Dietary practices, attitudes and nutritional knowledge of Auckland club rugby players

A thesis presented in partial fulfilment of the requirements for the degree of Masters of Science in Nutritional Science

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Abstract

Aim: The primary aim of this study was to establish the nutritional knowledge, attitudes and beliefs of Auckland rugby union players. Furthermore, a secondary aim was to investigate the dietary intake of these players and to examine how the knowledge and attitudes might affect nutritional intake.

Method: Sixty Auckland premier grade rugby union players, completed two self-administered questionnaires. The first was designed to determine nutritional knowledge, attitudes and beliefs of Auckland rugby union players and the second to investigate the physical activities of the participants. Four-day dietary record was kept for assessment of dietary intake. Finally, body composition of the players was measured using the International Society for the Advancement of Kinanthropometry anthropometry method.

Results: The rugby players had a mean ($\pm$SD) age of 22.8 $\pm$2.5 years, with a mean height and weight of 181$\pm$6.5 cm and 98.2 $\pm$14.2 kg. Only nine out of 60 players returned food record diaries. Their mean daily energy intake was 17.3 $\pm$4.3 MJ. The contribution of energy intake was 46% from CHO, 16% from protein, 35% from fat and alcohol supplied 3% of daily energy. The mean score of correct nutrition knowledge questions was 42% $\pm$20.

Conclusions: This study has shown that rugby union players have a few misconceptions regarding nutrition and performance. The major misunderstandings are mainly concerning major fuel source to provide energy. The majority of players believed that protein was the predominant source of fuel used by muscles. The data suggests that these athletes may benefit from nutritional support. The players mean daily intake was inadequate for the large amounts of training they were undertaking. However, the contribution of carbohydrate, protein, fat and alcohol to the mean daily energy intake was nearly identical to that of the general New Zealand population. Players need to increase the amount of carbohydrates that they consume as this may help to improve their performance and delay time to fatigue.

Key words: Questionnaire, nutritional information, physical characteristics, food diary

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1.0 Introduction

Since 1995, when professionalism was introduced to rugby union there has been an increase in research investigating the sport in an attempt to match the demands for increasing knowledge (Duthie, et al. 2003). However, there is still a surprising lack of published research into the nutritional intakes and needs, as well as the anthropometric and physiological characteristics of rugby union players.

Unfortunately, despite the growing interest in sports nutrition, there are only a limited number of studies published on physiology and nutritional needs of rugby union players e.g. (Morton 1978; Nicholas 1997; Deutsch, et al. 1998; Duthie, et al. 2003). There is relatively more research present for the body compositional characteristics of rugby union players e.g. (Dacres-Mannings 1998; Bell 1979; Holmyard and Hazeldine 1993; Bell 1995; Quarrie, et al. 1995; Babic, et al. 2001). However, many of these studies for nutrition, body composition and physiology of rugby were published before professionalism was introduced in 1995. Of the literature published after 1995, many tend to be a review of previous research.

Professionalism has influenced the game of rugby union, and over time changes in the body composition characteristics of players has occurred. Olds (2001) investigated this change in physique over time and found that in the last 25 years rugby union players have become taller, heavier and more mesomorphic. Therefore, using past research for comparison to current players might not be applicable due to these changes in physique.

Strenuous exercise like that in rugby union will cause an increase on the nutritional demands on the body (Robergs and Roberts 1997). If these additional demands are not met, a decrease in performance is generally seen towards the end of the exercise period (Balsom, et al. 1999). An adequate diet before, during and after training and competition has been shown to have a positive influence on sporting performance (Williams, et al. 1996). Published documentation of the current dietary patterns of New Zealand rugby players is limited. Concern has been expressed over this lack of published research on athlete's dietary practices (Brotherhood 1984). If data is not available, regarding what athletes are currently consuming the effects of the nutritional knowledge given to them is difficult to assess.

Due to this lack of research, comparisons have been made between similar football codes to determine the nutritional requirements of rugby union players. Australian rules football players have been observed to consume a diet with a mean daily energy intake of 14.2 MJ and was comprised of approximately 44% carbohydrate, 15% protein, 37% fat and 4% alcohol (Burke and Read 1988; Burke, et al. 1991). This led to the realisation that the dietary practices of Australian Rules football players were not adequate to meet daily training needs, and players were not optimising use of the latest sports nutrition knowledge (Burke and Read 1988). Conversely, results for soccer players have shown that they consume a diet in which carbohydrate makes up 55% of daily energy intake (Rico-Sanz 1998). Protein and fat were reported to be 15% and 30% of daily energy intake respectively. While carbohydrate intake is better than that for Australian Rules football players, the author stated that it was still below the desired intake (Rico-Sanz 1998). The optimal intakes for athletes have been expressed as 60-70% of daily energy coming from carbohydrates, 15% from protein (Howe, et al. 2002) and less than 30% fat (Burke and Read 1988). Increasing the knowledge of nutritional guidelines in rugby union players might cause a positive change in their nutritional intakes.

Important factors that will affect an athlete's dietary intake are their understanding of the current knowledge and how their attitudes and beliefs affect this (Jonnalagadda, et al. 2001). This understanding will enable the nutritionist or dietitian to determine a starting point for providing knowledge and an appreciation of how these attitudes and beliefs may affect certain nutritional practices. This may further assist the nutritionist to provide guidelines that may be better adhered to.

Researchers have observed that there is a positive relationship between nutrition knowledge and eating behaviour in a wide range of the population (Packman and Kirk 2000; Pirouznia 2001). Furthermore, it is known that attitudes towards food can influence food selection (Bergman, et al. 1992). Past research on the nutritional knowledge of athletes has shown that they have many misconceptions regarding nutrition and performance (Jacobson, et al. 2001; Jonnalagadda, et al. 2001; Cupisti, et al. 2002). These misconceptions of nutrition may be due to the sources of knowledge. A review of literature has shown that an athlete's main source of nutritional information were from parents, high school physical education courses and coaches (Shoaf, et al. 1986). While knowledge from high school physical education courses may be a valid source, the nutritional knowledge of coaches and parents could be brought into question (Sossin, et al. 1997; Smith-Rockwell, et al. 2001).

Most studies concerning an individual's nutritional knowledge are based on the general population, with only limited data being available on the sporting community. The scarcity of data that is available on athletes tends to focus on females as a group more than males (Barr 1987; Wiita and Stombaugh 1996; Chapman, et al. 1997; Cupisti, et al. 2002). This may cause problems in generalising findings to male athletes, as issues concerning the two sexes are diverse. Other problems relating to the lack of literature on rugby union has to do with researchers having to utilise research from other football codes to make comparisons with. This causes problems due to the differences in physiological requirements between the codes. The differences in physique and beliefs between football codes may also affect the nutritional requirements.

The majority of this current information on other football codes, whether it is nutritional or physiological, comes from different countries. The results obtained from these studies are limited in their comparisons to New Zealand due to various cultural differences and diverse environmental conditions. Comparisons might also be limited by the different age groups of the various studies. Generalising research that contained a sample of adolescent males to those of an older population would have obvious drawbacks, since the energy requirements of these two groups is inherently different. Various methods used by studies will also cause problems of comparisons of nutritional requirements, physiology and body composition methods. In past literature there have been a number of various methods used to assess dietary intake, from food record diary (Burke and Read 1988) to dietary questionnaires (Leblanc, et al. 2002). Different methods of body composition between studies include underwater weighing, anthropometry (Burke and Read 1988) and various other methods.

At present, published data on the nutritional knowledge of New Zealand rugby players is limited. Therefore, an investigation of New Zealand rugby union players' dietary habits, nutritional knowledge and attitudes and beliefs to nutrition needs to be undertaken to determine the current level of nutritional support players are receiving.

1.1 Aims of the study

The primary aim of this study was to establish the nutritional knowledge, attitudes and beliefs of Auckland rugby union players. Furthermore, a secondary aim was to investigate the dietary intake of these players and to examine how the knowledge and attitudes might affect nutritional intake.

2.0 Literature review

The purpose of this literature review is to determine the current dietary requirements of macronutrients and micronutrients for rugby union players and the methods available to measure these intakes. In addition, the current nutritional knowledge levels of athletes and the methods available to assess this nutritional knowledge will be investigated.

2.1 Rugby union

Rugby is a game of skill, strength and speed, dominated by short burst, high-intensity running and heavy tackling. Rugby is an 80-minute game broken into two 40-minute halves with a 10-minute break at half time. There is a maximum of 30 players on a field at one time with 15 from each team. Players each have a different number and position on the field. The players are broken down into groups. The first break down and the most general is the dividing of the team into forwards and backs. The forwards consist of the tight and loose-head props, hooker, left and right locks, open and blind side flankers and the number eight. The backs comprise the half back (or scrum half), first five-eighth, second five-eighth, left wing, centre, right wing and fullback.

2.2 Match analysis

Time-motion analysis is a very important tool used in rugby union. It can help coaches define the physiological requirements of rugby union and to determine what percentage of the game is spent in various intensities of physical activity, so that fitness and conditioning sessions can be more effective. Time-analysis can also help nutritionists to determine the energy needs of various players during matches, due to the breakdown of amounts of intermittent anaerobic or aerobic exercise the players complete throughout the game. Finally, comparison of time-analysis can help determine the similarities and differences between the different codes of football as well.

2.2.1 Differences between football codes

It is widely accepted that all codes of football are similar as they are intermittent in nature. Table 2.1 presents a breakdown of the physical demands of rugby union and the comparison of the demands of various football codes. From this table it is evident for rugby league that standing, walking, cruising and jogging makes up the majority of the game in averaging 89.5% over all positions of elite professional Australian rugby league players (Brewer and Davis 1995). Soccer players have been shown to maintain low intensity activities for an average of 87% of the time (Mohr, et al. 2003). Similarly for rugby union it has been observed that 85% to 89% of the time was spent at low intensity activity (Nicholas 1997; Deutsch, et al. 1998; Duthie, et al. 2003). The rest of the time in rugby union is spent in high intensity activity, which is made up of 6% running and 9% tackling, pushing and competing for the ball (Deutsch, et al. 1998; Duthie, et al. 2003). The levels, ages and number of players varied between these studies and reviews. Deutsch et al (1998) used 24 elite under-19 rugby union players, whereas the other two reviews have used a wide range of international first and second class teams with a mean age of 18 to 30.7 years (Nicholas 1997) and a variety of teams from age group rugby to international level (Duthie et al. 2003).

With the help of time-motion analysis methods it has been determined that rugby union is somewhat similar in physical activities to rugby league and soccer. From Table 2.1, one can see that there are substantial differences between these football codes. Rugby union is a sport made up of various intensities of activity including, sprinting, jogging, cruising, and other high intensity actions such as rucks, scrums, lineout jumping and tackling. These various activities will influence the different energy pathways used.

Table 2.1 Match play activity by rugby union, rugby league and soccer players and the percentage of mean total playing time

Activity	Rugby union (%)	Rugby league (%)	Soccer (%)
Standing	43.4	27.3	19.5
Walking	21.3	24.5	41.8
Jogging	19.6	4.6	16.7
Low-speed running/cruising	5.5	22.8	9.5
Backwards running		4.8	3.7
Sprinting	3.6	1.2	1.4
	Rugby union (m)	Rugby league (m)	Soccer (m)
Mean distance covered during match - Forwards	4240	6647	All players 10860
Mean distance covered during match - Backs	5640	7336	N/A

Data taken and adapted from various reviews or studies on football codes (Brewer and Davis 1995; Deutsch, et al. 1998; Mohr, et al. 2003). The levels of the teams may vary over the different sports

2.3 Physiological demands of rugby union players

Each phase of high- and low-intensity exercise is used in order to determine work to rest ratio (W:RRs). The pattern of W:RRs throughout the game is just as important a determinant of the physical demands on the player as total time or distance covered at different intensities (McLean 1992). The average work periods found by McLean was 19 seconds, but as seen by Deutsch et al (1998), the average time spent sprinting was from 2.8, 2.3 and 3.3 seconds (props and backs and outside backs respectively) (Deutsch, et al. 1998). From these studies it can be determined that the majority of the 19 seconds work period will be either walking, jogging or cruising. Thus it is important in showing that not only is the anaerobic energy system being used for short energy bursts but also the aerobic energy system to help enhance recovery between these bursts of high-intensity exercise. A breakdown of the times spent in each activity pattern, is presented in

Table 2.1. For further explanation on the W:RRs for rugby union players the reader is directed to the following work of McLean (1992) for additional analysis.

Consequently, intermittent sports like rugby union would use a combination of the creatine phosphate (CrP) pathway, anaerobic glycolytic systems and the aerobic glycolytic system. For activities where maximum strength or speed is used, such as scrums and breakaway sprints, the player will rely predominately on CrP pathway and anaerobic glycolytic systems (Nicholas 1997; Duthie, et al. 2003). Rugby players also require energy from the aerobic glycolytic system to sustain the low-intensity activity making up the rest of the time spent in the game (Nicholas 1997). The energy systems used are the same as those found in other team sports. If energy sources are not adequate to sustain these pathways during rugby, premature fatigue may occur. An analysis of the different causes of fatigue is outside the scope of this review, so the interested reader is referred to other reviews (Coyle, et al. 1983; Davis and Bailey 1997; Davis, et al. 2000). For the affects of CHO and fluid in fatigue, the reader is referred to section 2.6 and 2.10 of this literature review.

Using W:RRs of a sport such as rugby union can be an effective way of determining the percentage of times spent in various work intensities. This will help to understand the demands placed on the players. The demands of rugby union are diverse, with energy being derived from the use of CrP pathway, anaerobic glycolytic system and the aerobic glycolytic system. An understanding of these demands can help coaches and nutritionists to understand the training and nutritional requirements of the sport, in which body composition testing can be a valuable tool to determine if training activities are matched by energy needs.

2.4 Physical characteristics of rugby union players

The importance of different sizes and body compositions for the various different playing positions in rugby is widely accepted by coaches, selectors and players of the game (Quarrie, et al. 1996). Body composition can be used to predict fat mass (FM) and fat free mass (FFM), which consists of muscle, bone, and water. The results from a body composition test can be used in a variety of ways. It may be used to help select teams, identify desirable playing weights for players, and help observe effects of nutrition and training. If testing occurs at regular intervals, body composition can be used to assess nutritional status or adherence to a diet of the player. When energy input equals energy output, weight will be maintained (Robergs and Roberts 1997). To lose or gain weight, either or both of these factors need to be altered (Robergs and Roberts 1997). To lose weight there needs to be a reduction in energy input and, energy output must be increased (Robergs and Roberts 1997). Hence, adherence to a diet can enable a player to maintain an ideal playing weight.

Rugby union is a contact game where a large lean body mass increases the properties of inertia and momentum - an advantage at impact or during contact (Nicholas 1997; Babic, et al. 2001). Although additional fat can act as a protective barrier during moments of contact, it is a disadvantage to players during running and sprinting activities (Bell, et al. 1993; Nicholas 1997; Duthie, et al. 2003). Fat acts as a dead weight and can result in slowing a player down if excess FM is carried (Norton, et al. 2002). Therefore, for athletes a decrease in FM may be beneficial to improve their performance.

2.4.1 Compositional differences between positions

Numerous studies and reviews have shown differences in body composition characteristics between forwards and backs of rugby teams (Dacres-Mannings 1998; Holmyard and Hazeldine 1993; Quarrie, et al. 1995; Nicholas 1997; Babic, et al. 2001; Duthie, et al. 2003), whereas others have found the only differences are in height and weight (Bell, et al. 1993). Caution should be used when comparing results from different studies as various methods and equations have been used to determine body composition. Generally, forwards are found to be taller, heavier, have a higher fat percentage and a higher lean body mass in kilograms than backs (Nicholas 1997).

2.4.2 Body composition reporting

Previous studies on the various football codes, be it rugby union, rugby league, American football, soccer or Australian rules, have used an array of different methods to estimate body fat percentage, from anthropometry to underwater weighing. An extensive discussion of the relative merits of these methods is beyond the context of this review and the interested reader is referred to other reviews (Lukaski 1987; Wagner and Heyward 1999; Ellis 2000; Stewart and Hannan 2000). Numerous reviews have shown comparisons of the positional differences in height, weight, and body fat percentage in a football code, or the differences between codes (Brewer and Davis 1995; Pincivero and Bompa 1997; Ebert 2000). Many of these studies have made methodological errors to do with body composition reporting. Problems of these reviews are that it has not been made clear by the author whether the evaluated studies have all used the same body composition methods, and whether the testers were trained. If anthropometry was utilised the skin-fold callipers used, and the regression equations applied to predict body fat percentage were not mentioned. With this array of different methods and techniques for measuring and analysing body composition to choose from, it seems logical that researchers and reviewers should acknowledge this inconsistency of methods and equations being used when reporting comparisons to previous data, however, generally this is not happening.

In summary, estimation of body composition can be an important tool in assessing the dietary intakes of players. Researchers need to carefully consider the population being studied, the number of participants and the availability of time and money, when determining what method to use. Changes in the dietary intakes of rugby players may be the edge that they need for improving their performance.

However, these changes will not be able to be made unless the nutritionist or dietitian is aware of the energy requirements of the sport and the effects of fatigue, which might occur if this energy intake is not met.

2.5 Current dietary recommendations/requirements

During training and competition, rugby union players use the CrP pathway, anaerobic and aerobic energy pathways, thus highlighting an increased need for kilojoules, carbohydrate, protein, B-complex vitamins, water and electrolytes (Storlie 1991). The players may also experience an increased stress on the body, due to the high impact nature of the game (Takarada 2003). This will cause an elevated need of the above nutrients as well as vitamin C, iron, zinc, vitamin B_6 and B_{12} and calcium (Storlie 1991).

Nutrition provides the foundations of physical activity; it provides fuel for the working muscles and chemicals to be able to utilise this potential energy (McArdle, et al. 2001). Nutrients from foods also provide essential elements for repairing existing cells and synthesising new tissue (McArdle, et al. 2001). The general requirements are established from the guidelines made for the general population. The nutrient recommendations made for the general population were not intended to assess nutrient needs for conditions such as major illness, recovery, or excessive exercise (Massad and Headley 1999).

2.6 Carbohydrate (CHO)

Carbohydrate is stored in limited amounts only, and needs to be continuously replenished (Howe, et al. 2002). Endogenous CHO (glycogen) stores are a major source of fuel for the working muscle (Gardjean 1989). During exercise metabolism the role of CHO is determined by intensity and duration of exercise and the influence of physical training and diet (Gardjean 1989; Pavlou 1993). As well as providing fuel for endurance exercise, CHO also provides the superior fuel source for muscles during moderate to high intensity exercise (Robergs and Roberts 1997; Howe, et al. 2002). Rugby players require a large CHO intake to help with recovery from the weekly games and the subsequent daily training sessions. During the season, there are normally two formal training sessions a week and a weekly game as well as any additional training the individual completes.

2.6.1 Carbohydrate intake before exercise

A high-CHO diet is thought to be one of the most important nutritional recommendations that an athlete can follow. Often in team sports, the availability for ingestion of CHO during exercise is limited therefore, the pre-exercise meal is important to maintain blood glucose (DeMarco, et al. 1999). There are a number of studies that have shown an improvement in performance when a high-CHO diet was consumed before exercise. These observed effects include:

1) Sustained power output during repeated bouts of short duration high-intensity cycling, and a 265% increase in the number of 6-second sprints (Balsom, et al. 1994).
2) A significantly longer distance covered in an intermittent long-term running performance test. A positive aspect to this last study was the amount of CHO in the control diet (39% dietary intake), is the percentage of CHO usually consumed daily by soccer players (Bangsbo, et al. 1992).
3) Improved time to exhaustion during repeated bouts of short duration high-intensity cycling compared to a low-CHO diet. However, the difference between the time to exhaustion for the low-CHO and high-CHO diets were not significant. Nevertheless, the authors stated that despite this lack of significance the results suggest that a moderate alteration in dietary CHO may affect performance in high-intensity exercise (Pitsiladis and Maughan 1994).

