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Dietary intake and supplement use of under 21 rugby players, Blue Bulls

Script submitted in order to partially
meet the requirements for the degree
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Faculty of Health Sciences,
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Study leader: Prof A Dannhauser
Co-study leader: Ms E du Toit

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DECLARATION

I hereby declare that this script submitted for the degree Magister Scientiae in Dietetics (Sports Nutrition), at the University of the Free State is my own work and has not been previously submitted to any other university for this or any other purpose. I futhermore cede copyright of the script in favour of the University of the Free State.

Veronica Smith

Bloemfontein, March 2007

CANDIDATE

Dedicated with love to
my parents and husband

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ACSM	American College of Sports Medicine
ADA	American Dietetic Association
DC	Dietitians of Canada
CHO	carbohydrate
TE	total energy
/kg BW/d	per kilogram body weight per day
ml	millilitres
kg	kilogram
%	percent
HMB	β-hydroxy-β-methylbutyrate
DRI	Dietary Reference Intake
u/21	under 21
ATP	adenosine triphosphate
CP	creatine phosphagen
IMP	inosine monophosphate
NH_3	ammonia
LA	lactic acid
kJ	kilojoules
kJ/g	kilojoules per gram
FFA	free fatty acids
TG	triglycerides
RDA	Recommended Dietary Allowances
AI	Adequate Intakes
UL	Tolerable Upper Intake Levels
EAR	estimated average requirements
EER	estimated energy requirements
PA	physical activity
PAL	physical activity level
EEPA	estimated energy expended in physical activity
METs	metabolic equivalents
mph	miles per hour
kJ/d	kilojoules per day
GI	glycaemic index
CO_2	carbon dioxide
FMN	flavine adenine mononucleotide
FAD	flavine adenine dinucleotide
NH_4	ammonium
RNA	ribonucleic acid
DNA	diribonucleic acid
NAD	nicotinamide adenine dinucleotide
MRI	magnetic resonance imaging
NATA	National Athletic Trainers' Association
mmol/L	mill mol per litre

g/ml	grams per millilitre
mEq/L	milli equalibrium per litre
mg/L	milligrams per litre
IOC	International Olympics Committee
mg/kg	milligram per kilogram
OKG	ornithine alpha-ketoglutarate
UP	University of Pretoria
SSR	sport specific recommendations
g/d	grams per day
BMI	body mass index
±suppl	with and without supplements
RHI	recommendations for healthy individuals
kg/m^2	kilogram per square metre
m	metres
g	grams
PUFA	polyunsaturated fatty acids
MUFA	monounsaturated fatty acids
SFA	saturated fatty acids
Ca	calcium
Mg	magnesium
Na	sodium
K	potassium
Cl	chloride
EAS	Energy-Athletics-Strength
USN	Ultimate Sports Nutrition
ESPi	Evolutionary Sports Performance informatika
PVM	Protein-Vitamins-Minerals
CLA	Conjugated Linoleic Acid

CHAPTER 1 – INTRODUCTION

1.1 Background

Rugby is a very popular sport in South Africa (Burke, 1998, p.310). The duration of each game is 80 minutes. Fifteen players are part of one team playing against another team. Eight of the players are forwards and seven are backs (Reilly, 1997). The purpose of the game is to score a try or to kick a penalty in the other team's side (Rugby Football Union, 1997, p.2).

Rugby is a fast sport and rugby players have to commit to a high level of fitness (Burke, 1998, p.310). Common to all team sports, including rugby, is the intermittent, high intensity of play, which places great demands on both anaerobic and aerobic energy systems (Meltzer & Fuller, 2005, p.139). Most of the activity on the field is of short duration (Noakes & Du Plessis, 1996, p.190). Players are required to perform at a fast pace, recover quickly and have stamina and endurance. Aerobic fitness assists recovery between bursts of play (Meltzer & Fuller, 2005, p.139). Players need to have certain skills such as catching, passing and kicking of the rugby ball, scrumming, running and tackling depending on the position of the player plays (Williams, 1996). Concentration, skill, strategy, agility, explosive strength and sometimes jumping ability are factors that determine success in rugby (Meltzer & Fuller, 2005, p.139).

Recent analysis of field games, including rugby shows that players cover more distance at a higher intensity with less time for recovery, compared to their counterparts from several years ago. The physiological demands of the game have intensified so that today's players need to be fitter, faster and stronger. Training loads will vary according to the time of the season and according to the level of play, but training usually includes general conditioning, weight training and team practice. During the season, matches place additional demands on recovery and muscle glycogen stores (Meltzer & Fuller, 2005, p.140).

The American College of Sports Medicine (ACSM), American Dietetic Association (ADA) and the Dietitians of Canada (DC) wrote a joint position statement in which they claim that physical activity, exercise performance and recovery from exercise are enhanced by optimal nutrition. These organisations recommend appropriate selection of food and fluids, timing of intake and supplement choices for optimal health and exercise performance (ACSM et al., 2000).

Consuming adequate food and fluid before, during and after exercise can help maintain blood glucose during exercise, maximise exercise performance and improve recovery time (ACSM et al., 2000). During times of high physical activity, energy and macronutrient needs especially carbohydrate (CHO) and protein intakes must be met in order to maintain body weight, replenish glycogen stores and provide adequate protein for building and repair of tissue (ACSM et al., 2000). A single rugby game might not deplete the fuel stores of a trained rugby player, but the combination of regular training and competition will have a carry-over effect and slowly deplete reserves. For a week-round recovery and to prevent progressive fatigue, a habitual high-energy, high CHO diet is required (Meltzer & Fuller, 2005, p.141). The average dietary recommendation for CHO is 50-60 percent (%) of the total energy (TE) intake (O'Connor et al., 2002). CHO recommendations range from 6 to 10 g CHO per kilogram body weight per day (/kg BW/d) (ACSM et al., 2000). Protein needs for rugby players may be increased to build and maintain muscle mass and for recovery (Meltzer & Fuller, 2005, p.141). The average dietary recommendation for protein is 15-20% of the TE intake (O'Connor et al., 2002). According to ACSM et al. (2000) the protein recommendations for resistance and strength-trained athletes may be as high as 1, 6 to 1, 7 g protein/kg BW/d). However, other literature recommends protein for power sports, including rugby players, from 1,4 to 1,8 g protein/kg BW/d) (Bean, 2003, p.39; Smolin & Grosvenor, 2000, p.404; Tarnopolsky, 2002, p.109; Burke, 1998, p.48).

According to Meltzer and Fuller (2005, p.140) rugby players should always limit fat intake. Fat intake should be adequate to provide the essential fatty acids and fat-soluble vitamins as well as to help provide adequate energy for weight maintenance (ACSM et al., 2000). The average recommendation for fat is 25-30% of the TE intake (O'Connor et al., 2002). Athletes involved in power sports, including rugby have a high intake of protein and fat (ACSM et al., 2000). Burke (1998, p.312-314) recommends rugby players to receive appropriate nutrition education on: the quick and easy preparation of meals; better choices for take away and restaurant foods; alcohol use; guidelines to improve micronutrient and macronutrient intake which can help to improve their performance.

Dehydration decreases exercise performance and increases the risk of potentially life-threatening heat injury such as heat stroke (ACSM et al., 2000). The recommendation for fluid intake is to drink 400-600 millilitres (ml) of fluid two hours before exercise and 150-350 ml of fluid every 15-20 minutes. After exercise 450-675 ml of fluid should be ingested for every kilogram (kg) BW loss occurring due to sweat loss (ACSM et al., 2000). Much of the fluid can also be excreted via urination (Burke, 2002, p.357). According to Burke (1998, p.317) rugby tradition used to have dangerous fluid and electrolyte practices. Sport drinks and water are currently being provided during a rugby match. Sports drinks containing CHO provide both fluid and energy. In hotter environments the addition of electrolytes can be beneficial (Meltzer & Fuller, 2005, p.141). A recent study showed that 90 % of collegiate football players, which are similar to rugby players, recognise the importance of maintaining proper hydration practices (Jonnalagadda et al., 2001).

Body composition and BW are two of the many factors that contribute to optimal exercise performance. BW can influence speed, endurance and power, whereas body composition can affect strength, agility and appearance.

Athletes, including rugby players require a high strength-to-weight ratio to achieve optimal exercise performance (ACSM et al., 2000). The body composition and BW of rugby players vary according to the positions they play (Ebert, 2000). Rugby players come in all shapes and sizes, but lower body fat levels are desirable generally as this will maximise speed and agility and improve heat tolerance and stamina. Increased muscle mass and power is also required for rugby players, because rugby players need to be strong and have good body positioning to withstand the contact in a game (Meltzer & Fuller, 2005, p.140). Athletes, including rugby players have variable body fat levels of 6% to 19% (ACSM et al., 2000). Lower body fat levels and BW occur in rugby players doing more running for training (Burke, 1998, p.312). Rugby players in key roles have bigger heights and BW. Forwards, however, have more muscle mass and also more body fat than backs (Reilly, 1997). Typically, rugby players tend to have higher body fat levels at the start of a season. Training and heavy match schedules soon reduce their percentage body fat. Within a rugby team, rugby players' nutritional requirements will differ according to their position of play (Meltzer & Fuller, 2005, p.140). The rugby player's optimal BW and composition for health and competition should be determined individually (ACSM et al., 2000).

More than half of the athletic populations are supplement users, although the prevalence ranges between sports (Burke et al., 2002, p.459). Top sportsmen use dietary supplements to improve their performance (Schröder et al., 2002). Rugby players use supplements according to the position of play whether it be for extra speed, fat loss or muscle building (Burke et al., 2002, p.459). Although the use of performance enhancing substances is highest in elite athletes, there appears to be widespread use of banned supplements among sports achievers at schools and universities throughout South Africa. The increasing number of positive doping tests in sport is clearly also a cause for concern (SAIDS, 2006).

1.2 Problem statement

Now more than ever, the need for accurate sports nutrition information is increasing. Whether the athlete's performance is recreational or elite it will be influenced by what he eats or drinks. Unfortunately there is much misinformation regarding a proper diet for physically active people. Many health and fitness conscious people will try any dietary regimen or nutritional supplement in the hope of reaching a new level of physical performance (Berning, 2004, p.617).

Although the eating behaviours of athletes, including rugby players have not been studied extensively there are certain issues that require consideration (O'Connor et al., 2002). It has taken some time for nutrition to be recognised as an important performance-enhancing factor in team sports, including rugby, probably due to the strong culture and tradition of team sports (Meltzer & Fuller, 2005, p.139). Rugby players are contracted by Rugby Unions each year and often have to move to different towns and share houses with other rugby players. Few of these players have proper nutrition knowledge and cooking skills (Burke, 1998, p.312). Today's rugby players participate in more games with each passing season, limiting their off-season time. Travel is a huge challenge and they may even be juggling the demands of training and competition with full-time jobs (Meltzer & Fuller, 2005, p.140). Food is often the easiest form of recreation or release from strict daily regimen as other social or hobby type activities are necessarily limited (O'Connor et al., 2002). A pattern of skipped meals; reliance on take-away foods, cafeteria and buffet style eating is common amongst rugby players (Meltzer & Fuller, 2005, p.141; Kerr & Ackland, 2002, p.69). This has been associated with over consumption (Meltzer & Fuller, 2005, p.141). Typically, rugby players tend to follow a high fat, low carbohydrate and high protein intake (Nel et al., 2000).

Dehydration during exercise is usually the result of a mismatch between thirst and fluid requirements. That there is little evidence linking fluid imbalances with poor motor performance in team sports, including rugby is only because it is difficult to measure (Meltzer & Fuller, 2005, p.64, 141). The excessive use of alcohol among rugby players can influence performance negatively (O'Connor et al., 2002). Good drinking strategies should be practised giving attention to the duration and intensity of training; body size and composition; genetics and fitness; environmental conditions and clothing that will all affect an individual's fluid requirements (Meltzer & Fuller, 2005, p.64, 141).

Sport supplement use have been present since the 1980's when the Australian Sports Medicine Federation reported that the beliefs within a particular sport strongly influenced supplementation practices (Burke et al., 2002, p.459). Despite the lack of evidence from the benefit from the use of most nutritional supplements, commercial promotion of their use is a thriving and highly influential business (Schwenk & Costley, 2002, 908). Nutritional supplements are being used in the locker rooms of high schools, colleges and gyms (Johnston & Landry, 1998). Supplement use by elite athletes exceed that of college athletes which in turn exceed that of high school athletes (Schwenk and Costley, 2002, 910).

Although some surveys have suggested that certain types of athletes use supplements to compensate for poor food intake, the majority of current athletes are motivated by the direct performance or health claims made for various supplements (Burke et al., 2002, p.479; Stephens, 2001). Supplements promise to provide the athlete with a performance edge; meet unusual nutrient demands induced by heavy exercise; improvements in muscular strength and performance; prolonged endurance and faster recovery; losses of body fat; resistance to fatigue, illness or infection (Burke et al., 2002, p.455; Stephens, 2001). Many rugby players resort to using protein supplements, creatine and β-hydroxy-β-methylbutyrate (HMB) to increase their muscle mass (Meltzer & Fuller, 2005, p.141).

Supplements are classified as dietary supplements and nutritional ergogenic aids. Dietary supplements (sports drinks, sports gels, high CHO supplements, liquid meal supplements, sports bars, vitamin and mineral supplements) contain nutrients in amounts similar to the levels specified in the Dietary Reference Intakes (DRI) and similar to the amounts found in food. Nutritional ergogenic aids (creatine, stimulants, bicarbonate, macronutrient supplementation and herbal products) contain nutrients or other food components in amounts greater than nutrient DRI levels or the amounts typically provided by food (Burke et al., 2002, p.455). Dietary supplements, including CHO, proteins, vitamins, minerals and antioxidants, have a variety of roles in helping the athlete to achieve their nutritional goals for optimal performance (Burke et al., 2002, p.509). The role of most of the commonly sold nutritional ergogenic aids remains unsupported. There is good evidence that caffeine, bicarbonate and creatine offer the potential of performance benefits for specific athletes in specific situations. Further research is needed to clarify the potential for glycerol and antioxidant vitamins (Burke et al., 2002, p.509; Shröder et al., 2002, p.353). According to Fogelholm (2002, p.325) scientific data do not support the hypothesis that high micronutrient intake enhances performance in well-nourished athletes. Unless an individual is deficient in a given nutrient, supplementation with that nutrient does not have a major effect on performance (Berning, 2004, p.631).

Side effects of supplement use range from gastrointestinal symptoms and mood swings to heart and kidney failures (Batheja & Stout, 2001, p.33). Numerous cases of toxicity have been linked to the use of some supplements especially herbal products. The problems range from minor adverse reactions to serious physical disabilities and death (Burke et al., 2002, p.507, Winterstein & Storrs, 2001). Jaundice, liver damage, liver cancer, stunted growth in adolescents, muscle injuries, acne, abnormalities of the male and female reproductive systems, headache, dizziness, palpitations, restlessness, problems with coordination and balance, eating disorders, psychosis, addiction and dehydration have been documented (SAIDS, 2001). Overuse of protein supplements can be counterproductive and result in too much bulk and, and ultimately, fat mass gain (Meltzer & Fuller, 2005, p.141).

Supplement use may also have an inadvertent doping outcome and cause a failure to consider other real performance enhancing strategies (Burke et al., 2002, p.503). Before using a sport supplement a sound nutritional program is an indispensable prerequisite to athletic success and physique enhancement (Batheja & Stout, 2001, p.19). Supplements should never be taken to replace dietary strategies (Meltzer & Fuller, 2005, p.141). Some rugby players use an excessive amount of supplements and neglect their daily dietary intake (Smolin & Grosvenor, 2000, p.251). The athlete who wants to optimise exercise performance needs to follow good nutrition and hydration practices, minimise severe weight loss practices and eat a variety of foods in adequate amounts and lastly use supplements and ergogenic aids carefully (ACSM et al., 2000).

The literature available on the supplement use of South African and international rugby players are very limited. According to Burke et al. (2002, p.479-480) most studies fail to provide the most interesting information: the type of supplements used, the amounts taken and the rationale for their use (Jonnalagadda et al., 2001). Health professionals often lack the knowledge about the adverse effects, confidence in reporting side effects, routinely communicating with patients about supplements use and recording herbs and dietary supplements information in the medical record (Kemper et al., 2002, p.882).

This study was undertaken to identify the usual dietary intake and supplement use of the under 21 (u/21) Blue Bulls rugby players with the view to develop suitable nutrition education messages according to the problems related to dietary and supplement use; and to set up practical guidelines for the safe and effective use of supplements. There is also a possibility that other u/21 rugby players of different teams or university rugby players of the same age have the same eating habits and tendency to use supplements as the study population.

1.3 Objectives of this study

The main aim of this study was to determine the dietary intake and the use of supplements by 30 u/21 male rugby players from the Blue Bulls. The objectives of the study were to determine the:

1.3.1 usual dietary intake of the 30 u/21 rugby players;
1.3.2 supplement use of the 30 u/21 rugby players

Recommendations will be made regarding the adequacy of the usual dietary intake and supplement use among u/21 rugby players.

1.4 Organisation of the script

Chapter 2 that provides a review of the literature available follows the introductory chapter. Chapter 2 are divided into two parts. The first part discusses the recommendations for dietary intake that includes the energy, macronutrients, micronutrients and fluid intakes. The recommendations for supplement use by athletes are summarised in the second part of chapter 2.

The methodology used for this study is discussed in chapter 3 that include the study design, study population, measurements including variables and techniques, procedure and statistical analysis.

Chapter 4 includes a description of the results. The discussion of the results with reference to the relevant literature, conclusion and recommendations for further research are made in chapter 5.

A summary (600 words) in both Afrikaans and English are included in the back of the script.

CHAPTER 2 – LITERATURE STUDY

2.1 Introduction

Compared to all the sciences, nutrition may have more to offer the athlete than any other. Choosing appropriate foods in suitable amounts at the correct time will however, not compensate for a lack of natural ability, a reluctance to undertake the required training or an absence of tactical awareness. A poor diet will prevent athletes from achieving their potential. However, sports nutrition is in a process of constant change and evolution. New information emerges and the concept of what constitutes an appropriate diet changes. The recommendations given to athletes today are very different from those of a decade ago. The performances of today's athletes are far superior to those achieved in earlier times and as with improvements in the health of the general population, nutritional advances have played a role (Maughan & Burke, 2002, p.1-2).

Athletes of all performance levels strive to maximise physical abilities. Historically, ancient Greek Olympians ate mushrooms to enhance physical performance. Athletes in modern times have focused on dietary supplements as ergogenic aids to increase work output. Consumption of dietary supplements and ergogenic aids have become commonplace among athletes (Guest et al., 2004, p.21). Nutritional ergogenic aids have enjoyed recent attention and notoriety in the past decade more so than ever before. New regulations, more scientific study, more usage, more controversy, more media focus and more public scrutiny have enormously increased the awareness of nutritional ergogenic aids, but not necessarily an understanding. As with any emerging topic there are many hidden agendas, misperceptions, dogmas and beliefs surrounding ergogenic aids (Turpin et al., 2004, p.3-4).

Within this chapter the cycles of the mesocycle, dietary intake and supplement recommendations, specifically for rugby players will be discussed.

2.2 Cycles of the mesocycle

Periodisation offers a strategic advantage by organising training in cycles (phases) to optimise ones true genetic potential and help one attain peak performance. The mesocycle is of key importance in achieving peak competitive performance. It consists of 5 step-wise cycles: preparation or conditioning, basic strength and power (pre-season), in-season (pre-competition), peak or competition, and transition or active rest. Cyclic training provides the body with the variation in stress loads it can productively cope with, thereby preventing overstraining or under training. It also allows peak competitive performance to be reached at the right period of time, several times during the year (Matveyev, 1981). Dietary intake is influenced according to the intensity and volume of exercise during each cycle. The purpose and scope of each cycle will be mentioned.

2.2.1 Cycle 1 – conditioning

The purpose of the first cycle is to prepare the body to engage in future physically intensive athletic type strength and power training. The main focus of this cycle is low-intensity high volume aerobic work. Though endurance-oriented lifting, cycling, running and general conditioning activities, one should realise a positive change in aerobic capacity and body composition, as well as a decrease in % body fat and an increase in lean body mass. Rugby players need to have a certain level of aerobic fitness to decrease fatigue, associated with intensive weight training and to shorten the recovery time (Noakes & Du Plessis, 1996, p.195).

2.2.2 Cycle 2 – basic strength and power or pre-season

During cycle 2, gains in broad base strength provide the required foundation for further high intensity training. Strength, especially in the so-called power zone – the large muscles of the legs, hips, abdominal and lower back, increases sharply. This cycle, as set out by Matveyev (1981), is composed of a reduction in the volume in training and an increase in the intensity. Fewer repetitions of heavier weights are included.

2.2.3 Cycle 3 – in-season or pre-competition

Cycle 3 is associated with high-intensity explosive weight training. More repetitions of lighter weights are included. An increase in total strength can be expected. Cycle 3 is vital for success in rugby. Over training and injuries can occur in this cycle (Turnball et al., 1995, p.41).

2.2.4 Cycle 4 – competition or peak

Cycle 4, according to Matveyev (1981), involves peak strength and power training. There is a further increase in lifting intensity and a sharp reduction in volume. Rugby players emphasise movement speed, flexibility and technique work. Rugby players need to maintain strength and power levels developed during the off-season, by including weight-training twice a week. The first training session can include low-intensity exercise and the second training session medium to high-intensity exercise. Low-intensity exercise should be included after the competition day to prevent soar and stiff muscles and to increase muscle repair.

2.2.5 Cycle 5 – active rest

The wisdom of the active rest is that it contributes to steady long-term progress. Active rest is very important following a peaking or competitive period. When defined, it means that at the end of the mesocycle one should participate in another sport or recreational activity at a low to moderate intensity. The purpose of active rest is to help one generate physically and emotionally and rebuild ones motivational level before starting a new mesocycle. Examples of active rest include squash, jogging, swimming or bicycling 3 times per week. Two weeks of rest (doing nothing) are recommended for rugby players, followed by the active rest period of 2 to 4 weeks (Turnball et al., 1995, p.41).

2.3 Dietary recommendations for rugby players

Over the past 20 years research has clearly documented the beneficial effects of nutrition on exercise performance. There is no doubt that what an athlete eats and drinks can affect health, BW and composition, substrate availability during exercise, recovery time after exercise, and exercise performance (Manore & Thompson, 2002, p.124).

Nutritional aspects are based on periodisation depending on the type of exercise, intensity and duration of training. Dietary recommendations for rugby players will include energy, macronutrient, micronutrient, fluid and electrolyte recommendations; as well as pre-competition, competition and post-competition recommendations.

2.3.1 Energy

Meeting energy needs is the first nutrition priority for athletes. During times of high intensity training, adequate energy needs to be consumed to maintain BW, maximise the training effects and maintain health (ACSM et al., 2000). Achieving energy balance is essential for the maintenance of lean tissue mass, immune and reproductive function and optimal athletic performance (Manore & Thompson, 2002, p.124).

The energy metabolism and energy recommendations for rugby players will be discussed. The consequences of insufficient and excessive energy intakes are also included.

2.3.1.1 Energy metabolism

During physical activity the muscle cell convert energy, obtained from fuels stored as glycogen in muscle, as fat in adipose tissue and as circulating fuels (glucose and free fatty acids) into adenosine triphosphate (ATP) (Meltzer & Fuller, 2005, p.148).

i. Energy systems

The human body must be supplied with energy continuously to perform its many complex functions (Berning, 2004, p.617). Exercise requires a coordinated physiological response involving the interplay between systems responsible for increased energy metabolism, supply of oxygen and substrates to contracting skeletal muscle and the maintenance of fluid and electrolyte status (Hargreaves, 2002, p.14). The body uses 4 different energy system to supply energy for different types of events, namely: the (ATP-CP) phosphagen energy system, the anaerobic glycolytic system, the aerobic glycolytic and the aerobic lipolytic systems

These energy systems do not switch on and off, but they always work together with one system predominating according to the intensity of effort (Meltzer & Fuller, 2005, p.148).

Today rugby is a high intensity, explosive activity and is mainly driven by the anaerobic energy system. The anaerobic energy is released from the breakdown of ATP. Anaerobic energy in the form of ATP is stored within the muscle or produced either by splitting creatine phosphate (CP) or by degrading CHO to pyruvate (glycolysis) which leads to the formation of lactate (Hargreaves, 2002, p.15-16). This energy system contributes energy during an all-out effort lasting up to 60 to120 seconds (Berning, 2004, p.617). During sprints, heavy weight training and intermittent maximal bursts during sports like rugby, muscle glycogen rather than fat is the major fuel (Bean, 2003, p.9).

Aerobic fitness is needed for perseverance to complete 80 minutes of the game, to rest in between intervals and to follow a high work tempo (Bean, 2003, p.11). The production of ATP in amounts sufficient to support continued muscle activity requires the input of oxygen (Berning, 2004, p.617). A minor aerobic energy contribution can occur by the degradation of adenosine diphosphate to adenosine monophosphate and further to inosine monophosphate (IMP) and ammonia (NH_3). The aerobic energy is produced in the mitochondria in the muscle cell by using oxygen (Hargreaves, 2002, p.16). Table 1 gives a summary of the energy systems used during high intensity, interval activity such as rugby (Bean, 2003, p.11).

Table 1. Energy systems used during high intensity, interval activity (Bean, 1998, p.112)

	ANAEROBIC (without oxygen)		**AEROBIC (with oxygen)**
	CP-system	LA system	
Intensity	Very high Explosive 95-100%max effort	High 60-95% max effort	Up to 60% max effort
Duration	Up to 10 seconds	Up to 30 seconds (95% max) Up to 30 minutes (60% max)	No limit
Fuel	PC and ATP	Muscle glycogen & blood glucose	CHO, fat & protein
Waste product	None	Lactic acid	$CO2 + H2O$
Recovery time	Very quick	20 minutes to 2 hours	Time to replace fuel stores
In Rugby	Sprint to fast running score	Sprint to fast running score	Back-ground run/jog

*CP-Creatine phosphate
**LA-Lactic acid

ii. Conversion of food to fuel

Energy (fuel), measured in kilojoules (kJ) is provided in kJ per gram (kJ/g) by macronutrients CHO (17 kJ/g), protein (17 kJ/g) and fat (38 kJ/g). The body needs these nutrients in relatively large amounts (Meltzer & Fuller, 2005, p.15). Additional energy can be obtained from the oral intake of food and fluids that provide nutrients and contribute to the circulating fuels in the blood (Meltzer & Fuller, 2005, p.27).

The rate of ATP production during exercise and thus utilisation of substrates is controlled by the intensity of activity. Amino acid oxidation occurs to a limited extent during exercise. CHO and lipids are the most important oxidative substrates. During high intensity exercise, mitochondrial oxidation of free fatty acids (FFA) derived from both adipose tissue and muscle triglycerides are reduced and CHO is the major fuel. Amino acids, particularly branched chain amino acids can be oxidised during prolonged exercise. The contribution from amino acids is enhanced when CHO reserves are low. This is particularly important for athletes in heavy training who are likely to place a large stress on their endogenous CHO reserves (Hargreaves, 2002, p.18).

The amino acids in the plasma come from protein breakdown. The pathways for protein degradation in human skeletal muscle include the lysosomal and non-lysosomal (ubiquitin and calpain) pathways. During exercise it appears that the branched-chain amino acids (isoleucine, leucine and valine) are preferentially oxidised to their keto-acid analogues. In the cytosol, the amino-N group is transaminated to form glutamate that is in turn transaminated with pyruvate to form glutamate, which is in turn transaminated with pyruvate to form alanine or aminated to form glutamine. Some of the amino-N may end up as free ammonia released from muscle, however, during high intensity contractions most of the ammonia comes from myoadenylate deaminase pathway (Tarnopolsky, 2002, p.93-94).

The CHO for glycolysis is primarily glycogen stored within the exercising muscles, but glucose taken up from the blood can also be used. The glucose is taken up from the gut and released to the blood from the liver that forms the glucose from breakdown of glycogen (glycogenolysis) or from precursors such as glycerol, pyruvate, lactate and amino acids (gluconeogenesis) (Hargreaves, 2002, p.15).

