar connects them 3m above the ground.

Play begins with a place kick and is generally continued by a scrummage or scrum, in which the forwards of each team pack together with their arms across one another's shoulders and their heads down. Thus locked together, the forwards wheel and push against the opposing forwards, while attempting to hook the ball backward with their feet to one of the backs, called the scrum half. Having received the ball, the scrum half has several options: running with the ball until downed or until there is another chance to pass the ball, kicking the ball downfield, or immediately passing the ball to team-mates. If the scrum half chooses to pass the ball, the team-mates attempt to advance the ball forward and across the opponents' goal line. Once over the line the ball must be touched to the ground to score a try, which is worth 5 points. After scoring a try, a team is entitled to attempt a conversion similar to that in American football. In rugby the conversion kick is taken from anywhere on a line perpendicular to the goal line at the point that the ball was touched down. If the kicked ball passes over the crossbar and between the uprights, the team is awarded 2 additional points for the conversion.

Although the game appears complex, it is governed by only two major rules: (1) players may not pass the ball forward, and (2) players may not touch the ball while it is in play if it was last touched behind them (nearer their own goals) by players on their own teams. A minor infringement results in a scrummage. In the case of a serious infringement, or a foul, the referee, who is the only judge, may award a penalty kick against the offending team. A goal resulting from this kick scores 3 points. A goal scored from a dropkick (when during play a player drops the ball, lets it rebound off the ground, and kicks it over the crossbar and through the uprights) also counts 3 points. A mark occurs when a player standing behind that player's own 22 m (24 yd) line catches a ball on the fly from an opponent's kick and says, "Mark." The player making the mark may then attempt a free kick.

There are several aspects to the game of Rugby, not least because of the fact that the playing team can be split up into two different types of player – Backs and Forwards. Each of these separate sets of players has very different 'jobs' in the game of Rugby.

The forwards have arguably the most strenuous and fitness demanding part of the game. They need tremendous amounts of upper body strength for the part they play in the scrums, but they also need to have muscular endurance to get to all of the breakdowns, and ultimately, last the whole 90 minutes.

The forwards are used in the scrummage, and the total pack number is 8. Each person has a specific position in the pack, and their skill/size/speed/strength is what will decide the position that they are in.

The backs come into play after scrums and line-outs. Once the ball has been won – or lost in other cases – the backs receive the ball from the scrum half. The backs always attempt to break through the defences of the opposite side. This is done by running with the ball, and passing it if contact is taken. The backs are specialized in the way that they are, ideally, fast, strong, agile and posses' muscular endurance. In the format of attacking, the backs line up in a slanted format, so that each player is forced to run at pace, and when the ball is passed, it is done in front of the player, so that he is further forced to run at pace. In the format of defence, the backs line up in flat line, so that they can tackle the opposition as quickly as possible, and give them as little ground as possible.