Although the aforementioned studies have shown an improvement of intermittent high-intensity performance with an increase in daily CHO intake, they have been completed in a controlled laboratory setting on cycle ergometers or treadmills. Therefore, these studies are not a true representation of the energy requirements of team sports.

Balsom et al (1999) completed a study to determine the outcome of CHO intake during multiple sprint sports using a modified 4-a-side game of soccer. The purpose was to simulate game situations to determine the effect of a high-CHO (~65% of total energy intake) diet on muscle glycogen stores in comparison with a low-CHO (~30% of total energy intake) diet. The authors found that the amount of high intensity exercise, defined as the total amount of moderate to high speed running and sprinting performed during a small sided game of soccer increased by 33% and was influenced by pre-exercise muscle glycogen concentration (Balsom, et al. 1999). The researchers made a positive step to explain the effect muscle glycogen and CHO supplementation have on a soccer game if the subjects participated in a 90-minute game and with a 10-minute half-time period. In addition, the authors controlled the study well by holding the trial indoors' which reduced any environmental conditions, although this depicts a less accurate portrayal of what occurs during a real game situation. Limitations of this study are that it was conducted in a smaller field area than a normal game is played, which would mean that the length and time of sprints of the players would be less than that of a normal 11-a-side soccer match. Furthermore, the researchers did not take muscle biopsies post-game, so therefore no post-game muscle glycogen concentrations are known.

Although the above results have been found in a modified 4-a-side soccer match, due to the similarities between soccer and rugby union it can be hypothesised that the increase in high-intensity running after a high-CHO diet will occur in rugby players as well.

2.6.2 Carbohydrate intake during exercise

The effects of CHO ingestion during endurance sports have long been established (Coyle, et al. 1983; Fielding, et al. 1985; Coyle, et al. 1986; Coggan and Coyle 1987). Recently it has been observed that CHO intake during intermittent high-intensity exercise, acts as an exogenous energy source to delay fatigue, and improves sprint performance.

Researchers have found the following effects:

1) In a cycle test designed to simulate team sports the ingestion of both glucose and fructose at half time of a continuous 90-minute cycle test improved performance by 7% and 5%, respectively compared to the placebo (Sugiura and Kobayashi 1998). However, it was found that only glucose improved performance by 6% in the intermittent trials (Sugiura and Kobayashi 1998).
2) Improvement in a cycling performance test was observed by 6% after participants consumed a CHO beverage (Below, et al. 1995).
3) Consumption of a 20% CHO drink one hour before exercise and a 6% CHO-electrolyte drink 10 minutes before and every 15 minutes thereafter, resulted in a 52% improvement in run time to fatigue (Davis, et al. 1999). In a second study, the same investigators observed a 32% improvement in run time to fatigue following CHO ingestion (Davis, et al. 2000).
4) Conversely, Nicholas et al found similar 15 m sprint times between CHO and control trials (Nicholas, et al. 1999). However, consumption of a 6.9% CHO-electrolyte beverage caused a 22% reduction in the amount of muscle glycogen utilised, after a 90-minute intermittent shuttle run test (Nicholas, et al. 1999).
5) In a study designed to imitate the physical activity patterns of team sport the ingestion of a 20% CHO beverage resulted in a 37% improvement in run time to fatigue in high-intensity shuttle running (Welsh, et al. 2002). The authors also observed improved body motor skills, such as speed and agility (Welsh, et al. 2002).

Although the above findings demonstrate a positive effect of ingesting CHO during intermittent exercise, those results found in controlled laboratory settings on cycle ergometers may have limited use in determining the requirements of CHO during a game of rugby union.

In an attempt to determine the effects of CHO consumption during a soccer match, Zeederberg et al (1996) studied two rival soccer teams over two matches. Findings in this study contradicted Welsh et al (2002), as they found that CHO ingestion provided no benefit in soccer players ability to pass or control the ball, tackle, head, dribble or shoot successfully (Zeederberg, et al. 1996). This study, while less controlled than the laboratory study by Welsh et al (2002), was a positive step towards examining the effect of CHO during the physiological requirements of a soccer match (Zeederberg, et al. 1996). This study contradicts findings by previous authors and shows no benefit to motor skill proficiency for the use of CHO beverage during a soccer match. However, the effect of CHO on running performance was not assessed. At present due to the lack of data of the influence of CHO ingestion on rugby union matches, it could be suggested from the above laboratory studies that CHO may help delay fatigue, but there may not be an affect on motor skill proficiency in players.

2.6.3 Carbohydrate intake for recovery

Rugby union players undertake large amounts of physical activity with training and a weekly game. Recovery is an important aspect to ensure that at the next exercise session the player has restoration of muscle and liver glycogen stores (Burke 1996). It has been observed that during supra-maximal exercise there is a 28% reduction in muscle glycogen concentration (MacDougall, et al. 1977). MacDougall and colleagues found that glycogen resynthesis was fastest over the first five hours after high-intensity intermittent cycling exercise (MacDougall, et al. 1977). Five of the six participants displayed considerable glycogen repletion during the first two hours while participants were still fasting (MacDougall, et al. 1977).

Conversely, Ivy et al (1988) investigated the effect of time of CHO ingestion on synthesis of muscle glycogen. Participants completed 70 minutes of cycling of varying intensities to deplete muscle glycogen they then either received CHO immediately after 70 minutes of cycling (P-EX) or two hours after cycling (2P-EX) (Ivy, et al. 1988). The authors found that during the first two hours of recovery, there was a threefold increase in muscle glycogen in the P-EX treatment compared to the 2P-EX trial and the rate of glycogen storage for P-EX averaged 7.7 μmol • g^{-1} ww • h^{-1} (Ivy, et al. 1988). In the second hour, the rate of glycogen storage decreased from 7.7 to 4.3 μmol • g^{-1} ww • h^{-1} (Ivy, et al. 1988). However, for the 2P-ex treatment it was observed that the rate of glycogen storage was 2.5 μmol • g^{-1}ww • h^{-1} in the first two hours and increased to 4.1 μmol • g^{-1} ww • h^{-1} in the second two hours after the ingestion of CHO (Ivy, et al. 1988). From the findings the authors determined that the time of CHO administration was significant to maximise, recovery and that a two-hour delay in administration of CHO could result in a slower rate of glycogen storage (Ivy, et al. 1988). Ivy et al stated that the difference in storage rates among the studies could be explained by the different exercise types used to deplete muscle glycogen (Ivy, et al. 1988). Multiple high-intensity sprints used in the MacDougall study causes glycogen depletion which is accompanied by elevated blood glucose and blood and muscle lactate, which can be used as a substrate for glycogen synthesis (Ivy, et al. 1988). This effect is not observed in prolonged sustained exercise, therefore an exogenous CHO supply is needed to restore glycogen (Ivy, et al. 1988).

2.6.4 Recommendations for carbohydrate intake

General recommendations can be made to players, however, this advice should be fine-tuned to the training and match needs of the individual (Burke, et al. 2004). Researchers have suggested that a high-CHO diet (60 to 80% of daily energy intake) will improve performance when compared to a low-CHO diet (5 to 40% of daily energy intake) (Jacobs 1981; Bangsbo, et al. 1992; Balsom, et al. 1994; Pitsiladis and Maughan 1994; Balsom, et al. 1999). Past recommendations for training diet provide CHO requirements in terms of percentage of total energy intake. However, it is now thought that guidelines for CHO (or other macronutrients) should not be provided in terms of percentage contributions to total dietary energy intake (Burke, et al. 2004).

It is proposed that guidelines are now stated as an amount in grams per kilogram of body weight every day as it is considered easier and more user-friendlier for athletes (Burke, et al. 2004). Athletes are advised to consume around 5-7 g • kg^{-1} • day^{-1} of CHO if they are completing moderate duration or low intensity training, or 7-12 g • kg^{-1} • day^{-1} of CHO for athletes completing moderate to heavy endurance training. Even though rugby players are not participating in large amounts of endurance training, CHO intake should be between 7-12 g • kg^{-1} • day^{-1}, as their energy needs are large due to daily training or competition.

The recommendations for CHO intake before exercise is to consume a meal about three hours prior to the game supplying 200g of CHO (Howe, et al. 2002). A smaller CHO snack should be ingested one to two hours before exercise (Howe, et al. 2002). During exercise, when possible, beverages containing 4-8% CHO-electrolyte should be consumed (Howe, et al. 2002). Post-exercise recovery should begin as soon as possible to ensure optimal glycogen stores by the next bout of exercise. This can be achieved by consuming 1g·kg^{-1}BM of CHO straight after completion of the game and then consuming a high-CHO meal within the next two hours (Howe, et al. 2002). The period of two hours is important as shown by Ivy et al (1988) to maximise the ability of the body to replenish glycogen during a higher rate at this time.

In summary, although the above findings from laboratory and controlled match studies have shown that CHO will be beneficial in providing an exogenous energy source to spare muscle glycogen, caution should be taken when translating the findings to intermittent high-intensity sports such as soccer or rugby union. Also, comparing between these results should be made sparingly as different modes of activity were used in many of these studies. However, the research cited above show that a high-CHO diet prior to intermittent high-intensity exercise, like that found in the many codes of football and therefore rugby union, will help to increase the performance of the players. While players should try to increase their consumption of CHO, it is also important that they consume the required amounts of protein and fat.

2.7 Protein

Protein is needed in the body for a multiple of reasons including growth, developing strong muscles, repairing damaged muscles and tissues, carrying oxygen around the body, helping prevent illness (antibodies and a healthy immune system), and triggering reactions in the body (enzymes and hormones) (Howe, et al. 2002). Protein is not considered a major source of energy during exercise, since glucose and fatty acid oxidation serve this purpose more efficiently (Massad and Headley 1999). Carbohydrates in the body can be derived from proteins and nonessential fatty acids can be obtained from dietary CHO, however, proteins in the body are dependent on proteins in food for their formation and maintenance (Di Pasquale 2000). Non-essential amino acids are synthesised from essential amino acids, which are found as constituents of dietary protein. When protein intake is inadequate, there are insufficient amino acids entering the free pool to replace those lost from protein degradation (Lemon 1996). This results in a loss of muscle strength and size over time, which could ultimately affect performance (Lemon 1996). Conversely, when protein intake is excessive, excess amino acids are converted to CHO or fat and stored (Lemon 1996; Di Pasquale 2000; McArdle, et al. 2001).

In recent times there has been an increase in the number of studies investigating the role protein plays during exercise and whether the recommended dietary intake (RDI) of protein of athletes should be different from that of the sedentary individual, however, the answers still eludes researchers. The studies that have researched the requirements of protein for athletes have examined either the need for endurance (Meredith, et al. 1989; Phillips, et al. 1993) or strength athletes (Lemon, et al. 1992; Tarnopolsky, et al. 1992), and the intermittent sport athlete has received limited attention.

2.7.1 Physical exercise and protein metabolism

Research has now shown that physical exercise affects the metabolism of protein. When liver glycogen levels become low, glucose needs to be produced from other sources and protein catabolism is increased (Robergs and Roberts 1997). Consequently, gluconeogenesis increases, with which amino acids are a substrate (Robergs and Roberts 1997; Di Pasquale 2000; McArdle, et al. 2001). Amino acids are used in the skeletal muscle as substrates for the citric acid cycle intermediates as well (Robergs and Roberts 1997). Generally, protein intake only contributes 10% to 15% to the energy value of most well balanced diets and seldom exceeds 20% (Di Pasquale 2000; Maughan 2002). However, for some athletes in power sports and in bodybuilders who may be on very high-protein diets, the contribution can be as high as 50% (Di Pasquale 2000). In well-nourished individuals at rest, this protein catabolism contributed between 2% and 5% of the body's total energy requirements (McArdle, et al. 2001).

A rise in amino acid oxidation can be established from an increased excretion of urinary nitrogen (Robergs and Roberts 1997). Nitrogen balance occurs when nitrogen (protein) intake equals nitrogen excretion (McArdle, et al. 2001). Positive nitrogen balance arises when nitrogen (protein) intake exceeds that of nitrogen excretion (Lemon 1996; McArdle, et al. 2001). This can occur when an individual is involved in a resistance-training programme and dietary intake is adequate. Negative nitrogen balance is when the nitrogen excretion exceeds that of nitrogen intake, and generally this occurs when protein is being used as energy and muscle tissue is broken down (McArdle, et al. 2001). This is shown by the increase in urinary nitrogen excretion of specific amino acid derivatives only produced from muscle protein (Robergs and Roberts 1997). This increase in catabolism of body proteins can be observed by the increase in leucine oxidation (Brooks 1987).

Studies using nitrogen balance have described the need for an increase in protein content of endurance and strength-trained athletes. Philips et al (1993) observed that when endurance trained male athletes consumed their habitual protein intake of 0.94 $g \cdot kg^{-1} \cdot day^{-1}$ all six athletes were in a negative nitrogen balance. The amount of protein used in this study was above that of the RDI for New Zealanders. Similar results were found by Meredith and colleagues (1989), where at an average protein intake of 0.9 $g \cdot kg^{-1} \cdot day^{-1}$ seven of 12 endurance-trained men were in a negative nitrogen balance. The authors found 11 of the 12 participants were in a positive nitrogen balance when an average protein intake of 1.2 $g \cdot kg^{-1} \cdot day^{-1}$ (Meredith, et al. 1989). In strength athletes similar findings have been established. Tarnopolsky et al (1992) observed that when consuming a protein intake of 0.86 $g \cdot kg^{-1} \cdot day^{-1}$, five of seven strength athletes were in a negative nitrogen balance. During the moderate protein intake trial (protein intake 1.41 $g \cdot kg^{-1} \cdot day^{-1}$) there was an increase in whole body protein synthesis and no change in leucine oxidation was observed (Tarnopolsky, et al. 1992).

While rugby union is not entirely a strength or endurance sport, both of these components are vital attributes in rugby (Nicholas 1997). Strength is needed by players for scrums and mauls as well as tackles, and endurance is used by the players to sustain 80 minutes of play.

2.7.2 Recommendations for protein intake

The RDI of protein for the sedentary male in New Zealand is 55g (Truswell, 1990), this RDI follows FAO/WHO/UNU (1985) figures based on 0.75$g \cdot kg^{-1} \cdot day^{-1}$ of protein. The above findings support the need for an athlete to consume a high CHO diet to help conserve muscle tissue and reduce the amount of protein oxidation (McArdle, et al. 2001). Thus, the protein needs of athletes are substantially higher than sedentary subjects.

As suggested by Burke et al (2004), recommendations should now be stated in grams per kilogram of body weight to make them user-friendly to athletes. Similarly, the American Dietetic Association currently recommends a protein intake of 1 g • kg^{-1} • day^{-1} for athletes (Economos, et al. 1993). However, other authors contradict this recommendation. Di Pasquale (2000) suggests that once exercise increases to a certain intensity, protein is vital to maximise the synthesis of new tissues. Recommendations can be made from observations of Meredith et al (1989), who found that all but one of the 12 participants were in a positive nitrogen balance at an intake of 1.2 g • kg^{-1} • day^{-1}.

In an attempt to determine the protein needs for soccer players, Lemon (1994) put together a review of the literature on the requirements for endurance and strength athletes. Although soccer is not a sport that is either predominately an endurance or strength sport, both aspects are used over the 90-minute period (Lemon 1994). Lemon found that although insufficient data has been collected on soccer players, utilizing the current evidence from related studies it appears that they should consume about 1.4-1.7 g • kg^{-1} • day^{-1} (175-212% of the recommended dietary allowance) (Lemon 1994). Assuming a varied diet, this amount of protein should be easily consumed by most soccer players (Lemon 1994). This recommendation, while not being based on the literature of rugby union players, could be assumed similar to that of the soccer players due to the similarities between the two sports. At present there are no studies which have determined the protein requirements of rugby players, so until research is conducted to establish the protein needs of this group of athletes have been completed, the use of strength and endurance studies to base recommendations on will have to suffice.

In summary, from the information above it can be assumed that the recommendation of daily intake of protein for rugby union players could be approximated at 1.2-1.7 g • kg^{-1} • day^{-1}. Even though this information is based on literature of endurance and strength athletes, until the same research is completed on rugby union players these recommendations will suffice. In the future, more research is needed on the effects of protein metabolism during high-intensity maximal activity, such as that in a rugby union match before recommendations for rugby union or even soccer can be made more accurately. As stated above, protein is not a major source of fuel in exercise, therefore the athlete should ensure they are consuming enough CHO and fat to maximise the use of these nutrients for energy.

2.8 Fat

Fat provides the body's major store of energy (Howe, et al. 2002). During low-intensity exercise, lipid predominates as the primary substrate (Robergs and Roberts 1997). When the body's stores of CHO become low, the use of lipid and amino acids as substrates increases (Robergs and Roberts 1997). The increase of fatty acid oxidation as an energy source has a sparing affect on the glycogen stores of an athlete (Hurley et al. 1986). Fat also aids in the absorption and transport of fat-soluble vitamins (Howe, et al. 2002).

2.8.1 Fat consumption before exercise

Helge et al (1996) examined the effect of two different training diets, one fat-rich, the other CHO-rich, and their effect on exercise metabolism and endurance performance. The CHO-rich diet contained 65% energy from CHO, whereas the fat-rich diet included 62% of energy intake from fat (Helge, et al. 1996). The participants consumed either the CHO-rich diet for the eight week trial or the fat-rich diet for seven of the eight week trial and the CHO-rich diet for the eighth week (Helge, et al. 1996). The authors found that when the CHO-rich diet was consumed for seven weeks of endurance training, endurance performance improved markedly more (56%) than when the fat-rich diet was consumed (Helge, et al. 1996). The authors concluded that training on a fat-rich diet did not improve endurance performance and could even be detrimental as an significant increase in heart rate and norepinephrine concentration was observed during exercise (Helge, et al. 1996). These findings are contradicted by later research by the same authors, which observed that endurance was enhanced similarly by a fat-rich or CHO-rich diet after both two and four weeks of adaptation to training (Helge, et al. 1998). In both these studies the individuals were untrained, therefore the six week training programme may have been the reason why an improvement in endurance was seen in the latter study. It was also observed in the latter study that the mean age for the fat-rich diet was significantly higher than in the CHO-rich diet despite randomisation, which may cause the observed effect.

Okano et al, (1998) also studied the effect of a high-fat diet on exercise. The authors demonstrated that there was an increase in blood free fatty acid (FFA) levels after a single pre-exercise fat meal, which resulted in a decrease in CHO oxidation. This decrease in oxidation was observed for the first hour of exercise, however, only the difference seen in the first 20 minutes of exercise was significant (Okano, et al. 1998). It was stated by the authors that this small amount of oxidation might not be sufficient to spare glycogen (Okano, et al. 1998).

Hurley et al (1986) have suggested that CHO may also be spared due to the training effect. The authors used a 12-week training period of intermittent exercise and endurance training to evaluate the effects of training on fat oxidation (Hurley, et al. 1986). The authors observed that when participants were trained there was a 41% reduction in muscle glycogen utilisation compared to the untrained state (Hurley, et al. 1986). Concurrently, it was examined that in the trained state there was a greater depletion of muscle triglyceride stores (Hurley, et al. 1986). This same CHO sparing affect was observed by Martin et al (1993), where the authors found an increase in FFA oxidation in the trained individual.

2.8.2 Fat utilisation during exercise

McCartney et al observed that intramuscular triglyceride may serve as an energy substrate during maximal exercise (McCartney, et al. 1986). Eight participants performed four 30-second periods of maximal exercise on an isokinetic cycle ergometer, with four-minute rests in between each period (McCartney, et al. 1986). These results suggest that when there is an inhibition of glycogenolysis, intramuscular triacylglycerol stores might serve as an important substrate for energy metabolism (Anderson 2000). Similar results were found by Kanaley et al (1995), where the authors examined the use of fats as an energy source during running above and below the lactate threshold. The authors found that during exercise above or below the lactate threshold that FFA oxidation was unable to meet energy needs and intramuscular triglyceride stores were utilised (Kanaley, et al. 1995).