The substrates for fat oxidation are triglycerides (TG) stored within the muscles and fat carried in the blood (endogen energy) primarily FFA released from adipose tissue and to a lesser extent TG (Berning, 2004, p.619). The different processes related to energy production are summarised in Figures 1 and 2 (Hargreaves, 2002, p.15; Ekblom, 1994).

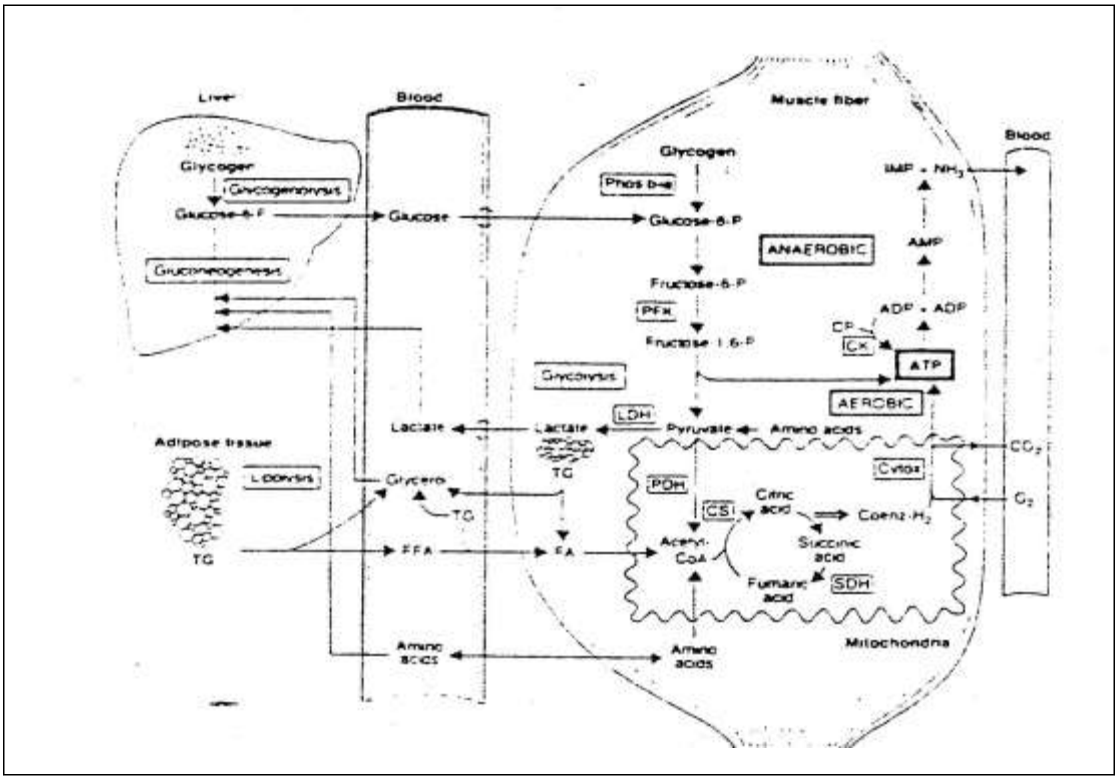

Figure 1. Biochemical pathways for ATP production in skeletal muscles and sources of substrates (Ekblom, 1994).

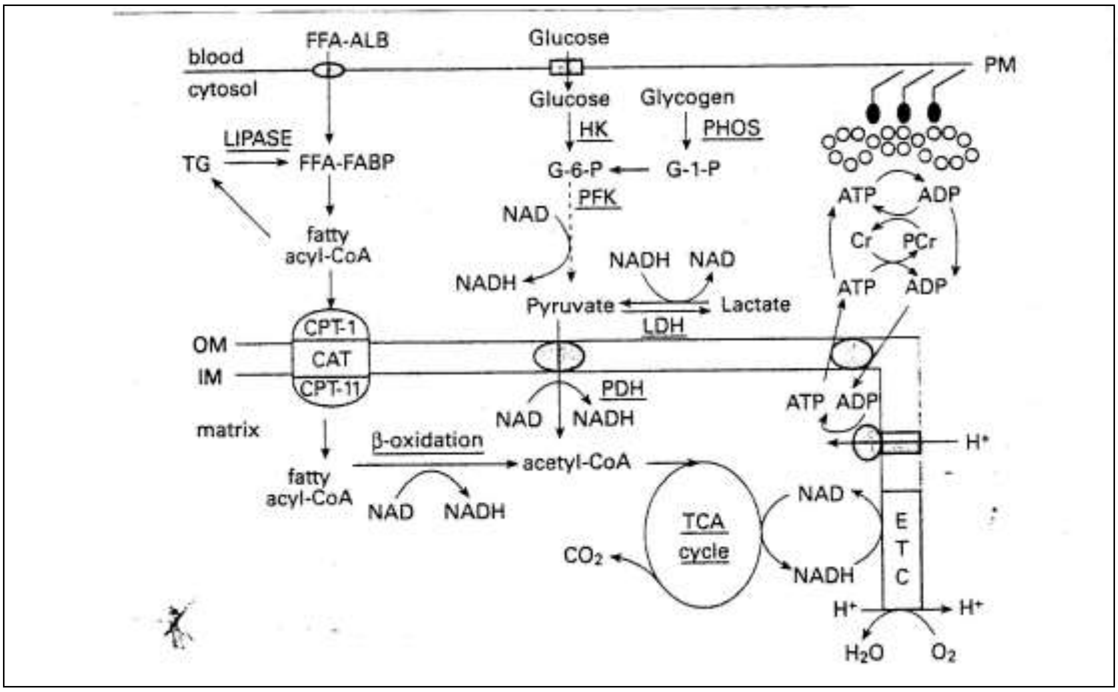

Figure 2. Schematic overview of energy metabolism in skeletal muscle (Hargreaves, 2002, p.15, figure 2.1).

CHO, fats and proteins are all capable of providing energy for exercise and can all be transported to and broken down in muscle cells (Bean, 2003, p.4). CHO and fat can be used as energy substrates during rugby depending on the intensity and duration of the activity, preceding diet and substrate availability, training status and environmental factors (Hargreaves, 2002, p.16; Bean, 1998, p.52). Proteins do not make a substantial contribution to the fuel mixture, except during prolonged or very intense bouts of exercise (Bean, 2003, p.4).

2.3.1.2 Energy recommendations

Traditionally, energy recommendations have been based on self-recorded estimates of food intake. However, it is now well accepted that these methods do not provide accurate or unbiased estimates of a person’s energy intake and that underestimation of food intake is pervasive (Frary & Johnson, 2004, p.29). The energy recommendations according to the new prediction equations will be discussed.

New prediction equations have been developed to estimate energy requirements for people according to their life-stage group. Table 2 lists average DRI values for energy in healthy, active people of reference height, weight and age for each life-stage group (Frary & Johnson, 2004, 29). The DRI is a set of 4 lists of nutrient intake values for healthy people in the United States and Canada. The DRI’s include Recommended Dietary Allowances (RDA), Adequate Intakes (AI), Tolerable Upper Intake Levels (UL) and Estimated Average Requirements (EAR). These values are used for planning and assessing diets. RDA is the nutrient intake goals for individuals, derived from the EAR. AI is used when RDA is not calculated. The UL is suggested upper limits of intake for potentially toxic nutrients that may cause illness or toxicity above these intakes. EAR is the population-wide average nutrient requirements used in nutrition research and policymaking (Sizer & Whitney, 2004, p.32).

Table 2. RDA/AI Values for Energy for Active Individuals, based on the Institute of Medicine of the National Academies (Frary & Johnson, In: Mahan & Escott-Stump, 2004, p.29, table 2.2)

		ACTIVE PAL EER (kJ/day)	
LIFE-STAGE GROUP	**CRITERION**	**MALE**	**FEMALE**
Infants			
0-6 months	Energy expenditure +	2394	2184 (3 months)
7-12 months	Energy deposition	3120,6	2839,2 (9 months)
Children			
1-2 years	Energy expenditure +	4393,2	4166,4 (24 months)
3-8 years	Energy deposition	7316,4	6896,4 (6 years)
9-13 years		9571,8	8698,2 (11 years)
14-18 years		13238,4	9945,6 (16 years)
Adults			
›18 years	Energy expenditure	12881,4	10092,6 (19 years)

Table 3 lists the estimated energy requirements (EER) prediction equations for boys 3 years and older and men 19 years and older. All equations have been developed to maintain current BW and current levels of physical activity for all subsets of the population; they are not intended to promote weight loss (Frary & Johnson, 2004, p.29).

The EER incorporates age, weight, height, gender and level of physical activity for people ages 3 years and older. Physical Activity (PA) coefficients correspond to a person's physical activity level (PAL). Four lifestyle categories of physical activity levels have been identified as sedentary, low active, active and very active (Frary & Johnson, 2004, p.30).

Table 3. Estimated Energy Expenditure Prediction Equations at four Physical Activity Levels (Frary & Johnson, 2004, p.30, box 2.1)

EER for Boys 3-8 years (within the 5th- 85th percentile for BMI) EER = TEE + Energy deposition EER = 88,5 – 61,9 x Age (years) + PA x (26,7 x Weight [kg] + Height [m]) + 20 (kJ for energy deposition)
EER for Boys 9-18 years (within the 5th – 85th percentile for BMI) EER = TEE + Energy deposition EER = 88,5 – 61,9 x Age (years) + PA x (26,7 x Weight [kg] + 903 x Height [m] + 25 (kJ for energy deposition) Where: PA = Physical activity coefficient for boys 3-18 years: PA = 1,0 if PAL is estimated to be ≥ 1,0 < 1,4 (Sedentary) PA = 1,13 if PAL is estimated to be ≥ 1,4 < 1,6 (Low active) PA = 1,26 if PAL is estimated to be ≥ 1,6 < 1,9 (Active) PA = 1,42 if PAL is estimated to be ≥ 1,9 < 2,5 (Very active)
EER for Men 19 years and older (BMI 18,5-25 kg/m² EER = TEE EER = 662 – 9,53 x Age (years) + PA x (15,91 x Weight [kg] + 539,6 x Height [m]) Where: PA = Physical activity coefficient: PA = 1,0 if PAL is estimated to be ≥ 1,0 < 1,4 (Sedentary) PA = 1,11 if PAL is estimated to be ≥ 1,4 < 1,6 (Low active) PA = 1,25 if PAL is estimated to be ≥ 1,6 < 1,9 (Active) PA = 1,48 if PAL is estimated to be ≥ 1,9 < 2,5 (Very active)

A nutrition professional can determine Estimated Energy Expended in Physical Activity (EEPA) with the method shown in Table 4, which represents energy spent by adults during various intensities of physical activity – energy that is expressed as metabolic equivalents (METs). Example: an adult who weighs 65 kg and is walking moderately at a pace of 4 miles per hour (mph) (MET value of 4,5) for 1 hour would expend 293 calories/ 1230,6 kilojoules (65 kg x 4,5 x 1 = 293 calories)

The highest energy requirements are for young athletes, strong build, still growing with high percentage fat free mass and who train for long durations at a high intensity (Frary & Johnson, 2004, p.29). Every rugby player's energy requirements are specific according to the individual's needs. According to previous research (Burke, 1998, p.41) the most important factors determining the energy needs, are the basal metabolic speed, growth and muscular work (Burke, 1998, p.41). According to

Frary and Johnson (2004, p. 29) the highest energy intakes occur among 16 to 29 year olds.

Table 4. Intensity and Impact of Various Activities on Physical Activity Level in Adults (Frary & Johnson, 2004).

PHYSICAL ACTIVITY	METs	ΔPAL/ 10 MIN	ΔPAL/ HOUR
Daily activities			
Lying quietly	1	0	0
Riding in a car	1	0	0
Light activity while sitting	1,5	0,005	0,03
Watering plants	2,5	0,014	0,09
Walking the dog	3	0,019	0,11
Vacuuming	3,5	0,024	0,14
Doing household tasks (moderate effort)	3,5	0,024	0,14
Gardening (no lifting)	4,4	0,032	0,19
Mowing lawn (power mower)	4,5	0,033	0,20
Leisure Activities: Mild			
Walking (2 mph)	2,5	0,014	0,09
Canoeing (leisurely)	2,5	0,014	0,09
Golfing (with cart)	2,5	0,014	0,09
Dancing (ballroom)	2,9	0,018	0,11
Leisure Activities: Moderate			
Walking (3 mph)	3,3	0,022	0,13
Cycling (leisurely)	3,5	0,024	0,14
Performing callisthenics (no weight)	4	0,029	0,17
Walking (4 mph)	4,5	0,033	0,20
Leisure Activities: Vigorous			
Chopping wood	4,9	0,037	0,22
Playing tennis (doubles)	5	0,038	0,23
Ice skating	5,5	0,043	0,26
Cycling (moderate)	5,7	0,045	0,27
Skiing (downhill or water)	6,8	0,055	0,33
Swimming	7	0,057	0,34
Climbing hills (5 kg load)	7,4	0,061	0,37
Walking (5 mph)	8	0,067	0,4
Jogging (10 minute mile)	10,2	0,088	0,53
Skipping rope	12	0,105	0,63

The RDA/AI values for energy for active individuals who are male and older than 18 years are 12 881,4 kJ per day (kJ/d) (Berning, 2004, p.618). Rugby players training or competing at a high intensity for longer than 90 minutes per day should increase their daily energy intake to 210 kJ/kg BW/d or more (ACSM et al., 2000, p.2123). The energy intake should increase from the conditioning to the competition cycle. Pre-, during and post exercise meals may need increased energy intakes for additional fuel and muscle recovery.

2.3.1.3 Insufficient and excessive intake

Inadequate energy intake relative to energy expenditure compromises performance and the benefits associated with training. Limited energy intake will cause an athlete to use fat and lean body mass for fuel (ACSM et al., 2000, p.2132). Insufficient energy intake will compromise the ability to obtain other essential nutrients such as CHO, protein, fat, vitamins and minerals that are necessary for sport performance and good health. Growth in younger athletes may be retarded and possibly stunted (Manore & Thompson, 2002, pp.124-126).

Insufficient energy intake fail to provide adequate protein and this is associated with complications including arrhythmia, heart failure and death. Initially a rapid early weight reduction is induced due to loss of glycogen, water and protein. After glycogen stores are exhausted stored fat is almost exclusively used to provide energy and this produces substantial ketosis. Potential side effects of insufficient energy include nausea, halitosis (bad breath), hunger, headaches, hypotension, light-headedness and precipitation of gout. Serious effects including glycogen depletion, loss of lean body mass, dehydration, electrolyte imbalance and hypotension make insufficient energy intake unsuitable and dangerous for athletes. Fatigue, decreased concentration and a fall in exercise performance can also occur. Weight loss in males is associated with endocrine changes e.g. reductions in testosterone. These reductions in testosterone concentration may make it difficult to optimise lean body mass and performance. Insufficient energy intake may result in an inadequate CHO and fat intake and these impacts on immunity. Energy restriction itself may induce a dysphoric mood and increase the risk of disordered eating in athletes (O'Connor et al., 2002, pp.156, 161- 166).

Excessive energy intake can lead to an increase in body mass and overweight which is the consequence of a positive energy balance. Overweight may influence sports performance. Lifestyle diseases e.g. hypertension and overweight may also occur (Manore & Thompson, 2002, p.124-126).

2.3.2 Macronutrients

According to McArdle et al., (2000, p.190) active men and women do not need additional supplementation if a balanced diet is taken in regularly. During times of high physical activity, energy and macronutrient needs must be met in order to maintain body weight, replenish glycogen stores and provide adequate protein for building and repair of tissue (ACSM et al., 2000, p.2130). The macronutrients include CHO, fat and protein.

2.3.2.1 Carbohydrates

Dietary CHO plays an important role for those who maintain a physically active lifestyle. The depletion of body CHO stores is a major cause of fatigue during exercise. Optimising CHO status in the muscle and liver is a primary goal of competition preparation. The key ingredient for glycogen storage before training or competition is dietary CHO intake and in the case of muscle stores tapered exercise or rest. The ingestion of CHO during high intensity exercise of about 1 hour may be useful for performance (Burke, 2002, p.343, 371). Recovery after exercise poses an important challenge to the modern athlete. Muscle glycogen resynthesis takes precedence over restoration of liver glycogen and even in the absence of a dietary supply of CHO after exercise it occurs at a low rate (Burke, 2002, p.396).

Both CHO metabolism and recommendations are important factors to consider. The consequences of excessive and insufficient intakes will be highlighted.

i. Carbohydrate metabolism

CHO balance is proposed to be precisely regulated such that CHO intake matches CHO oxidation. The ingestion of CHO stimulates both glycogen storage and glucose oxidation and inhibits fat oxidation. Glucose not stored as glycogen is oxidised directly in almost equal balance to that consumed (Manore & Thompson, 2002, p.126). Regulation of CHO balance is strictly controlled as the body has limited CHO stores. CHO promote their own oxidation by stimulating insulin secretion and cellular glucose uptake (ACSM et al., 2000, p.2134).

The intensity of exercise determines which fuel is used to supply energy to the working muscle. An increase in the intensity of exercise will increase the contribution of CHO to the energy pool (Berning, 2004, p.619).

ii. Carbohydrate recommendations

Recommendations for CHO intake for physically active individuals require the assumption that TE intake balances daily energy expenditure (McArdle et al., 2000, p.46).

Physically active people should contain at least 50% to 60% of total daily energy intake (McArdle et al., 2000, p.46).

Specific CHO recommendations exist for the rugby exercise cycle (mesocycle). During the conditioning phase 5 to 7 g CHO/kg BW/d are recommended. Pre season (basic strength) CHO intake should include 6 to 8 g CHO/kg BW/d. In season training and competition nutrition should include 7 to 10 g CHO/kg BW/d (O'Connor et al., 2002, p.169). During the off-season rugby players can ingest 5 g CHO/kg BW/d (Hawley & Burke, 1998, p.215; Burke, 1998, p.45). Energy restriction is best achieved by the implementation of a moderate-high CHO intake (6 to 8 g CHO/kg BW/d) (O'Connor et al., 2002, p.169).

iii. Insufficient and excessive intake

Exercising muscles rely on CHO as the main source of fuel. Therefore diets low in CHO can lead to a lack of energy during exercise, early fatigue, loss of concentration and delayed recovery (Meltzer & Fuller, 2005, p.15). Low CHO diets in general can influence performance negatively (Bean, 2003, p.16). The restriction of CHO facilitates improved lipolysis and weight loss (O'Connor et al., 2002, p.157-165). The weight loss is almost entirely due to loss of glycogen and water (Bean, 2003, p.3). When a person does not replenish depleted glycogen stores by eating CHO, a loss of lean body mass due to gluconeogenesis may occur (Whitney & Rolfes, 2005, p.115). Low CHO intake drives food consumption in humans. A lack of CHO results in adverse effects including ketosis, headaches, fatigue, nausea and bad breath. These adverse effects and the associated reduction in performance make such diets ineffective. Restricting the combination of protein and CHO immediately post exercise may also be detrimental to recovery.

Inadequate CHO intake can decrease immunity (O'Connor et al., 2002, p.157-165).

Excessive CHO will be stored as fat (Meltzer & Fuller, 2005, p.15). CHO may influence fat gain if it is eaten in excess and with fat. Other ways in which CHO may influence disease risk depend on the type of CHO or the glycaemic index (GI) (O'Connor et al., 2002, p.157-165). High CHO diets, especially refined CHO may increase the risk for heart disease, diabetes, gastrointestinal health and cancer if ingested in excessive amounts (Whitney & Rolfes, 2005, p.124).

2.3.2.2 Fat

Even though maximal performance is impossible without muscle glycogen, fat also provides energy for exercise. Fat is the most concentrated source of food energy and supplies more than twice the energy as from protein or CHO. Fat provides essential fatty acids, such as linoleic acid that are necessary for cell membranes, skin, hormones and transport of fat-soluble vitamins (Berning, 2004, p.548).

Fat metabolism and fat recommendations need to be considered for sport performance and good health, as well as the insufficient and excessive use of fat.

i. Fat metabolism

Fat is the major fuel for light to moderate intensity exercise (Berning, 2004, p.631). Fat metabolism is not as precisely regulated as CHO balance and protein balance. Plasma FFA is the predominant fuel during low intensity exercise. Well-trained athletes oxidise more fat than the untrained due to improved mitochondrial density and an increased concentration of oxidative enzymes (O'Connor et al., 2002, p.154, 155).

Transport of fatty acids into the mitochondria may be enhanced at a given sub-maximal workload well-trained athletes have lower levels of circulating catecholamines. These adaptations along with a greater capillary density and an increase in intra-muscular triglycerides enhance the delivery of oxygen and improve the ability to utilise fat especially during low to moderate intensity exercise. Enhanced fat utilisation mostly aids in weight control. There is some evidence that supports greater fat oxidation during recovery from both a single bout of resistance training and a 16-week strength-training program (O'Connor et al., 2002, p.154, 155).

Rugby players train at a high intensity. During high-intensity exercise at 85% of VO_2 max there is a decline in total fatty acid oxidations compared to moderate-intensity exercise. Lipolysis is markedly suppressed and the contribution of fatty acids oxidation to the TE requirements of exercise is diminished. Continuous high-intensity exercise is associated with high rates of glycogenolysis and the production of lactic acid that accumulates in muscle and blood (Hawley, 2002, p.436).

ii. Fat recommendations

Standards for optimal lipid intake have not been firmly established. A fat intake of 20-30% of TE intake is recommended (Berning, 2004, p.631). According to Bean (2003, p.10) the International Conference on Foods, Nutrition and Sports Performance in 1991 recommended a fat intake of between 15% and 30% of TE intake for sports people. Most adults should consume at least 20% of their TE intake from fat, but athletes need at least 30%. According to Whitney and Rolfes (2005, p.162, 163) athletes may ingest up to 35% of the TE intake as dietary fat. Poli-unsaturated fatty acids should constitute 70% of the total fat % and saturated fatty acids should not exceed 10% of the TE intake (McArdle et al., 2000, p.51). The requirements for essential fatty acids are in the range of 3 to 5% of the dietary energy for linoleic acid and 0,5 to 1% of dietary energy for linolenic acid (Berning, 2000, p.548). Fat intake should not be below 15% of TE intake in order to ensure and unrestricted absorption of fat-soluble vitamins, particularly vitamin A and E (Berning, 2004, p.631). A small amount of fat, about 300 to 400 g is stored in muscles but the majority is stored around the organs and beneath the skin (Bean, 2003, p.4).

The fat recommendations for rugby players vary according to the exercise cycle. The proposed fat intake for rugby players is as follows: 33% of TE during the conditioning phase, 27% of TE during the basic strength phase, 25% of TE during in-season phase and 22% of TE during the competition phase. During the active rest phase, the weight that should have been gained has been gained. To promote good health, lipid intake should probably not exceed 30% of the TE (Berning, 2004, p.51).

iii. Insufficient and excessive intake

Eating too little fat carries risk as fat provides fat soluble vitamins and essential fatty acids which have important immune protective functions (Meltzer & Fuller, 2005, p.18). Chronically, low-fat diets often result in a low energy and low nutrient intake overall. Low energy diets quickly lead to depleted glycogen stores, resulting in poor energy levels, reduced capacity for exercise, fatigue, poor recovery between workouts and eventual burn-out (Bean, 2003, p.106). Insufficient fat intake to less than

15% of the TE intake will limit performance (O'Connor et al., 2002, p.160-161).

Eating a diet high in fat will cause more fat to be oxidised as a fuel source. Persons who have tried to perform on high-fat diets find that their performance suffers because of lower glycogen stores. Glycogen stores are limited because the amount of CHO consumed in the diet is limited (Berning, 2004, p.620). Over the long term a positive fat balance due to excess energy intake from a palatable high fat diet will lead to a progressive increase in total body fat stores as the body attempts to achieve energy balance (Manore & Thompson, 2002, p.127). The use of high fat diets in the longer term may be associated with an increased risk of cardiovascular disease, although endurance training should attenuate this risk (O'Connor et al., 2002, p.160-161).

2.3.2.3 Protein

Proteins are critical molecules that serve structural and regulatory functions in the human body. Protein contributes to the energy pool at rest and during exercise, but in fed individuals it probably provides less than 5% of the energy expended (ACSM et al., 2000, p.2134).

Whenever the body is growing, repairing or replacing tissue, proteins are involved. Protein metabolism and recommendations as well as the excessive and insufficient intake of proteins are important factors for nutrition for rugby players.

i. Protein metabolism

The human body appears to adapt to exercise by matching protein and energy intakes to cover any increase in demand from the activity in question. The majority of the energy for exercise is derived from the oxidation of lipid and CHO. Skeletal muscle has the metabolic capacity to oxidise certain amino acids for energy. Amino acid oxidation may be required for exchange reactions in tricarboxylic acid cycle and this may increase their net utilisation. The increase in amino acid oxidation with exercise has been shown with leucine and lysine tracers. An increase in indispensable amino acid oxidation may affect protein requirements since it can only come from dietary intake and/or protein breakdown. Muscle fractional synthetic rate and fractional protein breakdown are increased in the post exercise period following resistance exercise (Tarnopolsky, 2002, p.96).

After body protein needs are met, the carbon skeletons of any excess amino acids are diverted into the energy substrate pool and used for energy. The adequacy of TE intake and CHO intake in particular, appear to dramatically affect this process (Manore & Thompson, 2002, p.127). Protein stores are tightly controlled (O'Connor et al., 2002, p.150).

ii. Protein recommendations

The majority of strength and endurance athletes consume adequate protein and energy to meet their needs. Even when one takes into account the modest increases required by certain athletes, most athletes are still above these levels (Tarnopolsky, 2002, p.90).

According to McArdle et al. (1999, p.191) the normal protein recommendations for sedentary people is 0, 8 g/kg BW/d. Protein intake recommended for power sports, including rugby players, vary from 1,4 to 1,8 g protein/kg BW/d (Bean, 2003, p.39; Smolin & Grosvenor, 2000, p.404; Tarnopolsky, 2000, p.109; Burke, 1998, p.48). Protein intake should be approximately 1, 2 to 1,4 g protein/kg BW/d during endurance training and 1,6 to1, 7 g protein/kg BW/d during resistance and strength training (ACSM et al., 2000, p.2131). The upper level of protein intake is recommended if energy restriction is substantial as this may assist the maintenance of lean body mass and help promote satiety (O'Connor et al., 2002, p.169).

Protein recommendations must include the assumption of adequate energy intake to match the needs of exercise. A protein recommendation for the conditioning stage would be 1,2 to 1,3 g/kg BW/d. The basic strength and power cycle, recommends an upper limit of 1,7 g/kg BW/d. This recommendation is aimed for strength training athletes. During the pre-season stage the proposed protein recommendation is 1,5 g/kg BW/d. During the competition stage a protein intake of 1,3 g/kg BW/d are recommended. The recommendations for general sporting activities, which during the active rest cycle vary between cycling, volleyball, amongst others, is between 0,8 to 1,2 g/kg BW/d.

iii. Insufficient and excessive intake

Insufficient intakes of either energy or CHO result in negative protein balance. The catabolism of muscle glycogen may occur which causes a decrease in lean muscle mass (Manore & Thompson, 2002, p.127). Insufficient amounts of important minerals e.g. iron, zinc and copper may be ingested due to insufficient protein intake (Ettinger, 2004, p.67).

Excessive intake of energy or CHO will spare protein. This protein is then available to support brief periods of protein accumulation until the protein pool is expanded to a new balance point (Manore & Thompson, 2002, p.127). The excess protein consumed or the protein made available through protein sparing may contribute indirectly to fat storage by diverting dietary fat for storage (Manore & Thompson, 2002, p.127).

Excessive protein in the diet stimulates its own oxidation (O'Connor et al., 2002, p.150). High protein diets often promote the virtues of avoidance of fat as well as the ability of protein to assist in the maintenance of lean body mass. High protein diets are more satiating and therefore less energy is taken in (O'Connor et al., 2002, p.159).

2.3.3 Micronutrients

Micronutrients including vitamins and minerals play an important role in energy production, haemoglobin synthesis, maintenance of bone health, adequate immune function, build and repair of muscle tissue following exercise and the protection of body tissues from oxidative damage (ACSM et al, 2000).

