Fueling the Rugby Player: Maximizing Performance On and Off the Pitch

Deena Casiero, MD[1–5]

Abstract
Fueling the rugby athlete requires a sports nutrition plan that balances energy intake with energy output while providing the athlete with adequate fuel for recovery. The content and timing of meals are fundamental parts of a successful regimen and often require the athlete to participate in extensive planning and preparation to succeed. Carbohydrates, protein, and fat are the primary fuel of the rugby athlete's diet, and proper hydration is imperative to optimize performance. The use of dietary supplements such as energy drinks and caffeine are controversial, and the supplementation of vitamins and minerals is generally not recommended. The use of creatine monohydrate as a supplement to a well-balanced diet has been shown to be safe and effective. With the help of sports nutritionists, team physicians, educated athletes, and coaches, a multifactorial all-encompassing plan is required generally to maximize optimal performance on and off the rugby pitch.

Introduction

Rugby is an extremely physical sport that requires players to engage in both low-intensity and high-intensity activities throughout the competition. These athletes are required to demonstrate speed, agility, endurance, and brute strength to excel in this sport. To optimize performance, one must pay close attention to the nutritional needs of these athletes. Rugby players come in many shapes and sizes, and because of this, a "one size fits all" nutritional plan is not advised. Depending on the athlete's body type, position, or underlying medical or orthopedic condition, each athlete will benefit from an individualized nutritional program made to fit his or her needs. The objective of this article is to review the main nutritional goals for the rugby athlete and to highlight important features that will help maximize their performance on the pitch as well as their recovery off the pitch.

[1]ProHEALTH Care Associates, Lake Success, NY; [2]USA 7's Women's Rugby, Boulder, CO; [3]U.S. Open Tennis Championships, Flushing Meadows, NY; [4]New York Islanders, Uniondale, NY; and [5]Hofstra University, Hempstead, NY

Address for correspondence: Deena Casiero, MD, ProHEALTH Care Associates, 2800 Marcus Ave, Suite 102, Lake Success, NY 11042; E-mail: Dcasiero@gmail.com

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Along with the macronutrients (*i.e.*, carbohydrates, protein, and fat) that make up the majority of our athlete's diet, sport supplements are ubiquitous in today's society and are a constant temptation for the modern athlete. In today's world, marketing campaigns play a huge role in what our athletes perceive about sports nutrition and supplementation. The sports supplement industry grosses billions of dollars a year and is a powerful influence on what our athletes choose to enhance performance. Unfortunately many rugby teams do not have access to sports nutritionists, leaving athletes free to gather information about nutrition from wary marketing campaigns, other players, and their coaches. One study performed by Zinn *et al.* (50) looked at New Zealand premier club rugby coaches who were imparting nutrition advice to their players. This study found that the coaches were not prepared adequately to provide good quality sports nutrition information and were in fact propagating false information to their players. This emphasizes the importance of educating athletes and coaches about proper sports nutrition and being aware of other avenues from which our athletes may be obtaining erroneous information.

Carbohydrate — the Master Fuel for the Rugby Athlete

In the 1980s, David L. Costill, PhD, FACSM, and his colleagues at Ball State University demonstrated the important effects of consuming a high-carbohydrate diet on improving performance and delaying fatigue (21,30). A diet rich in carbohydrates leads to the storage of this fuel in the muscles and liver known as glycogen, which can be accessed easily by the body during bouts of exercise. The availability of carbohydrate as a substrate for the muscle can be a limiting factor in the performance of athletes during exercise sessions lasting greater than 90 min (5). Therefore sports nutrition guidelines must focus on ways to optimize carbohydrate availability.

Depending on the intensity of the athlete's training routine, rugby players may require anywhere from 5 to 10 $g{\cdot}kg^{-1}{\cdot}d^{-1}$ of carbohydrate to optimize training and performance. Athletes participating in a moderate training program that occurs

5 to 6 times per week for 2 to 3 $h \cdot d^{-1}$ should consume 5 to 8 $g \cdot kg^{-1} \cdot d^{-1}$ of carbohydrate. Participation at a higher intensity level that includes 3 to 6 $h \cdot d^{-1}$ for 5 to 6 $d \cdot wk^{-1}$ may require a carbohydrate intake of 8 to 10 $g \cdot kg^{-1} \cdot d^{-1}$ (25).