2.8.3 Recommendations for fat intake

The above findings of a glycogen sparing effect of fat are encouraging, however, the results are contradictory and should be viewed with caution. The majority of these studies have used endurance athletes as participants, therefore, comparison of results to the rugby players may be limited due to different fat metabolism between athletes. Considering the above research with the research stated in the physiological requirements of rugby (section 2.3, p7) and the CHO section (section 2.6, p11) of this review, the importance of CHO in providing energy and delaying fatigue in intermittent team sports similar to rugby should be noted. Therefore, dietary fat should be reduced to allow for an increased intake of CHO (Hargreaves 1994). However, in saying this there is a need to maintain fat intake to enable the athlete to ingest essential fatty acids, which are required in the diet as they are important structural components of all tissues and are not able to be synthesized by the human body (Uauy et al 2000).

At present, the guidelines for amount of fat required for intermittent sport such as rugby are based on those for the general population. Most of the research has looked into the use of fat as a major energy source for low- to moderate-intensity endurance exercise (Hurley, et al. 1986; Martin III, et al. 1993; Helge, et al. 1998; Okano, et al. 1998; Pitsiladis, et al. 1999). No data is available on lipid metabolism during rugby; however, the laboratory based studies would suggest that there is also likely to be utilisation of fatty acids derived from both adipose tissue and muscle triglyceride reserves (Hargreaves 1994). Howe et al (2002), claim athletes should try to keep fat to a minimum, with diets containing less than 30% of daily energy intake from fat. Their guidelines are that most men should consume 40-60g of fat per day and larger and very active athletes should consume 80-100g per day (Howe, et al. 2002).

In summary, studies in which researchers have used repetitive maximal exercise have found that intramuscular triglycerides are used as a portion of energy (McCartney, et al. 1986; Kanaley, et al. 1995). Although this research has been conducted in a laboratory setting, it gives a direction for further research. As for current recommendations, until additional research is published supporting this role the recommendations should stay conservative such as that by Howe et al (2002).

2.9 Micronutrients

Many athletes and coaches believe that athletes have an increased need for vitamins and minerals than the general population (van Erp-Baart, et al. 1989). This theory persists even though opinions of researchers state supplementation should only occur if there are marginal intakes (van Erp-Baart, et al. 1989). Vitamins and minerals play an important role in the metabolism of nutrients (Economos, et al. 1993). The need for vitamins and minerals is increased during exercise, which can easily be met by consuming a balanced diet (Economos, et al. 1993).

2.9.1 Vitamins

Vitamins contain no useful energy for the body but instead, are regulators in the release of energy from metabolic reactions (McArdle, et al. 2001). Vitamins are also used in the synthesis of new tissues and help protect the integrity of the cell plasma membrane (McArdle, et al. 2001). The theoretical relationship between vitamins and exercise involves their role as coenzymes in the oxidative processes of cells or in the production and protection of red blood cells (Belko 1987). Some of the vitamins along with selenium also have a role as antioxidants.

Antioxidants are important in protecting cells from exercise-induced oxidative stress (Banerjee, et al. 2003). Selenium, and vitamins C and E have a role as exogenous antioxidants to protect against this oxidative damage (Palazzetti, et al. 2004). This elevation in oxygen consumption occurs with heavy weight training or high-intensity aerobic work and leads to an increase in hydrogen ions, which causes an accumulation of free radicals (Clarkson and Haymes 1994; Banerjee, et al. 2003). Free radicals are chemical species containing unpaired electrons that make them highly reactive with other cellular components (Clarkson and Haymes 1994). During physical activity inflammatory reactions occur which in turn activates the formation of free radicals (e.g. leukocyte activation with phagocytosis, leukotriene synthesis) (Simon-Schnass 1993). An adverse effect of this rise in free radical formation is muscle damage (Thompson, et al. 2001; Thompson, et al. 2003). Table 2.2 presents the roles of vitamins with regard to sport performance and the current New Zealand RDI of these vitamins for males.

Table 2.2 Vitamins and their role in sport performance and the current New Zealand RDI of vitamins for males aged 19-64 years

Vitamin	Role	RDI*
Vitamin B_1 (thiamin)	Facilitates the conversion of pyruvate to acetyl-coenzyme A (CoA) in CHO breakdown (McArdle, et al. 2001)	1.1 mg
Niacin and vitamin B_2 (riboflavin)	Regulate mitochondrial energy metabolism (McArdle, et al. 2001)	18-20 mg 1.7 mg
Vitamin B_6 and B_{12}	Catalyse protein synthesis (McArdle, et al. 2001)	1.3-1.9 mg 2 µg
Pantothenic acid,	Part of CoA, participates in the aerobic breakdown of the CHO, fat and protein macronutrients (McArdle, et al. 2001)	5 mg
Vitamin C	Scavenge superoxide, hydroxyl and lipid hydroperoxide radicals (Powers, et al. 2004)	40 mg
Vitamin E	Chain breaking free radical scavenger (Banerjee, et al. 2003; Powers, et al. 2004)	10 mg

*(Truswell, 1990)

For further information on the roles of the above vitamins during and following exercise and the current findings on the discussion to change the RDI's the reader is referred to other reviews (Belko 1987; Burke and Read 1989; Simon-Schnass 1993; Thompson, et al. 2001; Thompson, et al. 2003).

2.9.2 Minerals and electrolytes

Minerals serve as constituents of enzymes, hormones, and vitamins. They combine with other chemicals (e.g., calcium phosphate in bone, iron in the heme of hemoglobin) or exist singularly (e.g., free calcium and sodium in body fluids) (McArdle, et al. 2001). They provide structure to teeth and bones and functionally help maintain heart rhythm, muscle contractions, neural conductivity and acid-base balance (McArdle, et al. 2001). Minerals also help in metabolism by assisting in the release of energy during CHO, protein and fat catabolism (McArdle, et al. 2001). In addition, minerals also participate in the synthesis of nutrients – glycogen from glucose and proteins from amino acids (McArdle, et al. 2001).

Electrolytes modulate fluid exchange within the body's fluid compartments, promoting a constant well-regulated exchange of nutrients and waste products between the cell and its external fluid environment (McArdle, et al. 2001). Excessive water and electrolyte loss impairs heat tolerance and exercise performance and can lead to severe dysfunction, culminating in heat cramps, heat exhaustion or heat stroke (McArdle, et al. 2001). The role of minerals and electrolytes concerning sporting performance and the current New Zealand RDI's is shown in Table 2.3.

For further information on the roles of the above minerals and electrolytes during exercise and the current findings on the discussion to change the RDI's the reader is referred to other reviews (Haymes 1987; Economos, et al. 1993; Clarkson and Haymes 1994; Burke 1995).

In summary, vitamins and minerals play an important part in the process of energy metabolic reactions and in enzymes. However, the increased need for vitamins and minerals in the sporting community has not be proven, therefore the use of vitamins and minerals by rugby players is a choice for the individual to make.

Table 2.3 Role of minerals and electrolytes in sport performance

Mineral	Role	RDI
Calcium	Muscle stimulation, blood clotting, transmission of nerve impulses, activation of several enzymes, synthesis of catcitriol (active form of vitamin D), and transport of fluids across cell membranes (McArdle, et al. 2001)	800 mg
Iron	Formation of hemoglobin, myoglobin, cytochromes, iron-containing enzymes (Haymes 1987)	7 mg
Zinc	Important mineral found in more than 100 enzymes (Clarkson and Haymes 1994) and involved in energy metabolism, cell growth and differentiation, and tissue repair (McArdle, et al. 2001)	12 mg
Selenium	Essential component of the glutathione peroxidase (GSH-Px) (Clarkson and Haymes 1994)	85 mg
Electrolyte		
Potassium	Water balance in the body, muscle contraction, acid-alkali balance, nerve transmission, healthy heart and blood vessels and energy, protein and CHO metabolism (Reavley 1999)	50-140 mmol
Sodium	Water balance in the body, muscle contraction, acid-alkali balance, nerve transmission, energy production and stomach acid production (Reavley 1999)	40-100 mmol
Chloride	Water balance in the body, muscle contraction, acid-alkali balance, nerve transmission, and stomach acid production (Reavley 1999)	No RDI available

* (Truswell, 1990)

2.10 Fluids requirements for rugby union players

Fluid requirements for endurance trained athletes has attracted much attention (Barr, et al. 1991; Fallowfield, et al. 1996), yet only in recent times has there been an increase in the number of studies investigating the effects of fluid intake on performance during team sports. There are a number of ways team sports athletes may differ from endurance athletes in fluid losses and their fluid intake practices (Broad, et al. 1996). Team sports are generally of an intermittent nature, with higher intensity efforts interrupted by periods of minimal activity (Broad, et al. 1996). It is still unknown whether this form of intermittent exercise affects sweat losses differently than continuous, prolonged aerobic exercise or at least minimises hypohydration (Burke 1993). However, it is established that players need to match their fluid intake to sweat losses (Burke 1993).

2.10.1 Problems of hypohydration

In rugby union matches, sweat losses averaged 2.1 kg and mean water deficits have found to be between 1.51% and 2.52% per match, respectively (Cohen, et al. 1981; Goodman, et al. 1985). These losses of body water can cause rectal temperatures that have been reported to be between 38.5° & 40.3°C (Dancaster 1972; Cohen, et al. 1981; Goodman, et al. 1985). Increases in body temperature above 39.5°C can initiate hyperthermia, which causes adverse physiological responses (Robergs and Roberts 1997). One cause of hyperthermia has been attributed to hypohydration, or the loss of body water content, which is common during team sports. This loss of water causes a reduction in plasma volume, which in turn leads to the observed rise in core temperature (Barr, et al. 1991; Robergs and Roberts 1997; McGregor, et al. 1999; McArdle, et al. 2001).

Physiological changes that may occur due to hyperthermia are cardiovascular strain (Barr, et al. 1991; McGregor, et al. 1999; Medicine 1996), a decrease in blood volume, stroke volume, plasma volume (Barr, et al. 1991), cardiac output and blood pressure (Meir, et al. 1990). Hyperthermia can be reduced through heat loss. An important way of dissipating this heat is through sweating (Gisolfi and

Duchman 1992; Burke and Hawley 1997; Shirreffs, et al. 2004). However, the requirement to disperse heat causes the body to circulate the blood to the surface, therefore the blood volume is insufficient to supply oxygen to the working muscles as well as transport heat to the body surface, this response is termed cardiovascular drift (Cohen, et al. 1981). These changes impair thermoregulation, gastric emptying, mental functioning, and muscular endurance (Broad, et al. 1996).

With modifications in the physiological responses to dehydration, changes in physical performance have been observed. These differences are a decrease in the length of time to exhaustion, reduced time spent at high intensity exercise and a decrease in mental performance (Cohen, et al. 1981; Burke 1993; Broad, et al. 1996).

2.10.2 Fluid intake and performance

A number of studies have found that fluids are beneficial for high-intensity intermittent exercise. Results from Murray et al (1987), indicated that physiological function during intermittent, high-intensity cycling in a warm environment is as well maintained by consuming CHO beverages as by consuming a water placebo. Similarly, Below et al (1995), found when fluid or CHO was ingested individually, both improved performance times by about 6% compared to the placebo trial. These findings show that water alone can limit the detrimental effects of dehydration without the need for CHO or electrolytes. It was encouraging to see that Below et al (1995) included electrolytes in equal proportions in all four experimental trials. This means that any benefit found due to electrolytes would be experienced in all four trials. However, using these results in suggesting the type of fluid to use in a rugby union match should be made carefully as all eight of the participants in the Below et al study were endurance trained which may have an effect on their physiological functioning when compared to rugby union players. Additionally, Barr et al (1991), has also shown this increase in time to fatigue when fluids have been consumed compared to trials when no fluids have been consumed. The same author also observed that participants terminated the trials prematurely when no fluid was consumed (Barr, et al. 1991).

The above three studies, carried out in controlled environment chambers on cycle ergometers, have shown support for the need of fluids during high-intensity intermittent exercise. Caution needs to be employed when comparing these above results to the field setting as skill requirements and environmental elements such as temperature and wind factor will wield a different response. In addition, two of the above studies have used cycling as their mode of exercise, which may cause problems in comparisons to rugby union because of the different mode of activity used.

Fallowfield et al. (1999) examined the effects of fluid intake on treadmill running duration completed at 70% VO2 max. The authors observed that running time to exhaustion for the no-fluid trial was 77.7 minutes, compared to 103 minutes for the fluid-trial (Fallowfield et al. 1999). These results show promise regarding the improvement of endurance capacity with the ingestion of water, however there may be differences between fluid absorption during treadmill running and rugby union games so prudence should be exercised regarding the results.

McGregor et al (1999) found that prolonged intermittent high-intensity shuttle running without water ingestion resulted in 5% deterioration in performance of a soccer skill. The authors also found that the last 15-minutes sprint period in the no-fluid trial was significantly slower than the first 15-minute block; this was not the case in the fluid trial (McGregor, et al. 1999). This study was a positive step towards determining the effect of dehydration on soccer skills and whether water ingestion alone was sufficient to stop deterioration of soccer skills. Although these results do not completely demonstrate the effect of limited water ingestion during a soccer game, the test was a reflection of the minimum physical demands faced by soccer players during a game. Caution is needed however, when applying these results to other sports such as rugby.

2.10.3 Factors influencing fluid intake

The rules of the game are one major concern when determining fluid intake during exercise. Rules relating to fluid intake during a rugby match are rather lenient which allows for a larger amount of fluid to be ingested during the game as fluids can be consumed during injury time out, penalty shots at goal and half time. Additionally, a number of factors can affect fluid intake, such as awareness of sweat losses, availability of fluid, palatability of fluid, gastrointestinal comfort, attitude towards and awareness of the disadvantages of hypohydration, and fear of needing to urinate (Burke and Hawley 1997).

Gastrointestinal discomfort may occur after consuming large amounts of fluid or food, and may be increased in an individual if gastric emptying is inhibited (Burke 1993). A number of factors can influence gastric emptying, however, a detailed description of these factors is outside the scope of this review so the reader is referred to other reviews (Murray 1987; Costill 1990; Noakes, et al. 1991; Burke 1993). The problems (or at least, fear of these problems) associated with gastrointestinal disturbances may cause athletes to consciously or unconsciously limit fluid intake during games (Burke 1993). This behaviour can lead to "voluntary dehydration" ; a term used to describe the delay in drinking fluids to replace those lost during exercise (Szlyk, et al. 1989; Hubbard, et al. 1990; Szlyk, et al. 1990). To increase consumption of fluids palatability is an important aspect to consider. Palatability is enhanced by factors that include temperature, flavouring, CHO content, and electrolyte content (American College of Sports Medicine 1996).

Drink temperature has been shown to increase the total amount of fluid intake, with cold (0° to 5°C) and cool drinks (15°C) being preferred to warm drinks (20° to 50°C) (Szlyk, et al. 1989; Hubbard, et al. 1990; Burke and Hawley 1997). In addition, when flavouring was added to water consumption of both cool (15°C) and warm (40°C) water was improved by about 50% (Hubbard, et al. 1990). Sodium chloride concentration is also another important factor that enhances the palatability of fluid. Sodium also improves glucose and water absorption from the gut, maintains fluid balance and enhances fluid retention (Howe, et al. 2002). The amount of sodium lost in sweat during exercise is 20-80 mmol • L^{-1} (Burke 1996). It has been recommended that sodium content of (20-40 mmol • L^{-1}) be included in fluids to maximise rehydration decrease hyponatraemia and enhance palatability (Coyle 2004).

2.10.4 Carbohydrates

Another concern with fluid requirements is whether to consume a CHO containing beverage instead of just water. Murray et al, established that the effect of fluid and CHO feedings during intermittent cycling exercise when examining differences in beverage CHO content, CHO type, electrolyte content, and osmolality had little effect upon maintenance of fluid homeostasis during this type of exercise (Murray, et al. 1987). Although these findings have been found in intermittent exercise, it does not necessarily mean that the results will hold true for all types of intermittent sports. Other research has found that the amount of muscle glycogen utilized during prolonged, intermittent, high-intensity exercise was reduced by 22% when a CHO-electrolyte solution was consumed immediately before and at frequent intervals during exercise (Nicholas, et al. 1999). Similarly, Davis and colleagues (1999) showed that ingestion of CHO beverages 1-h prior and throughout exercise delays fatigue during intermittent high-intensity exercise. Additionally, Below et al (1995) observed during 1-hour of intense cycling exercise that although both CHO and water independently improved performance by 6%, and when CHO and fluids were combined in the form of 6% CHO-electrolyte solution, a 12% improvement in performance was observed. This last study shows the added benefit CHO can have to fluid intake. Many of these studies highlight the benefit of consumption of a CHO beverage in intermittent exercise similar to rugby union, for a more detailed review of the literature the reader is referred to section 2.6 in this thesis.

2.10.5 Recommendations for fluid intake

Recommendations for fluid consumption during a sporting game can vary depending on the source of publication. However, the requirements generally range from 200 to 600ml of fluid before the game (Cohen, et al. 1981; Hawley, et al. 1994; Broad, et al. 1996). At halftime an extra 250 to 600ml of fluid should be consumed (Cohen, et al. 1981; Hawley, et al. 1994; Broad, et al. 1996). Additional fluid could be consumed should play be interrupted (Cohen, et al. 1981), or during injury time outs and penalty shots. Some authors suggest that the player should ingest 800 to 1600ml.h^{-1} of a cool (5 to 15^{O}C) 6 to 8% CHO beverage during an event with 10-20mmol.L^{-1} of both sodium and chloride (Economos, et al. 1993; Hawley, et al. 1994). As soon as possible after each game, players should ingest a CHO-electrolyte beverage in sufficient volumes to replace all sweat lost during the match (Hawley, et al. 1994).

2.11 Alcohol

Alcohol has been a large part of the sporting culture since ancient times (O'Brien and Lyons 2000). Even though there is a large association of alcohol in sport there have been limited studies completed to date. The American College of Sports Medicine (1982) completed an analysis of alcohol and the effects on sporting performance and concluded:

1) The acute consumption of alcohol has detrimental effects on many psychomotor skills.
2) Acute ingestion of alcohol will not substantially influence metabolic and physiological functions, which are indispensable to the sporting performance in a significant way.
3) Acute alcohol may cause a decrease in sports performance including strength, power, muscular endurance, speed and cardiovascular endurance.

These effects on sporting performance are a worrying thought for those players who consume alcohol the night before a rugby match. The psychomotor skills that will be affected by alcohol include reaction time, eye-hand coordination, accuracy and balance (American College of Sports Medicine 1982; Gutgesell and Canterbury 1999; Howe, et al. 2002). Alcohol is postulated to have a negative effect on aerobic performance (O'Brien 1993; O'Brien and Lyons 2000). Additionally, it has been suggested that alcohol lowers muscle glycogen levels (O'Brien 1993; O'Brien and Lyons 2000)

The diuretic effect of alcohol, leads to dehydration, which results in a decrease of aerobic performance (O'Brien 1993; O'Brien and Lyons 2000; Howe, et al. 2002) (see section 2.10), this will also be a problem during recovery as the athlete will generally be in a hypohydrated state post exercise, and the diuretic affects of alcohol will compound this. Alcohol consumption might also reduce the ingestion of high-CHO foods and adequate water or CHO-containing fluids, which are needed to enable adequate recovery of fluid deficit and CHO depletion adequately.

When the patterns of alcohol use in New Zealand rugby union players was investigated, it was observed that 64% of the 257 males studied consumed alcohol at least two or three times per week (Quarrie, et al. 1996). It was reported that 61 percent of those who drank, consumed six or more drinks in a session each week (Quarrie, et al. 1996). When the authors compared alcohol consumption to the number of injuries sustained over the previous 12 months 14% of males' injuries was a result of drinking (Quarrie, et al. 1996). Reviews on alcohol have reported research demonstrating that athletes that consumed alcohol at least once per week had double the injury rate of athletes who were non-drinkers (O'Brien and Lyons 2000).

In summary, alcohol has a detrimental effect on psychomotor skills, hand eye coordination and reaction time. Alcohol is also a very poor hydrating fluid which is important for athletes involved in strenuous activity. Recommendations to athletes should include refraining from alcohol the night prior to a game or match and to ensure plenty of non alcohol fluids are consumed before alcoholic beverages to improve the chances of fluid losses to be meet.