Vitamins and minerals, including vitamin A, E, C, beta-carotene and selenium, that play an important role in protecting the cell membrane from oxidative damage, are called antioxidants (Berning, 2004, p.633). Antioxidants are thought to have a protective effect on the immune system (O'Connor et al., 2002, p.165). Strenuous exercise promotes free radical formation (Berning, 2004, p.633). Antioxidant vitamins participate in the buffer system against free radicals that are produced by increased energy turnover (Fogelholm, 2002, p.312). Antioxidant vitamins may have a role in enhancing recovery from exercise and maintaining optimal immune response (Berning 2004, p.633).

Regular, intense exercise increases the requirements for a number of vitamins and minerals such as vitamin E, C and B-vitamins (Bean, 2003, p.50). Exercise stresses many of the metabolic pathways in which these micronutrients are required, thus exercise training may result in muscle biochemical adaptations that increase micronutrient needs. Exercise may also increase the turnover of these micronutrients, thus increasing loss of micronutrients from the body (ACSM et al., 2000). It has been assumed that if the athlete meets requirements for increased energy, the vitamin and mineral requirements will also be satisfied. However, unless an individual is deficient in a given nutrient, supplementation with that nutrient does not have a major effect on performance (Berning, 2004, p.631).

The most important vitamins and minerals needed for energy metabolism and production are the B-complex vitamins, magnesium, iron, zinc, copper and chromium (Meltzer & Fuller, 2005, p.26). Vitamins and minerals are essential and will be discussed further.

2.3.3.1 Vitamins

Vitamins are organic compounds, essential in very small amounts in supporting normal physiologic function that cannot generally be biosynthesised quickly enough to meet the needs of the body (Gallagher, 2004, p.76). A distinct feature of vitamins is that the human body is not able to synthesise them (Fogelholm, 2002, p.312).

Vitamins are usually classified into two groups based on their solubility namely the fat-soluble vitamins and the water-soluble vitamins. The fat-soluble vitamins (A, D, E and K) are more soluble in organic solvents and the water-soluble vitamins (B complex and C) in water (Gallagher, 2004, p.76).

Most vitamins regulate processes essential for normal metabolism, growth and development (Meltzer & Fuller, 2005, p.24). Vitamin functions also include membrane stabilisers, hydrogen and electron donors and acceptors, hormones and coenzymes (Gallagher, 2004, p.76). Table 5 gives a summary of the functions of vitamins (Gallagher, 2004, p.114, 115).

Table 5. The functions of vitamins (Gallagher, 2004, p.114, 115).

Fat soluble vitamins	
Vitamin A	Antioxidant; growth and development; maintenance of epithelial tissue; essential for integrity of night vision; promote bone development and tooth formation
Vitamin D	Prohormone; growth and development; formation and maintenance of bone and teeth; influences absorption and metabolism of phosphorus and calcium
Vitamin E	Antioxidant; prevent oxidation of unsaturated fatty acids and vitamin A in intestinal tract and body tissue; protects red blood cells from haemolysis; role in epithelial tissue maintenance and prostaglandin synthesis
Vitamin K	Aids in production of pro-thrombin; bone metabolism
Water soluble vitamins	
Thiamine	Part of cocarboxylase; aids in removal of carbon dioxide (CO_2) from alpha-ketoacids during oxidation of CHO; essential for growth, normal appetite, digestion and healthy nerves
Riboflavin	Essential for growth; enzymatic role in tissue respiration and acts as a transporters of hydrogen ions; coenzyme forms flavine adenine mononucleotide (FMN) and flavine adenine dinucleotide (FAD)
Niacin	Part of enzyme system; transfer of hydrogen; acts in metabolism of CHO and amino acids; involved in glycolysis, fat synthesis and tissue respiration
Pantothenic acid	Part of coenzyme A; functions in synthesis and breakdown of many vital body compounds; essential in intermediary metabolism of CHO, fat and protein
Pyridoxine	Coenzyme; aids in synthesis and breakdown of amino acids and of unsaturated fatty acids from fatty acids; essential for conversion of tryptophan to niacin; essential for normal growth
Folate	Essential for biosynthesis of nucleic acids, especially in early foetal development; essential for normal maturation of red blood cells; functions as a coenzyme-tetrahydrofolic acid
Cobalamin	Involved in metabolism of single-carbon fragments; essential for biosynthesis of nucleic acids and nucleoproteins; role in metabolism of nervous tissue; involved with folate metabolism; related to growth
Biotin	Essential component of enzymes; involved in synthesis and breakdown of fatty acids and amino acids through aiding the addition and removal of CO_2 to or from active compounds and the removal of ammonium (NH_4) from amino acids
Ascorbic acid	Maintains intracellular cement substance with preservation of capillary integrity; co-substrate in hydroxylation requiring molecular oxygen; important in immune responses, wound healing and allergic reactions; increase absorption of nonheme iron

The functions of vitamins during exercise, vitamin recommendations, insufficient and excessive intake of vitamins for rugby players will be discussed.

i. Vitamins and exercise

Most vitamins participate in processes related to muscle contractions and energy expenditure (Fogelholm, 2002, p.313). Vitamins do not provide energy but are involved in the production of energy from fuel stores by acting as catalysts for metabolic reactions. More, specifically, they are responsible for the storage and utilisation of energy in the body (Meltzer & Fuller, 2005, p.24). Table 6 summarises the most important functions of vitamins on body functions related to athletic training and performance (Fogelholm, 2002, p.313).

Table 6. The most important functions of vitamins on body functions related to athletic training and performance (Fogelholm, 2002, p.313).

	Cofactors, activators for energy metabolism	**Nervous function, muscle contraction**	**Haemoglobin synthesis**	**Immune function**	**Anti-oxidant function**	**Bone metabolism**
Fat soluble vitamins						
Vitamin A				×	×	
Vitamin D						×
Vitamin E				×	×	
Vitamin K						
Water soluble vitamins						
Thiamine (B_1)	×	×				
Riboflavin (B_2)	×	×				
Niacin (B_3)	×	×				
Pantothenic acid	×					
Pyridoxine (B_6)	×	×	×	×		
Folate		×	×			
Cobalamin (B_{12})		×	×			
Biotin	×					
Ascorbic acid (C)				×	×	

Fat-soluble vitamins and water-soluble vitamins play important roles during exercise.

a) Fat soluble vitamins

Many athletes are exposed to high levels of oxidative stress due to increase in oxygen consumption during intense physical training or competition. High intake of carotenoids (precursors of vitamin A) may reduce the resulting damage, improve recovery, decrease chronic inflammation associated with sport injuries and stimulate the immune response. During outdoor sports carotenoids may protect the skin from sunburn and the eyes from light damage, ensure better acuity of vision and reduce glare. All these effects add up to improved condition of the athlete, general good health, stamina and the length of an individual's sport career, extending the ability to enjoy strenuous activities into the advanced age by preventing chronic diseases (Stacewicz-Sapuntzakis and Diwadkar-Navsariwala, 2004, p.345).

Vitamin D is required for adequate calcium absorption, regulation of serum calcium levels and promotion of bone health. Athletes who live at northern latitudes or who train primarily indoors throughout the year may be at risk for poor vitamin D status (ACSM et al., 2000). This is however, not applicable to athletes living at southern latitudes or who train outdoors throughout the year like most South African sports.

Vitamin E and other antioxidants may be especially effective for athletes exercising in extreme environments, such as heat, cold and high altitudes. During prolonged, high-intensity physical activity, the muscle's consumption of oxygen increases tenfold or more, enhancing the production of damaging free radicals in the body. Vitamin E is a potent antioxidant that vigorously protects cell membranes against oxidative damage (Whitney & Rolfes, 2005, p.488).

b) Water soluble vitamins

Water-soluble vitamins are not stored in the body and any intake in excess of daily requirements generally results in expensive urine. The most important vitamins needed for energy metabolism and production are the B complex group (Meltzer & Fuller, 2005, p.26).

B-complex vitamins are involved with muscle contraction, nerve function and also act as co-factors of enzymes for energy metabolism. Other functions of these nutrients include haemoglobin synthesis, immune and antioxidant function, as well as tissue repair and protein synthesis (Meltzer & Fuller, 2005, p.26). Thiamine, riboflavin, niacin, pantothenic acid, pyridoxine and biotin are involved in energy production during exercise (ACSM et al., 2000). The B-complex vitamins act as cofactors for enzymes regulating glycolysis, citric acid cycle, oxidative phosphorylation, beta-oxidation and amino acid degradation (Fogelholm, 2002, p.312). Folate and cobalamin are required for the production of red cells, protein synthesis and in tissue repair and maintenance (ACSM et al., 2000).

Vitamin C has several exercise-related functions. It is required for the formation of connective tissue and certain hormones, which are produced during exercise. Vitamin C is involved in the formation of red blood cells, which enhances iron absorption and it is a powerful antioxidant that can protect against exercise-related cell damage (Bean, 2003, p.50).

ii. Vitamin recommendations

According to ACSM et al. (2000) data available are not sufficiently precise to set separate vitamin recommendations for athletes or to quantitively link recommendations to energy expenditure. The current

RDA/AI is appropriate for athletes unless otherwise stated (ACSM et al., 2000). The RDA/AI and UI for vitamins according to the DRI's are summarised in Table 7 (Gallagher, 2004, pp.76-116).

Table 7. The RDA/AI and UI for individuals (males, 19-30 years of age) according to the DRI's for vitamin intake (Gallagher, 2004, pp.76-116).

	Recommended Dietary Allowance (RDA)/ Adequate Intake (AI)	**Tolerable Upper Intake (UI)**
Fat soluble vitamins		
Vitamin A	900 μg/d	3000 μg/d
Vitamin D	5 μg/d	50 μg/d
Vitamin E	15 mg d	1000 mg/d
Vitamin K	120 μg/d	ND
Water soluble vitamins		
Thiamin (B1)	1,2 mg/d	ND
Riboflavin (B2)	1,3 mg/d	ND
Niacin (B3)	16 mg/d	35 mg/d
Pantothenic Acid	5 mg/d	ND
Pyridoxine (B6)	1,3 mg/d	100 mg/d
Folate	400 μg/d	1000 μg/d
Cobalamin (B12)	2,4 μg/d	ND
Biotin	30 μg/d	ND
Ascorbic acid (C)	90 mg/d	2000 mg/d

iii. Insufficient and excessive intake

Short-term insufficiencies of vitamin intake is characterised by lowering of nutrient concentrations in different tissues and lowering of certain enzyme activities. Functional disturbances may appear later (Fogelholm, 2002, p.316). Deficiencies in any vitamins will impair metabolism, sport performance and health (Meltzer & Fuller, 2005, p.26).

Depletion studies show that even marginal vitamin deficiency conditions may impair physical performance. Nevertheless, the available data suggest that vitamin deficiencies in athletes are rare and no more common than in untrained individuals (Fogelholm, 2002, p.325).

Food (diet) rarely causes nutrient imbalances or toxicities, but supplements can. A higher dose causes a greater risk of harm (Whitney & Rolfes, 2005, p.360-361). The fat-soluble vitamins are stored in body tissues, so consuming excessive amounts of these vitamins can lead to toxicity and organ damage. However, this is not the case with water-soluble vitamins (Meltzer & Fuller, 2005, p.26). Table 8 summarises the deficiency and adverse effects/ toxicity symptoms associated with insufficient and excessive vitamin intake (Whitney & Rolfes, 2005, p.328-340; Turpin, Talbott, Feliciano & Bucci, 2004, p.479; Gallagher, 2004, p.82-103; Anderson, 2004, p.150; Fogelholm, 2002, p.316-329).

Table 8. Vitamins deficiency and toxicity symptoms (Whitney & Rolfes, 2005, p.328-340; Turpin, Talbott, Feliciano & Bucci, 2004, p.479; Gallagher, 2004, p.82-103; Anderson, 2004, p.150; Fogelholm, 2002, p.316-329).

Vitamin	Deficiency	Toxicity
Fat soluble vitamins		
Vitamin A and beta-carotene	Anaemia; cessation of bone growth; painful joints; diarrhoea; respiratory, bladder, digestive, vaginal infections; kidney stones; impaired growth; blindness; impaired vision	Liver damage, possible teratogenicity; overdoses can be lethal if continued; carotenemia (orange skin) –harmless; conflicting data on increased incidence of lung cancer from high dose (>100 000 IU/day) only in smokers drinking alcohol
Vitamin D	Bone pain and weakness; muscular tenderness, risk of fractures, joint pain, muscle spasms	Hypercalcaemia; tuberculosis, sarcoidosis at increased risk for adverse effects; most adverse effects from high-dose, parenteral administration (not applicable to dietary supplements)
Vitamin E	Red blood cell breakage, anaemia, weakness, leg cramps, increase in lipid peroxidation of cell membrane	Extensive human study data do not support adverse effects on coagulation at doses <2 400 IU/ day 1 of least toxic of the vitamins; decrease body's ability to use other fat soluble vitamins
Vitamin K	Haemorrhage, poor skeletal mineralisation, increased risk of hip fractures	Toxicity not common; no adverse effects; reduce effectiveness of anticoagulant drugs

Water soluble vitamins		
Thiamine	Exercise-induced blood lactate concentrations, anorexia, weight loss, cardiac and neurological signs, oedema, weakness, pain, apathy, loss of reflexes	No adverse effects
Riboflavin	Affect muscle metabolism and neuromuscular function – impair performance, inflammation of membranes of mouth, skin, eyes and gastrointestinal tract	Affect muscle metabolism and neuromuscular function; yellow discoloration of urine that might cause concern in people not aware of the origin of the colour
Niacin	Affect electron transport chain, include muscular weakness, anorexia, skin eruptions, vomiting, diarrhoea, abdominal pain, apathy and fatigue	Flushing (redness, tingling of face, neck), gastrointestinal upset, diarrhoea, vomiting, liver enzyme elevation, naturally occurring niacin from foods causes no harm
Pantothenic acid	Impairments in lipid synthesis and energy production; paresthesia in toes and soles of feet, burning sensations in feet, depression, fatigue, insomnia, weakness, vomiting	Mild intestinal distress and diarrhoea
Pyridoxine	Metabolic abnormalities, weakness, sleeplessness, peripheral neuropathies, cheilosis, glossitis, stomatitis and impaired immunity	Rare, sensory neuropathy (numbness, tingling),
Folate	Impaired biosynthesis of diribonucleic acid (DNA) and ribonucleic acid (RNA) - reducing cell division, poor growth, weakness, megaloblastic anaemia, depression and polyneuropathy, dermatological lesions	Interfere with zinc metabolism; naturally occurring folate from foods alone appears to cause no harm; excess folate from fortified foods can reach high enough levels to obscure a vitamin B_{12} deficiency and delay diagnosis of neurological damage
Cobalamin	Impaired cell division, pernicious anaemia, fatigue, neurological abnormalities, yellow skin and eyes, smooth and beefy tongue	No adverse effects
Biotin	Rare, skin rash, hair loss and neurological impairment	No adverse effects
Ascorbic acid	Anaemia, frequent infections, muscle degeneration, lesions, impaired wound healing, oedema, fatigue, haemorrhages; weakness in bone, teeth and connective tissue; swollen and bleeding gums, lethargy, rheumatic pains, muscular atrophy, reduced work efficiency at sub-maximal exercise	Acute (>2 000 mg): osmotic gastrointestinal effects; chronic (>2 000 mg/ day): rebound scurvy, oxalate kidney stones, pro-oxidant effects, excess iron uptake, vitamin B_{12} destruction, negative copper balance, lesions and impaired wound healing; oedema, haemorrhages, weakness in bone and connective tissue

2.3.3.2 Minerals

Minerals are inorganic substances found naturally on the earth (Fogelholm, 2002, p.312). The minerals are a large class of micronutrients, most of which are considered essential. Based on their daily requirements, minerals are usually classified as macro minerals or micro minerals. Macro minerals include calcium, phosphorus, magnesium and sulphur. Micro minerals include iron, zinc, fluoride, copper, iodine, selenium, manganese, chromium and molybdenum. Several other micro minerals of uncertain essentiality and requirements exist, including arsenic, boron, nickel, silicon and vanadium (Anderson, 2004, p.121).

Minerals have many essential roles, including serving as ions dissolved in body fluids and as constituents of essential molecules (Anderson, 2004, p.122). Several minerals act as enzyme activators in glycolysis, oxidative phosphorylation, maintenance of acid-base equilibrium, osmotic pressure, facilitate membrane transfer of essential nutrients and other molecules. Some minerals are structural constituents of extra cellular body tissues, involved in the growth process and immune function (Anderson, 2004, p.122). Minerals also affect muscle contraction (Fogelholm, 2002, p.312-314). Table 9 summarises the different functions of macro minerals and micro minerals in the body (Anderson, p.126-159).

The role of minerals during exercise, mineral recommendations, insufficient and excessive intake of minerals for rugby players will be summarised.

Table 9. Minerals and their functions (Anderson, 2004, p.126-159).

Macro minerals	**Functions**
Calcium	Bone and tooth formation; blood clotting; nerve transmission
Phosphorus	Bone and tooth formation; acid-base balance
Magnesium	Activates enzymes in protein synthesis
Sulphur	Acid-base balance; liver function
Micro minerals	
Iron	Constituent of haemoglobin and enzymes involved in energy metabolism
Zinc	Constituent of digestive enzymes
Fluoride	May be important to maintain bone structure
Copper	Constituent of enzymes associated with iron metabolism
Iodine	Constituent of thyroid hormones
Selenium	Functions in close association with vitamin E; involved in fat metabolism; antioxidant
Manganese	Constituent of essential enzyme systems and is rich in mitochondria of liver cells
Chromium	Constituent of some enzymes; involved in glucose and energy metabolism
Molybdenum	Constituent of an essential enzyme and flavoproteins
Boron	Functional efficiency of cell membranes
Cobalt	Constituent of cyanocobalamin, existing bound to protein in foods of animal origin; essential for normal function of all cells, particularly cells of bone marrow and nervous and gastrointestinal systems

i. Minerals and exercise

The most important macro and micro minerals needed for energy metabolism and production are calcium, magnesium, iron, zinc, copper and chromium (Meltzer & Fuller, 2005, p.26; Berning, 2004, p.631).

a) Macro minerals

Calcium is an integral part of bone structure, providing a rigid frame that holds the body upright and serves as attachment points for muscles, making motion possible (Whitney & Rolfes, 2005, p.413). Calcium is required for nerve transmission and regulation of heart muscle function (Anderson, 2004, p.125).

Phosphorus assists in energy metabolism. Many enzymes and the B-vitamins become active only when a phosphate group is attached (Whitney & Rolfes, 2005, p.419). The major cellular form of energy, ATP contains high-energy phosphate bonds, as do CP and phosphoenolpyruvate (Anderson, 2004, p.129).

Magnesium stabilises the structure of ATP in ATP-dependent enzyme reactions and is important in neuromuscular transmission and activity (Anderson, 2004, p.131). Magnesium is a required component for ATP metabolism and is therefore essential to the body's use of glucose, the synthesis of protein, fat, nucleic acids and the cells' membrane transport systems (Whitney & Rolfes, 2005, p.420).

Sulfur exists in the body as a constituent of 3 amino acids namely cystine, cysteine and methionine. Sulfur is also an essential component of 3 vitamins namely thiamin, biotin and pantotheic acid. Sulfur plays a role in cellular reactions and the structural modifications necessary for the activity of some enzymes, insulin and other proteins (Anderson, 2004, p.133).

b) Micro minerals

Iron performs several functions vital to muscle activity (Anderson, 2004, p.631). Iron forms a part of the electron carriers that participate in the electron transport chain which transfer hydrogen and electrons to oxygen, forming water and making ATP for the cell's energy use (Whitney & Rolfes, 2005, p.439).

Zinc plays important roles in growth, building and repair of muscle tissue and energy production (ACSM et al., 2000). Zinc supports the work of numerous proteins in the body, including the metalloenzymes that: manufacture heme for haemoglobin, participate in essential fatty acid metabolism, metabolise CHO, synthesise proteins and dispose damaging free radicals (Whitney & Rolfes, 2005, p.447).

Fluoride has no known requirement in human metabolic pathways (Anderson, 2004, p.147)

Copper plays an important role in many enzymes functions (Anderson, 2004, p.148). The copper-containing enzymes have diverse metabolic roles with one common characteristic: all involve reactions that consume oxygen or oxygen radicals (Whitney & Rolfes, 2005, p.454). Copper also has roles in mitochondrial energy production and protects against oxidants and free radicals (Anderson, 2004, p.149).

Iodine is an integral part of the thyroid hormones that regulate body temperature, metabolic rate, growth, blood cell production, nerve and muscle function. By controlling the rate at which the cells use oxygen, these hormones influence the amount of energy released during basal metabolism (Whitney & Rolfes, 2005, p.451).

Selenium is one of the body's antioxidant nutrients, working primarily as a part of the enzyme glutathione peroxidase. Glutathione peroxidase prevents free radical formation (Whitney & Rolfes, 2005, p.453). Selenium and vitamin E has an antioxidant effect on oxidative damage (Anderson, 2004, p.151).

Manganese is a component of many enzymes, including glutamine synthetase, pyruvate carboxylase and mitochondrial superoxide dismutase. Manganese is associated with the formation of connective and skeletal tissues, growth and reproduction and CHO and lipid metabolism (Anderson, 2004, p.154).

Chromium potentiates insulin action and as such influences CHO, lipid and protein metabolism (Anderson, 2004, p.155).

Molybdenum acts as a working part of several metalloenzymes (Whitney & Rolfes, 2005, p.457). Interrelationships among molybdenum, copper and sulphate absorption and between molybdenum intake and copper excretion have been demonstrated (Anderson, 2004, p.156).

The essentiality of boron for humans has not yet been established. Boron apparently binds to the active site of enzymes, reducing their ability to function. Boron is also thought to compete with some enzymes for the coenzyme nicotinamide adenine dinucleotide (NAD) (Anderson, 2004, p.157).

The well-known essential role of cobalt is as a component of cobalamin (vitamin B_{12}). The vitamin is essential for the maturation of red blood cells and the normal function of all cells. Methionine amino peptidase, an enzyme involved in the regulation of translation (DNA to RNA) is the only enzyme in humans, known to have an established requirement of cobalt (Anderson, 2004, p.158).

ii. Mineral recommendations

The data to date are insufficient to allow any quantification of mineral requirements in athletes. The RDA/AI for vitamin and minerals may still be used with caution for athletes, because of a wide safety margin (Fogelholm, 2002, p.320). The RDA/AI and UL have been established for 9 essential micro minerals namely chromium, copper, iodine, iron, manganese, molybdenum, selenium, zinc and fluoride (Anderson, 2004, p.126-159).

Table 10 gives a summary of the RDA/AI and UI for individuals according to the DRI's for mineral intake (Anderson, 2004, pp.126-.159).

Table 10. The RDA/AI and UI for individuals (male, age 19-30 years of age) according to the DRI's for mineral intake (Anderson, 2004, pp.126-159).

Macro minerals	**RDA/ AI**	**UI**
Calcium	1000 mg/d	2500 mg/d
Phosphorus	700 mg/d	4000 mg/d
Magnesium	400 mg/d	350 mg/d
Sulphur	ND	ND
Micro minerals		
Iron	8 mg/d	45 mg/d
Zinc	11 mg/g	40 mg/d
Selenium	55 μg/d	400 μg/d
Copper	900 μg/d	10 000 μg/d
Chromium	35 μg/d	ND
Fluoride	4 mg/d	10 mg/d
Iodine	150 μg/d	1100 μg/d
Manganese	2,3 mg/d	11 mg/d
Molybdenum	45 μg/d	2000 μg/d
Cobalt	Expressed in terms of vitamin B_{12}	
Arsenic		ND
Boron	ND	20 mg/d
Nickel		1 mg/d
Silicon		ND
Vanadium		1,8 mg/d

iii. Insufficient and excessive intake

Athletes at risk of poor micronutrient status are those who restrict energy intake or use severe weight loss practices, eliminate 1 or more of the food groups from their diet or consume high CHO, low micronutrient dense diets (ACSM, 2000, p.2135).

Short-term insufficiencies of mineral intake is characterised by lowering of nutrient concentrations in different tissues and lowering of certain enzyme activities. Functional disturbances may appear later (Fogelholm, 2002, p.316, 330). Sports performance may also be reduced.

Very large intakes increase the body pool and activity of some enzymes but do not necessarily improve functional capacity. The body pool of macro minerals and especially of trace elements is under strong homeostatic control. Therefore excessive intake by dietary means or supplements is rare. If however, toxic symptoms appear, they are severe and can even be fatal. Intakes needed for toxic effects are extremely high (Fogelholm, 2002, p.316, 330). Table 11 lists the deficiency and adverse effects/ toxicity symptoms associated with insufficient and excessive mineral intake (Whitney and Rolfes, 2005, p.421-457; Anderson, 2004, p.127-158; Bean, 2003, p.52; Fogelholm, 2002, p.325-330; Haymes & Clarkson, 1998, p.100).

Table 11. Mineral deficiency and toxicity symptoms (Whitney and Rolfes, 2005, p.421-457; Anderson, 2004, p.127-158; Bean, 2003, p.52; Fogelholm, 2002, p.325-330; Haymes & Clarkson, 1998, p.100).

Minerals	**Deficiency**	**Toxicity**
Macro minerals		
Calcium	Bone demineralisation, osteomalacia	Gastrointestinal upset, constipation; kidney stone; possible suppression of copper, iron, manganese, zinc uptake
Phosphorus (phosphate)	Neural, muscular, skeletal, haematological, renal and other abnormalities; symptoms result primarily from decreased synthesis of ATP	Gastrointestinal upset; osmotic diarrhoea with very large doses (over 4-5 g at once)
Magnesium	Tremors, muscle spasms, personality changes, anorexia, nausea and vomiting; hypocalcaemia, hypokalemia, sodium retention, impaired bone growth, osteoporosis, hypertension, coronary heart disease	Gastrointestinal upset, diarrhoea, laxative (>15 g), bone calcification, greater bone density
Micro minerals		
Iron	Iron anaemia; impair oxygen transport; pounding of feet such as running; negative impact on sports performance	Acute (>900 mg in children): overdose lethal; chronic: hereditary hemochromatosis; liver disease (cirrhosis); heart disease, gastrointestinal upset
Zinc	Decrease serum zinc concentration and muscle endurance; growth retardation, delayed sexual maturation, delayed wound healing, skin lesions, impaired appetite, immune deficiencies, behavioural disturbances; eye	Acute: nausea, vomiting, diarrhoea Chronic: suppression of copper status; hypo chromic, microcytic anaemia; HDL cholesterol decreased; lymphocyte stimulation decreased

	lesions including photophobia and night blindness and impaired taste	
Selenium	Rare; symmetrical stiffness; swelling; pain in the interphalangeal joints of the fingers; osteoarthritis in the elbows, knees and ankles; contribute to carcinogenesis	Rare; adverse effects on nails, hair, skin
Copper	Rare; anaemia, neutropenia, skeletal abnormalities especially demineralisation; subperiosteal haemorrhages; hair and skin depigmentation and defective elastin formation; failure of erythropoiesis; cerebral and cerebella degeneration; death; contribute to reduced immune responses	Unlikely, liver cirrhosis, hepatic necrosis, interferes with zinc absorption
Chromium picolinate	Insulin resistance; lipid abnormalities	Unlikely, skin lesions
Fluoride	Fluoride cannot have a true deficiency that results in disease, because fluoride has no known metabolic function	Mild fluorosis can develop from daily doses of 0,1 mg/ kg, include discoloration of the teeth and motting
Iodine	Goitre, poor cognition and retardation of neuromotor maturation	Hypothyroidism, goitre formation or hyperthyroidism
Manganese	Sterility in both sexes; striking skeletal abnormalities; weight loss, transient dermatitis, nausea, vomiting, change in hair colour, slow hair growth	More likely to occur from environment contaminated with manganese such as mines than from dietary intake; accumulate in liver and central nervous system; headaches, dizziness, abnormal magnetic resonance imaging (MRI) and hepatic dysfunction
Molybdenum	Mental changes and abnormalities of sulphur and purine metabolism	Rare; excessive molybdenum intake of 10 to 15 mg/day is associated with gout like syndrome
Cobalt	Cobalt deficiency develops only in relation to a cobalamin deficiency; insufficient cobalamin causes a macrocytic anaemia. A genetic defect limiting cobalamin absorption results in pernicious anaemia	Unknown

2.3.4 Fluid and electrolytes

The continual regulation of the volume and composition of body fluids is essential for optimal body functioning. This regulation involves the relationship between the external environment and the body, as well as the interchange taking place between the body's own cells, tissues and organs. Normal osmotic pressure, nerve function, muscle contraction, the movement of nutrients into cells and the removal of waste from cells is dependent on electrolytes and non-electrolytes held in solution. The regulation of electrolytes is closely tied to that of water. Water provides the medium for biochemical reactions within cell tissues and is essential for maintaining blood volume, acid-base balance, kidney and heart function as well as the regulation of body temperature (Meltzer & Fuller, 2005, p.62).