The effects of glycogen-depleting exercise on athletic performance has been established long since, as well as the dietary practice of carbohydrate loading. The focus, however, has shifted away from carbohydrate loading the day prior to competition and instead supports increased ingestion of carbohydrates in the 5 to 7 d leading up to competition to ensure maximum muscle and liver glycogen stores (6,14, 19,20,41). A study by Kavouras *et al.* (19) compared the postexercise muscle glycogen levels of cyclists who had eaten a low-carbohydrate diet (100 $g \cdot d^{-1}$) versus a high-carbohydrate diet (600 $g \cdot d^{-1}$) for 6 d. This study showed that the athletes who followed a high carbohydrate diet yielded considerably higher postexercise muscle glycogen levels (104.5 ± 9.4 $mmol \cdot kg^{-1}$ per wet weight) as compared to those athletes who ingested lower amounts of carbohydrate (72.2 ± 5.6 $mmol \cdot kg^{-1}$ per wet weight) in the days leading up to exercise.

Before the Match

The preexercise meal, and more specifically, the ingestion of carbohydrates before exercise, is extremely important for several reasons. As mentioned previously, adequate carbohydrate stores help maintain optimum energy throughout the activity and help to prevent low blood sugar levels, which can cause the athlete to feel fatigued and lose focus. Furthermore eating of carbohydrates hours prior to exercise prevents the athlete from feeling hungry during the workout or competition (Table 1).

The majority of the preexercise meal is best eaten 3 to 4 h before competition. This allows time for digestion and decreases the chances of gastrointestinal distress during activity. The preexercise meal should include moderately high glycemic foods (Table 2), which are easily digestible and relatively low in fat to avoid slow gastric emptying (5). Within 1 h of competition, an easily digestible snack (banana, pretzels, applesauce, and the like) or liquid carbohydrate can be consumed. The athlete should refrain from trying any new food or drink during this time. Protein (0.25 $gm \cdot kg^{-1}$) can be added to the preexercise meal, which can help to regulate energy levels by slowing carbohydrate absorption and delivering the fuel to the skeletal muscles at a consistent rate over time (20).

Table 1.
Prematch nutrition.

Do	Don't
Focus on hydration	Try any new foods or sport drinks
Finish prematch meal 3 to 4 h before the start of competition	Overeat within 1 to 2 h of match time
Have a light snack 1 to 2 h before the start of competition	Forget to hydrate!
Eat easily digestible carbohydrates and a small amount of protein	

Table 2.
Glycemic index.

High	Intermediate	Low
Cornflakes	Pasta	Soy milk
Bran flakes	Rice noodles	Yogurt
Shredded wheat	Mango	Skim milk
Bagel, plain	Peaches	Whole milk
Whole wheat bread	Figs	Chocolate milk
White bread	Papaya	Buckwheat
Rice cakes	Raisins	Bulgur
Graham crackers	Pineapple	Pearl barley
Watermelon	Banana	Cashews
Dates	Cornmeal	Peanuts
Fruit leather	Basmati rice	Hazelnuts
Jasmine rice	Cranberry juice	Walnuts
Polenta	Yam	Almonds
French fries	Corn	Orange juice
Potato, boiled	Beets	Pineapple juice
Potato, mashed	Artichoke	Apple juice
Parsnips	Cauliflower	Carrot juice
Pumpkin	Brussel sprouts	Tomato juice

During the Match

Once a rugby athlete has been engaging in activity for longer than 60 min, it is imperative that the muscles be supplied with adequate amounts of energy to ward off fatigue and a drop in performance. Carbohydrate fueling during a rugby match is achieved usually by way of a carbohydrate-containing fluid replacement drink or gel. Eating solid food during a rugby match usually is not recommended because of the possible gastrointestinal side effects that some athletes report. Fluids that have a carbohydrate concentration of 6% to 8% ($g \cdot mL^{-1}$) are recommended for most athletes. Approximately 8 to 16 fl oz should be consumed every 10 to 15 min to stay abreast with carbohydrate losses during exercise and to aid in rehydration (20). Also the addition of a small amount of protein (carbohydrate/protein ratio of 3 to 4/1) has been shown to improve endurance in some studies (18,37) (Table 3).

After the Match

The moment the rugby match ends, the recovery phase begins. It is crucial for any successful rugby athlete to establish good recovery nutrition habits to continue to improve performance and build strength. Carbohydrate intake after activity should not be delayed because early replenishment has been shown to promote faster uptake of glycogen and to speed recovery. Based on a study by Ivy (17), delaying carbohydrate intake by as little as 2 h can lower the rate of glycogen resynthesis by as much as 50%. To counteract this suboptimal outcome, a study by Millard-Stafford *et al.* suggests that athletes ingest 1.2 to 1.5 $g \cdot kg^{-1} \cdot h^{-1}$ of carbohydrate over 4 to 5 h starting 30 min after endurance exercise to maximize muscle glycogen storage (29). Foods with a high glycemic

Table 3.
During match nutrition.