2.12 Dietary intake assessment methods

Precise estimates of food, energy and nutrient intakes are important in assessing the dietary status of an individual and groups of individuals (Basiotis, et al. 1987). However, day-to-day variability in food energy and nutrient intake has been found which adversely affects the statistical precision or accuracy of estimates of intakes, and thus it must be taken into consideration in the design of studies of dietary status and in the interpretation of results (Basiotis, et al. 1987). Assessment of dietary intake can also help in determining whether nutritional knowledge correlates with a healthier diet.

Techniques in measuring diet include (a) 24-hour recall, (b) food frequency questionnaire, (c) food records (diet diary), and direct observation (Massad and Headley 1999; Black 2001; Biro, et al. 2002). Methods include various combinations of prospective and retrospective recording of daily intake; personal, telephone, and mail- and telephone-assisted reporting; semi-structured and open-ended recording documents; and number and spacing of days for recording intakes (Morgan, et al. 1987). The methods of measuring dietary intake that will be examined in this review are the food records, food frequency questionnaire, and 24-hour recall.

2.12.1 Validity of the methods

There have been a number of reviews describing the different dietary intake methods and their advantages and disadvantages (Block 1982; Black 2001; Biro, et al. 2002). The 24-hour recall and diet diaries are attempts to record exact intakes of food over a short period. Food frequencies, in contrast, are a more general evaluation of dietary patterns over a longer period (Sorenson, et al. 1985). When choosing a method for use within a study the validity and reliability must also be examined.

Validity ensures that the dietary method chosen has measured the true situation and what was believed to be assessed (Gersovitz, et al. 1978; Guthrie and Crocetti

1985; Livingstone 1995; Black 2001; Biro, et al. 2002). To be valid the methods need a large degree of accuracy. Therefore, it would be assumed that there are no errors in the data collection or interpretation of the data. However, various problems may occur for the different dietary assessment methods. Methods that rely on memory are prone to reporting errors, and with dietary records, changes in diets may occur during the collection time (Biro, et al. 2002). Errors may also arise from the use of food composition tables, food coding, portion estimation, daily variation, reporting error, change in diet and response bias and sampling bias (Biro, et al. 2002). Many of these reviews have found that the methods have some degree of validity when compared against each other.

Validity studies have found that the 24-hour dietary recall and seven-day dietary record provide similar estimates of the mean intake of a group of elderly subjects at a congregate meal site (Gersovitz, et al. 1978). However, the validity of a 24-hr recall showing a true picture of an average diet of an individual is low. Other factors that will also affect validity is the completeness of the food data base programme used to determine the nutrient content on the diet recorded and, when using a food record, the number of days the record is kept for can also affect the validity.

2.12.2 Reliability of methods

The reliability of the data depends on the accuracy of the method to repeatedly gain similar intakes on consecutive days (Guthrie and Crocetti 1985; Livingstone 1995). Generally, the fewer number of days energy intake is collected, the less reliable the data becomes as an accurate picture of the participants usual intake. Due to the variability of diets day to day, a single 24-hour recall does not represent the true intake at an individual level but characterises the average intake of a group quite well (Livingstone 1995; Biro, et al. 2002). However, there is also a decrease in reliability of dietary food record as the length of days recorded increases, because of fatigue of the respondents' (Biro, et al. 2002). The accuracy of recording methods rests on the assumption that respondents' do not change their dietary habits during the time of data collection (Livingstone 1995). If the list of foods is not comprehensive enough in food frequency questionnaire, then reliability may be low if the usual dietary patterns of the respondents' are not accurately expressed in the listed foods (Biro, et al. 2002). In addition, memory of the food pattern might cause the respondent to only list those foods most recently consumed, decreasing the accuracy of past dietary intake (Livingstone 1995; Biro, et al. 2002).

2.12.3 Food diaries

Research has found that as the number of days recorded in a food diary increases the validity of the record also increases (Gersovitz, et al. 1978; Basiotis, et al. 1987). Basiotis et al found that among the 13 males and 16 females participating in their study, those with the least variance in food energy intake would require 14 days of food intake records to estimate their true average intake with confidence (Basiotis, et al. 1987). In spite of this, earlier work by Gersovitz discovered that the food record diary was generally valid for group comparisons of nutrient intake during early days of record keeping, but the validity declines in later days (Gersovitz, et al. 1978). Individuals with greater variance in their day-to-day food energy intake would require a greater number of food intake records to estimate their true average intake (Basiotis, et al. 1987). When the researchers treated the participants in this study as members of a group, it was observed that the number of days required to estimate true average energy intake "accurately" with a 95% level of statistical precision was 3 days (Basiotis, et al. 1987). In assessing the validity of the seven-day record, an important methodological point has been raised by this study. Although 85% of the sample returned at least two usable records, the percentage of usable records declined to 60% by day 7 (Gersovitz, et al. 1978). Thus, it can be seen that more records does not always mean a more valid result.

2.12.4 Food frequency questionnaires

Bergman et al (1990) found that a food frequency questionnaire gave a higher estimation of group nutrient intake than diet records. The authors suggested that over estimation of food eaten might have been the reason for the higher nutrient values obtained by the food frequency. It was found that foods eaten once a week were remembered more often and with better accuracy than those eaten less than once a week. The participants ate a variety of food and the researcher found that only 10% of reported foods were eaten on a daily basis. This would reduce the likelihood of remembrance of foods (Bergman, et al. 1990). Bergman et al (1990) concluded that a diet record might offer a more accurate method of assessing nutritional adequacy when moderate to large groups are studied.

2.12.5 twenty-four hour recall

When using a 24-hour recall an interview process needs to be administered, either face to face or over the phone (Biro, et al. 2002). The recall of one day's intake is of interest only because of the implicit assumption that a single day is somewhat representative of a usual pattern of intake (Block 1982). It is general agreement by researchers that the information provided about diet from a 24-hr recall cannot be considered a true representation of usual dietary intake (Block 1982; Guthrie and Crocetti 1985; Livingstone 1995; Biro, et al. 2002). Its value in assessing the average intake of a group has considerable support, however (Block 1982).

Past studies completed on football teams have tended to use food diaries. The length of time the diaries were kept for varied with different studies. Researchers have used a four-day record (Schokman, et al. 1999), five-day record (Leblanc, et al. 2002) or a seven-day record (Burke and Read 1988; Burke, et al. 1991; Maughan 1997). Other studies used the recall method in an interview format by a registered dietitian (Hickson, et al. 1987). However, Gardjean (1989), stated that 4 to 6 days was the length of time needed to accurately estimate the true average group intake for fat, CHO and protein.

In summary, food record diaries, food frequency questionnaires and 24-hour food recall all have their strengths and weaknesses. It is up to the investigator to decide which method suits the study the best by increasing the validity and reliability of the results while an economical method.

2.13 Athletes knowledge, attitudes and beliefs to nutrition

This relationship between nutrition knowledge and behavioural change has been studied in detail in the past (Anderson, et al. 1998; McDonnel, et al. 1998; Wardle, et al. 2000; Pirouznia 2001) and researchers have observed a positive relationship between nutritional knowledge and behaviour (Packman and Kirk 2000; Pirouznia 2001). Yet, these studies have mainly examined knowledge between nutrition and disease, often looking at only one aspect of nutrition, i.e. how knowledge about fat affects intake of fat.

There are few studies investigating knowledge of nutrition in athletes and the effect it has on their diet. Many of the studies that have been conducted tend to focus more on the knowledge of females than males (Barr 1987; Wiita and Stombaugh 1996; Chapman, et al. 1997; Cupisti, et al. 2002). This may be due to the greater concern that if female athletes diets do not contain enough energy there can be detrimental effects to their health and performance. However, this leaves a gap in the research as, due to the different study populations and needs for those groups, it would not be appropriate to relate these findings to males. Furthermore, females tend to receive more information regarding nutrition than males (Jacobson, et al. 2001). In a study on the effect of gender differences on knowledge learning, Auld et al (2001) found that when retested on knowledge about fat after reading a bulletin of dietary guidelines for Americans, the men's treatment group showed a significant improvement in all knowledge sub-scores, however, the women's treatment group significantly improved only on the major concept sub-score.

2.13.1 Sources of nutritional information given to athletes

Past research has demonstrated that athletes have many misconceptions regarding nutrition and performance (Jacobson, et al. 2001; Cupisti, et al. 2002; Rosenbloom, et al. 2002). Athletes trying to reach peak performance mainly had misconceptions regarding protein, vitamins and mineral and fluids and their roles (Jonnalagadda, et al. 2001). One explanation for the differences between knowledge and practices may involve the source of nutrition information available to these athletes (Smith-Rockwell, et al. 2001) and the accuracy of the information that they are receiving from these sources. The majority of nutritional information gained by athletes' stems from magazines, coaches, trainers, parents, and peers (Barr 1987; Jacobson, et al. 2001; Cupisti, et al. 2002). In a study on nutrition knowledge, opinions, and practices of coaches and athletic trainers at American Division One Universities, it was found that participants were most knowledgeable about topics such as fluid needs, weight control and supplementation (Smith-Rockwell, et al. 2001). Even though the participants were knowledgeable about supplements, they were less knowledgeable about micronutrients (Smith-Rockwell, et al. 2001). It was also found that generally there was a tendency among those who coached or trained female athletes or both male and female athletes to give a greater number of correct responses than those who coached or trained only males (Smith-Rockwell, et al. 2001). This finding is of concern since coaches or trainers may be the first person that a player would go to for advice.

Nutrition knowledge dispersed to athletes by individuals without an education in nutrition might lead to faulty beliefs of what is proper nutrition (Jacobson, et al. 2001). As coaches appear to have a unique opportunity to influence food selection, (Sossin, et al. 1997) it is extremely important that they have the knowledge to reinforce the advice they administer to players. Moreover, coaches felt authorised to give nutritional advice, and 63% reported taking time to review wrestlers' food intake (Sossin, et al. 1997). Sossin et al's findings suggest that wrestling coaches are not fully prepared to provide recommendations and provide nutrition and weight loss advice to their athletes (Sossin, et al. 1997). This was shown by the substantial proportion of undecided responses to many questions, and shows that the coaches are not completely confident with their knowledge (Sossin, et al. 1997).

As previously stated, a main criticism of past studies on athletes and nutritional knowledge is that many of the studies use females as participants (Barr 1987; Wiita and Stombaugh 1996; Cupisti, et al. 2002). This is leaving large gaps in the current literature about the knowledge of male athletes. The present studies that have examined the nutritional knowledge have used American football players or varsity athletes as participants. The findings of these studies can only be used as a base for comparison to New Zealanders. This is due to the diverse dietary habits as well as different levels of knowledge given to the athletes of the various countries. In addition, all countries will have distinct nutritional public health messages depending on the prevalent concerns of the nation.

In summary, nutrition questionnaires developed to date generally have limitations in one or more areas (Parmenter and Wardle 1999). Either they lack the kind of psychometric validation, or they cover only a limited area of nutrition knowledge (Parmenter and Wardle 1999). This observed weak relationship between nutrition knowledge and nutritional behaviour may appear if the relationship itself is a weak one or the measures used to estimate the relationship are weak (Sapp and Jensen 1997). In addition, the use of knowledge questionnaires based on one nutrition area have limited use outside of that topic (Parmenter and Wardle 2000). Therefore, it is generally found that researchers wanting to gather information from a population on a variety of topics will construct their own questionnaire.

2.14 Questionnaires

Questionnaires are a great way of obtaining information for individuals in a formal way. When choosing to use a questionnaire there are many methods to be considered: whether the questionnaire will involve an interview process, be self-administered, have open or closed questions, and whether the questionnaire will be handed to the participant by the researcher or if it will be posted out. Each method has its own strengths and weaknesses and the method of choice will depend on the goals of the researcher.

2.14.1 Open or closed question debate

The choice to use either open- or closed-questions depends on the information required by the researcher. There are many negatives and positives for both. Open and closed questions of the same questions have been found to typically generate quite different response distribution and it is not obvious which format produces the most valid data (Foddy 1993). Answers to open questions have been found to often be less complete than answers to corresponding closed questions (Foddy 1993).

Closed question format is beneficial as participants will either know or not know the answer and will not feel obligated to word it properly, which could cause the participant to leave the option blank. The most persistent criticism of closed questions is that pre-set response options are likely to cause respondents to give answers they would not give if they had to provide them for themselves (Auld, et al. 1991; Foddy 1993; Suskie 1996). In saying this multiple-choice items are widely used, principally because they are quickly and easily answered and the responses are generally easy to tally (Suskie 1996). They are also particularly good for collecting factual-information (Suskie 1996). Conversely, the major difficulty in writing multiple-choice questions is making sure all possible answers are included (Suskie 1996). A second limitation of multiple-choice questions is that the data they yield is usually categorical or ordered, or respondents can check more than one answer, which can seriously limit the data analysis options (Suskie 1996).

Open-ended questions make a good choice when there are multiple responses (more than six or seven) and the possibility of options being left out is high (Suskie 1996). With open-ended questions the participant may leave questions blank, which leaves the researcher guessing whether the respondent missed the question or did not know the answer (Suskie 1996). Because of these disadvantages, Suskie (1996) states that open-ended questions should be used sparingly in any questionnaire. If the questionnaire is largely comprised on open-ended questions a telephone survey or focus group should be considered instead (Suskie 1996).

Open questionnaires are time consuming to administer and their answers hard to analyse with problems occurring during coding (Clark and Schober 1992; Suskie 1996; Jenkins 1999). However, those in support of open-ended questions state that a satisfactory coding scheme can be devised, due to the emergence of consistent categories (Foddy 1993). However, in the absence of clear guidelines on the sort of answers required, respondents could interpret the answer incorrectly and supply a variety of topics that are neither comparable or codable (Foddy 1993). For knowledge questionnaires, the ability to be able to code the answers easily will make it a lot easier to determine the score of knowledge more infinitely.

2.14.2 Interviewer or self-administered

Less accurate answers may be obtained from interviewer questionnaires as respondents may hurriedly answer the questions as they believe the interviewer is anticipating their response. Additionally, pressure is placed on interviewers to continuously ask themselves whether or not the answers received are of the sort required; can they understand the response given; and/or have the respondents specified the information wanted (Foddy 1993). If interviewers are trained properly and are aware of the researchers goals this pressure may lessen (Foddy 1993). Interviewing people face to face or by telephone enables the interviewer to clarify questions and answers if necessary (Jenkins 1999). On the other hand, conducting interviews is time consuming and there is the possibility that the interviewer may introduce bias by the way they ask questions or probe for answers (Jenkins 1999).

There are many differences between an interview survey and a self-administered survey or questionnaire. One main factor is that the cost of a self-administered questionnaire is low (Czaja and Blair 1996). However, if the respondent does not understand the questions, or considers questionnaires too time consuming they may leave the parts incomplete or make errors (Czaja and Blair 1996). A considerable problem with self-administered questionnaires is they may not be returned. In spite of this, there are ways to get a higher response rate. This can be to administer the questionnaire and ask the respondents to answer the questionnaire while the researcher waits. This has its disadvantages as participants may rush though the questionnaire without reading the questions properly as they feel that the researcher is waiting. In studies where there are other test being administered at a similar time, and the subjects are waiting around, this can be an ideal time to administer the questionnaires. However, a further problem with self-administered questionnaires is that participants are expected to show some degree of literacy. If this is not the case not all questions will be answered and might mean the participant gets help from others (Czaja and Blair 1996).

Many of the previous studies investigating nutrition knowledge of athletes have tended to use multiple-choice questions in their assessment of the knowledge of their participants (McDonnel, et al. 1998; Parmenter and Wardle 1999; Packman and Kirk 2000; Pirouznia 2001; Smith-Rockwell, et al. 2001; Cupisti, et al. 2002). Barr's, (1987) questionnaire contained 87 true/false questions and this method was also used by Smith-Rockwell et al (2001). Auld et al (1991), state that traditional true/false or multiple–choice formats tend to overestimate knowledge as respondents are prompted with a list of acceptable answers. Multiple-choice or true/false questions do not probe memory, fail to identify common misconception and do not indicate the individuals thought process (Auld, et al. 1991).

The choice of questions used in a questionnaire will be determined by the types of information required and whether the questionnaire is self-administered or has an interviewer. The choice in how the questionnaire is administered may have an affect on the cost and response rate of questions. However, the main determinant of all these factors will be what information is needed.

Summary

In summary, this literature review has aimed to highlight the demands of playing rugby union, the energy pathways used and the methods use to assess dietary intakes and nutritional knowledge. Rugby union is a sport that uses a combination of energy systems, CrP pathway, anaerobic glycolytic and aerobic glycolytic system. The use of the different energy systems would determine the players energy output which needs to be matched by the energy input to maintain current weight. To determine if this energy balance is being meet body composition testing is a very useful and inexpensive tool. If energy intake is reduced players tend to lose weight and the lack of dietary intake may lead to early fatigue during a rugby match. Consequently, CHO ingestion before, during and after training and match play can help reduce the affects of fatigue. Another cause of fatigue can be from dehydration, however, studies have observed improvements in performance from the consumption of fluids during exercise (Murray 1987; Below, et al. 1995).

The dietary habits of players can be affected by many factors, of which knowledge, attitudes and beliefs to nutrition may be a large influence. It has been shown that American football players have many misconceptions regarding protein intake, micronutrients and fluid requirements (Jonnalagadda, et al. 2001). These misconceptions may have arisen due to the source of nutritional knowledge players were receiving. The majority of nutritional information gained by athletes' stems from magazines, coaches, trainers, parents, and peers (Barr 1987; Jacobson, et al. 2001; Cupisti, et al. 2002). However, there is limited research on the nutritional knowledge and dietary practices of New Zealand rugby players. The effect of nutritional knowledge attitudes and beliefs and dietary practices of New Zealand rugby players needs further investigation.

3.0 Methodology

3.1 Participants

All participants were players from rugby teams playing in the 2004 Auckland premier grade competition. The players were invited to participate in the study by contacting team managers, coaches or trainers of the aforementioned teams, who informed players in their teams of the study. Players who agreed to participate gave their informed consent (Appendix 1 and 2) before the start of testing. All the requirements of this study were completed at the start of the 2004 season. The criteria of inclusion in the study were that they were male and members of the previously mentioned club teams.

3.2 Ethical issues concerning participants

Ethical approval for this study was sought and given by Massey University Ethics committee. The study was conducted in accordance with the Ethical standards. Confidentially was protected by giving each participant a coded number. This was how the participants were identified on all data collected from them. No harm was envisioned to come to the participants and any possible discomfort was minimized by the experience of the testers. All participants read the participant information sheet and signed a consent form before any data being collected. Players were informed that participation was optional and that they could decline to participate or withdraw from the study at any time.

3.3 Questionnaire development and content

The attitudes and beliefs questionnaire (AB-Q) was intended to supply information on Auckland rugby players' beliefs and attitudes towards nutrition and performance (Appendix 3). The questionnaire was also designed to assess the players' knowledge of nutrition and areas where they required further education. This process began by determining what the main topics of nutrition for athletes are. The questionnaire was then constructed with assistance from the supervisor and a questionnaire expert and then piloted and appropriate amendments made.

The research aimed to emphasise and investigate:

- Attitudes and knowledge to the use of supplements
- Perceptions to alcohol and performance
- Beliefs of how high carbohydrate intake might influence performance
- Beliefs of how protein intake might influence performance
- Knowledge and perceptions to intake of fat
- Beliefs concerning fluid requirements and hydration practices

Questions from the AB-Q were developed either by the researcher or taken and adapted from pre-existing questionnaire (Chapman, et al. 1997; Parmenter and Wardle 1999; Jonnalagadda, et al. 2001). A self-administered questionnaire was chosen due to low cost and enabling multiple questionnaires to be answered at once, which reduces the length of time a participants need to wait around. For the same reason only 30 questions were chosen for the AB-Q as questionnaires that are too time consuming or difficult may lead to incomplete or error-strewn questionnaires (Czaja and Blair 1996). As testing was completed either before or after training sessions, time was a critical factor to facilitate a greater number of respondents as the participants either wanted to go home or needed to start training.