The role of fluid and electrolytes in exercise, recommendations for fluid and electrolyte intake as well as the consequences involved with insufficient and excessive intakes are important factors to consider.

2.3.4.1 Fluid, electrolytes and exercise

During intense activity, muscle heat production can be 15 to 20 times greater than at rest (Whitney & Rolfes, 2005, p.490). Approximately 70 to 90% of this energy is released as heat that needs to be dissipated to achieve body heat balance. In hot climates a substantial volume of body water can be lost via sweating to enable evaporative cooling (Meltzer & Fuller, 2005, p.62). Sweat rates will vary depending on body size, exercise intensity, ambient temperature, humidity and acclimation but can exceed 1,8 litre per hour. Sweat also contains substantial amounts of sodium, modest amounts of potassium and small amounts of minerals such as iron and calcium (ACSM et al., 2000, p.2137).

Exercise performance is optimal when athletes maintain fluid balance during exercise; conversely exercise performance is impaired with progressive dehydration (ACSM et al., 2000, p.2136). Athletes who participate in short-duration activities such as sprint running in track and field or stop-and-go sports like rugby are just as likely to develop dehydration, as are distance runners (Berning, 2004, p.623). By replacing both fluid and electrolyte losses dehydration in rugby players can be avoided (Meltzer and Fuller, 2005, p.62).

Fluid balance during exercise is not always possible because maximal sweat rates exceed maximal gastric emptying rates that in turn limit fluid absorption. Rates of fluid ingestion by athletes during exercise fall short of amounts that could be emptied from the stomach and absorbed by the gut (ACSM et al., 2000, P.2137). A 1000 ml of fluid ingestion per hour is probably optimal to offset dehydration (McArdle et al., 1996, p.76). Gastric emptying is maximised when the amount of fluid in the stomach is high. It is reduced with hypertonic fluids or when CHO concentration is greater than or equal to 8%. (ACSM et al., 2000, p.2137).

2.3.4.2 Fluid and electrolyte recommendations

Athletes should attempt to remain well hydrated before, during and after training and competition (ACSM et al., 2000). Duration and intensity of training and competition will determine fluid requirements (Meltzer & Fuller, 2005, p.60).

i. Before exercise

Rugby players should begin training and competition in a well-hydrated condition (Meltzer & Fuller, 2005, p.64). General amounts of fluid should be consumed 24 hours before an exercise session. The ACSM and the National Athletic Trainers' Association (NATA) recommend drinking 400-600 ml of fluid 2 to 3 hours before exercise. This will optimise the athlete's, including rugby player's hydration status while allowing enough time for any excess fluid to be excreted as urine before beginning to exercise (ACSM et al., 2000).

ii. During exercise

Optimal hydration can be facilitated by drinking 150-350 ml of fluid every 15 to 20 minutes during exercise, beginning at the start of exercise (Berning, 2004, p.624). Rugby players are also allowed to drink fluids during half time (after 40 minutes) (Burke & Hawley, 1997). According to Bean (2003, p.86) thirst is not a good indicator of hydration status. Beverages containing CHO in concentrations of 4% to 8% are recommended for intense exercise events lasting longer than 1 hour (ACSM et al., 2000).

Using a sport drink during high-intensity stop-and-go sports helps delay fatigue and maintains hydration. Unfortunately, athletes who just consume water as a fluid replacement, even for short-term exercise, risk the chance of diluting the blood and increasing urine output, thus shutting off the drive to drink and becoming dehydrated (Berning, 2004, p.624).

There appears to be little physiologic need to replace electrolytes during a single exercise session of moderate duration (less than 3 to 4 hours), particularly if sodium was present in the previous meal. Including sodium in amounts between 0,5 and 0,7 g/litre is recommended during exercise lasting longer than 1 hour because it may enhance palatability and the drive to drink, therefore increasing the amount of fluid consumed. This amount of sodium exceeds that typically available in commercial beverages. Including sodium in fluid replacement beverages may also help prevent hyponatremia in susceptible people (ACSM et al., 2000).

iii. After exercise

In most cases, athletes, including rugby players do not consume enough fluids during exercise to balance fluid losses and thus complete their exercise sessions dehydrated to some extent (ACSM et al., 2000). Post exercise rehydration goals should be to replace any remaining fluid losses that may not have been made up during exercise as well as the continued losses that occur in the recovery period (Meltzer & Fuller, 2005, p.55). Consuming up to 150% of the weight lost during an exercise session may be necessary to cover losses in sweat plus urine productions (ACSM et al., 2000). Rugby players should drink 450-675 ml of fluid for every kg BW lost during exercise (Berning, 2004, p.624).

Rugby players should replace CHO, fluid and electrolytes (sodium and potassium) within 30 minutes after exercise (ACSM et al., 2000). In events lasting longer than 30 minutes, such as rugby, CHO-containing drinks have been shown to enhance performance more than plain water. A CHO-containing sports drink containing 52 mill mol/litre (mmol/L) sodium and 25 mmol/L potassium are ideal, but too much sodium affects the taste of the drink and so the amount of sodium in drinks (10 to 30 mmol/L) only partially replaces the sodium lost in sweat (ranging from 10 to 90 mmol/L) (Meltzer & Fuller, 2005, p.66).

Table 12 gives a summary of the nutrient and electrolyte content of commercial sport drinks and other solutions that can be ingested after exercise (Robergs & Roberts, 2000, p.234).

Table 12. The nutrient and electrolyte content of commercial sport drinks and other solutions that can be ingested after exercise (Robergs & Roberts, 2000, p.234)

DRINKS	CARBOHYDRATE (g/100ml)	SODIUM (mEq/L)	POTASSIUM (mg/L)
Diet carbonated drinks	0	0-25	trace
Coca-Cola	10,7	2	trace
Cranberry juice	10-15	2	7
Game	7,6	11	
Sprite	10,2	5	0
Lucozade	18	12	
Energade	7	16	
PowerAde	8	10	
Orange juice	11,8	0,5	58
Water	0	trace	Trace

Athletes, including rugby players sometimes drink beverages that contain caffeine or alcohol. Each of these substances can influence physical performance (Whitney & Rolfes, 2005, p.492).

a) Alcohol

Alcohol consumption has a detrimental effect on athletic performance. Even though alcohol reduces feelings of insecurity, tension and discomfort, it may cause the athlete to feel that he or she is performing better. Many athletes incorrectly believe that because alcohol contains CHO, they can load on beer to improve their performance (Berning, 2004, p.634).

Alcohol's diuretic effect impairs the body's fluid balance, making dehydration likely. Alcohol also impairs the body's ability to regulate its temperature, increasing the likelihood of hypothermia or heat stroke (Whitney & Rolfes, 2005, p.492). Alcohol reduces reaction time and impairs balance, accuracy, hand-eye coordination, strength, power and endurance. Alcohol also has a vasodilatory effect, which can increase bleeding and swelling, thus delaying recovery and healing (Meltzer &

Fuller, 2005, p.68). In addition alcohol deprives people of their judgement, thereby compromising their safety in sports. Many sports-related fatalities and injuries involve alcohol or other drugs (Whitney & Rolfes, 2005, p.493).

Clearly, alcohol impairs performance, but rugby players do drink on occasion (Whitney & Rolfes, 2005, p.493). Heavy drinking impedes the muscular reflexes controlling most visual skills (Meltzer & Fuller, 2005, p.156). Light social drinking (1 or 2 drinks) during the day before a competition will probably not influence athletic performance the following day (Berning, 2004, p.634). Alcohol should however, be avoided 24 hours before competition or training. After exercise, rehydration and refuelling take first priority (Meltzer & Fuller, 2005, p.69). Water and caffeine free fluids should be drunk after exercising before drinking alcohol (Whitney & Rolfes, 2005, p.493).

b) Caffeine

Caffeine and caffeine-like substances may be present in some drinks and food such as coffee, tea, sports bars and gels, chocolate bars and colas Caffeine has a diuretic effect and should be avoided in the post-exercise recovery period. However, during exercise it does not increase urine production. As of 2004, the International Olympics Committee (IOC) (Meltzer & Fuller, 2005, p.492) no longer considers caffeine a banned substance.

Caffeine is a stimulant and some athletes use it to enhance performance (Whitney & Rolfes, 2005, p.492). Caffeine contributes to endurance performance during the conditioning phase of the rugby player's training cycle, because of its ability to enhance mobilisation of fatty acids and thus conserve glycogen stores. Caffeine may directly affect muscle contractility possibly by facilitating calcium transport and reduce fatigue by reducing plasma potassium accumulation, which contributes to fatigue (Berning, 2004, p.634).

2.3.4.3 Insufficient and excessive intake

Insufficient fluid and electrolyte intake can cause dehydration. Dehydration increases the risk of potentially life threatening heat injury such as heat stroke (ACSM et al., 2000, p.2136).

Disturbances of fluid and electrolyte balance that can occur in athletes include dehydration, hypo hydration and hyponatremia (over hydration). Exercise induced dehydration develops as a consequence of fluid losses that exceed fluid intake (ACSM et al., 2000).

2.3.5 Pre-competition, competition and post-competition diet

The pre, during and post exercise meals may influence sports performance and are discussed separately.

2.3.5.1 Pre- exercise meal

Eating before exercise as opposed to exercising in the fasting state has shown to improve performance. The meal or snack consumed before exercise or competition prepare athletes for the upcoming activity and leaves him/her neither hungry nor with undigested food in the stomach (ACSM et al., 2000). The pre-exercise meal maintains optimal levels of blood glucose for the exercising muscles (Berning, 2004, p.25). The pre-exercise snack can be used to top up liver glycogen stores (especially after an overnight fast) and also to hydrate (Meltzer & Fuller, 2005, p.53). Athletes who train early in the morning before eating or drinking risk developing low liver glycogen stores and this can impair performance particularly if the exercise regimen involves endurance exercise (Berning, 2004, p.25).

The size and timing of the pre-exercise meal are interrelated. Smaller meals should be consumed in closer proximity to the event to allow for gastric emptying. Larger meals can be consumed if more time is available before exercise or competition (ACSM et al., 2000). The pre-exercise meal should be high in CHO, non-greasy and readily digested (Berning, 2004, p.627). According to Berning (2004, p.627) the pre-exercise meal should be eaten 3 to 4 hours before exercise or competition and should provide 200 to 350g of CHO (4 g/kg). The closer the pre-exercise meal eaten before exercise, the lesser the CHO intake should be.

CHO feedings before exercise can help to restore sub optimal liver glycogen stores that may be called on during prolonged training and high-intensity competition (Berning, 2004, p.627). The recommendations on CHO consumption within 1 hour before activity have been controversial. Hypoglycaemia and pre-mature fatigue may occur after a pre-exercise meal 1 hour before activity (ACSM et al., 2000). 1 to 4 g CHO/kg BW should be ingested before training or competition. Within 15 minutes before a long event the athlete should drink 500 ml water or fluid. This prehydration allows for maximal absorption of fluid without urination (Berning, 2004, p.627). The choice of low glycaemic index (GI) CHO rich foods in the pre-exercise meal may sustain the delivery of CHO during exercise, however this does not provide a guaranteed performance advantage especially when additional CHO is consumed during the event (Burke, 2002, p.359). Some athletes, including rugby players consume a substantial meal 2 to 4 hours before exercise or competition. Others may suffer severe gastrointestinal distress following such a meal and need to rely on liquid meals (ACSM et al., 2000). Commercial liquid formulas providing an easily digested high CHO fluid intake are popular with some athletes (Berning, 2004, p.627).

Athletes should always ensure that they know what works best for themselves by experimenting with new foods and beverages during practice sessions and planning ahead to ensure they will access to these foods at the appropriate time (ACSM et al., 2000).

Fat should be limited because it delays stomach-emptying time and takes longer to digest (Berning, 2004, p.627). A meal eaten 3,5 to 4 hours before competition can have as much as 25% of the TE from fat (Berning, 2004, p.627). Closer to the event, the fat content should be less than 25% of the TE. Foods with a low to moderate protein content are the preferred choice for the pre-event menu since they are less likely to cause gastrointestinal upsets (Hawley & Burke, 1998, p.272).

2.3.5.2 During exercise meal

Food and fluid consumed during exercise are part of a specific short-term nutritional strategy aimed at maximising performance at that particular time (Maughan & Burke, 2002, p.84). CHO (food or fluid) and fluid need to be ingested during exercise, especially if the exercise is longer than 30 minutes (Meltzer & Fuller, 2005, p.54). During exercise depletion of the liver and muscle glycogen occur. The availability of CHO as a substrate for muscle metabolism is a critical factor in the performance of high intensity, stop-start sports (Hawley & Burke, 1999).

CHO intake should begin shortly after the onset of activity. Athletes who exercise in the morning after an overnight fast when liver glycogen levels are low will benefit from CHO consumption during exercise or competition (ACSM et al., 2000). According to ACSM et al (2000) CHO consumption in amounts typically provided by sport drinks (4% to 8%) improves performance in events lasting 1 hour or less. Performance advantages in stop-start activities may not be apparent when exercise is done in the non-fasting state (ACSM et al., 2000).

Rugby provides formal and informal pauses in play for opportunities to consume CHO and fluid (Maughan & Burke, 2002, p.84). Rugby players should consume about 30 to 60g CHO per hour during exercise. The maximum that the body is able to oxidize is 60 g CHO per hour (Meltzer & Fuller, 2005, p.54). Where a sports drink with CHO is consumed during exercise, the rate of CHO ingestion should be about 26 to 30 g CHO every 30 minutes. This amount is equivalent to 1 cup of 6% to 8% CHO solution taken every 15 to 20 minutes. This ensures that 1 g CHO will be delivered to the tissues per minute at the time fatigue sets in. A CHO concentration of less than 5% is unlikely enough to help performance, but solutions with a concentration greater than 10% are often associated with abdominal cramps, nausea and diarrhoea (Berning, 2004, p.628).

Medium to high GI CHO are the best choices for CHO intake during exercise (Meltzer & Fuller, 2005, p.54). The form of CHO does not seem to matter. Some athletes prefer to use a sports drink whereas others prefer to eat a solid or gel and consume water (Berning, 2004, p.628). Foods high in lipid content should be eliminated from the diet on the day of competition. This is because these foods are slowly digested and remain in the digestive tract longer than foods containing a similar amount of energy in the form of CHO (McArdle et al., 2000, p.214).

2.3.5.3 Post-exercise meal

Recovery after exercise and competition is important for rugby players; otherwise training and performance will be compromised. Recovery nutrition (post exercise) should replenish liver and muscle glycogen stores, replace fluid and electrolytes lost in sweat, and regenerate and repair damaged tissue (Meltzer & Fuller, 2005, p.55, 141). The timing and composition of the post-exercise meal or snack depend on the length and intensity of the exercise session and when the next intense workout will occur (ACSM et al., 2000).

Timing of the post-exercise CHO intake affects glycogen synthesis over the short term (ACSM et al., 2000). Only 5% of the muscle glycogen used during exercise is resynthesised each hour following exercise. At least 20 hours are required for complete restoration after exhaustive exercise, provided about 600 g CHO is consumed (Berning, 2004, p.628). Consuming a given amount of CHO as a bolus after 2 hours of exercise is not as effective as consuming the same amount at 15 to 20 minute intervals during the first 2 hours of activity (ACSM et al., 2000).

Resynthesis is promoted when CHO are consumed immediately after exercise and the current recommendations are to consume about 100 g CHO within 30 minutes after exercise to maximise muscle glycogen synthesis (Berning, 2004, p.628). Rugby players should ingest 1 to 1,5 g CHO/kg BW within 60 minutes after exercise and at frequent intervals until the next meal (Meltzer & Fuller, 2005, p.55).

High GI, low fibre, CHO rich foods should be ingested 1 to 2 hours after exercise to fasten the rate of muscle recovery (Burke, 2002, p.402, 419). When comparing simple sugars, glucose and sucrose, appear equally effective when consumed at a rate of 1, 5 g CHO/kg BW for 2 hours.

Fructose alone is less effective (ACSM et al., 2000). Rugby players should follow a low fat diet after exercise; otherwise less energy from CHO will automatically be consumed (Berning, 2000, p.546). The combination of high GI CHO and protein (10 g) ingestion after exercise will increase recovery more after exercise (Berning, 2004, p.628). The reason for protein aiding in the recovery of glycogen is that there will be an elevated release of insulin which will thus, accelerate glycogen synthesis (Robergs & Roberts, 2000, p.241). This is important for athletes, including rugby players that lack appetite or have a short recovery period (Meltzer & Fuller, 2005, p.55). While adding protein may not appreciably enhance glycogen storage, protein may provide needed amino acids for muscle repair and promote a more anabolic hormonal profile (ACSM et al., 2000). Energy from CHO will automatically be consumed (Berning, 2000, p.546).

2.4 Supplement recommendations for rugby players

Certain dietary supplements and ergogenic aids can improve sport performance and others only help to improve an athlete's nutritional status. The use of any supplement in the right situation, timing and amount will influence the effect it has on sport performance (Burke, 1998, p.360, 361).

Supplements can be classified as dietary supplements and nutritional ergogenic aids.

2.4.1 Dietary supplements

According to Burke et al. (2002, p.460) dietary supplement can be defined as 'sport supplements' that:

- contain nutrients in amounts similar to the levels specified in the Recommended Dietary Allowances (RDA's) and similar to the amounts found in food;
- provides a convenient or practical means of ingesting these nutrients, particularly in the athletic setting;
- allows or aids the achievement of known physiological or nutritional requirements of an athlete to improve sports performance;
- is generally acknowledged as a valuable product by sports medicine and science experts.

Dietary supplementation includes proteins and amino acids, CHO, lipids and lipid derivatives and micronutrients. A list of dietary supplements can be found in Table 13 (Berning, 2004, p.630-631; Whitney & Rolfes, 2002, p.492-501; Whitney et al., 2001, p.90; Sizer & Whitney, 2000, p.373; Burke, 1998, p.141).

There are specific recommendations for the use of dietary supplements and will be discussed further.

*Table 13. A list of dietary supplements (ΦBerning, 2004, p.630-631; *Whitney and Rolfes, 2002, p.492-501; †Whitney et al., 2001, p.90; **Sizer and Whitney, 2000, p.373; ΨBurke, 1998, p.141)*

Dietary supplement	Description	Claim	Adverse side effects/ caution
Protein powders (including whey proteins, purified protein)	*Muscle building blocks; provide amino acids to body	*Repair damaged muscle; increase muscle growth and gain	ΦDehydration, hypercalciuria, weight gain, stress on kidney and liver †Overdose-increase fat storage
Amino acids and derivatives	ΨFree form/ single amino acids and combinations produced through microbial fermentation processes	**Increase muscle mass	**High concentrations and combinations difficult to handle by human body; compete for absorption, deficiencies and toxicities
CHO and electrolytes (including sports drink, sports gel, sports bar)	ΦEnergy from complex or simple CHO	ΦImprove athletic performance; energy for intense muscular activity	Unknown
Lipids and derivatives	ΦMost concentrated source of food energy; supplies more than twice as many energy as protein or CHO	ΦMajor fuel for light to moderate activity	
Vitamins/minerals	Organic and inorganic compounds	Improves performance	Toxicities

2.4.1.1 Protein and amino acids

According to Berning (2004, p.630) protein and amino acids supplementation in the form of powders or pills is not necessary and should be discouraged (Berning, 2004, p.630). Whey proteins do not increase muscle mass. To build bigger muscles athletes, including rugby players need to eat food with adequate energy and protein to support the weight-training work that does increase muscle mass (Whitney & Rolfes, 2005, p.501). Purified protein preparations contain none of the other nutrients needed to support the building of muscle, and athletes who eat food do not need the protein they supply (Whitney & Rolfes, 2005, p.501). Most healthy athletes eating well-balanced diets do not need amino acid supplements (Whitney & Rolfes, 2005, p.501). Amino acids will be discussed as nutritional ergogenic aids in 2.4.2.

2.4.1.2 Carbohydrates

CHO intake before, during and after exercise can improve athletic performance (Burke & Hawley, 1998, p.515). CHO can also be supplemented in combination with fat and protein (Berning, 2004, p.626-627).

2.4.1.3 Lipids and lipid derivatives

Even though maximal performance is impossible without muscle glycogen, lipid/ fat supplementation also provides energy for exercise. Lipid/ fat are the major, if not most important fuel for light to moderate intensity exercise (Berning, 2004, p.631). Lipid derivates will be discussed as nutritional ergogenic aids in 2.4.2

2.4.1.4 Micronutrient supplementation

The dietary micronutrient intake of rugby players was already discussed in 2.3.3. At date there is no sound evidence to confirm that the consumption of additional vitamin, mineral and antioxidants over and above the known requirements of an athlete improves performance (Fogelholm, 2002, p.333). In the case of the inability or unwillingness of an athlete to improve their dietary intake, the use of a specific macronutrient or micronutrient supplement may be warranted. A low dose (<2 to 3 times DRI), broad range multivitamin/mineral supplement is the best option for general dietary support. Dietary supplementation may also be needed in the case of a diagnosed macronutrient or micronutrient deficiency, however steps should also be taken to improve the dietary intake so that long-term supplementation can be avoided (Fogelholm, 2002, p.333). Table 14 presents the suggested UI levels and daily values for selected vitamins and minerals and the quantities typically found in supplements (Whitney & Rolfes, 2005, p.361).

Table 14. Vitamin and mineral supplement intake by adults (Whitney & Rolfes, 2005, p.361)

Nutrient	UI	Daily values	Typical multivitamin-mineral supplement	Average single-nutrient supplement
VITAMINS				
Vitamin A (retinal)	3000 µg (10 000 IU)	5000 IU	5000 IU	8000-10000 IU
Vitamin D3 (cholecalsiferol)	50 µg (2000 IU)	400 IU	400 IU	400 IU
Vitamin E (tocopherols)	1000 mg (1500-2200 IU)	30 IU	30 IU	100-1000 IU
				-
Vitamin K		80 µg	40 µg	50 mg
Thiamine	-	1,5 mg	1,5 mg	25 mg
Riboflavin	-	1,7 mg	1,7 mg	100-500 mg
Niacin (niacin amide)	-	20 mg	20 mg	100-200 mg
Vitamin B6	35 mg	2 mg	2 mg	400 µg
Folate	100 mg	400 µg	400 µg	100-1000 µg
Vitamin B12	1000 µg	6 µg	6 µg	100-500 mg
Pantothenic acid	-	10 mg	10 mg	300-600 µg
Biotin	-	300 µg	30 µg	500-2000 mg
Vitamin C (ascorbic acid)	-	60 mg	10 mg	
	2000 mg			
MINERALS				
Calcium	2500 mg	1000 mg	160 mg	250-600 mg
Phosphorus	4000 mg	1000 mg	110 mg	-
Magnesium	350 mg	400 mg	100 mg	250 mg
Iron	45 mg	18 mg	18 mg	18-30 mg
Zinc	40 mg	15 mg	15 mg	10-100 mg
Iodine	1100 µg	150 µg	150 µg	-
Selenium	400 µg	70 µg	10 µg	50-200 µg
Fluoride	10 mg	-	-	-
Copper	10 mg	2 mg	0,5 mg	-
Manganese	11 mg	2 mg	5 mg	-
Chromium	-	120 µg	25 µg	200-400 µg
Molybdenum	2000 µg	75 µg	25 µg	-

2.4.2 Nutritional ergogenic aids

The desire to win by going faster, higher and stronger motivates athletes, including rugby players to look for anything to improve performance. In the case of nutrition, ergogenic aids refer to supplements that contain nutrients or food chemicals in amounts greater than would be found in dietary sources and are purported to have a direct supra-physiologic or drug-like effect on performance (Meltzer & Fuller, 2005, p.93).

Nutritional ergogenic aids with clear scientific support, mixed scientific support and unproven ergogenic aids will be discussed.

2.4.2.1 Clear scientific support

Well-conducted scientific trials have produced evidence that some ergogenic aids can enhance sporting performance. This section reviews several products, which enjoy such support. It should be noted that each work within a specific and narrow set of exercise situations and should not be considered a universal sports supplement. Athletes also need to be educated on appropriate situations of use and supplementation protocols. Studies show that some athletes are non-responders to these protocols and some may actually experience side effects or negative outcomes. Athletes should experience with supplements before using them during important competitions and will benefit from the assistance and monitoring provided by sports scientists. A list of ergogenic aids with clear scientific support can be found in Table 15 (Whitney & Rolfes, 2005, p.500-502; Meltzer & Fuller, 2005, p.97-99; Magkos & Kavouras, 2004, p.312; Haub, 2004, p.264; Kreider et al., 2004, p.90; Berning, 2004, p. 635; Burke et al., 2002, p.472-478).

*Table 15. Ergogenic aids with clear scientific support (**Whitney & Rolfes, 2005, p.500-502; •Meltzer & Fuller, 2005, p.97-99; ††Magkos & Kavouras, 2004, p.312; †††Haub, 2004, p.264; ***Kreider et al., 2004, p.90; †Berning, 2004, p. 635; *Burke et al., 2002, p.472-478).*

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Ergogenic aid	Description	Claim	Adverse side effects/ caution
*Creatine	*Compound derived from amino acids, stored in skeletal muscle	•Rapid available source of fuel to regenerate ATP **Enhance performance of high-intensity activity **Increase muscle strength and size, cell hydration, glycogen loading capacity	•Weight gain ***Fat free mass increase †Muscle strains and pulls, dehydration •High blood pressure, kidney damage, muscle cramps **Risk for athletes with kidney disease, long-term use unsure, use discouraged for younger than 18 years
•Caffeine	***Member of methyl xanthenes, a family of naturally occurring stimulants found in the leaves, nuts and seeds of a number of plants	•Enhance performance, increase alertness ††Increase speed, prolong time to fatigue during intense exercise bouts	†Diuretic effect **Stomach upset, nervousness, irritability, headaches •Anxiety, palpitations, dehydration, short term fat loss
•Sodium bicarbonate, lactate, citrate	**Baking soda or alkaline salt *Extra cellular buffers	•Prevention of acid build-up and cramps during exercise **Reduce pain, enhance workload *Delay onset of muscular fatigue *Sports dependent on repeated anaerobic bursts may benefit	†††Intestinal cramping, diarrhea, flatulence, cardiac arrhythmias, apathy, muscle spasms or gastric ruptures

Ingesting 20 g daily (four 5 gram doses per day) for 5 days can produce a 20% increase in muscle creatine levels (Berning, 2004, p.635). Alternatively a daily dose of 3 g/d will achieve a slow loading over 28 days. Elevated muscle creatine stores are maintained by continued daily supplementation of 2 to 3 g (Burke et al., 2002, p.474). Co-ingesting creatine with glucose or increasing muscle creatine content prior to CHO loading (75 to 100g) enhance muscle glycogen retention (Kreider et al., 2004, p.82). Creatine appears to be trapped in the muscle in the absence of continued supplementation and it takes 4 to 5 weeks to return to resting creatine concentrations. Because an excess creatine cannot be stored in the muscles and must be excreted by the kidneys, it is recommended that a maintenance dose be no more than 5 g daily (Berning, 2004, p.635). However, it has been shown that a slow loading of 3 g/d will achieve the same increase in a given time. Any extra creatine is excreted via the urine (Meltzer & Fuller, 2005, p.99).