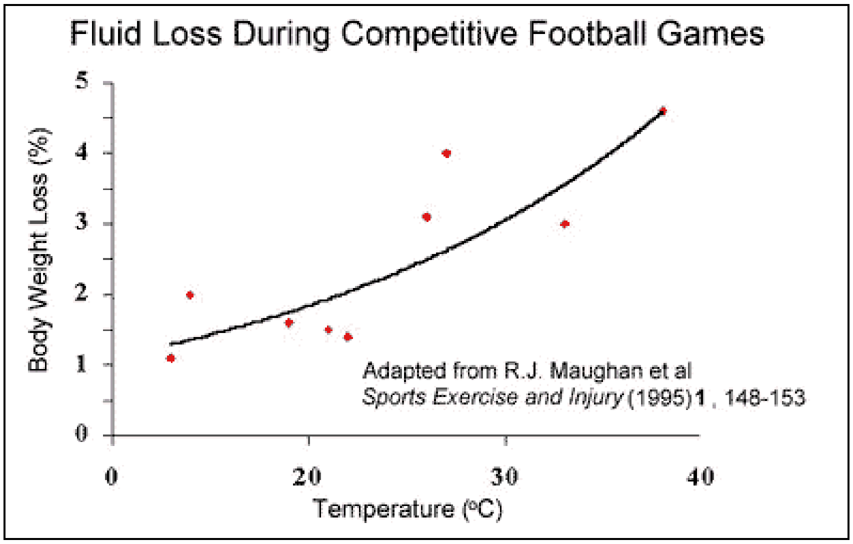
I.II - OPTIMAL PERFORMANCE

I.III - BACKGROUND INFORMATION

Water is essential for human life and whilst not strictly a nutrient it performs many essential functions in the human body. Healthy adults can survive for many weeks without food but they can only live for a few days without water. The human body is made up of around 75% water which is essential for maintaining body processes like digestion and absorption of food and blood circulation. Consuming fluid at regular intervals during exercise is therefore essential to safeguard health and optimize performance. Failure to maintain fluid levels during exercise particularly in the heat and during endurance events can be dangerous.

Exercise generates heat, which must be released to prevent the body overheating. Sweating is the most important body mechanism to control this temperature rise and is linked to the need to maintain body temperature with narrow limits of 37-38°C Even during light exercise fluid loss from sweating and breathing can be very high. For example if running normally fluid loss can be as much as 1-2 litres per hour and in a marathon as much as 2.5-4 litres can be lost.

(Fig 1.1)



It is essential that fluid lost as sweat and through breath is replaced, or performance will be impaired and the fluid loss could even be life threatening If heat is not lost via sweat evaporation, the body temperature could rise by 1°C every 5 minutes, which in theory would be lethal after 30-40 minutes. Scientific studies have shown that losses of as little as 2% of the body weight as fluid can impair physical and mental performance. If the effects of fluid loss can be prevented, an individual will feel better, continue to perform better and recover more quickly.

(Fig 1.11)

Physiological Effect	% body weight lost as sweat
Impaired performance	2%
Capacity for muscular work declines	4%
Heat exhaustion	5%
Hallucinations	7%
Circulatory collapse and heat stroke	10%

It is well established that there are two main factors that limit prolonged exercise:

- Depletion of the body's carbohydrate energy stores
- Dehydration

These factors, in combination, limit endurance and power, affecting performance. Scientific research has shown that the foods and drinks which sports people take, in combination with their training programs, can have an important role to play in enhancing their performance.

This has led to the need for specially formulated sports drinks that can be taken before, during and after exercise.
Sports drinks are specially formulated carbohydrate electrolyte drinks, which are designed to improve sporting performance. They deliver a boost of carbohydrate energy to working muscles, and also supply fluid fast. Together these help to maximise performance and endurance.

In addition to providing carbohydrate, sports drinks provide fluid to maintain hydration. A sportsperson's state of hydration can have a major impact on sporting performance. Isotonic carbohydrate electrolyte drinks have carefully selected levels of carbohydrates and electrolytes to help replace fluid quickly. The addition of electrolytes to drinks, especially sodium and potassium, reduces urine output in the post exercise period, and is effective in increasing the fraction of ingested fluid that is retained, thus effectively promoting rehydration.

I.V - EXPERIMENTAL PROPOSITION

SECTION 2
THEORY AND LITERATURE REVIEW

II.I – THE BODY'S ENERGY RESOURCES

The ability to execute exact neuromuscular functions is dependant upon the availability of glycogen. In activities where glycogen is depleted (e.g., in the latter stages of a training session, the end of an extended endurance performance) muscular function (skill) will be altered. At training, activities which depend upon exact muscular function (e.g., skill learning) should be performed before any reduction in glycogen availability occurs. For training and competitions, frequent carbohydrate supplementation is necessary to sustain glycogen levels and thus, contribute to neuromuscular efficiency.

Schiestl, G., et al. (1997). *Medicine and science in sports and exercise, 29*, 112.