Closed-questions are quick and easy to answer therefore reducing the time taken to answer the questionnaire (Suskie 1996). They are also particularly good for collecting factual-information (Suskie 1996). Therefore, 28 of the 30 questions in the AB-Q were closed questions. Two of the 30 questions were open-ended, as they required the participants to list either supplements they take or future nutrition topics on which they required knowledge. If closed questions were used, there would be too many answers to list and there would be a good chance that not all possible answers would be included in the answer selection, therefore missing vital information. The nutritional topics that were chosen were supplements, alcohol, carbohydrates, protein, fats, fluids and nutritional knowledge. These topics had various knowledge, beliefs or attitude questions in them to determine the understanding and thought processes of Auckland rugby players concerning nutrition.

The physical activity questionnaire (PA-Q) was developed to gather a crude estimate of the amount of physical activity the participants were involved in each week (Appendix 4). The PA-Q consisted of 18 multiple-choice questions. Multiple-choice questions were chosen for ease of answering to limit time.

Questionnaires were piloted with the intention to check that the wording was understood by the layperson and, any changes suggested by the pilot participants were made if it was thought that it would improve the understanding of the question or information gathered from the rugby players. A cross section of laypeople with limited nutritional knowledge and individuals with a reasonable amount of nutritional knowledge was used. The following changes were made based on the feedback from the pilot studies:

- Question (7). The pilot studies highlighted that not all options were included for those that drank alcohol infrequently. The option of "other" was added to enable those to answer whose drinking habits did not fall into the other available categories.
- Question (13). Individuals in the pilot study suggested that time a frame was needed to determine what food would be the best choice before training.
- Question (14). It was revealed that this question also needed a time a frame was required to determine what food would be the best choice after a game.

3.4 Dietary assessment methods

Participants were asked to complete a 4-day food diary on two-week days and two weekend days and to include one training day, one game day, one recovery day and another day during the week (Appendix 5). The number of days was chosen to obtain a comprehensive view of the players' diet and not just a snap shot. This was to obtain a detailed description of the food and beverages consumed, including the cooking methods, preparation, brand name of food and time of day of food consumption. Instructions were given written and verbally to participants on how to measure and record all food and beverages consumed. Participants were given measuring cups (Décor, The Décor Corporation Pty Ltd, Victoria Australia) to help estimate the amount of food consumed, and an example sheet was given to the participants to show them how to complete the food record diaries. Participants were also asked to include any additional supplements taken; whether they were vitamins, minerals, or sporting ergogenic aids (e.g. protein or creatine powder) in the food record diaries as well.

3.5 Dietary analysis

Each diet record was analysed using dietary analysis computer software, (Foodworks professional edition, version 3, Xyris software, Australia, Pty Ltd). Dietary analysis included total daily energy intake, macronutrient, cholesterol, fiber, water, alcohol and micronutrients. The nutrient intakes were collected from the participants' dietary sources as well as any supplements (meal replacements, sports bars, vitamin and mineral tablets, or sport ergogenic aids), which were all included in the analysis. Where required, food items or supplements were entered into the computer software if they were not already listed.

3.6 Body composition assessment

Players were tested at the start of the 2004 season. Each player underwent a restricted profile, body composition test. Measurements were taken in agreement to that of the International Society for the Advancement of Kinanthropometry (ISAK) (Norton, et al. 2002). Measurements taken included eight skin-fold sites to measure thickness of fat and skin, five girth measurements, two bone breadths, and height and mass. The tester responsible for measuring all skin-folds had completed an ISAK Level 3 course. Calibrated Slimguide callipers (Creative Health Products, Plymouth, Michigan) were used to measure all skin-folds, a Lufkin small steel tape (Executive thinline, W606PM) was used for girths and bone callipers (Vertex sliding Vernier calliper) were used to measure the biepicondyles of the humerus and femur. Weight was measured with a calibrated scale (Seca alpha, Atrax, model 770), and stretch stature was measured with a Stadiometer (Seca 206-CM Bodymeter Measuring Tape).

3.7 Experimental procedures

Participants were instructed to continue with normal training and dietary habits for the time before and during data collection week. Participants reported to the first experimental session after their evening training practice for three of the premier rugby teams, and before the evening training session for the other team. The experimental sessions were completed at the club training ground for ease of burden to the participants. Upon arrival at the first session participants' body composition measurements were taken. The players were then instructed to complete the 18-question PA-Q and the 30-question AB-Q. The protocol for completing the dietary intake diaries was explained to them and any questions they may have regarding the protocol were answered.

The second testing session was completed one week after the first. Once again the participants reported to the session after their evening training, or before in the case of the one premier rugby team. In this session, the participants handed back their 4-day food diaries and were given back the results to their body composition tests. If food record diaries were not returned, participants were reminded by coaches or trainers' twice a week and the researcher would revisit the club the once a week for the following six weeks to collect any outstanding food record diaries.

3.8 Statistical analysis

Data are presented as means $\pm$ standard deviations. Somatotype calculations to quantify body shape as a three-figure number determining the fatness, muscularity and linearity were made according to the Heath-Carter anthropometric method (Carter, 1996). Excel 2001 (Microsoft Corporation, 2000) was used to calculate means, standard deviations and percentges.

4.0 Results

4.1 Participants

Sixty New Zealand rugby union players volunteered for the study. However, not all players completed every aspect of the study. The players had a mean (±SD) age of 22.8 (±2.5) years, the mean age of the forwards was 22.9 (±2.7) years, and the backs mean was 22.8 (±2.3) years. The mean (±SD) number of years the participants have been playing rugby was 11.8 (±5.3) years. The mean number of years playing rugby for the backs and forwards are 10 (±5) years and 14 (±4.6) years, respectively.

4.2 Anthropometric profile

Anthropometric data was collected for 48 participants. The players' mean ±SD height and weight was 181.0 ±6.5 cm and 98.2 ±14.2 kg, respectively. The mean ±SD of all the players sum of eight skin-folds was 123.30 ±42.6 mm. Anthropometric values of the players broken into their different positional groups are summarised in Table 4.1.

Table 4.1 Mean and standard deviation values for mass, height, sum of eight skin-folds and somatotype profiles for Auckland club rugby union players

	All players	Forwards	Backs
n	48	27	21
Mass (kg)	98.2 ±14.2	107.3 ±11.6	86.5 ±6.6
Height (cm)	181.0 ±6.5	184.0 ±6.5	177.3 ±4.2
Sum of 8 skin-folds (mm)	123.3 ±42.6	146.0 ±38.9	94.1 ±26.6
Endomorphy	4.2 ±1.5	4.9 ±1.5	3.3 ±1.0
Mesomorphy	7.7 ±1.3	8.2 ±1.4	7.2 ±0.9
Ectomorphy	0.6 ±0.6	0.5 ±0.7	0.8 ±0.5

4.3 Dietary intake

Nine of the 60 participants completed and returned their food diaries. The mean daily nutrient intake of the players is summarised in Table 4.2. Mean daily intake was 17.3 MJ. Mean CHO intake was 491 g, supplying 46% of daily energy intake. The mean daily intake of protein, fat, and alcohol were 165 g, 160 g, and 14 g respectively, supplying 16%, 35% and 3% of total energy intake.

Table 4.2 Mean daily intake of nutrients of rugby union players (n = 9)

Nutrient		Mean	SD
Energy	MJ	17.3	4.3
Macronutrients			
Carbohydrate	g	491	146
Protein	g	165	61
Fat	g	160	54
- saturated fat	g	71	24
- polyunsaturated fat	g	17	7
- monounsaturated fat	g	55	20
Alcohol	g	14	22
Micronutrients	RDI*	Mean	SD
Calcium (mg)	800	1421	1012
Iron (mg)	7	25	14
Zinc (mg)	12	22	6
Vitamin B1 (Thiamin) (mg)	1.1	5	7
Vitamin B2 (Riboflavin) (mg)	1.7	6	7
Niacin equivalents (mg)	18-20	73	17
Vitamin A –total equivalents (mg)	750	1316	840
Vitamin C (µg)	40	207	146

* (Truswell, 1990)

Figure 4.1 presents the percentage of daily energy supplied from protein, fat, carbohydrate and alcohol. When expressed as grams/kilogram of body weight, the rugby players consumed 5 $g \cdot kg^{-1} \cdot day^{-1}$ in CHO and 1.7 $g \cdot kg^{-1} \cdot day^{-1}$ in protein.

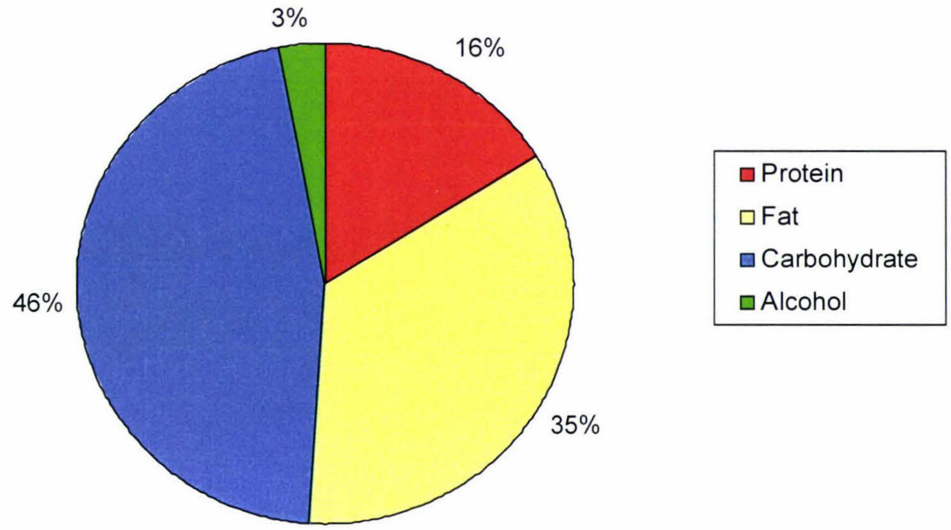

Figure 4.1 Percentage of daily energy from protein, fat, carbohydrate and alcohol (n=9)

4.4 Physical activity questionnaire

Out of the 60 players that completed the study, only 53 participants answered the PA-Q, and not all questions were answered by all participants[1]. From the responses of the PA-Q, a breakdown of the physical characteristics of New Zealand rugby players is presented Table 4.3. The majority (56%) of players trained 1-2 times a week as a team on rugby skills and game tactics.

[1] The number of participants answering each question for the PA-Q differs. Therefore, the percentage of players' responses has been calculated and rounded to the nearest whole number for the number of respondents for each question. Those who did not answer the question have been taken out of the analysis.

Table 4.3 Breakdown of the PA-Q responses of Auckland rugby union players

		Percentage of players			
	n	Twice a day	1-2 x a week	3-4 x a week	5 or more x a week
How many times a week do you train as a team on rugby skills?	52	8	56	27	10
		Once a day	1-2 x a week	3-4 x a week	5 or more x a week
How many times a week would you, weight train?	51	6	67	27	0
How many "cardio" training sessions do you participate in weekly?	51	6	69	24	2
		1-2 sets	3-4 sets	5-6 sets	7 or more sets
How many sets do you complete when weight training?	49	2	76	16	6
		4-8 reps	9-12 reps	13-15 reps	16 or more reps
On average, how many repetitions do you do for each set?	50	36	58	6	0

Weight training was completed by 67% of the players 1-2 times a week. The majority of players (69%) completed "cardio" training 1-2 times a week. The length of time players spent in physical activity is shown in Figure 4.2. Most (76%) of the players completed 3-4 sets, and 16% of the participants completed 5-6 sets during each weight training session.

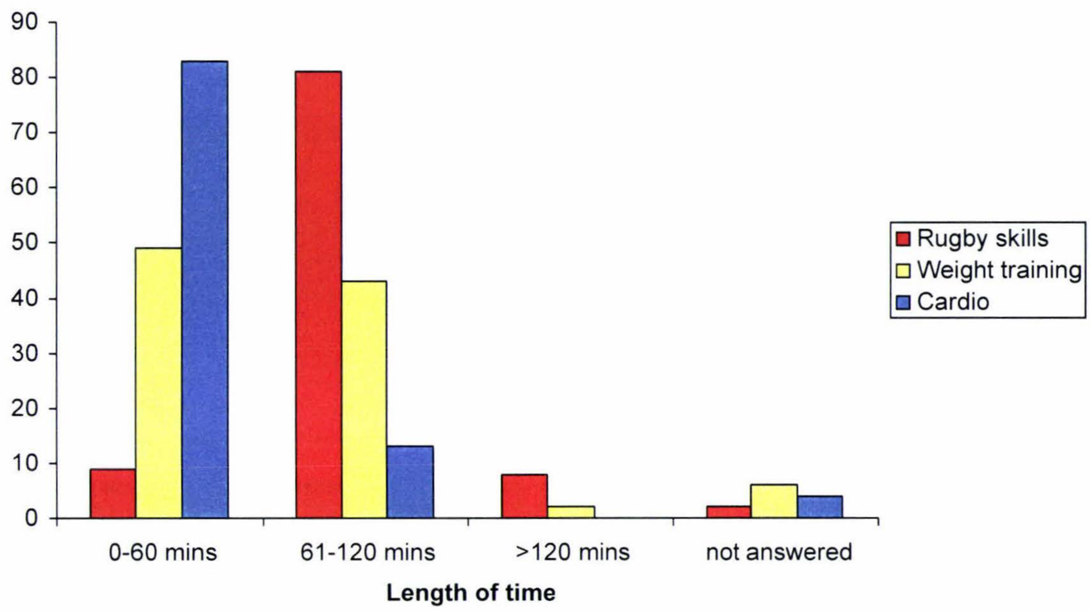

Figure 4.2 Length of time players spent in each activity (n=53)

Fifty-five percent of the players who weight trained completed 9-12 repetitions in each set that they completed. The intensity of the weight training and "cardio" training sessions is presented in Figure 4.3. All players only played one game per week.

Forty-three percent of the players had a job that was not physical in nature. Twenty-four percent had a job that was occasionally physical. The remaining 34% had a job that was physical most of the time (16%), or all of the time (18%). The majority (80%) of the participants did not cycle or walk to work. Fourteen percent occasionally walked or cycled to work and the final 6% walked or cycled most of the time (4%) or walked or cycled all of the time (2%) to work.

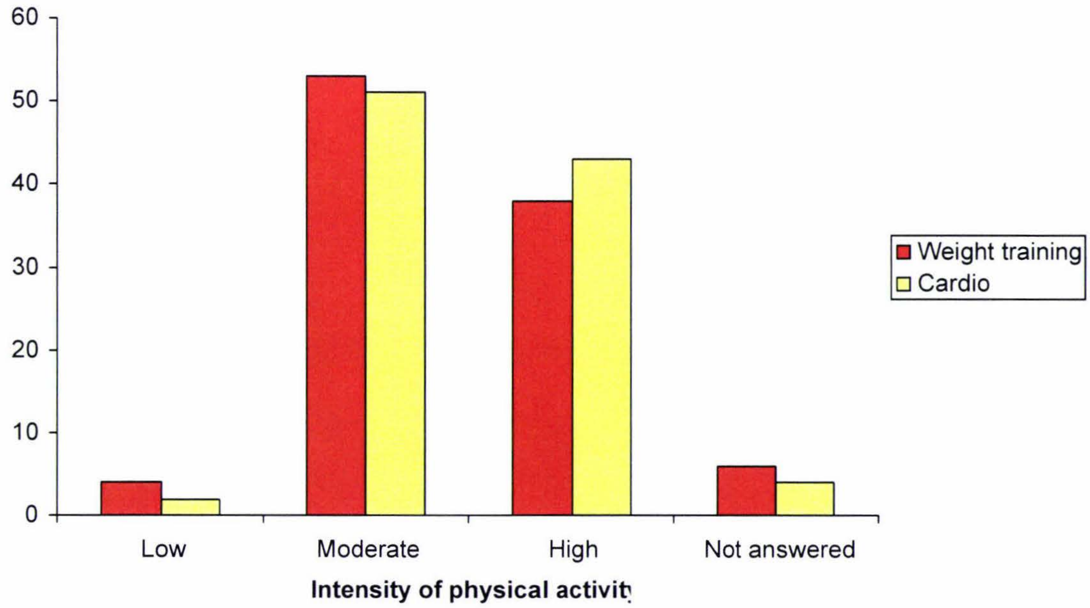

Figure 4.3 Intensity of exercise during weight training and cardio sessions (n=53)

4.5 Nutrition attitudes, beliefs and knowledge

Out of the 60 players who participated in this study, only 51 answered the AB-Q and not all of them answered every question. For reasons of limited numbers, those with half-completed questionnaires are entered into the analysis of results.

4.5.1 Supplement intake

Out of the participants who answered the AB-Q, only 18 (35%) of the 51 took supplements. Table 4.4 shows the supplements used by this group. The main supplement used by this group was protein, which was used by 12 of the players.

Table 4.4 Supplements used by rugby union players

Supplement	Number of rugby players using supplement (n=18)
Protein	12
Vitamins	2
Creatine	3
Hydroxycut	1
Pro MA	1
HMB	1
Krealkyline	1
BCAA	1
Antioxidant	1
Minerals	1

Figure 4.4 shows the responses to the question. "Which supplements do you think would aid your performance?" It was found that 71% of the players said they would not take supplements if experts said they were harmful. However, 6% said they would and 20% were not sure if they would take supplements believed to be harmful.

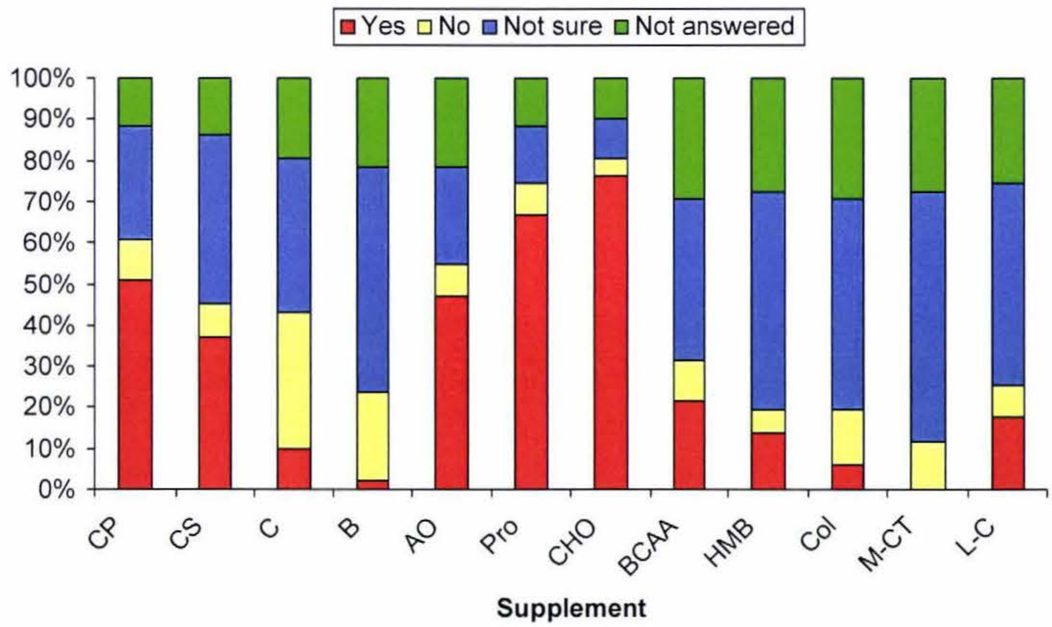

Figure 4.4 Responses to which supplements players believe will aid their rugby performance (n=51)

Key to abbreviations for Figure 4.4

Abbreviation	Supplement
CP	Creatine powder
CS	Creatine serum
C	Caffeine
B	Bicarbonate
AO	Antioxidants
Pro	Protein
CHO	Carbohydrate
BCAA	Branched chain amino acids
HMB	Hydroxy-methylbuterate
Col	Colostrum
M-CT	Medium-chain triglycerides
L-C	L-carnitine

4.5.2 Nutrition knowledge

The mean score of correct nutrition knowledge questions was 42% (±20). The mean scores for incorrect and 'not sure' answers were 21% (±10) and 21% (±17), respectively. The mean score for not answered questions was 11%[2] (±16). Table 4.5 presents the attitudes, beliefs and knowledge of these players with regard to various nutrition questions.