Individuals respond differently to caffeine, but performance-enhancing effects are found at doses as low as 1 to 3 milligram per kilogram (mg/kg) BW (50-100 mg caffeine). There is no additional benefit in taking larger doses (Meltzer & Fuller, 2005, p.100). Benefits have been seen when caffeine are fed in association with CHO at modest doses throughout the exercise bout. Further research is needed to explore the timing of doses, particularly in events of 60 min or greater. At present there is no clear mechanism to explain beneficial effects of caffeine supplementation. If glycogen sparing occurs during sub maximal exercise events, it appears to be limited to the first 15 to 20 minute of exercise (Burke et al., 2002, p.476).

'Soda loading' or 'bicarbonate loading' has been trailed by athletes and studied by scientists for over 70 years. Sodium citrate has also been used as a buffering agent (Burke et al., 2002, p.478). As with most ergogenic aids the administration and dose need to be investigated to determine issues related to safety and efficacy (Haub, 2004, p.261). Athletes usually ingest about 0,3 g of sodium bicarbonate (4 to 5 teaspoons bicarbonate or soda), 0,3 to 0,5 g sodium citrate, or 0,4 g sodium lactate/kg BW, 1 to 2 hours before exercise (Meltzer & Fuller, 2005, p.103). Consuming the sodium bicarbonate with plenty of water (1 litre or more) may help to prevent hyper osmotic diarrhoea (Burke et al., 2002, p.478).

2.4.2.2 Mixed scientific support

Ergogenic aids with mixed scientific support including antioxidant supplements, amino acids and glycerol are shown in Table 16 (Meltzer and Fuller, 2005, p.99; Lukaski, 2004, p.422-424; Turpin et al., 2004, p.471; Kandiah, 2004, p.455-461; Stacewicz-Sapuntzakis and Diwadkar-Navsariwala, 2004, p.337; Wildman, 2004, p.57; Spruce and Titchendal, 2004, p.171; Robertson, 2004, p.198; Guest et al., 2004, p.21; Jonnalagadda and Skinner, 2004, p.130; Burke et al, 2002, p.483, 505).

*Table 16. Ergogenic aids with mixed scientific support (*Lukaski, 2004, p.422-424; ΦTurpin et al., 2004, p.471; ***Meltzer and Fuller, 2005, p.99; **Kandiah, 2004, p.455-461; ‡Stacewicz-Sapuntzakis and Diwadkar-Navsariwala, 2004, p.337; •Wildman, 2004, p.57; †Spruce and Titchendal, 2004, p.171; ††Robertson, 2004, p.198; •••Guest et al., 2004, p.21; †††Jonnalagadda and Skinner, 2004, p.130; ••Burke et al, 2002, p.483)*

Ergogenic aid	**Description**	**Claim**	**Adverse side effects/ caution**
*alpha-lipoic acid (dihydrolipoic acid)	*Growth factor for potatoes *Synthesises by plants and animals *Unique and vital antioxidants	*Enhance sport performance, antioxidant properties, spare other antioxidants, interaction with antioxidants, optimal glucose utilisation	*Allergic skin reactions, hypoglycaemia in diabetics
**Tannins	**Phenolic compounds	**Antioxidant properties, ergogenic effect	Unknown
‡Carotenoids (beta-carotene, beta-cryptoxanthin, lutein, zeaxanthin, lycopene)	‡Long-chained hydrocarbons compounds of plant origin; provide red, orange and yellow colour to fruits and vegetables; precursors of vitamin A	‡Antioxidant properties; reduce exercise damage; hasten recovery, ameliorate chronic inflammation; stimulate immune response	••Toxicity, carotenemia
ΦGlutathione, soy isoflavones, tocopherols	Component of vegetable oils; complex ring structure and long saturated side chain	Antioxidant, increase strength and muscle mass	Decrease body's ability to use other fat soluble vitamins
***Isoleucine, leucine and valine	*******Branched chain amino acids	*******Better absorption compared to intact protein •Inhibit fatigue, enhance protein	*******Production of ammonia may cause fatigue

		synthesis, decrease reductions in immune system capabilities after exercise	
••Arginine ••Ornithine and ornithine alpha-ketoglutarate (OKG)	•••Complex amino acid ††Metabolite of arginine	•••Androgenic effect; increase muscle mass, decrease body fat ††Stimulate insulin release; enhance glycogen storage	***Fat gain
***Lysine	†Amino acid	***Bone and joint repair; recovery from injury	Unknown
***Glutamine	***Most versatile amino acid	***Improve recovery †††Ergogenic effect, oxidative fuel	†††Gastrointestinal discomfort
••Glycerol	••Three-carbon alcohol	••Rehydration after high intensity exercise	***Headaches, gastrointestinal distress, nausea, blurred vision
•HMB	†Metabolite of amino acid leucine	•Increase muscle mass; enhance gains in strength and body mass, loss of body fat, enhance recovery	•Elevated protein catabolism **Gastrointestinal upset (>6g)

Until convincing data from food fortification or supplementation trials with alpha-lipoic acid are available, it is merely speculative that this natural antioxidant promotes physical function and sport performance in humans. The antioxidant properties of alpha-lipoic acid and its interaction with other key antioxidants such as vitamin E, ascorbate and glutathione will provide numerous opportunities for future research activity health promotion (Lukaski, 2004, p.424).

Although many beneficial health effects of tea have been discussed, inconsistencies exist in the literature. There is a strong possibility that the antioxidant properties in tannins may enable them to exert an ergogenic effect, thereby preventing the onset of vascular diseases and cancer (Kandiah, 2004, p.461).

Clear evidence of a beneficial role for antioxidants in exercise-induced lipid peroxidation is not available, nor in their ability to improve physical performance. More systematic and well-controlled investigations need to be undertaken with carotenoids as the single supplements before they can be prescribed as ergogenic aids (Stacewicz-Sapuntzakis and Diwadkar-Navsariwala, 2004, p.342).

Despite an intriguing theory of potential performance benefits, there is no substantial proof that BCAA supplementation enhances exercise performance (Burke et al., 2002, p.483).

Arginine, ornithine and lysine have been claimed individually and in combinations to promote the release of growth hormone, leading to an increase in muscle mass and a decrease in body fat. These amino acids have been marketed as 'legal anabolic compounds', recovery agents and stimulators of muscle growth (Burke et al., 2002, p.484). The use of arginine as an ergogenic aid cannot be recommended at this time (Guest et al., 2004, p.31). The anticatabolic and anabolic effects of ornithine and OKG have not been substantiated in active individuals or athletes (Robertson, 2004, p.204). Ergogenic benefits of lysine appear to be non existent or to too minor to measure (Spruce & Titchenal, 2004, p.189).

The immune system enhancing effects and the antiproteolytic effects of glutamine have implications for athletes involved in intense training activities (Burke et al., 2002, p.485). The ergogenic benefits and the immune system enhancing effects of glutamine supplementation for the active individual are yet to be realised. Long-term studies examining the effect of glutamine supplementation on protein synthesis, body composition, prevention of infections and increase in muscle glycogen stores are necessary before glutamine supplements can be advocated to athletes (Jonnalagadda & Skinner, 2004, p.142).

Some studies have observed enhanced exercise performance with glycerol ingestion, others not (Meltzer & Fuller, 2005, p.67). This includes exercise of high intensity and/or hot and humid environments, where sweat losses are high and opportunities to replace fluid are substantially less than the rates of fluid loss (Burke et al., 2002, p.486). Rugby players do not follow these rehydration strategies. Glycerol hyper hydration can therefore not be recommended (Meltzer & Fuller, 2005, p.67).

2.4.2.3 Unproven ergogenic aids

A list of unproven ergogenic aids can be found in Table 17 (Meltzer and Fuller, 2005, p.101; Berning, 2004, p.636; Wolinsky & Driskell, 2004, p.21-455; Turpin et al., 2004, p.471; Burke et al., 2002, p.487-502).

*Table 17. Unproven ergogenic aids (••Meltzer and Fuller, 2005, p.101; *Berning, 2004, p.636; † Wolinsky & Driskell, 2004, p.21-455; **Turpin et al., 2004, p.471; • Burke et al., 2002, p.487-502)*

Ergogenic aid	Description	Claim	Adverse side effects/ caution
†Aspartate	Amino acid	Benefits for high intensity sports	Carcinogenic
*Glycine	Amino acid that is phosphocreatine precursor	Improves muscle contraction	•cramping, diarrhoea
**Tryptophan	Amino acid somatropin secretagogues	Maintain or improve muscle mass, strength, protein synthesis, anaerobic exercise performance	•cramping, diarrhoea
**Tyrosine	Amino acid somatotropin secretagogues	Maintain or improve muscle mass, strength, protein synthesis, anaerobic exercise performance	•cramping, diarrhoea
**Taurine	Amino acid	Maintain or improve muscle mass, strength, protein synthesis, anaerobic exercise performance	•cramping, diarrhoea
**DL-phenylalanine	Amino acid	Improve body fat loss or leanness	•cramping, diarrhoea
†•*Carnitine	A compound synthesized in the body from lysine and methionine (vitamin-like)	Improves cardiovascular function and muscle strength, delays fatigue, decreases muscle pain, decreases body fat	Although necessary for fat metabolism, appears that body synthesizes adequate amounts, osmotic diarrhoea in massive doses (>6g)
†Gelatine	Protein derived from collagen	Protective/ recovery properties for collagen or cartilage based disorders	Anaphylactic reaction
†Glucosamine and chondroitin sulphate	Amino acid derivative (neutraceuticals), homeopathic remedies	Reduce symptoms of osteoarthritis	**Occasional gastrointestinal upset, little harm

†*Conjugated linoleic acid (CLA)	Structured lipid	Antioxidant, addition of lean body mass and reduction of body fat, modulates serum glucose	No human studies have been published
†•*Medium chain triglycerides	Fatty acids with shorter carbon chain lengths (8-12)	Improves performance by sparing muscle glycogen, promotes muscularity and lower body fat	Gastric distress
**Omega-3 fatty acids	Poli-unsaturated fatty acid (PUFA)	Support maintenance or improve muscle mass, strength, protein synthesis and anaerobic exercise performance	Anticoagulant properties
†*Octacosanol	Alcohol isolate extracted from wheat germ oil	Supplies energy and improves performance, cholesterol lowering effect	Unknown
*Boron	Non-metallic trace element that influences calcium and magnesium metabolism	Increases testosterone	Intakes of 50 mg/ day may be toxic
•*Chromium/ †5chromium picolinate	Essential component of the glucose tolerance factor	Improves insulin sensitivity and carbohydrate metabolism during exercise	Prolonged or excessive supplementation may lead to chromium accumulation in the body- chromosomal damage
*Superoxide dismutase	Antioxidant enzyme	Protects body against oxidative cell damage	Antioxidant protection
†•Coenzyme Q10	Ubiquinone, non essential (vitamin-like)	Enhance energy	Unknown
*Choline	Precursor of the neurotransmitter acetylcholine (vitamin-like)	Improves performance	Should be avoided by athletes with gout
†Myo-inositol	Glucose isomer, structural support in membranes (vitamin-like)	Reduce symptoms associated with mental conditions	Unknown
*Lecithin	phosphatidylcholine	Decreases triglyceride and cholesterol levels	Unknown
*DNA/ RNA	Deoxyribonucleic acid, ribonucleic acid	Tissue regeneration	Unknown
•Inosine	Nucleic acid derivative	Increase ATP supply, increase oxygen release	Elevated uric acid levels –gout, performance impairment
†*Pangamic acid	Also referred to as 'vitamin B15' – modified amino acid, intermediary metabolite	Potent methyl donor, Increases delivery of oxygen	Unknown
†Pyruvate and dihydroxyacetone	3-carbon carbohydrate metabolites	Reduction of body mass and fat, lowering of blood lipids, improve aerobic exercise	**gastrointestinal upset (>5g), osmotic diarrhoea
*Bee pollen	Mixture of bee saliva, plant nectar and pollen	Increase energy levels, enhances physical fitness	Reports anecdotal, not proven, allergic reactions in bee sensitive individuals,
*Brewer's yeast	By product of beer brewing, rich source of B vitamins and bio available chromium	Increases energy levels	Claims of blood glucose improvement due to chromium

			content are documented
*Ephedra/ ma huang	Amphetamine-like stimulant	Enhances performance	Banned-dizziness, irregular heart beat, heart attack, stroke, death **anxiety, nervousness, increased heart rate and blood pressure
*Ginkgo	From leaves of chinese ghinkgo tree, biologically active compounds	Improves cognitive function	Delays blood clotting
†•*Ginseng	Extract of ginseng root	Protects against tissue damage	Variable quality and strength
*Guarana, Kola-Nut, Yerba Mate	Derived from seeds of South American shrub that contains twice the caffeine of coffee beans	Enhances performance	Risks associated with caffeine
*Kelp	Seaweed	Vitamin/ mineral source, especially iodine	Monitor iodine allergy
*Spirulina	Microscopic blue green algae, excellent source of beta-carotene	Protein source	Powerful antioxidant
*Yohimbine/ yohimbe bark	Nitrogen containing alkaloid from the bark of the yohimbe tree	Functions as a alpha 2 adrenoreceptor blocker, increasing blood levels of norepinephrine stimulant	Anxiety, insomnia, hypertension, dizziness, headaches
**Chrysin, diindolylmethane, indole-3-carbonol	Anti-extrogenic herbal compounds	Maintain or improve muscle mass, strength, protein synthesis and anaerobic exercise performance	Unknown
•Colostrum	Protein rich substance secreted in breast milk. Contains immunoglobulins and insulin-like growth factors (IGF's)	Performance benefits	Unknown
**Cystoseira canariensis algal extracts	Myostatin inhibitors	Maintain or improve muscle mass, strength, protein synthesis and anaerobic exercise performance	Unknown
**Octopamine	Citrus aurantium extracts, synthetic (norsynephrine)	Maintain or improve muscle mass, strength, protein synthesis and anaerobic exercise performance, improve body fat and leanness	Unknown
**Para-synephrine	Citrus aurantium extracts	Improve body fat loss and leanness	Unknown
••Ribose		Increased ATP and creatine phosphate levels	Unkown
**Beta-sitosterol, gamma oryzanol, sarsaparilla, smilax	Sterols	Maintain or improve muscle mass, strength, protein synthesis and anaerobic exercise performance	Unknown
**Chitosan	Fat trappers	Decrease fat mass	Unknown

**Forskolin	Coleus forskholii extracts	Improve body fat loss and leanness	Unknown
**Guggul lipids	Commiphora mukul extracts	Improve body fat loss and leanness	Unknown
**Hydroxycitric acid	HCA or Malabar tamarind rinc extract	Improve body fat loss and leanness	Unknown
**Phaseolamin	Amylase inhibitor	Improve body fat loss and leanness	Unknown
**Melatonin		Enhance performance	Possible interaction with warfarin and other coagulants

2.4.3 Doping

Doping has been defined by the International Olympics Committee (IOC) as 'the administration' or the use by a competing athlete of any substance foreign to the body or of any physiological substance taken in abnormal quantity or taken by an abnormal route of entry into the body with the sole intention of increasing in an artificial or unfair manner his performance in competition. The substances and methods that are banned by most sport organisations are based on the list prescribed by the IOC – see Table 18 (Burke et al., 2002, p.503).

Table 18. Substances or methods banned by the IOC (Burke et al., 2002, p.503).

A. Stimulants	Pseudo-ephedrine Ephedrine Amphetamines
B. Anabolic agents, anabolic and androgenic steroids, non-steroidal agents	Nandrolene DHEA Androstenedione 19-norandrostenedione Pro-steroid hormones Beta 2 agonists (except inhalants of salbutamol and terbutaline
C. Diuretics	Frusemide (lasix) Spironolactone (Aldactone)
D. Narcotic analgesics	
E. Peptide and glycoprotein hormones and analogues	Human growth hormone (HGH) Human chorionic gonadotrophin Corticotrophin Erythropoetin (EPO)
F. Blood doping	
G. Pharmacological, chemical and physical manipulations	Catheterisation (drawing urine from bladder) Masking agents, swapping urine

There is a small but real risk of inadvertent doping through supplement use. The problem exists for a minor percentage of people who undertake sport or exercise activities. The outcome for these athletes can be a substantial loss of success, reputation and earnings (Burke et al., 2002, p.505). The use of dietary supplements and some sports food is never risk-free and each athlete must make their own decision about whether or not to accept the risk (Turpin et al., 2004, p.481).

2.5 Summary

Nutrition may have more to offer the athlete than any other. Choosing appropriate foods in suitable amounts at the correct time will not compensate for a lack of natural ability, a reluctance to undertake the required training, nor an absence of tactical awareness. A poor diet will prevent the athlete from achieving his/ her potential (Maughan & Burke, 2002, p.1, 2). A fundamental role of nutrition in sport is to supply fuel for energy as well as all the essential nutrients and fluid. However, there is currently much debate on the bigger role that nutrition may play in enhancing performance by decreasing the perception of effort (Meltzer & Fuller, 2005, p.13).

Exercising individuals universally want to perform better and are willing to try almost anything that offers a promise of better performance (Wolinsky & Driskell, 2004, p.516). There has been a dramatic increase in the number of nutritional supplements on the market, all packaged with promises and claims of addressing one or more of the performance-limiting factors (Meltzer & Fuller, 2005, p.13). Most of the nutritional ergogenic aids are foods, food derivatives or body metabolites. More research, particularly long-term well-controlled research, is needed on the effects of nutritional ergogenic aids on physical performance (Wolinsky & Driskell, 2004, p.516).

CHAPTER 3 - METHODOLOGY

3.1 Introduction

The main aim of this study was to determine the dietary intake and the use of supplements by 30 u/21 male rugby players from the Blue Bulls. The Blue Bulls is a provincial team in South Africa. A description is given of the study design, sample, measurements used, pilot study, research procedures, statistical analysis and problems encountered in the study. These were all carried out to gather the relevant valid and reliable data to meet the aims of the study.

3.2 Study design

Rugby players playing for the Blue Bulls did a descriptive survey on the dietary intake and the use of supplements.

3.3 Sample

This study investigated the characteristics of a specific population, who share common characteristics, namely u/21 rugby players playing for the Blue Bulls. The u/21 Blue Bulls rugby team is one of the top 3 u/21 rugby teams in South Africa.

Thirty rugby players were part of the study. This included the 15 players chosen for the match on the following Saturday as well as the 15 substitute players (7 reserves and 8 not playing). This specific sample size was chosen because 30 rugby players were part of the u/21 rugby-training group.

Of the 30 players, 26 players returned the background information questionnaire and the supplement questionnaires. Two incomplete questionnaires could not be used. The required information could thus be collected only from 24 players.

3.4 In- and exclusion criteria

Only male rugby players between the ages 18 and 21 that were part of the Blue Bulls training group at the time of the study took part in the study. Only Afrikaans and English speaking players were included.

Females, rugby players from other u/21 team and athletes in other sports were excluded from this study. University of Pretoria (UP) u/20 rugby players that were part of the pilot study and promoted to the u/21 Blue Bulls at the time of the study were also excluded from this study.

3.5 Measurements

Measurements include variables and measuring techniques used.

3.5.1 Variables and work definitions

Variables are descriptions or explanations of the terms that are measured to complete objectives of the research project. The variables were defined as work definitions and included the usual dietary intake and supplement use.

3.5.1.1 Dietary intake

Dietary intake refers to the usual dietary intake of 4 consecutive days including the training day, pre-competition day, competition day and weekend day.

The usual dietary intake for the purpose of this study refers to the energy, macronutrient and micronutrient intake, with and without supplement use, as well as the fluid intake on the training day, pre-competition day, competition day and weekend day.

The adequacy of the rugby player's diet was determined by calculating the average of the median of 4 days' dietary intake and comparing it to the RDA's/AI's or recommendations for healthy individuals (RHI) where applicable. The Recommended Dietary Allowance (RDA), Adequate Intake (AI) and Tolerable Upper Intake Levels (UL) are part of the DRI's. The RDA's and AI's were used in the present study. The median dietary intake on the exercise days including the training day and competition day were compared to sport specific recommendations (SSR), where applicable. The rugby players rested on the pre-competition day and weekend day/ post-competition day.

3.5.1.2 Supplement use

Supplement use refers to the type, amount, duration and reasons for supplement use.

i. The type of supplement refers to all the extra products that rugby players ingest to enhance performance or health excluding food; including dietary supplements (sports drinks, vitamin and mineral supplements and other), as well as nutritional ergogenic aids (stimulants, herbal supplements and other).

ii. The amount of supplement used refers to the actual intake of products in grams per day (g/d). The amount of supplement use was compared to the dose on the supplement labels.

iii. The duration of supplement use refers to the time of day the rugby player has been using the supplement explained as before, during or after exercise.

iv. The reasons for supplement use include weight loss, building muscle and improving physique, reducing fatigue, enhancing performance and other.

3.5.1.3 Background information

Background information refers for the purpose of this study to name and surname, age, body mass index (BMI) and rugby playing position.

3.5.2 Measuring techniques

BMI, including height and weight measurements, questionnaires and a four-day food record were used to collect the data for this study.

3.5.2.1 Validity and reliability

Validity is concerned with the soundness and effectiveness of the measuring instrument. In a standard test, validity would raise questions concerning what was measured, what was supposed to be measured and how comprehensively and accurately it was measured (Leedy, 1997, p.32). Validity of the questionnaire refers to its ability to measure the phenomenon it intends to measure (Katzenellenbogen et al., 1999, p.82).

Reliability is the consistency with which a measuring instrument performs (Leedy, 1997, p.32). Reliability indicates whether the results are repeatable or reproducible (Monsen, 1992, p.110). Collecting accurate information ensures reliability of the measuring techniques (Joubert et al., 1999, p.45). A reliable measuring technique is one that gives the same results when the method is repeated on the same person several times (Gregoire, 1992, p.326).

3.5.2.2 Questionnaires

Each respondent in this study completed the background information and supplement questionnaires.

i. Background information

The background information questionnaire (Appendix A) in this study was used to determine background information on each rugby player. Valid questions that were relevant to the respondent's background information such as name, weight and height, age, date of birth and position of play were used.

A short questionnaire with simple questions was used. English and Afrikaans were chosen as the two languages. The questionnaire consisted of open-ended questions. Questions were clear and specific so that it could not be interpreted in a different way. The ability of the respondents to answer questions, the length, design and readability of the questionnaire were taken into account. An experienced person used standard techniques for weight and height measurements as well as interviews for incomplete questionnaires.

ii. Supplement questionnaire

The supplement questionnaire (Appendix B) was developed to determine the type, amount, period and reasons for supplement use. Literature was collected on the specific study subject. Questions that were relevant to the research objectives and suitable to the problem situation were formulated. Valid questions were included such as product name, amount of supplement use per day, reasons for supplement use, period and duration of supplement use.

Repeatability was ensured by choosing English and Afrikaans as the two languages. The questionnaire consisted of simple and open-ended questions to ensure repeatability. Clear and specific questions were ensured through pilot testing to avoid misinterpretation. The ability of the respondents to answer questions, the sequence, layout, design and length of the questionnaire were taken into account. The respondents completed the questionnaires by writing answers to questions that were asked about their supplement use. Photocopies of supplement labels (Appendix C) used by the rugby players were made to ensure accuracy of the completed supplement questionnaires. This written answer and photocopy-method had the advantage that the researcher could see first hand the type, amount and reasons for supplement use. The researcher could see the container in which the supplement was sold as well as the scoop size inside the container. The researcher interviewed respondents with incomplete questionnaires to determine outstanding information.

3.5.2.3 Anthropometry

Standard methods as described by Leedy (1997) were used to determine current weight and height. Choosing applicable standard methods and techniques ensured validity. A calibrated scale and stadiometre were used.

To enhance reliability, the same person experienced in taking standardised measurements measured the height and weight of each rugby player. The height and weight measurements were noted on the background information questionnaire (Appendix A). The height and weight measurements of each rugby player were taken at the same time of day with light clothing and no shoes. The BMI of each respondent were also calculated.

3.5.2.4 Four-day food record

The four-day food record was used to collect data on the usual dietary intake of rugby players. According to Burke and Deakin (2002, p.34) food records is the most valid method to determine usual food intake of small groups of athletes such as rugby players. Data sheets were developed to record the usual dietary intake of rugby players on four consecutive days such as a training day (week day), pre-competition day, competition day and post-competition day (weekend day). Each respondent completed a simple, one page per day four-day food record (Appendix D). The average dietary intake on the four days was compared to the RDA/AI and recommendations for healthy individuals to calculate the adequacy of the usual dietary intake of rugby players. According to Perkin (1992, p.125) food records require subjects to measure or estimate, and record all foods consumed over a specified period, usually 3 to 7 consecutive days. An instructions page containing information about the measuring or estimation of portion sizes were included in the four-day food record.

English and Afrikaans were chosen as the two languages. The four-day food record was pre-tested in a pilot study. Respondents were motivated to complete their food and drink intake on the four-day food record as honestly and accurately as they could. The researcher checked the completed four-day food records.

3.6 Pilot study

A pilot study was conducted on the u/20 rugby players from the UP prior to the main study in order to test the contents and procedures of the background information questionnaire (Appendix A), supplement questionnaire (Appendix B), supplement labels (Appendix C) and four-day food record (Appendix D). The pilot study was done on 5 rugby players whom are not included in this study. The 5 rugby players were expected to complete each questionnaire and food record correctly on their own. The respondents' understanding and completion of the questionnaires and food record were also tested. The respondents indicated in writing on the questionnaires where they did not have a clear understanding of the questions. The measuring of weight and height; collection of information on the questionnaires and food record were tested. Changes were made to the planned study, questionnaires and the food record.

Problems identified during the pilot study, including misunderstanding of how to complete the questionnaires and food records that led to incomplete questionnaires being handed in, were corrected and addressed. After the pilot study, the researcher made the necessary changes to the questionnaires, food records and procedures to ensure optimal understanding. These changes included an instructions page and improved training of respondents on how to complete the questionnaires. After the pilot study, the researcher also included scheduled contact sessions for respondents with incomplete questionnaires.

3.7 Procedure of data collection

The procedures of data collection will be described according to Figure 3.

3.7.1 Phase 1: Initial phase

This initial phase was prior to collection of the background information. Ethical approval to do the study (Appendix E) was obtained from the University of the Free State Ethical Committee. A pilot study was conducted and changes were made to the study. Written consent (Appendix F) was obtained from the rugby players and implications of the study were explained.

3.7.2 Phase 2: Background information questionnaire

Background information was collected before the training session on Monday morning, 20 September 2004 (day 1). The researcher handed out the background information questionnaires (Appendix A) to the rugby players. The respondents received training on how to complete the background questionnaire and were expected to complete the questionnaires on their own.

The height and weight of each rugby player were measured before training Monday morning, 20 September 2004 by the biokineticist (Appendix A). The biokineticist recorded the height and weight measurements on each respondent's questionnaire.