The energy that our bodies use is created from 'turning' a molecule called adenosine triphosphate (ATP) into adenosine diphosphate (ADP). The enzyme ATPase is used to split one of the three phosphate molecules present in ATP, leaving behind the ADP. The splitting of the molecules releases chemical energy and this is used directly by the muscles fires to in turn create mechanical energy i.e. movement.

In order for this energy system to work, ATP needs to be preset in the muscles of our bodies, and in reality, there is finite amounts of ATP stored in the muscle cells, ultimately being equivalent to single weight lift or kick of a rugby ball. Energy is then used from other sources to turn the ADP back into ATP, and therefore this particular energy cycle can only continue as long as there is energy to ADP back into ATP. The energy used to turn ADP back into its original form of ATP comes from another molecule called Creatine phosphate which similar to that of ATP is broken down to produce energy, and similar again in the sense that there is only a limited amount present in the muscle cells. Ultimately via the use of Creatine phosphate there is enough potential for the ATP breakdown to create approximately 10-15 seconds energy.

This amount of energy is evidently not enough for those sportspeople who participate in events longer than say the 100m. When the energy created from the ATP CP system is exhausted the demand calls for the use of another energy system, called Anaerobic Glycolysis. This system is involved with the breakdown of glycogen or glucose without oxygen hence the term 'anaerobic'. Essentially, glycogen that is stored in the muscles and liver, and glucose that is stored in the blood are broken down in a complex process involving 12 enzymatic reactions creating energy and a by-product called Pyruvic acid. Pyruvic acid on its own is not harmful, however without oxygen it is turned into another acid called lactic acid, and this is harmful creating cramps around the body via OBLA (of onset of blob lactate accumulation where the lactate accumulates in the blood). This accumulation also slows the energy production, but there is ultimately enough energy to complete a 400m race for trained individuals.

The final way of obtaining energy is one that does involve oxygen and to that end it is called the aerobic system. The system, just like the anaerobic system uses the breakdown of glycogen or glucose to produce energy. In fact the only difference between the two systems is that oxygen is used in the latter to Pyruvic acid produced by Glycolysis and in turn into more energy instead of lactic acid. The aerobic system also produces electrons and hydrogen ions, which are eventually turned into water and excreted through sweat and exhalation. This system provides by far the greatest amount of energy and is favoured by the body for any activities lasting over three minutes. If the heart and lungs can deliver enough oxygen, energy can continue to be supplied for as long as the supplies of glucose and glycogen.

11.11 – The loss and Replacement of Fluids and Electrolytes

Water is essential for human life and whilst not strictly a nutrient it performs many essential functions in the human body. Healthy adults can survive for many weeks without food but they can only live for a few days without water. The human body is made up of around 75% water which is essential for maintaining body processes like digestion and absorption of food and blood circulation. Consuming fluid at regular intervals during exercise is therefore essential to safeguard health and optimize performance. Failure to maintain fluid levels during exercise particularly in the heat and during endurance events can be dangerous.

An athlete's problem is maintaining internal body temperature within the limits which permit him to function efficiently, which is a core temperature of 22°C. The sweat glands produce large quantities of sweat when the body becomes hot; up to two litres per hour. The sweat on the skin soon evaporates into the air surrounding the body. As the air close to the body becomes saturated, new air arrives to accept the evaporating sweat. And by this process heat can be loss in attempts to maintain 22°C.

Loss of fluid left unchecked leads to dehydration and this results in premature fatigue and increases the risk of heat illness. Dehydration disturbs fluid and electrolyte balance in the body, can damage the energy producing processes of the muscle cells and put increased stress on the heart. In response to dehydration, the body triggers responses in an effort to conserve fluid and return itself to normal. These include stimulation of thirst, a reduced urine output and conservation of sodium by the kidneys, plus a reduced sweat output. The reduced sweat output brings about a further rise in core temperature and the demand for more sweat increases. Failure to produce more sweat is followed by another rise in temperature. The blood thickens and the heart rate increases. Dehydration is cumulative - if lost fluids are not replaced this dehydration will eventually lead to circulatory collapse and heat stroke

The composition of sweat varies between individuals, but also within the same individual depending on the quantity secreted, fitness levels and the state of heat acclimatization. When athletes train in warm climates, the sweat rate increases with training and acclimatisation while the electrolyte content decreases. These adaptations allow more efficient heat regulation while conserving electrolytes. (Fig 11.1 shows the normal electrolyte composition of sweat).