Table 4.5 Attitudes, beliefs and knowledge of rugby union players with regard to nutrition related topics

	Percentage of players		
	Agree	Disagree	Not sure
Do you believe protein supplements (bars and shakes) are needed in addition to diet, for muscle growth and development? (n=49)	57	22	20
Do you feel that carbohydrate supplements (sports drinks or carbohydrate gels) during a game will improve performance? (n=47)	55	6	38
Do you believe a high intake of CHO is important to enhance your performance? (n=46)	61	13	26
Do you believe that protein is the major source of energy for your muscles? (n=48)	50	21	29
Do you feel that eating large amounts of red meat will increase your muscle size? (n=48)	42	23	35
Do you believe that meals high in fat will enhance your performance when consumed 2 to 3 hours before training or competition? (n=47)	4	66	30

[2] The number of participants answering each question differs. Therefore, the percentage of players' responses has been calculated and rounded to the nearest whole number for the number of respondents for each question. Those who did not answer the question have been taken out of the analysis

The majority (>50%) of players believed that they need protein supplements in addition to what they consume in their normal diet for muscle growth, and protein was a major source of energy for the muscles. They also believed CHO supplements during a game as well as a high intake of CHO would enhance their performance. However, 66% reported that a high fat meal 2-4 hours before a game would enhance performance.

Figure 4.5 shows what foods players believed were high or low in CHO. Pasta, baked beans and bread were correctly reported to be high in CHO by 76%, 67% and 73% of the participants, respectively. However, only 37% of players believed that honey is high in carbohydrates and 27% thought that honey was low in CHO. Eight percent of the players believed that both cheese and red meat were high in CHO.

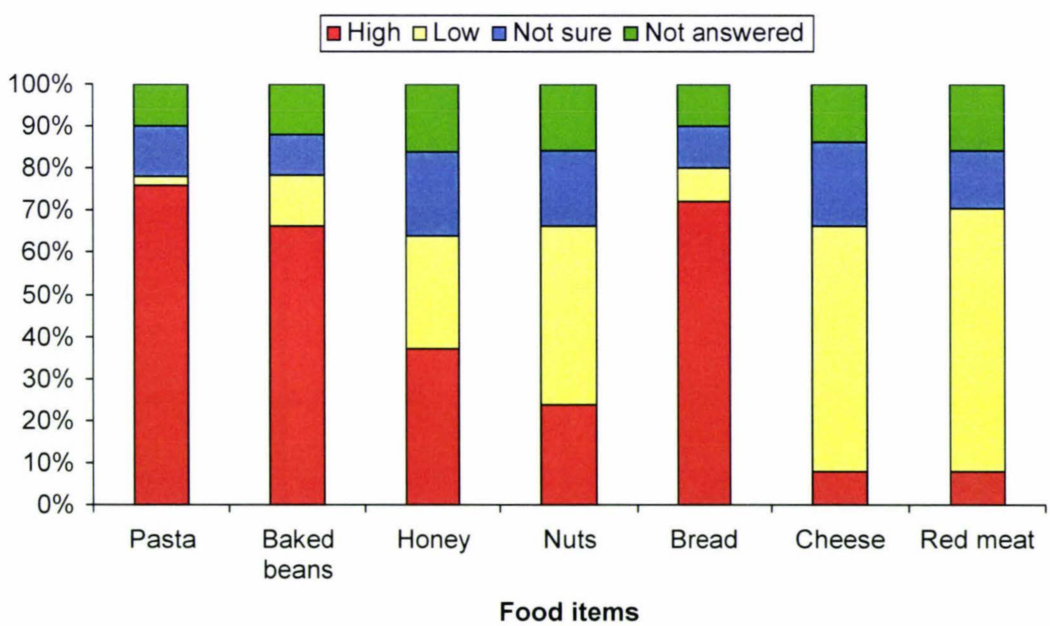

Figure 4.5 Carbohydrate content of foods (n=51)

Out of the 43 participants who answered the question regarding the type of fat experts suggest cutting down, 64% correctly answered saturated fat was the fat to cut down. However, 4 and 9% of players answered monounsaturated and polyunsaturated fats, respectively. The remaining 23% were not sure which type of fat experts suggested to cut down on.

Figure 4.6 illustrates that the players were unsure what food item contains the most amount of monounsaturated fat. The majority (38%) of players believed that butter is the food item which contains the largest amount of monounsaturated fats whereas only 21% of players responded correctly stating olive oil to have the most monounsaturated fat. In addition, only 38% correctly answered thick cut chips contained the least amount of fat compared to thin and crinkle cut.

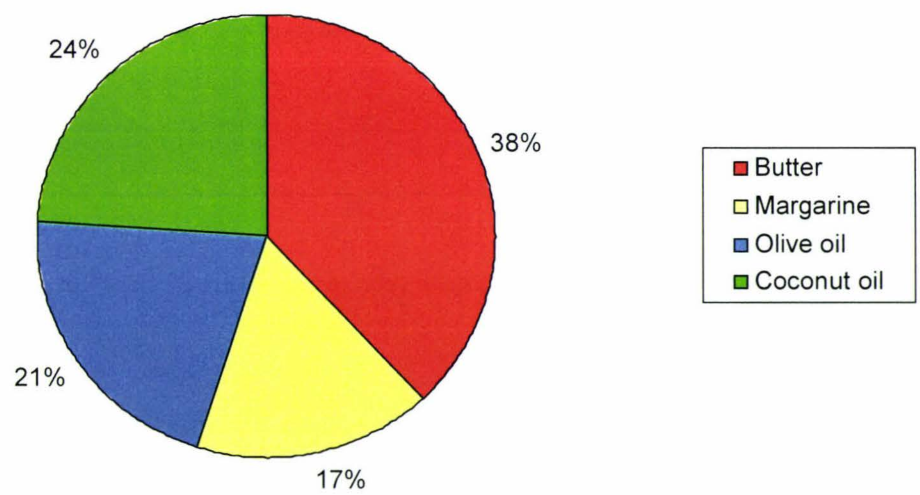

Figure 4.6 Players responses regarding which food items are highest in monounsaturated fat (n=42)

4.5.3 Alcohol intake

Figure 4.7 shows how many times a week players drink alcohol. Out of the 51 participants 15 stated they never drank alcohol. Therefore, out of the other 36 players, 36% stated that if they were drinking alcohol they would consume more than seven drinks a night.

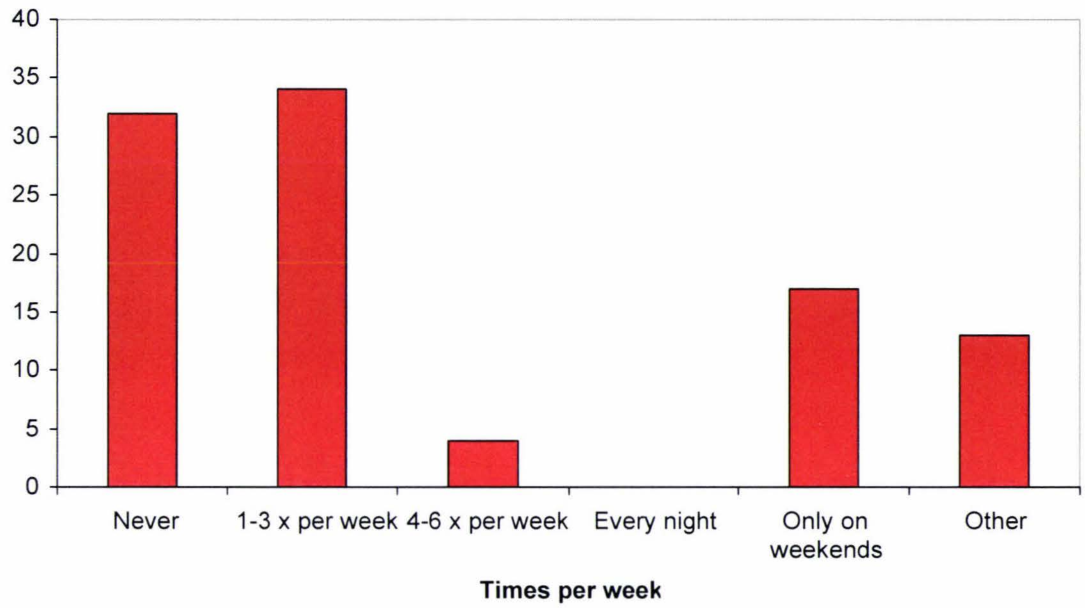

Figure 4.7 Number of times per week players consume alcohol (n=47)

The amount of alcohol that players believed would affect performance is presented in Figure 4.8. Most (>50%) of the players reported that 1-2 drinks every night or a night binge drinking once a week would affect their performance. The majority (71%) of the players thought that alcohol will not affect their recovery, 15% agreed that alcohol would affect performance and 15% were not sure.

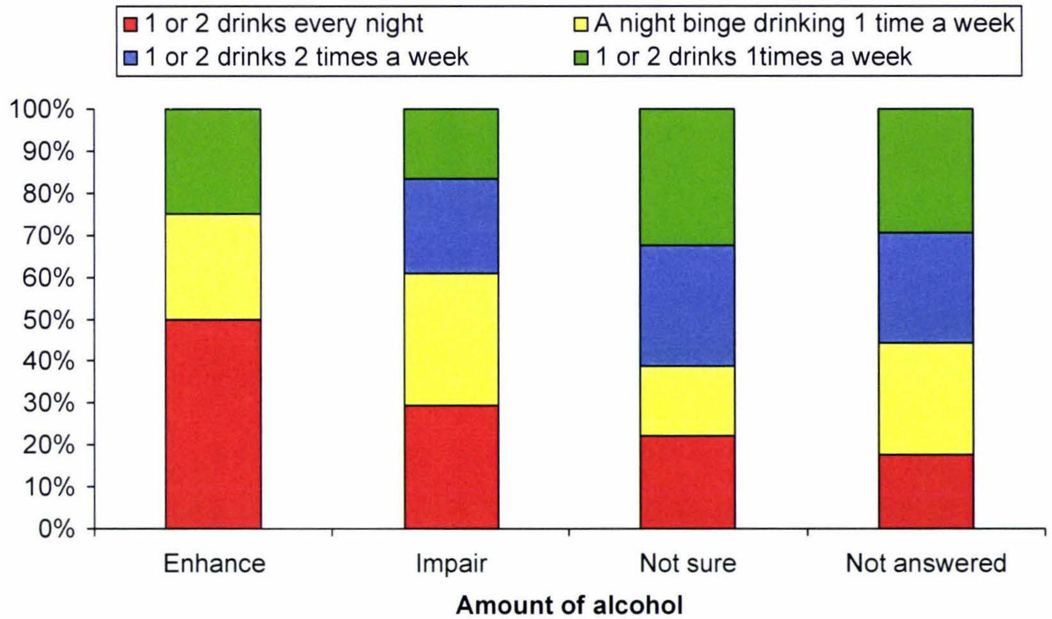

Figure 4.8 Percentage of players who believe different amounts of alcohol affects rugby performance (n=51)

4.5.4 Knowledge of fluid intake

Table 4.7 presents the attitudes and beliefs of the players with respect to fluid intake and training and competition. Not all questions were answered by the same number of players. The majority (>79%) of the participants believed that players should replace their fluids before, during and after training/competition, and performance was impaired when dehydrated. However, 52% of participants agreed that thirst was a good indicator of when fluids should be consumed, while 35% disagreed with this statement. Only 31% thought that sports drinks would restore fluid losses better than water.

Table 4.7 Attitudes and beliefs of rugby union players with respect to fluid intake and training and competition

	Percentage of players			
	n	Agree	Disagree	Not sure
Do you believe players should replace fluids before, during and after training/competition?	48	88	2	10
Do you believe that thirst is a good indicator to determine when fluids should be consumed during and after training/competition?	48	52	35	13
Do you feel sports drinks (e.g. Replace) restore fluid losses better than water?	48	31	29	40
Do you feel that performance is impaired when you are dehydrated?	45	80	11	12

4.6 Role of nutrition knowledge

The majority (86%) of rugby union players thought that nutrition plays a role in their performance and 51% have received nutrition advice in the past. Sources of nutrition information that participants have received are presented in Table 4.8. Only 30 of the 51 players who answered the AB-Q responded to the question regarding sources of information. The main source of nutrition knowledge for this group of players was professional advice (47%). Just under half (47%) of the participants felt that they had sufficient nutrition knowledge for their needs; 14% thought their nutrition knowledge was insufficient for their needs and 16% were unsure if their knowledge was adequate. Nutritional knowledge topics in which players expressed interest in learning additional information, are shown in Table 4.9. Only 29 of the 51 participants conveyed which topics of nutritional knowledge they would like more information regarding.

Table 4.8 sources of nutrition information used by rugby union players in this study (n=30)

Sources of nutrition information †	Percentage of rugby union players that have used the source of information
Professional dietary advice	47
Friends and/or family	14
Magazines and/or books	20
School classes	6
University classes	20
Health food shop	10

†Many subjects selected more than one source of information used

The majority (97%) of the 29 participants who expressed an interest in further nutrition knowledge stated they would like to learn more with regard to nutrition to enhance performance. The other most popular topics were healthy eating, including serving sizes and low fat options, and weight gain/muscle gain.

Table 4.9 Nutritional topics that rugby union players are interested in learning more information (n=29)

Topic	Number of players interested in topics †
Nutrition to enhance performance	28
Weight gain/muscle gain	7
Weight loss/fat loss	3
Fluids	1
Supplements	3
Cooking demonstrations and meal alternatives	4
Macronutrients	3
Healthy eating (serving sizes and low fat options)	10

† Some players conveyed interest in more than one topic

5.0 Discussion

The main purpose of this study was to establish the nutritional knowledge, attitudes and beliefs of Auckland rugby union players. A further aim was to investigate the dietary intakes of these players and to examine how knowledge and attitudes might affect nutritional intake.

The results in this study showed that the participants had a large number of misconceptions regarding nutrition and performance. For instance, the belief of over half the players was that protein was the major source of fuel for the muscles, and that ingesting large quantities of protein will increase muscle size. In addition, while most players believed that CHO was important for performance, a large number were not sure or disagreed. These findings may help explain why the mean intake of CHO as a percentage of energy intake was below the recommended requirements for team sport participants. However, only nine of the participants returned their completed food diaries and this intake may not be represent the intake of the players as a whole.

5.1 Anthropometric profiles

Few recent studies have estimated the body composition of rugby union players. Data from this research show that the mean height and weight of the rugby players was 181 cm and 98 kg, respectively. These findings are similar to data obtained from other researchers who have observed that forwards tend to be heavier and taller than backs (Quarrie, et al. 1996; Dacres-Mannings 1998). It needs to be noted, that the methods used to measure the height of players in this present study and in a study by Dacres-Manning (1998) was stretch stature, which helps to decrease diurnal variations in height. It is not clear which method was used by Quarrie et al (1996). In addition, in the present study the sum of eight skin-folds was greater by approximately 52 mm in the forwards than the backs a similar result has been observed in other studies (Dacres-Manning 1998). However, a sum of nine skin-folds was taken in the Dacres-Manning research instead of a sum of eight skin-folds, which was done, in the present study. Therefore, comparisons by value to the current athletes cannot be made.

Somatotype is a measure of the fatness, muscularity, and linearity of individuals. Forwards tended to be more endomorphic and mesomorphic and less ectomorphic than backs in this current study. The mean somatotype for the players as a whole was 4.2–7.7–0.6. The mean somatotype for the forwards and backs were 4.9–8.2–0.5 and 3.3–7.2–0.8, respectively. The backs in the present study were more endomorphic and less ectomorphic than those in Dacres-Mannings study (Dacres-Mannings 1998). The forwards and backs from senior A teams in the study by Quarrie et al (1995) were found to be less endomorphic and mesomorphic than for the current players and had a higher ectomorphy score.

The reasons for the differences in somatotype scores between studies may be due to the level of the teams tested. Players in the current study were from Auckland's premier club grade, whereas Dacres-Mannings (1998) players were from New South Wales Super 12 teams. A similar grade of players has been used by Quarrie et al (1995) compared to the current study, however, the players were from Dunedin teams, which may have a different level of skill in the senior A teams than in Auckland. Age may be another factor determining differences in the body composition of players between teams. The mean age of the forwards and backs is similar between the study by Quarrie et al and the current study. The age of the players in Dacres-Manning (1998) study was not stated.

5.2 Dietary intakes

The lack of data on the dietary intakes of New Zealand rugby union players as well as other players in the sport around the world, prompted assessment of dietary habits. Unfortunately, only nine of the participants were involved in the analysis of dietary intakes, as the rest of the participants failed to return their completed food diaries. Energy intakes of the players varied considerably, ranging from 12.7 to 26.9 MJ • day^{-1} or equivalent to 0.13 to 0.28 MJ • day • kg^{-1} of body weight. The mean energy intake of the rugby players in this study was 17.3 MJ • day^{-1} or 0.18 MJ • day • kg^{-1} of body weight. In comparison the average New Zealand males mean daily energy intake has been reported to be 11.6 MJ • day^{-1} (Russell, et al. 1999). Studies on Australian Rules football players have shown lower mean daily energy intakes (13.2 to 14.2 MJ • day^{-1} or 0.15 to 0.17 MJ • day • kg^{-1} of body weight), than those seen in the present study (Burke, et al. 1991; Schokman, et al. 1999).

The percentage of energy contributed by CHO in the daily intake of players by the macronutrients was 46% from CHO, 16% from protein, 35% supplied from fat, and alcohol supplied 3% of daily energy intake. Burke and Read (1988) have reported similar intakes from a group of Australian Rules players, whose daily energy intake was 46%, 15%, 37% and 4% from CHO, protein, fat and alcohol, respectively. The intakes observed in the present study are also similar to those for the New Zealand male population which was observed to have a daily intake of 47% CHO, 15% protein, and 35% fat (Russell, et al. 1999).

With calculations from the food database (see section 3.5, p51), the mean energy intakes of the players were estimated to range from 59-131% of the RDI for daily energy requirements, with a mean energy intake of 72%. These requirements are crude estimate calculated from height, weight and activity levels of the nine players. This shows that the average player was in a negative energy balance, which could result in a reduction of fat mass and lean body mass. Consequently, although the players had a greater need for CHO than the average New Zealand male it can be seen that rugby players are consuming a similar percentage of daily intake. When CHO and protein intake was expressed relative to body mass, the rugby players consumed 5 $g \cdot kg^{-1} \cdot day^{-1}$ of CHO and 1.7 $g \cdot kg^{-1} \cdot day^{-1}$ of protein.

Carbohydrate has been established as an important factor in delaying fatigue due to muscle glycogen depletion (Coyle, et al. 1983; Davis, et al. 1999). Researchers have shown that soccer players should consume diets containing 65% of energy intake from CHO as they have observed a significantly greater (~33%) amount of high intensity exercise (Balsom, et al. 1999). As there are no known nutrient requirements for rugby union players at present, the application of the above requirements for soccer players can be relevant regarding the similarities between the two sports.