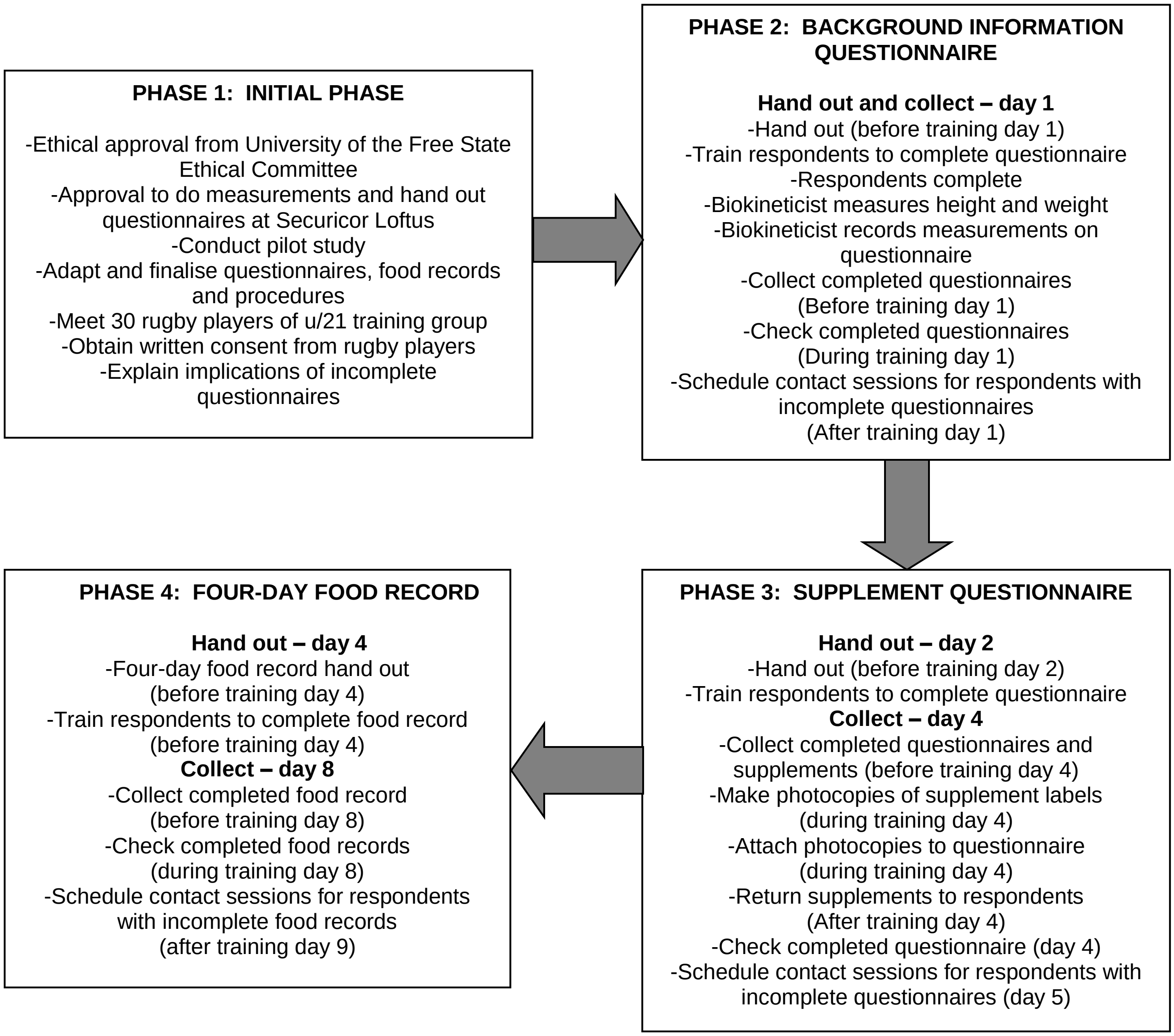

Figure 3: Flow diagram of procedure of data collection

The researcher was present during completion of the questionnaires at Securicor Loftus and collected the completed questionnaires before training Monday, 20 September 2004. The researcher checked the completed questionnaires during the respondents' training session. Scheduled contact sessions were made after the training session with respondents who had incomplete questionnaires.

3.7.3 Phase 3: Supplement questionnaire

The researcher handed out the supplement questionnaires (Appendix B) before training Tuesday morning, 21 September 2004 (day 2). The respondents were trained during a group session before training how to complete the questionnaire. The respondents were asked to bring the supplements they use to training on day 4.

The researcher collected the completed questionnaires and supplements used before training Thursday morning, 23 September 2004 (day 4). Photocopies were made of the supplement labels (Appendix C) during the respondents' training session. The photocopies were attached to the questionnaire according to the respondent number. The researcher returned the supplements to the respondents after the training session Thursday morning, 23 September 2004. The researcher checked the completed supplement questionnaires on day 4 and scheduled contact sessions on Friday, 24 September 2004 (day 5) with respondents to confirm incomplete data. The supplement labels were used together with the questionnaire after the collection of data to evaluate and calculate the amount of supplement use.

3.7.4 Phase 4: Four-day food record

The four-day food records (Appendix D) was handed out to each respondent before training Thursday morning, 23 September 2004 immediately after collection of supplement questionnaires (day 4). The researcher trained respondents during a group session before training to complete the food record. The completed food records were collected before training Monday, 27 September 2004 (day 8). The researcher checked the completed four-day food records on Monday, 27 September 2004 while the respondents were training and scheduled contact sessions, after training, with respondents who had incomplete food records on Tuesday, 28 September 2004 (day 9).

3.8 Ethical procedure and approval

The researcher obtained ethical approval from the Ethics Committee of the University of the Free State (ETOVS nr. 142/04). Approval to do the study at Securicor Loftus in Pretoria was obtained (Appendix E). The researcher obtained written consent (Appendix F) from the rugby players and information concerning the study was handed out to all the rugby players in their language of preference (Afrikaans or English). The consent form explained the aim, procedures and benefits of the study.

3.9 Statistical analysis

The Department of Biostatistics, Faculty of Health Sciences, University of the Free State did the statistical analysis.

Numerical variables were summarised by means of means and standard deviations, or percentiles if the distributions are skew. Categorical variables were summarised by means of frequencies and percentages.

The nutrient intake per person was analysed by computer using the MRC Food Composition Tables. Nutrient intakes were compared to the DRI. The RDA and AI were used where DRI values were not available.

Nutrient intake with and without supplements was determined. The change in nutrient intake with and without supplements were calculated and described by means of 95% confidence intervals for the median difference for paired data.

The average of the median of the 4 days, with and without supplements, was calculated and compared to the RDA's/AI's and RHI. The dietary intake on the training day and competition day was compared to SSR, where applicable.

3.9 Problems

Two supplement questionnaires and four food records were incomplete of which the data on four food records were easily collected in the contact sessions. Due to a lack of cooperation, the incomplete supplement questionnaires of two participants could not be gathered or used and were thrown out (6,6%). Four participants did not complete the full course of the study and dropped out (13,3%) because of a loss of interest. Conclusively, two incomplete supplement questionnaires were thrown out and four participants dropped out of the study. Therefore the information of a total of six participants could not be used in the study (19,9% of 30).

The required information could thus be collected from 24 of the 30 participants (80,1%), which is acceptable. The guideline is that if more than 20% of the participants do not complete the full course of the study, results may be influenced to such an extent that they do not reflect the truth. The results of this study, however, were not influenced in such a way.

CHAPTER 4 - RESULTS

4.1 Introduction

The background information, supplement use and usual food intake of the rugby players who completed the study will be described. Results will be demonstrated with the use of tables and short discussions.

4.2 Background information

Background information such as age, rugby position played and BMI will be described.

4.2.1 Age

The mean age for the u/21 rugby players was 19 years and 9 months.

4.2.2 Position played

Table 19 shows the number of players (n=24) chosen in different playing positions. Three (12,5% of the 24) players played each in prop, hooker and wing positions. Two (8,3% of the 24) players played in each of the following positions: lock; scrumhalf; fullback; centre, wing and fullback; flank and eight man. One (4,1% of the 24) player played each in flank, eight men, fly half, centre, fly half and fullback position.

4.2.3 Anthropometry/ Body Mass Index

The mean BMI (27, 1 kg/m²) for the u/21 rugby players is higher than the normal healthy range of between 18,5 to 25 kg/m².

Table 19. Players in different rugby playing positions

Rugby playing position	Frequency (N = 24)	%
Prop	3	12,5
Hooker	3	12,5
Lock	2	8,3
Flank	1	4,1
Eighth man	1	4,1
Scrumhalf	2	8,3
Fly half	1	4,1
Wing	3	12,5
Centre	1	4,1
Fullback	2	8,3
Centre, wing, fullback	2	8,3
Fly half, fullback	1	4,1
Flank, eighth man	2	8,3

4.3 Usual dietary intake

The energy, macronutrient, micronutrient and fluid intake of the rugby players on a training day, pre-competition day, competition day and weekend day, as well as the average of the 4 days with (+) and without (-) the use of supplements (suppl) (Tables 20 to 22) will be shown.

4.3.1 Energy and macronutrient intake

The average of the median energy and macronutrient intake of the 4 days were compared to the RDA/AI and RHI in Table 20. The median energy and macronutrient intake on the training day and competition day were compared to SSR for rugby players, where applicable, in Table 21. For the purpose of this study, the pre-competition day was not included as an exercise day because it was a rest day for the study population. There are no recommendations for the pre-competition day, only for the pre-competition meal.

The energy needs is influenced by height and weight status. Therefore, the mean BMI was taken into consideration when evaluating the energy intake. The average BMI for the u/21 rugby players in this study was 27,1 kilogram per square metre (kg/m^2). An average BW of 88 kg and length of 1,8 metres (m) were used. The % of TE and amount in grams (g) of each macronutrient on different days were calculated.

4.3.1.1 Energy intake

The average of the median energy intakes for the 4 days (14708 & 12274 kJ: ±suppl) were higher than the RDA/AI (12180 kJ) for moderately active men older than 18 years (Table 20). The median energy intakes on the training day (152 & 126 kJ/kg/d: ±suppl) were lower than the SSR (155 to 210 kJ/kg/d) and the median energy intakes on the competition day were within the SSR (155 to 210 kJ/kg/d) (Table 21).

4.3.1.2 Macronutrient intake

The total CHO (including added sugar), dietary fiber, fat (including saturated, mono-unsaturated, poly-unsaturated and cholesterol intakes) and protein (including amino acids) intakes with and without supplements were calculated and compared to the RDA/AI, RHI and SSR, where applicable.

i. Total carbohydrates

Expressed as %TE of the 4 days, the average of the median CHO intakes (45,9 & 44,4% TE: ±suppl) were lower than the RDA/AI (50-60% of TE) (Table 20). The median CHO intakes on the training day (3,9 and 3 g/kg/d: ±suppl) and competition day (5 and 4,1 g/kg/d: ±suppl) were lower than the SSR (6-10 g/kg/d) for rugby players (Table 21).

The average of the median refined sugar intake (12,4 and 10,7 %TE: ±suppl) was higher than the RHI (<10% TE) (Table 20). Compared to the SSR, the refined sugar intake was according to SSR (<14%TE) on the training day (12,7 and 11,7% TE: ±suppl) and competition day (13,8 and 10,9% TE: ±suppl) (Table 21).

The rugby players did not meet the RHI (25-35 g/d) for dietary fibre intake (24,3 and 23,2 g: ±suppl) (Table 20).

Table 21. The median energy and macronutrient intake compared to the sport specific nutritional recommendations (m=88kg, L=1,8m)

	Training day		**Competition day**		
Macronutrients	**Med -Suppl**	**Med +Supp**	**Med -Suppl**	**Med +Suppl**	**Sport specific recommendations**
Total Energy	11095 kJ 126 g/kg/day	13424 kJ 152 g/kg/day	14198 kJ 161 g/kg/day	16926 kJ 192 g/kg/day	155-210 kJ/kg/day
Total CHO	270,8 g 3 g/kg/day	346,6 g 3,9 g/kg/day	362,6 g 4,1 g/kg/day	441,4 g 5 g/kg/day	528-880 g 6-10 g/kg/day
Total refined sugars	11,6%	12,7%	10,9%	13,8%	<14% CHO
Total fat	42,9% 1,4 g/kg/day	36,5% 1,5 g/kg/day	35% 1,5 g/kg/day	31% 1,5 g/kg/day	20-35% TE 1-1,5 g/kg/day
Total protein	19,9 % 1,4 g/kg/day	20,7 % 1,8 g/kg/day	18 % 1,7 g/kg/day	18 % 1,9 g/kg/day	15-20% TE 1,2-2 g/kg/day

-Suppl: Median without supplements
+Suppl: Median with supplements

ii. Total fat

According to Table 20, the average of the median fat intake (33,2 and 37,6% TE: ±suppl) was higher than the RDA/AI (≤30% of TE). The median fat intake was within the SSR (1-1,5 g/kg/d) on the training day (1,5 and 1,4 g/kg/d: ±suppl) and competition day (1,5 g/kg/d: ±suppl) (Table 21).

The average of the median polyunsaturated fatty acid (PUFA) intakes (5,7 and 6,8% TE: ±suppl) and monounsaturated fatty acid (MUFA) intakes (11,4 and 13,4% TE: ±suppl) were within the RHI of 5-10% and 10-15%TE, respectively. The average of the median saturated fatty acids (SFA) intake (10,9 and 12,4% TE: ±suppl) was higher than RHI (≤10% of TE).

The average of the median cholesterol intake (665 and 628,7 mg: ±suppl) was especially much higher than the RHI (300 mg) (Table 20).

iii. Total protein

The average of the median protein intake (19,6 and 19,9% TE) was within the RDA/AI (15-20%)(Table 20). RDA/AI values for amino acids and derivatives have not been determined, but the intake of leucine, isoleucine and valine all exceeded the suggested 3 g per day (Table 20).

The median protein intakes on the training day (1,8 and 1,4 g/kg/d: ±suppl) and competition day (1,9 and 1,7 g/kg/d: ±suppl) fell within the SSR (1,2-2 g/kg/day) for rugby players (Table 20).

4.3.2 Micronutrient intake

The average of the median vitamins, minerals and electrolyte intakes for rugby players, with and without supplements, on 4 days including the training, pre-competition, competition and weekend days were compared to the RDA/AI in Table 22.

4.3.2.1 Vitamins

The average of the median vitamins intake was within the RDA/AI. Only the average of the median vitamin E intake (13,3 mg) without supplements was lower than the RDA/AI (15 mg).

The UL for niacin intake was exceeded on the competition day, with and without supplements. The average cobalamin intake was more than 300% of RDA/AI, but no UL has been determined (Table 22).

4.3.2.2 Minerals

Most of the mineral intakes were adequate, except the lower calcium, magnesium and iodine intakes. The average of the median calcium (935,7 mg & 803 mg) and magnesium (381,1 mg & 352 mg) intakes, with and without supplements, for the 4 days, were lower than the RDA/AI (Ca: 1000 mg & Mg: 400 mg). The average of the median iodine intakes (114,3 and 114 µg: ±suppl) were also lower than the RDA/AI (150 µg) (Table 22).

Of the electrolytes the average of the median sodium (3082,7 and 2537,8 mg), potassium (3916,3 and 3499,1 mg) and chloride (3922 and 3519,5 mg) intakes, with and without supplement use, were higher than the RDA/AI (Na: 500 mg; K: 2000 mg; Cl: 750 mg). The sodium and chloride intakes of the rugby players were more than 300% of the RDA/AI (Table 22).

4.3.3 Fluid intake

The rugby players drank fluid such as water, 100 % fruit juice, coffee and tea, alcoholic drinks (beer, whiskey, sparkling wine and wine), carbonated beverages (only Coke and Fanta) and cordials (only Oros). The average of the median fluid intake of the rugby players was the same with and without supplements. Table 23 summarises the different fluids and average of the median fluid intake, with and without supplements, of the 4 days.

The average of the median water intakes with and without supplements (1341,3 ml) were lower than the daily water recommendations (2000 ml/d) for healthy individuals. Fruit juice, carbonated beverages and cordials supplied 299,4 ml fluid per day (Table 23). Coffee/ tea and alcohol intakes did not exceed the safe intake recommendations for healthy individuals (Table 23).

4.4 Supplement use

Information gathered through the supplement questionnaire included the type of supplement used; amount of supplement used; timing and duration of supplement use; and reasons for using the supplements.

4.4.1 Type of supplement

The type of supplement will be described according to the manufacturer and product name. Eight (33,3% of the 24) players indicated that they did not use supplements and 16 (66, 6% of the 24) players used supplements.

Table 23. Median fluid intake on the training day, pre-competition day, competition day and weekend day (±suppl) *(N=27)*

Fluid	Safe intake recommendations for healthy individuals (ml/d)	Training	Pre-competition	Competition	Weekend	Average of the median for 4 days
Water	>2000 (>8 glasses)	1207,2 (77, 7 %)	1387 (80, 2 %)	1840,8 (73, 1 %)	930,2 (63, 2 %)	1341,3 (67,1%)
100 % fruit juice	100-300 (1-3 servings fruit)	37 (2, 3 %)	74 (4, 2 %)	12,5 (0, 4 %)	-	30,8
Coffee/tea	250-500 (1-2 cups)	55,5 (3, 5 %)	18,5 (1 %)	9,2 (0, 3 %)	64,8 (4, 4 %)	37
Beer	340 (1 can)	37,7 (2, 4 %)	75,5 (4, 3 %)	239,2 (9, 5 %)	25,1 (1, 7 %)	94,3
Whiskey + water	30-60 (1-2 tots)	4,4 (0, 2 %)	-	8,8 (0, 3 %)	4,2 (0, 2 %)	4,3
Sparkling wine	100-200 (1-2 glasses)	-	-	7,4 (0, 2 %)	13,8 (7, 4 %)	5,3
Red wine	125-250 (1-2 glasses)	-	-	92,5 (3, 6 %)	46,2 (3, 1 %)	34,6
Carbonated beverages	ND	25,1 (1, 6 %)	62,9 (3, 6 %)	193,3 (7, 6 %)	200,7 (13, 6 %)	120,5
Cordials	ND	185,1 (11, 9 %)	111,1 (6, 4 %)	111,1 (4, 4 %)	185,1 (12, 5 %)	148,1
Total fluid		**1552**	**1729**	**2514,8**	**1470,1**	**1816,2**

ml: millilitres ND: Not determined >more than
ml/d: millilitres per day ( ): % of total fluid intake

The 16 rugby players used 19 different supplements that were categorised in 7 groups. Some players used more than 1 supplement (Table 24). Most (n=10) of the supplements were manufactured by Energy-Athletics-Strength (EAS), followed by Ultimate Sports Nutrition (USN) (3), Evolutionary Sports Performance informatika (ESPi) (2), Cadbury Beverages (1), Protein-vitamins-minerals (PVM) (1), Bayer Healthcare (1) and RxMed (1). Listed are the type of supplement and the frequencies that it was used, as well as the manufacturers and product names (Table 24).

Most (18,7% of 16) players used Myoplex Simply Protein/ MyoPro Whey Protein and Muscle/ Mass factor (EAS), followed by equal use of Precision Protein, Betagen, Phosphagen HP and Energade (12,5% of 16) (Table 24). Single individuals used the other supplements that are listed. Nearly 50% (n=8) used protein powders for supplementation; followed by 31,2% (n=5) using powders containing amino acids and derivatives; meal replacements used by 31,1% (n=5); powders containing CHO, amino acids and electrolytes used by 18,6% (n=3); 12,5% (n=2) using sports drinks containing CHO and electrolytes; 12,4% (n=2) using fat supplements and vitamin/ mineral supplements (Table 24). Creatine supplements were used by 5 individuals and include Creatine phosphagen (n=2), Muscle/ Mass factor (n=1) and Betagen (2). HMB supplements that were used include Betagen (n=2).

Table 24. Type of supplement and frequencies used

Type of supplement and supplement name	Manufacturer	Frequency (N=16)	%
Protein (powder)			
*Myoplex Simply protein/ MyoPro Whey Protein	EAS	3	18,7
Myoplex Carb Sense	EAS	1	6,2
Precision protein	EAS	2	12,5
Muscle Mass	ESPi	1	6,2
Pure Protein	USN	1	6,2
			49,8
Amino acid and derivative (powder)			
L-Glutamine	USN	1	6,2
Betagen	EAS	2	12,5
Phosphagen HP	EAS	2	12,5
			31,2
Carbohydrate, amino acid and electrolyte (powder)			
Enduro Load	ESPi	1	6,2
Cytovol	EAS	1	6,2
Iso-Drive	EAS	1	6,2
			18,6
Carbohydrate and electrolyte (sports drink)			
Energade	Cadbury	2	***12,5***
Meal replacement			
**Muscle/ Mass factor (powder)	EAS	3	18,7
Myoplex Original (powder)	EAS	1	6,2
Energy bar (sports food)	PVM	1	6,2
			31,1
Fat (soft gels/ capsules)			
Conjugated Linoleic Acid (CLA)	USN	1	6,2
Conjugated Linoleic Acid (CLA)	EAS	1	6,2
			12,4
Vitamin and mineral			
Berocca (tablet)	Bayer	1	6,2
Vitathion (powder)	RxMed	1	6,2
			12,4

* Myoplex Simply Protein has been replaced by MyoPro Whey protein
** Muscle factor has been replaced by Mass factor

Some individuals each used 1 supplement and others used more than 1 supplement. Table 25 explains the single supplements used and the different combinations of supplements used where more than 1 supplement were used together. Nine of the16 rugby players (55,9%) used single supplements. Seven of the 16 rugby players (43,4%) used combinations of more than 1 supplement (Table 25).

Table 25. The single and combinations of supplements used by the rugby players

Single and combinations of supplements used	N=16	%
Single supplements used		
MyoPro Whey (EAS)	1	6,2
Precision Protein (EAS)	1	6,2
Muscle Mass (ESPi)	1	6,2
Pure Protein (USN)	1	6,2
Betagen HP (EAS)	1	6,2
Enduro (ESPi)	1	6,2
Muscle/ Mass factor (EAS)	2	12,5
Vitathion (RxMed)	1	6,2
		55,9
Combinations used		
MyoPro Whey (EAS) + Phosphagen HP (EAS)	1	6,2
Phosphagen HP (EAS) + Cytovol (EAS)	1	6,2
Betagen (EAS) + Energy bar (PVM)	1	6,2
L-Glutamine (USN) + Energade (Cadbury)	1	6,2
Energade (Energade) + Berocca (Performance)	1	6,2
MyoPro Whey (EAS) + Muscle/ Mass factor (EAS) + CLA (EAS)	1	6,2
Precision Protein (EAS) + IsoDrive (EAS) + Myoplex Original (EAS) + MyoplexCarb Sense (EAS) + CLA (USN)	1	6,2
		43,4

4.4.2 Amount of supplement used

Table 26 summarises the amount of different supplements used by the rugby players. The median amount of supplement used was compared to the dosage recommended according to the supplement labels listed in *Appendix C.*

According to Table 26, 3 individuals used Myoplex Simply Protein/ MyoPro Whey Protein (EAS) and Muscle/ Mass factor (EAS), followed by Betagen (EAS) (2), Phosphagen HP (EAS) (2), Energade (Cadbury) (2), and Precision Protein (EAS) (2).

The median intake for supplements including Myoplex Simply Protein/ MyoPro Whey Protein, Energade, Muscle Mass, Pure Protein, L-Glutamine, Cytovol, Iso-Drive, CLA and Vitathion were within the dosage recommended according to the supplement labels in Appendix C, for these supplements (Table 26). The median intake for 8 supplements including Phosphagen HP, Muscle/ Mass factor, Precision Protein, Myoplex Carb Sense, Enduro Load, Myoplex Original, Energy bar and CLA (EAS) were lower than the dosage recommended for these supplements. The median intake for Betagen and Berocca were higher than the dosage recommended (Table 26).

Table 26. Amount of supplement use compared to the dosage recommended according to the supplement labels.

Supplement name	**N=16**	**Dosage recommended (g/d)**	**Max (g/d)**	**Med (g/d)**	**Min (g/d)**
MyoPlex Simply Protein/ MyoPro Whey Protein (EAS)	3	43 –172	162	99	60
Betagen (EAS)	2	19,8	39,6	29,7	19,8
Phosphagen HP (EAS)	2	172	86	52,4	28,4
Energade (Cadbury)	2	250	250	250	250
Muscle/ Mass factor (EAS)	3	174 – 348	174	98,2	16,6
Precision Protein (EAS)	2	27	39	25,5	12
Carb Sense MyoPlex (EAS)	1	90 – 135	20	20	20
Muscle Mass (ESPi)	1	70 – 210	70	70	70
Pure protein (USN)	1	108 – 216	108	108	180
L-Glutamine	1	10 – 25	10	10	10
Enduro Load (ESPi)	1	50 – 150	8,2	8,2	8,2
Cytovol (EAS)	1	5 – 10	7	7	7
Iso-Drive (EAS)	1	35 – 70	35	35	35
Myoplex Original (EAS)	1	152 – 228	20	20	20
Energy bar (PVM)	1	40 g	6,6	6,6	6,6
Conjugated Linoleic Acid (USN)	1	3 –6	6	6	6
Conjugated Linoleic Acid (EAS)	1	24	12	12	12
Berocca (Bayer)	1	8 (1 tablet)	16	16	16
Vitathion (RxMed)	1	5–10 (1-2 sachets)	10	10	10

4.4.3 Duration of supplement use

The rugby players ingested supplements at different times of the day. The duration of supplement use were categorised according to before, during or after exercise and are listed in Table 27.

Four (24,9%of 16) rugby players used supplements before exercise; 7 (43,5% of 16) used supplements after exercise; 12 (74,6% of 16) used supplements before and after exercise, 2 (12,4% of 16) during and after exercise; and 2 (12,4% of 16) before, during and after exercise. Although most of the rugby players used supplement before and after exercise, no specific pattern or timing of supplement use was followed (Table 27).

Table 27. Duration of supplement use

Duration	***Supplement***	***Frequency (N=16)***	***%***
Before exercise	Enduro (ESPi)	1	6,2
	Muscle/ Mass factor (EAS)	2	12,5
	Vitathion (RxMed)	1	6,2
		4	***24,9***
After exercise	Muscle Mass (ESPi)	1	6,2
	Pure Protein (USN)	1	6,2
	Betagen (EAS)	2	12,5
	Phosphagen HP (EAS)	1	6,2
	Cytovol (EAS)	1	6,2
	Energy bar (PVM)	1	6,2
		7	***43,5***
Before and after exercise	Myoplex Simply Protein/ MyPro Whey Protein (EAS)	2	12,5
	Myoplex Carb Sense (EAS)	1	6,2
	Precision Protein (EAS)	2	12,5
	Iso-Drive (EAS)	1	6,2
	Energade (Cadbury)	1	6,2
	Muscle/ Mass factor (EAS)	1	6,2
	Myoplex Original (EAS)	1	6,2
	CLA (USN)	1	6,2
	CLA (EAS)	1	6,2
	Berocca (Bayer)	1	6,2
		12	***74,6***
During and after exercise	Myoplex Simply Protein/ MyoPro Whey Protein (EAS)	1	6,2
	Phosphagen HP (EAS)	1	6,2
		2	***12,4***
Before, during and after exercise	L-Glutamine (USN)	*1*	6,2
	Energade (Cadbury)	*1*	6,2
		2	***12,4***

4.4.4 Reasons for supplement use

Table 28 summarises the reasons given for supplement use among the rugby players. The reasons for using supplements were included in the supplement questionnaire.

Table 28. Reasons for supplement use

Reasons	Frequency (N=16)	%
Building muscle and muscle repair	16	100
Muscle repair, weight gain and fat loss	4	25
Energy and rehydration	6	37,5

All the rugby players used the supplements for building muscle and muscle repair (100%); while 6 (37,5% of 16) used supplements for muscle repair, weight gain and fat loss; and 4 (25% of 16) used supplements for energy and rehydration. Some of the rugby players used more than 1 reason for using supplements.

CHAPTER 5 – DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

Observations were made in the study and will be discussed and compared to the relevant literature available. The most important observations that were made include:

- The average of the median energy and macronutrients intakes with and without supplements, of the 4 days, were within the RDA/AI, except for the lower average of the median CHO and dietary fibre intakes; as well as the higher average of the median sugar intake. The median energy and total CHO intakes, with and without supplements were lower than the SSR on the training day and both exercise days, respectively.
- The average of the median fat, SFA and cholesterol intakes, with and without supplements was higher than the RDA/AI and RHI, where applicable.
- The average of the median vitamins intakes, with and without supplements was higher than the RDA/AI and was adequate, except for a lower vitamin E intake without supplement use. The UL for niacin intake was exceeded on the competition day, with and without supplements.
- The average of the median minerals intakes, with and without supplements, of the 4 days, was higher than the RDA/AI and was adequate, except for the lower calcium, magnesium and iodine intakes. Average of the median sodium and chloride intakes, with and without supplements, were more than 300% of RDA/AI.
- The average of the median fluid intake of rugby players was lower than the proposed maximum intake.

- The majority of the u/21 Blue Bulls rugby players used supplements.
- Protein powders were the most frequent types of supplements used.
- Most of the supplements were used in amounts within the recommended dosages.
- Supplements were used before and after exercise in no specific pattern.
- Reasons for using supplements were mostly muscle building and repair.

5.2 Limitations

The present study was limited to the u/21 Blue Bulls rugby players only. Six participants did not complete the study. The study population was therefore limited to 24 of the 30 participants. Information could therefore, only be gathered from a small group.