	Concentration (mmol/l)		
	Sweat	**Plasma**	**Intracellular**
Sodium	20 - 80	130 - 155	10
Potassium	4 - 8	3.2 - 5.5	150
Calcium	0 - 1	2.1 - 2.9	0
Magnesium	< 0.2	0.7 - 1.5	15
Chloride	20 - 60	96 - 110	8
Bicarbonate	0 - 35	23 - 28	10
Phosphate	0.1 - 0.2	0.7 - 1.6	65
Sulphate	0.1 - 2.0	0.3 - 0.9	10

Table taken from Oxford Textbook of Sports Medicine, 1996

When individual are exposed to daily 5-6% body weight fluid losses, there is a risk of an electrolyte deficit occurring. Under such conditions, small amounts of electrolytes should be consumed during physical activity. The ACSM recommends: (a) 218mg of sodium, (b) 337mg of chloride, and (c) 183mg of potassium per quart of water.

Hecker, A. L., & Wheeler, K. B., (1994). The journal of the National Athletic Trainers Association, 19, 4-9.

In humans, thirst is a very poorly developed mechanism. Thirst tends to be quenched when we swallow enough fluid to relieve the dry feeling in the mouth. However, by the time the sportsperson feels thirsty the body is in a state of dehydration which can be difficult to rectify whilst continuing to exercise. Thirst is a subjective sensation that is caused by a hormonal response to loss of fluid from the body resulting in decreased blood volume and an increased blood/plasma osmolality (concentration of particles).

Therefore, it is important to ensure that the body is fully hydrated prior to exercise, and that fluid continues to be consumed regularly throughout the exercise period and afterwards. Drinking plain water may not be the best fluid replacement for rapid correction of dehydration as it can have the effect of causing a rapid fall in plasma sodium and plasma osmolality. This has the effect of reducing the stimulus to drink (thirst) even before sufficient fluid has been consumed to replace losses, and also stimulates urine production, both of which will delay rehydration. The addition of electrolytes, especially sodium and potassium, to sports drinks, does not promote such a urine production and as such reduces urine output in the post exercise period and is effective in increasing the fraction of the ingested fluid that is retained - thus effectively promoting rehydration.

Serious attention to fluid replacement on a scheduled basis is required for all sports that induce considerable sweating and/or are performed in hot humid conditions.

Hecker, A. L., & Wheeler, K. B., (1994). The journal of the National Athletic Trainers Association, 19, 4-9.

II.III - CHO DRINKS AND SUPPLEMENTATION

Isotonic sports drinks are scientifically formulated with carefully selected levels of carbohydrate and electrolytes (sodium). Their main benefits include fast carbohydrate energy and fluid delivery and also taste. Consuming carbohydrate before, during and after exercise helps prevent blood glucose levels falling too low and will also help spare the body's glycogen stores. Water does not contain any carbohydrate; therefore a sportsperson would need to consume carbohydrate containing foods before, during and after exercise to achieve the same effects. Many sportspeople do not wish to, or cannot, eat immediately prior to or during their exercise session, thus a sports drink containing a carefully selected quantity of carbohydrate is a convenient way to provide carbohydrate. Research has consistently demonstrated that consumption of carbohydrate-electrolyte drinks during exercise, which lasts even as little as one hour, results in improved sporting performance. It allows you to work longer, harder, and feel better than when just a plain water placebo is consumed.

CHO loading and in-task replenishment affects the perception of exertion in the latter stages of long-duration tasks. Thus, for long training session as well as long competitive tasks it is a factor which must be considered. Although this study's task was limited to running, until evidence to the contrary is produced, it should also be considered for games such as soccer and Australian Rules football which normally last for periods well in excess of two hours.