The players in the present study ingested 5 $g \cdot kg^{-1} \cdot day^{-1}$ of CHO. Burke et al reviewed the literature of CHO ingestion in recovery and training and stated that studies on trained individuals over 24 hours post exercise observed that with an increase in CHO intake there is an increase in glycogen storage (Burke, et al. 2004). A threshold was reached in glycogen storage at a CHO intake of 7-10 $g \cdot kg^{-1} \cdot day^{-1}$ (Burke, et al. 2004). Therefore, it could be assumed that the players in the current study were starting each exercise session with low glycogen stores, which has been shown to be detrimental to performance. For instance, Bangsbo et al (1992) observed that participants starting a game with low glycogen stores because of a low CHO (39%) intake displayed a reduced performance during intermittent exercise, as muscle glycogen was almost depleted at the end of the soccer match. The findings in this study illustrate that the current quantity of CHO consumed by the players in the present study is insufficient to maintain optimal glycogen stores. Therefore, the players need to consume at least an extra 2 $g \cdot kg^{-1} \cdot day^{-1}$ of CHO to attain levels where the glycogen storage threshold is reached (Burke, et al. 2004).

Protein requirements for soccer players have been suggested to be around 1.4-1.7 g • kg^{-1} • day^{-1} (175-212% of the recommended dietary allowance), on evidence based on a review of the requirements for strength and endurance athletes (Lemon 1994). The players in the current study meet this requirement with a mean intake of 1.7 g • kg^{-1} • day^{-1}. The increase in protein requirements of rugby union players from that of the recommendations of the sedentary individual will be a consequence of increased amino acid oxidation (Tarnopolsky, et al. 1988; Phillips, et al. 1993). This occurs in exercise when there is inadequate glycogen to supply energy and additional substrates such as protein and fatty acids are required (Robergs and Roberts 1997).

The high intake of fat of the rugby players (35% of energy intake) is similar to that of players from other football codes (Burke and Read 1988). Breaking down the total fat percentage into the three different types of fat, it was observed that the proportions were 16% saturated fat, 4% polyunsaturated fat and monounsaturated fat supplied 12% of the total fat intake. This is similar to the general New Zealand population who received 15%, 5% and 12% from saturated, polyunsaturated and monounsaturated fats, respectively. The percentage of saturated fat compared to the RDI for the general population is higher with the RDI stating saturated fat should contribute 8% to 12% of energy intake. The players intake of polyunsaturated and monounsaturated fats were lower than the RDI which emphasises that 6% to 10% and up to 20% of fat intake should be supplied from these fats respectively. Burke and Read (1988) have suggested that the high fat intake associated with their players might be in part due to the high intake of foods containing animal protein. In addition, cooking methods regularly included the addition of fat especially when take-away meals were ingested. In the current study, these dietary patterns were also observed. Players consumed large amounts of meat. Also, take-away meals contributed a large percentage of food intake in a couple of players. Due to the small sample size this intake might have influenced the overall mean intakes of the players as a group.

Vitamin and mineral intake of the players in the present study was above the RDI for the five vitamins (thiamin, riboflavin, niacin, vitamin A, and vitamin C) and the three minerals (calcium, iron, and zinc) analysed. Two of the players ingested a multivitamin daily, which may have helped to increase the mean intakes of the players. Nevertheless, the levels are extremely high compared to the RDI for all of the vitamins and minerals, which may not be explained by the use of multivitamins in two participants. Similarly, other studies have found vitamin and mineral intakes above RDI for Australian Rules football (Burke and Read 1988) and soccer players (Hickson 1987). Vitamin and mineral intakes of participants from the present study were above that for the sedentary New Zealand male, whose intakes were described as satisfactory (Russell, et al. 1999).

The mean alcohol intake of the players was 14g $\pm$22 or 3% of mean daily energy intake. However, since only nine players returned their completed food diary, caution needs to be taken when reading this section, as this observed intake may not be typical of all Auckland rugby players. The mean intake of the players was lower than that for the average New Zealand male population, which has been reported as $20g \cdot day^{-1}$ (Russell, et al. 1999). Alcohol was consumed by only four participants during the study period, and from questions answered in the AB-Q, it was determined that all these players usually consumed alcohol. Three of the players who did not consume alcohol during the study period stated they usually consumed alcohol 1-3 times a week and the fourth stated he only consumed alcohol on the weekend. It is not evident why these players did not record any alcohol during the four-day dietary record period. Players may have omitted alcohol from their diary in the fear of coaches finding out or they may have abstained specifically from alcohol for the four-day period. Additionally the days that dietary intake was recorded for may not be days on which players usually consume alcohol. However, the use of a four-day diary, recording food intake from a game day, training day, recovery day and an additional week day tried to control for the difference in food or fluid intake during various days of the week.

5.3 Physical activity questionnaire

The majority (55%) of players trained one to two times per week as a team on rugby skills and game tactics due to twice-weekly team trainings, which commonly lasted between 60 to 120 minutes. In addition to specific rugby training, the majority (>65%) of players completed one to two cardiovascular and weight training sessions per week and one game a week. From data presented in Figure 4.2 and 4.3, respectively, it was observed that players trained at a relatively high intensity for a long duration. This shows that the players generally had a very high-energy expenditure and may have trained six days a week and the importance of recovery after each exercise bout needs to be stressed.

From the data collected in the present study, weekly energy expenditure cannot be determined and further research needs to be completed on this aspect of rugby union players. Rough estimates of energy requirements were calculated from the dietary analysis programme and the results showed that the nine players mean energy intake did not match their energy expenditure. However, future research is needed to accurately determine energy balance of rugby players. The activities that were undertaken by the participants were rugby training, cardiovascular and weight training. These activities should determine the types of food required by the players. From the review of literature of CHO requirement (section 2.6, p14) it can be determined that CHO is an important energy source to help improve performance during continuous and intermittent exercise for 90 minutes (Sugiura and Kobayashi 1998). Carbohydrate has also been established to be important in maintaining energy during soccer match play (Balsom, et al. 1999). Due to the similarities between football codes it can be theorised that CHO will also improve performance in a rugby union match.

5.4 Nutrition attitudes, beliefs and knowledge

The mean knowledge score of correct answers was 42%. This shows that rugby union players have limited nutritional knowledge and the lack of this knowledge may in turn affect their nutritional intake. The knowledge score was determined by calculating the number of correct answers compared to incorrect answers for the 20 knowledge questions. The correct answers were determined by the researcher. Correct answers for supplements was decided by the amount of scientific support for that supplement, while other questions regarding protein, CHO, fat, and fluid intake was determined by consulting nutrition books (Burke 1993; Howe, et al. 2000) to determine the correct responses. The following sections provide a discussion on the results obtained from knowledge questions in the AB-Q.

5.4.1 Supplement intake

The usage of supplements by participants shows that they are not widespread in this group of rugby players. Thirty-five percent of participants stated that they currently used supplements. The most common supplement was protein, which was used by 12 of the 18 players who consumed supplements. A higher percentage (42%) of American football players reported consumption of supplements, demonstrating that supplements were popular with this population (Jonnalagadda, et al. 2001). The most common supplements participants consumed from the Jonnalagadda et al (2001) study were creatine (36%) followed by vitamins (23%) and protein (13%), with limited numbers of players consuming other supplements. In a study on Norwegian athletes, the researchers found that 51% of male athletes tended to consume supplements compared to 32% of male control (Sundgot-Borglund, et al. 2003). The supplements that were used most compared to controls were amino acids (12%) and creatine (12%) (Sundgot-Borglund, et al. 2003). The two main reasons given by male athletes as to why they supplemented their diet was to improve performance (27%) and because they believed they needed it in addition to their daily intake (56%) (Sundgot-Borglund, et al. 2003). Players in the present study obviously felt they did not need to supplement their diet and this may be due to not believing in supplementation, believing their current diet is adequate, or not being able to afford supplements. Further research is required to determine the true reasons for this low intake of supplements among these athletes.

Vitamin supplementation was reported by two of the participants and mineral supplementation by one player in the present study. Comparatively, Burke and Read (1998) observed that vitamins and minerals were used regularly by 14% of 56 elite Australian Rules players. Although the reasons for use of vitamin and mineral supplements was not investigated in the present study, past research has shown 7% of Australian Rules players consumed vitamin and minerals with the aim of enhancing performance (Burke and Read 1988). Other reasons given by the Australian Rules players were to compensate for inadequate nutrition and a poor lifestyle, or in response to respiratory infections and excess alcohol consumption (Burke and Read 1988). The most usual supplement consumed by the participants in Burke and Read's study was a multi-vitamin and mineral preparation or a B-complex vitamin mixture, no other supplement use was reported by this group of athletes (Burke and Read 1988). Players in the Burke and Read (1988) study have shown a greater intake of nutritional supplements than participants in the current study. Further investigation is required into the reasons why Auckland rugby union players supplement their diet as there is currently no information on this topic.

A promising finding in the current study was that 71% of the players stated that they would not consume supplements if experts had understood them to be harmful. Unfortunately that suggests that 29% would still use harmful supplements to gain an improvement in performance. It was observed that there is still a lot of uncertainty whether or not supplements will produce an enhancing effect to performance. Figure 4.4 shows the responses to whether players thought supplements would enhance their performance. The supplements most regularly thought to enhance performance were CHO, protein and creatine powder. For other supplements many of the responses were not sure, or not answered. The reason for this uncertainty may be due to the limited knowledge players have regarding the scientific research which has been published in support or opposing the use of many of these supplements. Additionally, information provided by coaches whether true or false might influence the players' thoughts on supplements, and therefore their consumption. Future research may be useful to provide information on the coaches' beliefs to nutrition and supplements as well.

5.4.2 Nutrition knowledge

With respect to the nutrition knowledge responses given by the participants, it seems there are a few misconceptions or uncertainties concerning macronutrients, especially protein. It was established that 57% of the participants believed that protein bars were needed in addition to diet for muscle growth and development. Similarly, 50% thought protein was the major fuel for their muscles and 42% believed eating large amounts of protein would increase their muscle size. Comparably Jonnalagadda et al. (2001) found that more than 50% of the American football players studied in their research also believed protein was the main source of energy to the muscles, and protein supplements were needed in addition to diet for muscle growth. Similar results found by other researchers show athletes' misconceptions of the use of protein in the body (Wiita and Stombaugh 1996; Jacobson, et al. 2001). However, Jacobson et al. (2001), found that compared to 1992 there was a decrease in athletes misconception regarding protein in 1998. This observation shows that there has been a positive step towards nutrition education for athletes in the United States, however, applying these results to New Zealand athletes needs to be done with caution. Even though the majority of the players believed that protein was the major source of fuel for their muscles' it seems they may be unaware of what foods other than meat contain protein. Merely 29% of the players correctly answered that milk had the highest content of protein per 100g compared to white rice or spinach. The reader is referred to section 4.5.2 p 63 for a further breakdown of the foods players thought contained the greatest quantity of protein.

Positively, it was seen that 66% of the players believed consuming a high-fat diet two to three hours before training or competition would not enhance their performance. Using a similar line of questioning it was observed in a past study that only 32% of football players correctly answered the question (Jonnalagadda, et al. 2001). In addition, 64% of players answered that saturated fat was the fat to cut down in their diet. However, when asked what food contained the greatest amount of monounsaturated fat, the majority of players answered this incorrectly. The largest percent (38%) of players believed that butter contained the greatest content of monounsaturated fat and only 21% correctly guessed olive oil. This shows that although many of the players were aware of the need to reduce intake of saturated fats they are not knowledgeable in where these fats are found. The reason that so many of the players may have been aware that saturated fat needed to be reduced may be from advertisements of products such as ones which contain the Heart Foundation "tick of approval". The "tick of approval" demonstrates to an individual products that are low in saturated fats and sodium without having to read the label; this may have lead to players being more conscious of the health effects of saturated fat. Similarly, many of the players seemed unaware of ways to reduce fats by food choices. Only 38% correctly answered that thick cut chips should be consumed if a person was wishing to limit their fat intake. Although the players may recognize the need to decrease fat intake they might need help in putting this knowledge into practice.

Misconception over fuels used in rugby union is noticeable when examining the responses to CHO intake and rugby performance. Only 61% of the players believed that CHO was important to their performance. This may explain the low CHO intake of players as a large number of the participants were unaware of CHO and its role in providing energy for exercise and delaying fatigue (Bangsbo, et al. 1992; Balsom, et al. 1994; Pitsiladis and Maughan 1994; Below, et al. 1995; Sugiura and Kobayashi 1998; Balsom, et al. 1999; Davis, et al. 1999; Davis, et al. 2000). Studies examining the consequence of a high CHO diet and the effects of fatigue have shown that participants were better able to maintain a high-power output after consumption of a high-CHO diet and were able to complete an average of an extra 183 sprints before fatiguing (Balsom, et al. 1994). In addition, sprint time to fatigue during shuttle running has been observed to improve by 32% after consumption of CHO (Davis, et al. 2000). Therefore, it may be of benefit for players if they were provided with seminars on the fuel utilisation during rugby and nutritional requirements to enable the players to make better food choices to help improve their performance.

A promising finding was that a large percentage of the players who completed the AB-Q questionnaire correctly answered that pasta, baked beans, and bread were high in CHO and that cheese and red meat were low in CHO. However, only 37% of the players believed honey was high in CHO. Obviously, players were unaware that honey was a high source of CHO, which indicates that players are uninformed that honey was a good source of fuel to enhance recovery. This last statement is reinforced by the finding that only 24% of the rugby players in the current study thought that high-CHO foods should be consumed straight after training. Thirty-three percent of the players responded that foods containing CHO and protein were the best option following a game. However, many players are not consuming high quantities of CHO post-game (Schokman, et al. 1999) and high sugar foods may be ways of increasing this CHO intake.

The intake of high-CHO foods as soon as possible after exercise is important to enhance glycogen storage (Ivy, et al. 1988). Ivy et al observed that glycogen storage was threefold faster when CHO was consumed immediately following exercise than when it was consumed two hours after exercise (Ivy, et al. 1988). The consumption of CHO also decreases the catabolism of protein through gluconeogenesis, which results when glycogen levels are low (Robergs and Roberts 1997; Di Pasquale 2000; McArdle, et al. 2001). Additionally, the consumption of $1.2 \text{ g} \cdot \text{kg}^{-1} \cdot \text{day}^{-1}$ of protein post-exercise has been established to provide enough protein that all but one endurance trained athlete was in a positive nitrogen balance (Meredith, et al. 1989). Similarly, in strength trained individuals an intake of 1.41 $g \cdot kg^{-1} \cdot day^{-1}$ of protein has resulted in whole body protein synthesis (Tarnopolsky, et al. 1992). Therefore, this shows that the consumption of both CHO and protein post-exercise will be beneficial to rugby players. Although rugby is not predominately a strength or endurance sport, both of these components are crucial elements of rugby union (Nicholas 1997). However, care needs to be taken by the player that they do not underestimate the need for CHO during recovery and overestimate the need for protein, as many players have stated they believe protein is the major source of energy for the muscles. Therefore, promoting high-CHO foods with a moderate intake of protein after exercise would be beneficial to players to ensure enhanced glycogen storage and protein synthesis.

The majority of the players in the present study were correct in their responses concerning foods that were best consumed before training. Most of the players (>70%) believed that pasta and sandwiches were good choices before training, while meat pie, and foods from fast food establishments such as "McDonalds", and "KFC" were not. Seventy-one percent correctly answered that lemonade was not a good food item to consume before training. The carbonation of most soft drinks has been known to cause gastrointestinal problems in athletes, like nausea, bloating and vomiting (Howe, et al. 2002).

When answering the AB-Q, many participants selected "not sure" as their chosen response or left the option blank. "Not sure" demonstrates areas where information may be needed for a large number of players. When players leave the questions blank however, it makes it difficult assess whether the participants missed the question or did not know the answer.

5.4.3 *Alcohol intake*

Twenty-nine of the players stated that they never consume alcohol. The most common drinking patterns other than abstention, of the players was "one to three times a week" followed by "only on weekends". Even though the days on which players generally consumed alcohol was not assessed it could be assumed that they may have consumed alcohol following training or a game. Burke and Read (1988) observed that patterns of alcohol consumption demonstrated the effects of peer influence and team bonding. The authors established that heavy alcohol consumption on Saturdays after a match and at the end of the season were believed to be an important part of post-game relaxation and team bonding (Burke and Read 1988). This observation has been seen in other studies where men drank alcohol more excessively when socialising with sporting teams than with any other group (Black, et al. 1999). Although the alcohol consumption was not excessive in the present study, this increase in alcohol intake in relation to team bonding may cause players to delay recovery in inhibiting the players' dietary intake that is already inadequate.

The majority of players believed that alcohol would not affect their recovery rate. Alcohol may cause its detrimental affects on recovery by stopping the athlete to properly restore fluid lost during exercise, and hinder the players' capacity to consume adequate high-CHO foods. Alcohol is thought to be a poor fluid replacement following exercise due to its diuretic affect (O'Brien 1993; Gutgesell and Canterbury 1999; Howe, et al. 2000). The reason for fluid consumption following exercise is to replace fluid loss through sweating (Burke 1993; O'Brien 1993; American College of Sports Medicine 1996; Burke and Hawley 1997). Even though there is limited research on the physiological affects of alcohol during recovery, the consumption of alcohol may replace the ingestion of appropriate fluids and CHO, which could have a detrimental affect on the recovery period. However, further research into the responses to fluid and CHO replacement and consumption of alcohol post game and training, needs to be undertaken for rugby union players.

5.4.4 Fluid knowledge

Although the players in the present study recognised the need to replace fluids before, during, and after training/competition and that performance was impaired when dehydrated, over half (52%) of the participants believed that thirst was a good indicator for when fluids should be consumed. Jonnalagadda et al (2001) observed that only 13% of the football players examined in their study thought that thirst could be relied on to ensure adequate fluid replacement. However, the researchers found that although the football players were aware of the correct hydration practices, they were not employing these practices (Jonnalagadda, et al. 2001). Overall, it is observed that these players might benefit from education on the proper hydration techniques. This is extremely important considering the large sweat losses, which occur during a rugby match and training, and the affects dehydration may have on their next exercise bout (see chapter 2; p 32).

Merely 31% of the players from the current study agreed that sports drinks would restore fluids better than water, and 40% of the players were unsure whether sports drinks or water would restore fluids better. This illustrates that there is a lack of knowledge regarding fluid practices being disseminated to rugby union players. Jonnalagadda et al (2001) found that 71% of American football players disagreed with the statement that sports drinks would replace fluids better than water. The reasons for sports drinks enhancing fluid restoration are not necessarily due to an increased absorption rate. Depending on the CHO concentration and whether the fluid is being consumed during or after exercise different sports drinks will be more beneficial at various times. However, the flavouring and sodium in sports drinks have both been observed to influence a greater consumption of fluid than water due to the increase in palatability (Szlyk, et al. 1989; Coyle 2004). This lack of knowledge regarding whether water alone or sports drinks are more beneficial may be a result of provision of one or the other by team management during games and training. If this was the case, it might be advantageous to provide knowledge regarding fluid practices to coaching staff as well as players. In saying this, teams may not be able to provide sports drinks to players due to the added cost compared to water.

5.5 Role of nutrition knowledge

The majority (86%) of players thought that nutrition played a role in their performance. However, only 49% of the participants stated that they had received formal nutritional advice in the past. The main source of nutrition knowledge for the 28 players who have received nutrition information in the past was professional advice (89%). Unfortunately, the other 23 players involved in this study had received no nutritional advice. In other studies assessing the information sources athletes have utilised it has been observed that the most used sources of nutritional information for male athletes were strength and conditioning coaches, closely followed by the athletic trainer and then individual sport coaches and magazines (Jacobson, et al. 2001). These authors found that female athletes were more likely to receive nutrition information than their male counterparts (Jacobson, et al. 2001). This finding is important when examining the lack of research on the nutritional knowledge of male athletes. Therefore, it is promising to see that in the current study 49% of the players as a whole have received nutritional information in the past from a professional.

From table 4.10 it can be seen that the nutritional information that players in the present study would like to learn more regarding, are nutrition to enhance performance, followed by healthy eating, which included serving sizes and low fat options, and weight and muscle gain. These are similar topics to which athletes in Jonnalagadda et al's. (2001) study expressed interest in. The top two main topics were found to be nutrition for peak performance and weight gain (Jonnalagadda, et al. 2001). With the insight or areas in which players in the present study would like more nutritional information it would be beneficial to New Zealand rugby to provide players with information in these areas. This information could be provided to players in the form of pamphlets or seminars for players and coaches.