The information gathered did not include detail of the pre-event meal or snack, during competition nutrition or after competition meals. The aim of this study could however be accomplished to determine the dietary intake and supplement use of the study population.

5.3 Discussion

Energy and macronutrients, as well as micronutrients and fluid intakes of the rugby players play an important role in sports nutrition and performance.

5.3.1 Energy and macronutrients

The average of the median energy intake of the rugby players, with and without supplements, of the 4 days, compared to the RDA/AI was adequate. Active individuals who are male and older than 18 years, should have an energy intake of 12 180 kJ/d according to the RDA/AI (Berning, 2004, p.618). The median energy intake, with and without supplements, compared to the SSR on the competition day was adequate. Usually, normally active people are counselled to consume an energy intake of 1, 7 times resting energy expenditure expressed as 155 to 173 kJ/kg/d. Thus, rugby players competing at a high intensity for longer than 90 minutes per day should increase their daily energy intake to 210 kJ/kg/day or more (ACSM et al., 2000, p.2123). Depending on the rugby player's weight and position of play, some rugby players may ingest up to 15000 kJ or more on an active day. For any one individual the factors that influence energy balance may be numerous including gender, age, family history, dietary choices, level of daily activity and stress level (Manore & Thompson, 2002, p.140).

Depending on the training regimen, athletes need to consume at least 50 to 60 % of TE from CHO (Berning, 2004, p.625). In the present study the average of the median CHO intake, with and without supplements, of the 4 days, was inadequate. The median CHO intake, with and without supplements also did not meet the SSR for rugby players on the training day and competition day. Athletes in heavy training should consume a CHO intake of 6 to 10 g/kg BW/d to prevent daily CHO and glycogen depletion (Berning, 2004, p.626). According to Bean (2003, p.17) athletes exercising to a moderate intensity from 1 to 4 hours/day should ingest 6 to 8 g CHO/kg BW/d and individuals training for longer than 4 hours per day should ingest 8 to 10 g CHO/kg BW/d (Bean, 2003, p.17). The amount required depends on the athlete's total daily energy expenditure, type of sport, gender and environmental conditions (Berning, 2004, p.626). Diets low in CHO can lead to a lack of energy during exercise, early fatigue, loss of concentration and delayed recovery (Meltzer & Fuller, 1005, p.15).

The RHI for the average sugar intake should not exceed 10 % of TE intake. In the present study the average of the median sugar intake, with and without supplements, of the 4 days, was higher than the RDA/AI (10% of TE) and within the SSR on the training day and competition day. When added sugars occupy too much of a diet, intakes from the 5 food groups fall below recommendations. Perhaps an athlete in training whose energy needs are high can afford the added sugars from sports drinks without compromising nutrient intake, but most people would do better using added sugars more sparingly (Whitney & Rolfes, 2005, p.123).

The recommendation for dietary fibre is 25 to 35 g per day for active individuals (Ettinger, 2004, p.48). In the present study the average of the median dietary fibre intake, with and without supplements, of the 4 days was inadequate. The median dietary fibre intake on the competition day with supplements (26,5 g) was much higher than the other days. A high fibre supplement could be the cause.

Athletes including rugby players should consume 20% to 30 % of TE from fat (Meltzer & Fuller, 2005, p.46). In this study the average of the median fat intake, with and without supplement use, of the 4 days was higher than the RDA/AI (20-30% TE). Carrying around excess body weight in the form of fat is a distinct disadvantage in almost every sport. In explosive sports such as rugby, where you must transfer or lift the weight of your whole body very quickly, extra fat again is non-functional weight, slowing you down, reducing your power and decreasing your mechanical efficiency. Muscle is useful weight, whereas excess fat is not (Bean, 2003, p.98). The median fat intake, with and without supplements, was within the SSR (20-35% TE). The recommendations on upper limits of fat intake for adults must take into account the degree of physical activity. Active individuals in energy balance may consume up to 35% of their TE intake as dietary fat (Berning, 2002, p.631). Carrying extra body fat can be an advantage in certain sports e.g. in certain positions of play in team sports such as lock or prop in rugby, it protects organs. However, in most sports, extra body fat is simply additional dead weight, affecting the athlete's speed and agility (Meltzer and Fuller, 2005, p.18). As soon as fat intakes become too high or too low, the immune system is affected, which in turn will affect sports performance and general health (Venkatraman et al., 2000).

Most of the fat intake should come from unsaturated fats, including PUFA (5 to 10 % TE) and MUFA (10 to 15 % TE) (Ettinger, 2004, p.51). According to the results of this study the average of the median PUFA and MUFA intakes, with and without supplements, was within the RHI. Recent evidence shows that PUFA's and MUFA's are the most easily oxidized (burnt) of all the fats and should therefore receive preference when planning a daily fat allowance (Meltzer & Fuller, 2005, p.20). The SFA intake should not exceed 10% TE per day (Ettinger, 2004, p.51). In the present study the average of the median SFA intake, with and without supplements, of the 4 days was higher than the RHI (≤10% TE). A cholesterol intake of 300 mg is recommended per day (Earl & Borra, 2000, p.345). The average of the median cholesterol intake of the rugby players, with and without supplements (628,7 mg and 665 mg: ±suppl) was more than double the RHI (300 mg). This could be due to the high fat and SFA intake. SFA intake should be limited because it increases blood cholesterol levels the most (Meltzer and Fuller, 2005, p.20). According to Bean (2003, p.108) SFA should be avoided to achieve peak sports performance, because they provide no positive benefit. Persons who have tried to perform on high-fat diets find that their performance suffers because of lower glycogen stores. Glycogen stores are limited because the amount of CHO consumed in the diet is limited (Berning, 2004, p.620).

In the present study the average of the median protein intake, with and without supplement use, of the 4 days was within the RDA/AI. The RDA/AI for protein intake for athletes is between 12% and 20% of the TE intake that represents between 1, 2 to 2 g protein/kg BW/d (Berning, 2004, p.630). The protein recommendations for resistance and strength-trained athletes (including rugby players) may be as high as 1, 6 to 1, 7 g/kg BW/d (ACSM et al., 2000). In the present study the median protein intakes were within the SSR (1,2 to 2 g/kg/d) on the training day and competition day. It is noteworthy that the customary diets of most athletes provide sufficient protein to cover even the increased amounts that may be needed (ACSM et al., 2000).

One of the biggest myths is that large amounts of protein are required to build muscle. Muscles can only use a limited amount of protein for growth, provided there is enough energy and CHO to fuel the strength-training required for muscles to grow (Meltzer & Fuller, 2005, p.21). Consuming excessive protein certainly offers no advantage in terms of health or physical performance. Once protein requirements have been met, additional protein will not be converted into muscle, nor will it further increase muscle size, strength or stamina (Bean, 2003, p.4). Any excess protein will be broken down for energy and excreted as urea. A consistently high protein intake may contribute to kidney disease, gout and arthritis (Meltzer and Fuller, 2005, p.21).

Branched chain amino acids (isoleucine, leucine and valine) are purported to increase mental endurance and physical power by decreasing central fatigue through the competitive inhibition of dietary tryptophan transport across the blood-brain barrier (Schwenk & Costley, 2002). RDA/AI for amino acids has not been determined (Berning, 2004, p.630). A branched chain amino acids intake of 3 g/d has been proposed (Schwenk & Costley, 2002). In this study isoleucine, leucine and valine have been ingested with and without supplements, in amounts larger than 3 g/d. The amino acid pool is more tightly regulated to allow protein to be used preferentially for vital body functions other than energy. This makes the dietary manipulation of amino acid stores for muscle growth more challenging which is probably why many athletes resort to alternative methods. Safety and efficacy data is still lacking for single amino acid supplementation and no upper safety limits have been set (Meltzer and Fuller, 2005, p.22).

The average of the median energy and macronutrients intakes, with and without supplements, of the 4 days were adequate, except for an inadequate CHO and dietary fibre intake. The average of the median sugar, fat, SFA and cholesterol intakes with and without supplements was higher than RDA/AI. Compared to the SSR, the median energy and CHO intakes, with and without supplements did not meet the requirements on the training day and competition day.

5.3.2 Micronutrients

Athletes at the greatest risk of poor micronutrient status are those who restrict energy intake or use severe weight-loss practices, eliminate one or more of the food groups from their diet or consume high carbohydrate low micronutrient dense diets (ACSM et al., 2000). In the present study, the average fat-soluble vitamin intakes with and without supplements were adequate, except for the insufficient vitamin E intake without supplement use. Vitamin A and E are antioxidant nutrients that play an important role in protecting the cell membrane from oxidative damage increased by intense exercise (Berning, 2004, p.632).

Regular, intense exercise increases an athlete's requirements for a number of vitamins and minerals, particularly those involved in energy metabolism, tissue growth and repair, red blood cell manufacture and free radical defence, including the B complex vitamins (Bean, 2003, p.50). In the present study, the average of the median water-soluble vitamin intakes, with and without supplements, of the 4 days was adequate. The UL for niacin intake was exceeded on the competition day with and without supplements and can be the cause of a high meat, poultry and fish intake of the study population on that specific day. Naturally occurring niacin from foods causes no harm (Whitney and Rolfes, 2005, p.331), but the excessive intake of niacin through supplements can cause toxicity symptoms such as flushing, gastrointestinal upset, diarrhoea, vomiting and liver enzyme elevation. The average of the median cobalamin intake of the rugby players was also considered as very high (more than 300% of the RDA/AI) and no adverse effects have been reported for excess cobalamin (Whitney and Rolfes, 2005, p.343).

In the present study the average of the median macro mineral intakes, with and without supplements, for the 4 days, were adequate, except for calcium and magnesium. Calcium is an important mineral in bone formation, but it also plays an important role, together with magnesium, in muscle growth, muscle contraction and nerve transmission (Bean, 2003, p.52). Many people, including athletes have an inadequate magnesium intake (Schwenk & Costley, 2002).

In the present study, the average of the median micro mineral intakes, with and without supplements, of the 4 days, were adequate, except the inadequate intake of iodine. Deficiencies of micronutrients will impair metabolism, sports performance and of course health (Meltzer and Fuller, 2005, p.26). The iodated salt that is used in South Africa was not taken into account. Therefore, the rugby players probably had an adequate iodine intake.

The average of the median electrolytes intakes, with and without supplements, of the 4 days was adequate. The average of the median sodium and chloride intakes was more than 300% of RDA/AI. Sodium regulates the volume and plasma volume of the extra cellular fluid an also aids in nerve impulse conduction and muscle contraction control. An UL of 2400 mg sodium has been recommended (Whitmire, 2004, p.170) and was exceeded by the study population. The high sodium and chloride intakes of the study population can be due to increased reliance on restaurants and fast foods, as well as sodium chloride comes from sodium chloride (table salt) that is 60 % chloride by weight. The amount in food and added table salt provides approximately 3 to 9 g/d. The potassium content of muscle is related to muscle mass and glycogen storage, therefore if muscle is being formed, an adequate supply of potassium is essential (Whitmire, 2004, p.170-172). Dairy products such as yoghurt and cheese, fresh meat, fruits and vegetables ingested by the rugby players could be the cause for high potassium intakes by the study population.

The average of the median micronutrient intakes were adequate, with and without the use of supplements, except the inadequate vitamin E intake without supplement use; and the calcium and magnesium intakes with and without supplements use. The average of the median cobalamin, sodium and chloride intakes was more than 300% RDA/AI.

5.3.3 Fluid

The recommendation for normal individuals not training is to drink 2000 ml (8 cups) of clean water per day (Whitmire, 2004, p.168). The fluid recommendations for men ages 19 to 50 years is 2660 to 2870 ml (11 to 12 cups) per day for light to moderate activity of water each day (Whitmire, 2004, p.168). Adequate fluid before, during and after exercise is necessary for health and optimal performance. The ACSM and NATA recommend drinking 400-600 ml of fluid 2-3 hours before exercise (ACSM et al., 2000). Theoretically, athletes including rugby players should aim to drink enough to offset fluid losses. In practical terms, athletes should aim to drink as much as is comfortable and practical (Maughan, 2002, p.386), according to the rules of the game. Rugby players should also make the most of opportunities to drink such as stoppages and injury time during a match. Generally, optimal hydration can be facilitated by drinking 150-300 ml of fluid every 15 to 20 minutes during exercise, beginning at the start of exercise. (Meltzer & Fuller, 2005, p.60, 64). The recommended fluid intake after exercise is 450-675 ml of fluid for every kg BW lost through sweat during exercise (Berning, 2004, p.624). In the present study the average of the median fluid intake was 1816,2 ml of which 1341,2 ml was water. The average of the median water intake of the rugby players, with and without supplement use, was lower than the safe intake recommendations for healthy individuals (2000 ml/ day). The rugby players in this study are at risk of becoming dehydrated, because of the low fluid intake. Since in most occasions, fluid balance during exercise will be unable to match the rate of sweat loss, it is critical for the athlete to start the session well hydrated (Burke, 2002, p.356).

Fruit juices, cordials and carbonated beverages added to the fluid intake of the rugby players. According to Hawley and Burke (1998, p.326) a CHO-electrolyte drink (including cordials) will help to rehydrate an athlete quicker than pure water. Fruit juices are a negligible source of electrolytes but diarrhoea may occur in some sensitive individuals because of the high fructose content. Cordials and carbonated beverages may be more slowly absorbed due to the higher carbohydrate content and some beverages may contain caffeine (Meltzer and Fuller, 2005, p.63). Caffeine-containing beverages can potentiate fluid, electrolyte and mineral losses (Brouns et al., 1998). Caffeine is a diuretic, so drinking 8 cups of coffee does not result in the same net water gain as drinking 8 cups of water (Whitmire, 2004, p.168). The rugby players in this study should be advised to preferably not drink caffeine-containing beverages for rehydration purposes, because of the diuretic properties of caffeine (Meltzer & Fuller, 2005, p.67).

The average of the median alcohol intake with and without supplements (138,5 ml) was lower than the safe intake recommendations for healthy individuals (1-2 drinks/ day). In the present study the alcoholic intake was high (347,9 ml) on the competition day. This high alcohol intake on the competition day can be due to fact that athletes including rugby players tend to enjoy having a celebratory drink after a match (Burke, 1998, p.33). After exercise alcohol interferes with the recovery of CHO stores and acts as a diuretic thereby aggravating dehydration (Meltzer & Fuller, 2005, p.68).

The fluid and water intake of the rugby players was insufficient. Sports drinks are specially formulated to meet the dual aims of CHO and fluid delivery. Unfortunately, athletes who just consume water as a fluid replacement, even for short-term exercise, risk the chance of diluting the blood and increasing urine output, thus shutting off the drive to drink and becoming dehydrated (Berning, 2004, p.624). Caffeine and alcohol containing beverages are not ideal rehydration fluids since they promote an increased rate of diuresis (Maughan, 2002, p.418).

5.4 Supplement use

According to Burke et al., (2002, p.456), half the athletic population is supplement users, although the prevalence ranges between sports. In the present study most (66,6% of 24) of the study population used supplements.

According to Schwenk and Costley (2002) muscle gain and strength improvements are the most frequently promoted benefits of supplement use. In the present study most of the rugby players used protein powders (49,8%) for supplementation. Whey proteins and amino acid supplements are positioned as high quality protein and amino acid sources and may efficiently promote protein synthesis and increase performance (Ha & Zemel, 2003). Approximately 70% of studies that have evaluated the potential ergogenic value of amino acid and derivative powders such as creatine have reported significant improvements in performance particularly those involving high-intensity exercise or training (Kreider et al., 2003). 31% of the study population used creatine supplements that could also have an effect on the hydration status of the rugby players.

The use of supplements should remain well within the safe levels of intake (Fogelholm, 2002, p.328). Dosages of supplements need to be calculated to avoid overdose. More is not always better since there is an optimal level of nutrient functioning beyond which they become detrimental (Meltzer & Fuller, 2006, p.106). In the present study, the total daily intake of the majority (9) supplements was within the recommended dosages and most of the supplements were used before and after exercise, in no specific pattern.

The reasons most often given in this study for using supplements were building muscle and repair. Resistance exercise increases protein requirements (ACSM et al., 2000) and is part of a rugby player's training program. Power, speed and strength are important elements in rugby. High repetitions of lighter weights as well as strength training are essential for conditioning rugby players (Turnball et al., 1995, p.41).

Athletes and coaches are convinced that a performance edge can be found through the use of sports supplements (Burke et al., 2002, p.508). However, the use of supplements are only recommended for athletes with restricted energy intakes, strict vegans and those who consume diets high in processed carbohydrates (Schwenk & Costley, 2002). The nutrients that can be provided by supplements to greatest effect are fluid and CHO (Burke et al., 2002, p.509).

The majority of the study population used supplements. This was expected because of the high use of supplements among athletes in all kinds of sports.

The type of supplements that were most used included protein powders and the amounts used were within recommended dosages. Most of the rugby players used supplements that were claimed to increase muscle mass and strength and ultimately improve sports performance. Although most of the rugby players used supplements before and after exercise, no specific pattern or timing of supplement use was followed. Athletes (rugby players) are currently responsible for their use of supplements and no guarantees can be given for safety or efficacy of these products.

5.5 Conclusion

The average of the median dietary intake of the rugby players without supplements, were adequate, except for the total CHO, dietary fibre, vitamin E, calcium and magnesium intakes that were inadequate. Supplementation did not contribute significantly to the dietary intakes of the rugby players, except for the boost in vitamin E intake. The average of the median sugar, fat, SFA intakes was higher than the RDA/AI and RHI, where applicable. The average of the median cholesterol and cobalamin intakes were much higher than the RDA/AI and RHI, as well as sodium and chloride.

The median energy and CHO intakes compared to the SSR were inadequate on the training day and competition day, respectively. The average of the median fluid intake, with and without supplements, of the 4 days, was also lower than the proposed maximum intake.

The majority of the study population used supplements. Protein powders were most often used. Most of the supplements were used in amounts that were within the recommendations. Supplements were used before and after exercise, in no specific pattern. Muscle building and repair were most often used as reasons for using supplements.

5.5 Recommendations

The need for accurate sports specific nutrition information is increasing. Rugby players need education on the benefit of a high CHO, low fat diet on health and sports performance. From the study results it is evident that rugby players also need further education in terms of the importance of rehydration strategies and fluid intake, as well as the fluids recommended, and the effect of different supplements on the hydration status. Rugby players need more education and practical guidelines on their dietary habits and salt intake. Recommendations can be made to increase CHO and dietary fibre intakes, as well as vitamin E, calcium and magnesium in the usual diet.

Before any supplementation practices are considered by the rugby players, an adequate diet should be followed. Practical guidelines for the safe and effective use of supplements, including the type if supplements used and the reasons for using them, will help athletes (rugby players) to make informed decisions on the use of supplements. Rugby players should also be warned against toxicity when exceeding the UL of micronutrients.

Supplements should not be used until the athlete has not carefully evaluated the product and discussed the use of the product with a qualified dietician/ nutritionist or health professional specialising in Sports Nutrition. Dieticians/ nutritionists should therefore, have the knowledge of the newest trends and information, to provide the athletes with valuable assistance.

The rugby players in this study relied on supplements that eventually replaced their dietary intake. A balanced diet is the basis of good sports nutrition and dieticians should spread this message. In case of any macronutrient or micronutrient deficiencies supplementation can be used.

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Appendix A (English)
Background information questionnaire

Instructions **Write your answer on the space provided**	**For office use**
1. Respondent number:________	☐☐ 1-2
2. Weight:____kg ____kg ____kg = ____kg	☐☐☐☐☐ 3-7
3. Height:___m ___m ___m = ____ m	☐☐☐☐ 8-11
4. Name/s:______________________________	☐☐ 12-13
5. Surname:_____________________________	☐☐ 14-15
6. Date of birth:____(dd)____(mm)_____(yy)	☐☐☐☐☐☐ 16-21 dd mm yy
7. Age:_______(years)	☐☐ 22-23
8. What position/s do you play in rugby? ____	☐☐ 24-25
9. Are you playing OR on the bench for the next match OR neither? ____	☐☐☐ 26-28
10. Date of study:____(dd)____(mm)______(yy)	☐☐☐☐☐☐ 29-34 dd mm yy

Appendix A (Afrikaans)
Agtergrondinligting vraelys

Instruksies **Skryf u antwoord op die spasie voorsien**	**Kantoor gebruik**
1. Respondent nommer:_________	☐☐ 1-2
2. Massa:____kg ____kg ____kg = ____kg	☐☐☐☐☐ 3-7
3. Lengte:___m ___m ___m = ____ m	☐☐☐☐ 8-11
4. Naam/e:________________________________	☐☐ 12-13
5. Van:_______________________________	☐☐ 14-15
6. Geboortedatum:____(dd)____(mm)_____(jj)	☐☐☐☐☐☐ 16-21 dd mm jj
7. Ouderdom:_______(jare)	☐☐ 22-23
8. Watter rugbyposisie/s speel jy? ____	☐☐ 24-25
9. Speel jy OF is jy reserwe vir die volgende wedstryd OF geen een van bogenoemde? ____	☐☐☐ 26-28
10. Datum van studie:____(dd)____(mm)______(jj)	☐☐☐☐☐☐ 29-34 dd mm jj

Appendix B (English)

SUPPLEMENT QUESTIONNAIRE

Instructions | **For office use**

Please record any supplements, products or drinks you use to improve your performance or health. Please record the data as accurate and honest as possible.

PLEASE BRING THE PRODUCTS YOU USE ALONG. THIS WILL BE USED TO EVALUATE THE NUTRITIONAL INFORMATION. EVERYTHING WILL BE RETURNED TO YOU AFTER THE TRAINING SESSION.

Respondent number:_____ ☐☐ 1-2

Date:____(dd)____(mm)____(yy) ☐☐☐☐☐☐ 3-8

dd mm yy

PRODUCT NAME	AMOUNT (PER DAY / WEEK IN GRAMS)	CONTENTS IN µg/mg (FOR OFFICE USE)	REASONS FOR SUPPLEMENT USE	WHEN DO YOU USE SUPPLEMENTS?	HOW LONG HAVE YOU BEEN USING THIS PRODUCT (MONTHS)?	
1.						1-2 3-6 7-10 11-12 13-14
2.						19-22 23-26 27-28 29-30
3.						35-38 39-42 43-44 45-46
4.						49-50 51-54 55-58 59-60 61-62 63-64

Appendix B (Afrikaans)

SUPPLEMENT VRAELYS

Instruksies | **Kantoor gebruik**

Skryf asseblief alle supplemente, produkte of drankies neer wat u gebruik om prestasie of gesondheid te bevorder. Alle inligting moet so akkuraat en eerlik as moontlik gegee word.

BRING ASSEBLIEF ALLE PRODUKTE WAT U GEBRUIK SAAM. LAASGENOEMDE SAL GERUIK WORD OM DIE VOEDINGINLIGTING VAN ELKE SUPPLEMENT TE EVALUEER. ALLES SAL NA DIE OEFEN SESSIE AAN U TERUGBESORG WORD.

Respondent nommer:_____ | ☐☐ 1-2

Datum:____(dd)____(mm)____(jj) | ☐☐☐☐☐☐ 3-8

dd mm jj

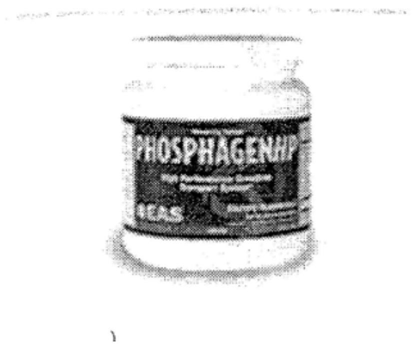
PRODUK NAAM	AANTAL (PER DAY / WEEK IN GRAMS)	BESTANDDELE IN µg/mg (KANTOOR GEBRUIK)	REDES VIR SUPPLEMENT GEBRUIK	WANNEER GEBRUIK JY SUPPLEMENTE?	HOE LANK GEBRUIK JY AL DIE PRODUK (MAANDE)?	
1.						1-2 3-6 7-10 11-12 13-14
2.						19-22 23-26 27-28 29-30
3.						35-38 39-42 43-44 45-46
4.						49-50 51-54 55-58 59-60 61-62 63-64

Appendix C

SUPPLEMENT LABELS

Creatine Phosphagen HP (EAS)

Nutritional information
Serving size: 1 scoop (43g)



Nutrient	Amount
Calories	140
Fat	0
Sodium	95 mg
Potassium	80 mg
Total Carbohydrates	35 g
Sugars	34 g
Proteins	0
Phosphorus	200 mg
Magnesium	60 mg
Creatine monohydrate	5,25 g
Taurine	1 g

Protein MyoPro Whey (EAS)

Nutritional information
Serving size: I scoop (43 g)

Nutrient	Amount
Calories	120
Fat calories	20
Total fat	2 g
Saturated fat	1 g
Cholesterol	40 mg
Total Carbohydrates	5 g
Sugars	4 g
Proteins	20 g
Dietary fibre	<0.5 g
Sodium	65 mg
Porassium	220 mg
Calsium	120 mg

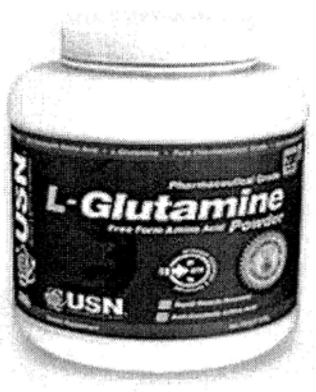
Enduro Load (ESP)

Nutritional information
Serving size: 3 scoops (100 g)

Nutrient	Amount
Calories	1424
Total Carbohydrates	89 g
Vitamin C	300 mg
Sodium	100 mg
Calcium	140 mg
Potassium	90 mg
Chromium	100 mg
Taurine	1000 mg
L-glutamine	200 mg
Magnesium	100 mg
L-leucine	1000 mg
L-valine	600 mg
Isoleucine	300 mg
L-carnitine	400 mg
MSM	10 mg
Siberian Ginseng	10 mg
Guarana	10 mg
Vitamin complex	100 mg

L - glutamine (USN)

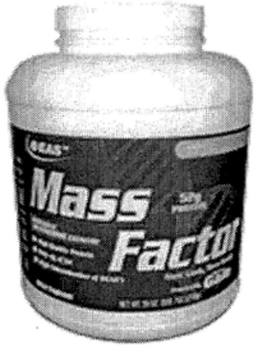
Nutritional information
Serving size: 1 scoop (1/2tsp)



Nutrient	Amount
L-glutamine	2500 mg

Muscle / Mass Factor (EAS)

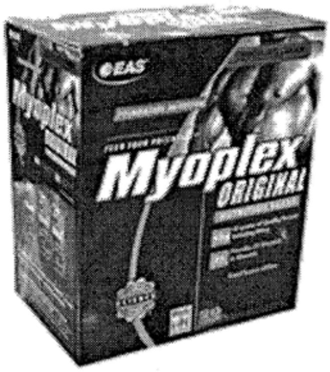
Nutritional information
Serving size: 3 scoops (87 g)



Nutrient	Amount
Calories	340
Fat calories	70
Total fat	7,5 g
Saturated fat	2,4 g
Cholesterol	35 mg
Total carbohydrates	46 g
Sugars	26 g
Proteins	23 g
Creatine monohydrate	5 g
Taurine	200 g
Dietary fibre	0
Sodium	550 g
Potassium	380 g

Myoplex Original (EAS)

Nutritional information
Serving size: 76 g



Nutrient	Amount
Calories	280
Fat calories	20
Total fat	2 g
Saturated fat	1 g
Cholesterol	15 mg
Total carbohydrates	24 g
Sugars	3 g
Proteins	42 g
Dietary fibre	<1 g
Sodium	330 mg
Potassium	550 mg

Carb Sense Myoplex (EAS)

Nutritional information
Serving size: 1 packet (45 g)