Kang, J., et al. (1997). Medicine and science in sports and exercise, 29, 111.

Playing high-intensity intermittent-exercise games in the heat requires CHO drink supplementation if performance standards are to be prolonged

Bergen, J. .L., et al. (1998). Medicine and science in sports and exercise, 30, 23.

The osmolality or tonicity of a fluid is a measure of the number of particles in a solution. In a drink, these particles will be ingredients in the drink, such as carbohydrate, sodium, sweeteners or preservatives. In blood plasma, the particles will be molecules such as sodium, proteins and glucose. Drinks which are isotonic contain roughly the same number of particles per kg as blood plasma. Blood plasma has an osmolality, or tonicity, around 280-300mOsm/kg. Drinks with an osmolality of 270-330mOsm/kg are often said to be in balance with the body's fluid and are categorised as isotonic.

Hypotonic drinks provide fluid but only very low levels of carbohydrate and are therefore ideal for those individuals who need fluid without extra calories, for example, jockeys and ballet dancers, who sweat and lose fluid but need to maintain a low body weight. Hypertonic drinks, in general, are used to supplement daily carbohydrate intake after exercise to help top up muscle glycogen stores.

The consumption of CHO during an extended exercise might be more important for affecting performance than pre-exercise meals,

Burke, L. M., et al. (1998). Medicine and science in sports and exercise, 30, 471.

The consumption of carbohydrates before, during and after activity is important, however research increasing shows that CHO ingestion during exercise is the most important, as it sustains muscle glycogen stores for activity. That is why sportspeople choose to use isotonic drinks, because they provide a glucose boost to the working muscles, quench thirst and replace lost electrolytes.

Ingesting a high carbohydrate-electrolyte solution preserves muscle glycogen concentration in intermittent high intensity exercises such as field games

Nicholas, C. W., et al. (1999). Medicine and science in sports and exercise, 31, 1280-1286

In extended exercise in males, in the second half and latter stages of performance, CHO ingestion is very important for it extends performance capabilities.

Coggan, A. R., & Coyle, E. F. (1989). Medicine and science in sports and exercise, 21, 59-65.

Although on the whole research with regards to the use of isotonic drinks is positive, in the sense that most believe that isotonic drinks do prolong performance and replace lost electrolytes, there is also research to the contrary.

Although blood glucose levels are altered by their supplementation, neither carbohydrate nor caffeine improved performance in a 30minute cycling time trial.

Rehre, N. J., et al. (1997). Medicine and science in sports and exercise, 29, 1434.

Performance differences under fuel-additive conditions are largely due to a placebo rather than a real effect. This could explain why investigations measuring CHO-loading effects often produce insignificant results.

Clark, V. R., et al. (1998). Medicine and science in sports and exercise, 30, 346.

A feeding of CHO very close to the commencement of an endurance exercise bout does not affect the endurance performance of untrained adolescent boys. It would be interesting to see what happens with trained boys.

Hendelman, *D. L.*, et al. *(1997)*. *M*edicine and science in sports and exercise, *29, 724.*

Hendelman et al *(*extract above*)* investigated the effects of pre-exercise carbohydrate feeding on responses to endurance exercise and performance in untrained high school boys and found no effect. He says that it would be interesting to see if that is the case in trained boys, and is indeed the focus of this research. Where the focus of his research was on pre-exercise ingestion of carbohydrate, this particular project will focus on ingestion during and after the activity also, in attempts to discover if Carbohydrate supplementation in the form of isotonic drinks does have an effect on optimal performance.

When ingesting CHO prior to an event, the form of the CHO does not matter as long as there is adequate time for solid food to be assimilated, however, when time is short, the fastest is liquid compared to the slowest which is solid. A conservative approach would be to always prefer the liquid form of CHO since it also offers some fluid replacement.

*D*oyle, *J.* A., et al. *(1997)*. *M*edicine and science in sports and exercise, *29, 718.*

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