5.6 Limitations of this study

The accuracy of the estimated dietary intake may be limited due to the small number of completed food diaries. A longer time of data collection may enable more food diaries to be completed. However, due to the lateness of data collection from waiting for the season to start this was not applicable for this study. The sample collected was calculated as being representative to the whole study population. However, the lack of numbers brings into question the accuracy of the estimated intake. In addition, since only 4-days was used to assess dietary intake the estimated intake may only be valid for energy, as it has been established that protein, CHO, and fat required 4, 5, and 6 days, respectively in a group of 13 males to estimate true average intake (Basiotis, et al. 1987). However, as the number of days food records are kept for increases, there is a decrease in the completed records and a reduction in the number of food record diaries returned (Gersovitz, et al. 1978). Additionally, misreporting of dietary intake intentionally or unintentionally might affect the validity of estimated dietary intake.

Accuracy of dietary analysis may also be affected by limitations of the food database. Substitutions were made when a food item could not be matched or recipes for foods were made available. Input errors might cause errors as well. Accuracy of nutritional knowledge questionnaire results could also be affected by input error.

Due to the number of participants information was gathered from in this study, the results can only provide a snap shot into the Auckland rugby teams dietary practices, nutritional knowledge, attitudes, and beliefs. The results will not be able to be transferable to other New Zealand club teams or other countries. Care must also be taken in applying these results to female rugby union players or players of a different age group. The attitudes, beliefs and knowledge may be different in these various populations, therefore, further research is needed in these groups.

Accuracy of the results may be questioned when transferred to a wider population of rugby players as the study population was not chosen at random. The players were asked by coaches and trainers of rugby union clubs in which the researcher had connections. Players who answered the questionnaires and completed food record diaries may have been the players from each team who had an interest in improving their nutritional knowledge. Therefore, the exclusion of players who did not participate in the study has added non-response bias to the results.

Validity of the questionnaire is dubious as no psychometric evaluation was undertaken on the questionnaire before administered to the participants, which would increase the validity and reliability of the answers collected. In addition, because of the limited number of participants, even though not all questions were answered by all participants, these half answered questionnaires were still used.

5.7 Recommendations

In summary, based on the requirements of macronutrients intake established from the literature review and from the findings from this study a number of recommendations for future research on New Zealand rugby union players can be made.

Future research needs to include accurate measurements of rugby union players energy expenditure and energy intake. Accurate measurements could be achieved through using a food diary method and validating the results using a biological marker to assess dietary intake. Energy expenditure also needs to be properly measured by using the doubly-labelled water or other such techniques such as heart rate monitoring or electronic motion sensors, however, there will be limitations to using some of these techniques during a rugby match.

The current study has only included Auckland rugby union players, therefore, future research needs to study the knowledge, attitudes and beliefs of nutrition and the dietary practices of the remainder of the New Zealand unions to determine if the findings in this present study is similar over the rest of New Zealand. Additionally, in order to establish the nutrition knowledge of different rugby grades, future studies need to include players with varying skill levels of rugby throughout New Zealand as only premier club rugby teams were used for the current study.

Future research on coaches and training staff might show an insight into whether those involved with rugby union have correct knowledge on nutrition and how it affects performance and if they are providing information to players.

The current study was conducted to investigate the participants knowledge of fluid practices, however, it did not ascertain whether the players fluid intake was determined by their knowledge. Future research should investigate the relationship between fluid knowledge and consumption, and determine the fluid practices of rugby union players. Additionally, the patterns of alcohol consumption post-game and training should be determined and the influence that this has on the ingestion of high-CHO containing foods and other beverages like water or sports drinks.

Future work is required to assess whether rugby union players are aware of the glycaemic index of food, and whether high, moderate or low glycaemic index should be consumed before, during, and after exercise.

Future research should also be conducted to investigate the reasons why New Zealand rugby players use supplements. At the same time, it would be helpful to discover if coaches believe in supplements and whether they advise players to consume supplements.

6.0 Conclusions

This study has shown that rugby union players have a few misconceptions regarding the nutrition and performance. The major misunderstandings are mainly concerning major fuel sources that provide energy during exercise. The majority of players believed that protein was the predominant source of fuel used by the muscles and that they needed to consume protein supplements in addition to diet for muscle growth and development. Similarly, a moderate percentage of players thought that CHO did not enhance performance.

Unfortunately, only nine of the players returned their completed food diary. Compared to the general New Zealand population, players had a higher total energy intake, however, it was observed that the players CHO ingestion as a percentage of energy intake was inadequate compared to the recommendations for team sport athletes. It was also established that the players' intake of fat as a percentage of energy was too high compared to the recommendations, however, the players' protein intake was adequate. The percentage of energy intake of the macronutrient was similar to that of the average New Zealand population.

The average player had a high-energy expenditure and may have been training six days a week. Crude estimates of energy intake of the nine participants, determined by the players' height, weight and activity level established that players were consuming inadequate energy to match their energy expenditure.

Future nutritional knowledge topics players wished to gain information regarding were, nutrition to enhance performance, healthy eating including serving sizes and low fat options, and weight and muscle gain. These topics are similar to those of interest to players of other football codes.

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Appendix 1

Participant information sheet

Participant Information Sheet

Study title: Nutrient intake, dietary attitudes and beliefs of professional New Zealand rugby players

Invitation to Participate in Research Study

My name is Susan Buxton and I am currently studying towards a Masters of Science (Nutritional Science) at the Institute of Food Nutrition and Human Health at Massey University. Previously I completed a Bachelor of Science majoring in Sports and Exercise. This year I am completing a research study to investigate the nutritional knowledge, attitudes and beliefs of rugby players from Auckland premier teams. Furthermore, I aim to investigate whether the knowledge they have obtained has influenced their dietary habits.

I have picked this topic, as there is a lack of information regarding the actual nutritional habits of rugby players and their beliefs of nutrition in optimising rugby performance. Questions remain about the efficacy of the nutritional information players receive, their eating habits, and their viewpoint towards nutritional guidelines and supplement use.

Participant Recruitment

All participants will be recruited on the criteria that they are members of teams from University, Suburbs or Waitemata premier club rugby teams. I aim to recruit approximately 60 participants, as this will maintain a high statistical power. There will be no foreseeable risks to you as the participant for taking part in this study. Any possible discomfort you might feel during the body composition testing will be minimised by the experience of investigators.

Procedures

You will be asked to attend the following sessions:

Preliminary session, where you will:

- Be informed of what this study entails and what the requirements of your time will be.
- Complete a preliminary questionnaire (which will take approximately 10 minutes) relating to your physical activity levels and some personal details.
- Have your body composition measurements taken (approximately 20 minutes).
- Be asked to record your food and fluid intake for a 3-day period. This is to be completed by the following session. To ensure the proper completion of the food record diaries the investigator will explain how to accurately fill out the diaries and will answer any questions you may have.
- Complete a questionnaire regarding your attitudes and beliefs towards nutrition and performance (approximately 30 minutes).

Second session, where you will:

- Return the completed food diary from the previous week.

Measurements taken

Your body composition will be assessed using ISAK level 1 body composition procedure. This involves skin fold measurements taken at eight sites of the body, as well as five girth measurements and two bone breadths. These measurements will be used to provide more descriptive data of the participants in this study. However, if you are not happy with this aspect of the study you have the right to abstain from the body composition measurements while still being involved as a participant.

Participant's Rights

If you agree to take part in this study you may:

- Decline to answer any particular question.
- Withdraw from this study at any time even if you have previously signed a consent form. Can you please inform the primary researcher if you wish to abstain from any part of the testing procedures or withdraw from the study?
- Ask the investigators any questions you have relating to the study at any time during your participation.
- Provide information on the understanding that your name will be not used at any time by the researcher in any publications, and your data will be expressed as a mean of the group.
- Access a summary of the project findings on completion of this study.

Confidentiality

The data collected will be used as part of a Masters thesis and for research papers resulting from this study. The data collected may be presented in various forms (journal articles, papers etc). All data will be dealt with confidentially and, as it will be present in aggregate form, it will not be possible to identify any individuals who participate in this study. Upon completion of the data analysis you will be given a personal feedback sheet and can ask further question regarding your results.

At no times will your dietary habits be discussed or shown to the coach or management staff of your team. A coded number will identify you on the questionnaires and diet record sheets. Only the researcher will have access to the codes and identity of the participant. The results will be given back to you personally and it is up to you whether or not you choose to share the results with anyone else.

Further Information

Any questions about this study are welcome. Please do not hesitate in contacting Susan Buxton on email susanbuxton@hotmail.com with any queries or if you would like further information about this study. My Research supervisor Dr Ajmol Ali can be contacted by phone on (09) 414 0800 ext 9638 or email A.Ali@massey.ac.nz.

Committee Approval Statement

This project has been reviewed and approved by the Massey University Human Ethics Committee, ALB Protocol MUAHEC 03/062. If you have any concerns about the conduct of this research, please contact Professor Brian Murphy, Chair, Massey University Campus Human Ethics Committee: Albany, telephone 09 414 0800 x 9539, email B.Murphy@massey.ac.nz.

Appendix 2

Participant consent form

Statement of Informed Consent

This consent form will be held for a period of five (5) years

I have read the information sheet, and have had the details of the study explained to me. My questions have been answered to my satisfaction and I understand that I may ask further questions at any time.

I understand I have the right to withdraw from the study at any time and to decline to answer any particular questions.

I agree to provide information to the researcher on the understanding that my name will not be used without my permission. *(The information will be used only for this research and publications arising from this research project).*

Name: ________________________________ Phone number: _____________

Age: ________________________________ Date of Birth:_______________

Address: ____

Signed: ________________________________

Date: ________________________________

Appendix 3

Questionnaire of attitudes and beliefs of nutrition and performance of New Zealand rugby players

Massey University

NEW ZEALAND RUGBY UNION

QUESTIONNAIRE OF ATTITUDES AND BELIEFS OF NUTRITION AND PERFORMANCE OF NEW ZEALAND RUGBY PLAYERS

Code Number of Participant:

Date of Interview:

Day Month Year

1) Do you take dietary supplements?

Yes	☐
No ➔ go to question 3	☐
Not sure	☐

2) Name the supplements you take:

____
____
____
____
____
____
____
____

3). Which of the following supplement ingredients do you believe would aid your sport performance:

	Yes	No	Not sure
Creatine powder	☐	☐	☐
Creatine serum	☐	☐	☐
Caffeine	☐	☐	☐
Bicarbonate	☐	☐	☐
Antioxidants (vitamin C & E)	☐	☐	☐
Protein (bars & shakes)	☐	☐	☐

Question 3 continued···

	Yes	No	Not sure
Carbohydrate (sports drinks or carbohydrate gels)	☐	☐	☐
Branched chain amino acids	☐	☐	☐
Hydroxy-methylbutyrate (HMB)	☐	☐	☐
Colostrum	☐	☐	☐
Medium–chain triglycerides	☐	☐	☐
L- carnitine	☐	☐	☐

4). If experts say that some supplements have harmful effects would you still take these supplements if you believed they would enhance your sport performance?

Yes	☐
No	☐
Not sure	☐

5). Do you believe protein supplements (bars and shakes) are needed in addition to diet, for muscle growth and development?

Agree	☐
Disagree	☐
Not sure	☐

6). Do you feel that carbohydrate supplements (sports drinks or carbohydrate gels) during a game will improve your performance?

Agree	☐
Disagree	☐
Not sure	☐

7). On average how many times a week would you drink alcohol: *(tick one)*

Never ➔ (go to question 9)	☐
1-3 times per week	☐
4-6 times per week	☐
Every night	☐
Only on weekends	☐

Other (please specify)____________________

8). On average if drinking alcohol how many drinks would you consume a night: *(tick one)*

1-3 drinks a night	☐
4-7 drinks a night	☐
More than 7 drinks' a night	☐

9). Do you believe the following quantities of alcohol enhance or impair performance:

	Enhance	**Impair**	**Not sure**
1 or 2 drinks every night	☐	☐	☐
A night binge drinking once a week	☐	☐	☐
1 or 2 drinks twice a week	☐	☐	☐
1 or 2 drinks once a week	☐	☐	☐

10). Drinking alcohol will **<u>not</u>** affect my rate of recovery from injury:

Agree	☐
Disagree	☐
Not sure	☐

11). Which of these foods do you believe have a high or low amount of carbohydrate:

	High	**Low**	**Not sure**
Pasta	☐	☐	☐
Baked beans	☐	☐	☐
Honey	☐	☐	☐
Nuts	☐	☐	☐
Bread	☐	☐	☐
Cheese	☐	☐	☐
Red Meat	☐	☐	☐
Fruit	☐	☐	☐

12). Do you believe a high intake of carbohydrate is important to enhance your sport performance?

Agree ☐
Disagree ☐
Not sure ☐

13). Of the following food items, which do you feel would be a good choice of fuel 2-4 hours **before** training:

	Yes	No	Not sure
Lemonade	☐	☐	☐
Pasta	☐	☐	☐
Red meat	☐	☐	☐
Sandwich	☐	☐	☐
Meat pie	☐	☐	☐
KFC	☐	☐	☐
McDonalds	☐	☐	☐

14). What of the following options do you feel would be the **best** option to consume straight after a game to help with recovery: *(tick one)*

High carbohydrate foods (e.g. jelly beans) ☐
High protein foods (e.g. steak) ☐
Foods containing both carbohydrates and protein (e.g. stir-fry with white rice and meat) ☐

15). Do you believe that protein is the major source of energy for your muscles?

Agree ☐
Disagree ☐
Not sure ☐

16). Which of the following foods do you feel has a greater protein content per100g:

White rice ☐
Milk ☐
Spinach ☐

17). Do you feel eating large amounts of red meat will increase your muscle size?

Agree ☐
Disagree ☐
Not sure ☐

18). Which type of fat do you think experts suggest cutting down on: *(tick one)*

Saturated fat ☐
Monounsaturated fat ☐
Polyunsaturated fat ☐
Not sure ☐

19). Do you believe that meals high in fat will enhance your performance when consumed 2 to 3 hours before training or competition?

Agree ☐
Disagree ☐
Not sure ☐

20). Which would be the best choice of chips to have if you wanted to reduce the amount of fat in your diet? *(tick one)*

Thick cut chips ☐
Thin cut chips ☐
Crinkle cut chips ☐
Not sure ☐

21). Which of the following do you believe has the largest amount of monounsaturated fats: *(tick one)*

Butter ☐
Margarine ☐
Olive oil ☐
Coconut oil ☐

22). Do you believe players should replace fluids before, during, and after training/competition?

Agree ☐
Disagree ☐
Not sure ☐

23). Do you believe that thirst is a good indicator to determine when fluids should be consumed during and after training/competition?

Agree ☐
Disagree ☐
Not sure ☐

24). Do you feel that sports drinks (e.g. Replace) restore fluid losses better than water?

Agree ☐
Disagree ☐
Not sure ☐

25). Do you feel that your performance is impaired when you are dehydrated?

Agree ☐
Disagree ☐
Not sure ☐

26). Do you believe that nutrition may have a role in your performance?

- Agree ☐
- Disagree ☐
- Not sure ☐

27). Have you ever received formal nutritional advice?

- Yes ☐
- No ☐
- Not sure ☐

28). If yes, where do you get your nutritional information?

- Professional dietary advice ☐
- Friend and/or family ☐
- Magazines and/or Books ☐
- School classes ☐
- University courses ☐
- Health food shop ☐

29). Do you feel that the nutritional knowledge you have received is sufficient in helping you with your needs?

- Agree ☐
- Disagree ☐
- Not sure ☐

30). If you were to be given additional nutrition advice what would you want information on?

____

____

____

____

____

____

____

____

Appendix 4

Physical activity questionnaire

Massey University

NEW ZEALAND RUGBY UNION

PHYSICAL ACTIVITY QUESTIONNAIRE

Code Number of Participant:

Date of Interview:

Day Month Year

1. How many times a week do you train as a team on rugby skills and game tactics?

   Twice a day ☐
   1 – 2 times a week ☐
   3 – 4 times a week ☐
   5 or more times a week ☐

2. What is the average length of time for each rugby training session?

   0 – 60 minutes ☐
   61 – 120 minutes ☐
   More than 120 minutes ☐

3. How many times a week would you weight train?

   Once a day ☐
   1 – 2 times a week ☐
   3 – 4 times a week ☐
   5 or more times a week ☐

4. What is the average length of each weight training session?

   0 – 60 minutes ☐
   61 – 120 minutes ☐
   More than 120 minutes ☐

5. What is the intensity of the majority of your weight training sessions?

   Low ☐
   Moderate ☐
   High ☐

6. How many sets do you complete?

   1 – 2 sets ☐
   3 – 4 sets ☐
   5 – 6 sets ☐
   7 or more sets ☐

7. On average how many repetitions do you do for each set?

   4 – 8 reps ☐
   9 – 12 reps ☐
   13 – 15 reps ☐
   16 or more reps ☐

8. How many cardio training sessions do you participate in weekly?

   Once a day ☐
   1 – 2 times a week ☐
   3 – 4 times a week ☐
   5 or more times a week ☐

9. What is the average length of each cardio training session?

- 0 – 60 minutes ☐
- 61 – 120 minutes ☐
- More than 120 minutes ☐

10. What is the intensity of the majority of your cardio training sessions?

- Low ☐
- Moderate ☐
- High ☐

11. How many games a week do you play?

- One ☐
- Two ☐
- Three ☐
- Four times or more ☐

12. Is your job physical in nature?

- No ☐
- Occasionally ☐
- Most of the time ☐
- All the time ☐

13. Do you walk or cycle to work?

- No ☐
- Occasionally ☐
- Most of the time ☐
- Part of the way ☐
- All the time ☐

14. Age: ______________________________

15. Rugby team: ______________________________

16. Team Level: ______________________________

17. Position Played: ______________________________

18. Number of years playing rugby: ____________

Appendix 5

Food diary

Massey University

NEW ZEALAND RUGBY UNION

Food Diary
Nutrient Intake of New Zealand Rugby Players

Nutrition Study

Code Number of Participant:

Food Diary Instructions

In order to gain the correct dietary information for entering into the computer software programme, four days of recorded food intake is required. This should include two-week days and two-weekend day. Please try to choose one training day, one non-training day through the week and the game day itself.

Please follow these instructions when recording your dietary intake:

- Include all food eaten: meals, snacks, and foods you picked at. Also, please include any fluids that you have consumed, including water.

- Use the diet sheets provided to list the details.

- Where appropriate, record the volume of each food in terms of teaspoons, tablespoons or cups. Otherwise record the number of units eaten e.g. 6 slices of toast - sliced white bread; 2 medium gala apples etc. IF YOU CAN WEIGH YOUR FOOD THEN PLEASE DO SO.

- The weight of some food items is written on the container itself (e.g. Mars Bar – 65g) and these may be used directly.

- Where possible record the recipes of home-prepared dishes and the proportion of the dish you consumed.

- Record cuts of meat, type of milk, type of bread, fruit varieties, brand names etc. and whether the food was fresh, tinned or frozen e.g. bread, Tip Top multigrain, slice of toast

- Do remember to describe the cooking method used.

- After a meal, any left over edible food must be estimated and subtracted from the amount originally recorded. Inedible matter like bones, fruit peel, cores and stones are already accounted for in the database and do not need to be subtracted.

- Include all hot and cold fluids consumed. Record brand names and whether it was fresh, concentrate or powder.

- Please do not forget to include food consumed when dining at a restaurant or away from home. Indicate this on the recording sheet by writing 'estimate' in brackets.
- Please include any supplements (sport supplements or vitamin and mineral tablets) that you are taking. Also, indicate the quantities consumed and frequency of intake.

Please record as accurately as possible and choose a week that is as close to your typical dietary habits as possible. Please start a new page for each day.

DAY AND DATE: ______________

Eating time	Meal type	Food and Beverage Name, Brand, Description	Preparation i.e. boiling, frying, microwave etc, and recipe if necessary. Whether fresh, frozen, dried, canned.	Amount or volume consumed. In weight, cups or portion size.
GENERAL COMMENTS:				