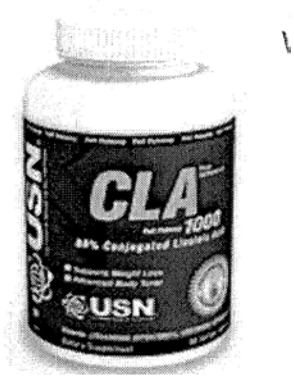
Nutrient	Amount
Calories	170
Fat calories	35
Total fat	4 g
Saturated fat	3 g
Cholesterol	50 mg
Total carbohydrates	8 g
Sugars	0
Proteins	25 g
Dietary fibre	3
Sodium	460 mg
Potassium	840 mg
Calcium	120 mg
Vitamin A	40%
Vitamin C	100%
Iron	50%
Vitamin E	100%
Thiamine	50%
Riboflavin	50%
Niacin	50%
Vitamin B6	50%
Folate	50%
Vitamin B12	50%
Biotin Pantothenic Acid	50%
Phosphorus	50%
Iodine	50%
Magnesium	50%
Zinc	50%
Selenium	35%
Copper	50%
Manganese	100%
Chromium	80%
Molybdenum	70%

Iso - Drive (EAS)

Nutritional information
Serving size: 1 scoop (35 g)

Nutrient	Amount
Energy	543 kJ
Protein	0,4 g
Carbohydrates	31 g
Fat	0
Vitamin B1	0,4 mg
Riboflavin	0,4 mg
Niacin	4,5 mg
Vitamin B6	0,5 mg
Vitamin B12	0,3 mg
Biotin	0,04 mg
Pantothenic acid	1,5 mg
Sodium	100 mg
Magnesium	45 mg
Chromium	25 mg
Potassium	100 mg
L-glutamine	200 mg
Taurine	100 mg

CLA (USN)



Nutritional information
Serving size: 1000 mg tablet

Nutrient	Amount
Conjugated Linolic Acid	750 mgl
D alpha tocopherol acetate (Vitamin E acetate)	250 ppm

Pure protein (USN)

Nutritional information
Serving size: 2 scoops (54 g)

Nutrient	Amount
Calories	193
Total fat	2 g
Total carbohydrates	2,9 g
Proteins	40 g
Sodium	350 mg
Potassium	500 mg
Vitamin A	500 RE
Vitamin B1	350 mcg
Vitamin B2	400 mcg
Vitamin B6	1000 mcg
Vitamin B12	0,5 mcg
Vitamin D3	1,25 mcg
Vitamin C	30 mg
Niacin	2 mg
Pantothenic Acid	2,5 mg
Folic Acid	100 mcg
Biotin	100 mcg
Calcium	500 mg
Magnesium	210 mg
Zinc	18 mg
Phosphorus	400 mg

CLA (EAS)

Nutritional information
Serving size: 2 capsules (4 g)

Nutrient	Amount
Calories	19
Fat calories	19
Total fat	2 g
Saturated fat	<0,5 g
Polyunsaturated fat	1,5 mg
Monounsaturated fat	320 mg
CLA	1,5 g

Betagen (EAS)

Nutritional information
Serving size: 1,5 tsp (6,6 g)

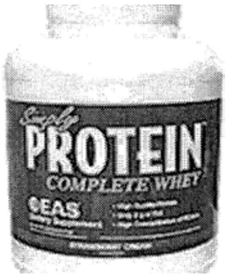
Nutrient	Amount
Calories	10
Fat calories	0
Sugars	1 g
Total carbohydrates	2 g
Potassium	15 mg
Calcium	140 mg
L-glutamine	400 mg
Taurine	2 g
HMB	1 g
Creatine Monohydrate	2 g

Cytovol (EAS)

Nutritional information
Serving size: 1scoop (5 g)

Nutrient	Amount
Calories	100
Fat calories	0
Total fat	0
Cholesterol	0
Total carbohydrates	18 g
Sugars	1 g
Proteins	5 g
Sodium	140 mg
Potassium	45 mg
Niasin	5 mg
Pantothenic Acid	2,3 mg
Roboflavin	0,39 mg
Zinc	3 mg
Vitamin B6 (pyridoxine)	0,46 mg
Vitamin B12 (cyanocobalamin)	1,35 mcg
Vitamin A	1138 iu
Vitamin E	5 iu
Vitamin C	55 mg
L-glutamine	3 g
Taurine	1 g
L-alanine	5 g
Glycine	500 mg
Wheat Gluten (glutamine peptide)	500 mg

Simply protein (Myoplex EAS)



Nutritional information
Serving size: 1scoop (27g)

Nutrient	Amount
Calories	115
Total fat	2 g
Total carbohydrates	3 g
Proteins	21 g

Muscle Mass (ESPi)

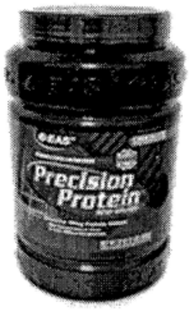
Nutritional information
Serving size: 1 scoop (70 g)

Foto volg

Nutrient	Amount
Energy	1060,39 kJ
Total fat	6,75 g
Total carbohydrates	34,66 g
Proteins	14,05 g
Prebiotics (FOS)	3 g
Probiotics μμ	8,2 x 108 cfu
Biotin	50μg
Taurine	300 mg
L-arginine	125 mg
L-glutamine	175 mg
L-carnitine	250 mg
Folic acid	66 μg
Pantothenic Acid	1,98 mg
Nicotinamide	5,94 mg
Vitamin A	330 μg RE
Vitamin B1	0,46 mg
Vitamin B2	0,53 mg
Vitamin B6	0,66 mg
Vitamin B12	0,33 μg
Vitamin C	29,8 mg
Vitamin D3	1,65 μg
Vitamin E	3,3 mg TE
Calcium	280 mg
Iron	14 mg
Zinc	45 mg
Selenium	55 μg
Chromium	70 μg
Manganese	1,05 mg
Iodine	52,5 μg
Magnesium	105 mg
Copper	400 μg
Molybdenum	105 μg

Pecision protein (Myoplex EAS)

Nutritional information
Serving size: 1 scoop (25,5 g)



Nutrient	Amount
Calories	100
Fat calories	9
Total fat	1 g
Saturated fat	0,5 g
Cholesterol	15 mg
Total carbohydrates	2,5 g
Sugars	2 g
Protein	20 g
Dietary fibre	<1 g
Sodium	50 mg
Potassium	80 mg
Chromium	96 mcg

Berocca (performance)

Nutritional information
Serving size: 1 tablet

Nutrient	Amount
Vitamin C	300 mg
Vitamin B1	15 mg
Vitamin B2	15 mg
Nicotinamide	25 mg
Vitamin B6	10 mg
Folic acid	400 µg
Vitamin B12	10 µg
Biotin	150 µg
Pantothenic acid	23 mg
Calcium	100 mg
Magnesium	100 mg
Zinc	10 mg

Vitathion

Nutritional information
Serving size: 1 - 2 sachets (5 - 10 g)

Nutrient	Amount
Ascorbic Acid	500 mg
Glutathion	0,5 mg
Vitamin B1	2,0 mg
Sodium Adenosine Triphosphate	0,5 mg
Calcium Inositol Hexaphosphate	100 mg
Excipients	5 g

Energy Bar PVM)

Nutritional information
Serving size: 50 g

Nutrient / 100 g	Amount
Energy	1679 kJ
Calories	400
Protein	11.87 g
Carbohydrates	61, 37 g
Total fat	11,97 g
Sodium	165 mg
Potassium	576 mg
Calcium	404 mg
Phosphorus	331 mg
Magnesium	60 mg
Iron	1.40 mg
Zinc	1.50 mg
Vitamin A	400 µg RE
Vitamin D	3.40 µg
Vitamin E	10 mg
Vitamin C	60 mg
Thiamine (B1)	0.7 mg
Ribovlvin (B2)	0.8 mg
Niacin (B3)	9.0 mg
Pyridoxine (B6)	1.0 mg
Folic Acid	100 µg
Vitamin B12	0.7µg
Biotin	75 µg
Pantothenic Acid	3.0 mg

Appendix D (English)
4-DAY FOOD RECORD

Name:__________________________

Respondent number:______

Type and duration of exercise per week (eg weight training 3× per week – Monday, Tuesday, Thursday for 1 hour each day etc)

____
____
____
____
____
____
____

Instructions

- Please record **EVERYTHING** (all the food, drinks, in between meal snacks and nutritional supplements) eaten during the **SPECIFIC** day.
- Please follow your **normal eating pattern** and record the data as **accurate and neatly** as possible.
- Amounts of how much you eat and drink should be given in **household measurements** eg 1 teaspoon, 1 heaped tablespoon, 1 teacup, 2 provitas, 2 slices 'Blue Ribbon' brown bread, 3 scoops protein powder, 1 litre 100% apple juice. **Detail** is very important. Give the amounts in litres or grams if indicated on the product.
- Please indicate **what you add** to your food eg 1 teaspoon butter and 2 teaspoons apricot jam with brown bread, 2 teaspoons brown sugar and full cream milk with filter coffee, 1 teaspoon floro light margarine with porridge etc.
- **Take aways, restaurant** foods and drinks, **sweets** and **cooldrinks** should also be mentioned eg Debonairs Hawaiian pizza large – 4 slices, Spur – chocolate milkshake, 1 BarOne (50g), 1 can Coke, 500ml Appletizer.
- Any **alcoholic drinks** consumed eg 1 bottle Windhoek beer or 1 can Castle light should be included.
- Water intake per day (not water mixed with cooldrink) – **PURE water.**
- In case you need **more writing space**, please continue on the back of the paper.
- **Scheduled interviews** will be held for participants with **incomplete food records**.
- **The food records will be collected on Monday morning.**

Thank you for your cooperation!!!

Date of food record: ___(day)___(month)____(year)

1. DIETARY INTAKE ON A TRAINING DAY(Wednesday)

TYPE OF FOOD EATEN AND DRINKS	QUANTITY ml/g/ts/tblsp/cup
BREAKFAST: TIME:_______	
MORNING SNACK: TIME:_______	
LUNCH: TIME:_______	
AFTERNOON SNACK: TIME:_______	
DINNER: TIME:_______	
LATE NIGHT SNACK: TIME:________	

PLEASE CHECK THAT YOU FULLY COMPLETED THIS DAY'S FOOD RECORD AS ACCURATELY AS POSSIBLE!!!

Date of food record: ___(day)___(month)____(year)

2. DIETARY INTAKE ON A PRE-COMPETITON DAY (Friday)

TYPE OF FOOD EATEN AND DRINKS	QUANTITY ml/g/tsp/tblsp/cup
BREAKFAST: TIME:_______	
MORNING SNACK: TIME:_______	
LUNCH: TIME:_______	
AFTERNOON SNACK: TIME:_______	
DINNER: TIME:_______	
LATE NIGHT SNACK: TIME:________	

PLEASE CHECK THAT YOU FULLY COMPLETED THIS DAY'S FOOD RECORD AS ACCURATELY AS POSSIBLE!!!

Date of food record: ___(day)___(month)____(year)

3. DIETARY INTAKE ON A COMPETITION DAY (Saturday)

TYPE OF FOOD EATEN AND DRINKS	QUANTITY ml/g/tsp/tblsp/cup
BREAKFAST: TIME:______	
MORNING SNACK: TIME:______	
LUNCH: TIME:______	
AFTERNOON SNACK: TIME:______	
DINNER: TIME:______	
LATE NIGHT SNACK: TIME:_______	

PLEASE CHECK THAT YOU FULLY COMPLETED THIS DAY'S FOOD RECORD AS ACCURATELY AS POSSIBLE!!!

Date of food record: ___(day)___(month)____(year)

4.DIETARY INTAKE ON A WEEKEND DAY (Sunday)

TYPE OF FOOD EATEN AND DRINKS	QUANTITY ml/g/tsp/tbsp/cup
BREAKFAST: TIME:______	
MORNING SNACK: TIME:______	
LUNCH: TIME:______	
AFTERNOON SNACK: TIME:______	
DINNER: TIME:______	
LATE NIGHT SNACK: TIME:_______	

PLEASE CHECK THAT YOU FULLY COMPLETED THIS FOOD RECORD AS ACCURATELY AS POSSIBLE!!!

Appendix D (Afrikaans)
4 – DAG VOEDSELREKORD

Naam:___________________________

Respondent number:______

Tipe en duur van oefening per week (bv krag oefening 3× per week – Maandag, Dinsdag, Donderdag vir 1 uur elke dag ens.)

____
____
____
____
____
____
____

Instruksies

- Dui asseblief **ALLES** (voedsel, drankies, versnaperinge en supplemente) aan wat op die **SPESIFIEKE** dag ingeneem word.
- Eet asseblief soos u **gewoonlik** eet en dui asseblief alle inligting so **akkuraat** en **netjies** as moontlik aan.
- **Hoeveelhede** van wat jy eet en drink kan in **huishoudelike mates** gegee word bv. 1 teelepel, 1 eetlepel opgehoop, 1 teekoppie, 2 provitas, 2 snye 'Blue Ribbon' bruinbrood, 3 scoops proteien poeier, 1 liter 100% appelsap **Detail** is baie belangrik. Dui die hoeveelhede in liter en gram aan indien dit op die produk aangedui word.
- Dui asseblief aan **wat jy by jou voedsel voeg** soos 1 teelepel botter en 2 teelepels appelkooskonfyt op bruinbrood, 2 teelepels bruinsuiker en volroommelk by filterkoffie, 1 teelepel floro light margarine by pap
- **Wegneemetes, restaurant** voedsel en drankies, **lekkers** en **koeldranke** moet aangedui word bv. Debonairs Hawaiian pizza large – 4 stukke, Spur – sjokolade melkskommel, 1 BarOne (50g), 1 blikkie Coke, 500ml Appletizer.
- Enige **alkoholiese drankies** wat ingeneem word bv 1 bottel Windhoek bier of 1 blikkie Castle light moet ingesluit word.
- Waterinname per dag (nie water gemeng met koeldrank nie) – **SUIWER water**
- Indien **meer spasie** benodig word kan u op die agterkant van die bladsy voortgaan.
- **Onderhoude** sal gehou word vir deelnemers met **onvolledige voedselrekords**.
- **<u>Voedselrekords sal Maandagoggend ingehandig word.</u>**

Dankie vir u samewerking!!!

Datum van studie: ___(dag)___(maand)____(jaar)

1. DIEETINNAME OP 'N OEFENDAG (Woensdag)

TIPE VOEDSEL EN DRANKIES WAT GEEET WORD	HOEVEELHEID ml/g/teel/maatl/kop
ONTBYT: TYD:_______	
LAATOGGEND: TYD:_______	
MIDDAGETE: TYD:_______	
LAATMIDDAG: TYD:_______	
AANDETE: TYD:_______	
LAAT AAND: TYD:________	

MAAK ASSEBLIEF SEKER DAT JY DIE VOEDSELREKORD SO AKKURAAT AS MOONTLIK INGEVUL HET!!!

Datum van studie: ___(dag)___(maand)____(jaar)

2. DIEETINNAME OP 'N VOOR-KOMPETISIE DAG (Vrydag)

TIPE VOEDSEL EN DRANKIES WAT GEEET WORD	HOEVEELHEID ml/g/teel/maatl/kop
ONTBYT: TYD:_______	
LAATOGGEND: TYD:_______	
MIDDAGETE: TYD:_______	
LAATMIDDAG: TYD:_______	
AANDETE: TYD:_______	
LAAT AAND: TYD:________	

MAAK ASSEBLIEF SEKER DAT JY DIE VOEDSELREKORD SO AKKURAAT AS MOONTLIK INGEVUL HET!!!

Datum van studie: ___(dag)___(maand)____(jaar)

3. DIEETINNAME OP 'N KOMPETISIE DAG (Saterdag)

TIPE VOEDSEL EN DRANKIES WAT GEEET WORD	HOEVEELHEID ml/g/teel/maatl/kop
ONTBYT: TYD:_______	
LAATOGGEND: TYD:_______	
MIDDAGETE: TYD:_______	
LAATMIDDAG: TYD:_______	
AANDETE: TYD:_______	
LAAT AAND: TYD:________	

MAAK ASSEBLIEF SEKER DAT JY DIE VOEDSELREKORD SO AKKURAAT AS MOONTLIK INGEVUL HET!!!

Datum van studie: ___(dag)___(maand)____(jaar)

4. DIEETINNAME OP 'N NAWEEK DAG (Sondag)

TIPE VOEDSEL EN DRANKIES WAT GEEET WORD	HOEVEELHEID ml/g/teel/maatl/kop
ONTBYT: TYD:_______	
LAATOGGEND: TYD:_______	
MIDDAGETE: TYD:_______	
LAATMIDDAG: TYD:_______	
AANDETE: TYD:_______	
LAAT AAND: TYD:________	

MAAK ASSEBLIEF SEKER DAT JY DIE VOEDSELREKORD SO AKKURAAT AS MOONTLIK INGEVUL HET!!!

Appendix E
APPROVAL FOR THE STUDY

Blue Bulls Coach u/21 rugby players

Dear Ashley

SPORTS NUTRITION PROJECT: 2004: DIETARY INTAKE AND SUPPLEMENT USE OF UNDER 21 RUGBY PLAYERS

Permission is requested to go ahead with the above mentioned project. The aim of the project is to determine the dietary intake and supplement use of u/21 rugby players.

Each rugby player will be invited to sign an informed consent before admission to the study. The study will be submitted to the Ethics Committee of the Faculty of Health Sciences at the Free State University to ensure compliance to ethical considerations and confidentiality will be ensured.

A dietitian will be responsible for data collection and a biokineticist will measure each rugby player's weight and height. Each rugby player will receive questionnaires and a food record to complete and return after a few days. Rugby players will be asked to bring the supplements they use to enhance performance of health to a training session. The duration of the data collection will be from 20-27 September 2004.

The u/21 Blue Bulls rugby players will benefit from the study by receiving more information concerning the use of supplements in conjunction with a healthy diet. The gym at Loftus Versfeld will be requested to provide standardised weight and height measuring instruments. During the study period, no other form of nutrition intervention or supplementation should take place extra to what the rugby players have been using prior to the study.

Your consideration to this matter would be appreciated. I rely on you motivating the players to give their full cooperation for this study to be of any success. In case of any queries, please contact Veronica Smith (mobile: 082 768 4844).

Your kind assistance will be appreciated

Yours sincerely

____
Veronica Smith
(Researcher & Registered Dietitian South Africa)

Appendix F (English)
CONSENT FORM: RUGBY PLAYER

I ___________________________(name and surname) hereby declare to participate in this research project as explained to me.

- I declare to voluntary partake in this Masters Degree study done by a postgraduate student of the Department of Human Nutrition, Free State University
- I declare to provide the researcher with honest and accurate information
- The purpose of this study is to evaluate the dietary intake and supplement use of rugby players to enhance performance or health
- 30 under/21 rugby players will be asked to complete questionnaires and food records concerning their dietary intake and supplement use
- Weight and height measurements will also be taken by the team's trainer
- No substances will be given to any rugby player and therefore no risks are involved
- The u/21 Blue Bulls rugby players will benefit from the study by receiving more information concerning the use of supplements in conjunction with a healthy diet
- Each rugby player will be expected to eat, drink and use supplements as they usually do during the rugby season
- Participants should not be experimenting with new products during the duration of the study (20-27 September 2004)
- Participation is voluntary and I can withdraw at any time
- Information gathered will be treated confidentially and I give consent that the results may be published for further research purposes

I am fully informed of the above aspects of the research project. I voluntarily gave my consent to be part of this research project.

Signed on ________(dd)_______(mm)_______(yy) at ________________
Signature (Participant):_____________
Signature (Researcher and Registered Dietitian South Africa):______________

Appendix F (Afrikaans)
TOESTEMMINGSBRIEF: RUGBYSPELER

Ek________________________(naam en van) onderteken hiermee om deel te neem aan die navorsingsprojek soos aan my verduidelik.

- Ek onderteken dat ek vrywillig deelneem aan die Meestersgraad navorsingsprojek wat gedoen word deur 'n nagraadse student van die Departement Menslike Voeding, Universiteit van die Vrystaat
- Ek onderneem om inligting so eerlik en akkuraat as moontlik weer te gee
- Die doel van die navorsingsprojek is om die dieetinname en supplement gebruik van rugbyspelers te evalueer
- 30 o/21 rugbyspelers word gevra om vraelyste en voedselrekords oor die dieetinname en supplement gebruik te voltooi
- Massa en lengte metings sal deur die afrigter gedoen word
- Geen supplemente sal vir rugbyspelers gegee word nie en die studie hou dus geen risiko's vir rugbyspelers in nie
- Die o/21 Blou Bulle rugbyspelers sal voordeel trek uit die navorsingsprojek deurdat meer inligting oor die gebruik van supplemente in kombinasie met 'n gesonde dieet aan hulle beskikbaar gestel sal word
- Elke rugbyspeler word versoek om te eet, drink en supplemente te gebruik soos gewoontelik is gedurende die rugbyseisoen
- Deelnemers moet nie met nuwe produkte eksperimenteer vir die duur van die navorsingsprojek nie (20-27 September 2004)
- Deelname is vrywillig en ek kan ter enige tyd onttrek
- Inligting sal vertroulik hanteer word en ek gee toestemming dat die groep resultate vir navorsingsdoeleindes publiseer kan word

Ek is ten volle ingelig oor die navorsingsprojek. Ek gee my vrywillige toestemming om deel van die navorsingsprojek te wees.

Geteken op_______(dag)______(maand)________(jaar) te__________________
Handtekening (Deelnemer):____________
Handtekening (Navorser en Geregistreerde Dieetkundige SA):_______________

SUMMARY – ENGLISH

Dietary intake and supplement use of u/21 rugby players, Blue Bulls

The need for accurate sports nutrition information is increasing. Whether the athlete's performance is recreational or elite it will be influenced by what he eats or drinks. More than half of the athletic populations are supplement users, although the prevalence ranges between sports. Despite the lack of evidence from the benefit from the use of most nutritional supplements, commercial promotion of their use is a thriving and highly influential business. Little research has been done on the dietary intake and supplement use of South African and international rugby players. The purpose of this study was to determine the dietary intake and the use of supplements by u/21 male rugby players with the view to develop suitable nutrition education messages according to the problems related to dietary and supplement use; and to set up practical guidelines for the safe and effective use of supplements.

Common to rugby, is the intermittent, high intensity of play, which places great demands on both anaerobic and aerobic energy systems. Physical activity, exercise performance and recovery from exercise are enhanced by optimal nutrition. A fundamental role of nutrition in sport is to supply fuel for energy as well as all the essential macro - and micronutrients and fluid. Exercising individuals universally want to perform better and are willing to try almost anything that offers a promise of better performance. Consumption of dietary supplements and ergogenic aids have become commonplace among athletes.

The main aim was to determine the dietary intake and the use of supplements by 30 u/21 male rugby players from the Blue Bulls. A pilot study was conducted on 5 of the u/20 rugby players from the UP prior to the main study. A background

information questionnaire, supplement questionnaire and four-day food record were used to collect data. Of the 30 players, 26 players returned the background information questionnaire and the supplement questionnaires. Two incomplete questionnaires could not be used. The required information could thus be collected only from 24 players.

The average dietary intake of the rugby players without supplements, were adequate, except for the total CHO, dietary fibre, vitamin E, calcium, magnesium and iodine intakes that were inadequate. The average fluid intake was also lower than the proposed maximum intake. The majority of the study population used cordials and carbonated beverages for rehydration purposes. The alcohol intake of the study population was low except for on the competition day. Supplementation did not contribute significantly to the dietary intakes of the rugby players, except for an adequate vitamin E intake. The rugby players ingested an average high fat, SFA, cholesterol, sodium and chloride intakes. The energy and CHO intakes compared to the SSR were inadequate on the training day and both exercise days, respectively. The majority of the study population used supplements. Protein powders were most often used. Most of the supplements were used in amounts that were within the recommendations. Supplements were used before and after exercise, in no specific pattern. Muscle building and repair was the reason most used for supplement use.

Before any supplementation practices is considered by the rugby players, an adequate diet should be followed. Rugby players need more education and practical guidelines on their dietary habits; the benefit of a high carbohydrate, low fat diet on health and sports performance; the importance of rehydration strategies, fluid intake and types of fluid ingested; the safe and effective use of supplements.

Key words: dietary intake, supplements, sports nutrition, rugby player, macronutrients, micronutrients, fluid, nutritional ergogenic aids, exercise, performance

OPSOMMING - AFRIKAANS

Dieetinname en supplement gebruik van o/21 rugby spelers, Blou Bulle

Die behoefte aan akkurate sportvoeding neem al meer toe. ‘Meer as helfte van die atletiese populasie is supplementverbruikers, alhoewel die voorkoms daarvan wissel tussen sporte. Die kommersiële verspreiding van supplemente is ‘n invloedryke besigheid, ten spyte van die tekort aan voldoende bewyse. Navorsing oor die dieetinname en supplement gebruik van Suid Afrikaanse en internasionale rugby spelers is min. Hierdie studie is gedoen om die dieetinname en supplement gebruik van die o/21 rugby spelers te bepaal. Die doel was om voedingsboodskappe volgens geidentifiseerde probleme saam te stel; en om praktiese riglyne vir die veilige en effektiewe gebruik van supplemente, daar te stel.

Rugby is ‘n hoë intensiteit spel wat groot fisieke vereistes op die anaerobiese en aerobiese energie sisteme plaas. Optimale voeding bevorder fisieke aktiwiteit, sport prestasie en herstel na oefening. Die verskaffing van energie asook essensiële makro – en mikrovoedingstowwe en vloeistof is die belangrikste rol van voeding in sport. Alle sportlui wil graag beter vaar en sal enige iets probeer om sport prestasie te verbeter. Die gebruik van dieetsupplemente en ergogene hulpmiddels kom algemeen voor onder sportlui.

Die hoofdoel van die studie was om die dieetinname en supplementgebruik van 30 o/21 rugbyspelers van die Blou Bulle te bepaal. ‘n Loodstudie is op 5 o/21 rugbyspelers van die UP gedoen voor die aanvang van die studie. ‘n Agtergrondinligting vraelys, supplement vraelys en 4-dag voedselrekord is gebruik om inligting te versamel. Slegs 26 van die 30 rugby spelers het die

agtergrondinliging vraelys en supplement vraelys ingehandig. Twee onvoltooide vraelyste kon nie gebruik word nie. Gevolglik kon die nodige inligting slegs van 24 spelers verkry word.

Die gemiddelde mediaan dieetinname van die rugby spelers met en sonder supplementgebruik, was volgens die RDA/AI en aanbevelings vir gesonde individue toereikend, behalwe die totale koolhidraat, dieetvesel, vitamien E, kalsium en magnesium innames wat ontoereikend was. Die gemiddelde mediaan van vloeistofinname was laer as die aanbevole maksimum inname. Die meerderheid van die studiepopulasie het aanmaakkoeldrank en gaskoeldranke as rehidrasie drankies gebruik. Die alkoholinname van die studiepopulasie was laag, behalwe vir die hoër inname op die kompetisie dag. Supplementasie het nie tot die dieetinname van die rugbyspelers bygedra nie, behalwe vir die toename in vitamin E inname met supplementgebruik. Die gemiddelde mediaan van suiker, vet, versadigde vette, cholesterol, kobalamin, natrium en chloried inname was hoër as die RDA/AI en aanbevelings vir gesonde individue. Die mediaan vir energie en koolhidraat innames was volgens die sport spesifieke aanbevelings ontoereikend op die oefendag en kompetitisiedag. Die meerderheid van die studiepopulasie het supplemente gebruik. Proteinpoeiers is die meeste gebruik. Die meeste supplemente is gebruik in hoeveelhede wat binne die aanbevelings vir supplementgebruik is. Supplemente is gebruik voor en na oefening, volgens geen spesifieke patroon. Spierbou en herstel is as redes vir supplementgebruik verskaf.

Rugbyspelers moet eerstens ‘n toereikende dieet volg, voordat supplementasie oorweeg kan word. Rugby spelers benodig meer voedingonderrig en praktiese riglyne oor dieetgewoontes; die voordele van ‘n hoë koolhidraat, lae vet dieet vir gesondheid en sportprestasie.; die belang van rehidrasie, vloeistofinname en

tipes rehidrasie drankies wat ingeneem word; asook die effektiewe en veilige inname van supplemente.

Sleutelwoorde: dieetinname, supplemente, sportvoeding, rugbyspeler, makrovoedingstowwe, mikrovoedingstowwe, vloeistof, rehidrasie, oefening, sport prestasie.