Do	Don't
Refuel and rehydrate frequently during the match	Eat solid carbohydrates
Drink 6 to 8 oz of fluid every 5 to 15 min during exercise	Forget to refuel and rehydrate often throughout the match
Consume 8 to 16 oz of 6% to 8% carbohydrate solution every 10 to 15 min	
Add small amount of protein to improve endurance (carbohydrate/protein ratio of 3 to 4/1)	

index should be consumed during the recovery phase as this has been shown to improve glycogen stores when compared to foods of a lower glycemic index (Table 2) (20). If an athlete can not tolerate solid foods within 30 min after competition, liquid carbohydrate drinks should be offered and solid foods should be attempted again 2 to 4 h later (Table 4).

Protein — the Building Block for the Rugby Athlete

Protein is an essential nutrient for rugby athletes to help build and maintain muscle mass. Rugby players require more protein than the average individual to help aid in muscle repair and growth. Some studies indicate that an athlete's diet should contain two times the recommended daily allowance of protein to maintain protein balance (7,26,42). If athletes do not ingest a sufficient amount of protein while training, they may fall into a negative nitrogen balance, which can slow recovery, impair performance, and increase further protein catabolism (27).

Depending on the size, position, sex, and age of the athlete, different protein requirements may be indicated. Rugby players involved in moderate amounts of training should consume 1.0 to 1.5 $g \cdot kg^{-1} \cdot d^{-1}$ of protein, while athletes participating at higher training intensities should consume closer to 1.5 to 2.0 $g \cdot kg^{-1} \cdot d^{-1}$. The type of protein ingested must be considered also. For example, casein and whey proteins display varying rates of digestion and absorption and have more beneficial effects on whole body catabolism and anabolism (2). Rugby athletes should be encouraged to eat not only an adequate amount of protein but also protein from quality sources such as light skinless chicken, fish, egg whites, and skim milk.

Larger athletes requiring a higher amount of protein may complement the diet with nutritional supplements to obtain their recommended intake. It is recommended these athletes try natural whey protein, casein, milk, and egg proteins. Caution should be advised regarding supplementation from unnatural sources as there is very little regulation in this industry and some supplements may contain trace amounts of illegal or banned substances.

The timing of protein supplementation has been well studied, and the assumption is that increased protein synthesis and decreased protein breakdown will lead to muscle hypertrophy and increased lean body mass over time (47). According to two studies performed by Tipton *et al.* (44,45), protein is best given to athletes before and immediately after exercise. Protein supplementation during this time has been shown to increase the rate of protein synthesis, decrease the rate of protein degradation, and aid in recovery. Another study by Rasmussen *et al.* (35) also demonstrated that protein synthesis was enhanced for several hours after exercise when a carbohydrate-protein supplement was ingested 1 to 3 h following exercise.

Fat — a Necessary Evil for the Rugby Athlete

Fat is a valuable metabolic fuel and performs many important functions in the body of a rugby athlete such as providing energy, aiding in nutrient absorption, and maintaining core temperature. Adequate consumption of essential fatty acids, maintenance of energy balance, and the replenishment of intramuscular triacylglycerol stores are of great importance to athletes of all kinds (46). However care should be taken to avoid a diet that is too high in fat to prevent unnecessary weight gain and a possible decrement in performance.

It is recommended that an athlete's fat intake comprise about 20% to 30% of their total daily caloric intake (46). Rugby athletes engaged in regular and prolonged high-level training may safely ingest up to 50% of their total daily caloric intake as fat, but special attention must be paid to the body weight of these athletes. For those rugby players who need to lose weight, a safer recommendation would be to consume 0.5 to 1.0 $g \cdot kg^{-1} \cdot d^{-1}$ of fat.

Fluids and Hydration

Water is arguably the most important nutritional ergogenic aid for the rugby athlete. A 2% loss of body weight from sweat loss will induce a significant impairment in exercise capacity. A loss of body weight due to excessive sweating during exercise that approaches 4% can lead to heat illness, heat exhaustion, heat stroke, and even death (28). Hence it is imperative that the athlete maintain an adequate fluid balance throughout competition. On average, athletes sweat at a rate of 0.5 to 2.0 $L \cdot h^{-1}$ depending on the temperature, humidity, exercise intensity, and the athlete's individual sweat response to exercise (28).To offset this water loss and help maintain adequate hydration status, they must drink at a rate of 6 to 8 oz every 5 to 15 min during exercise (3). Athletes should be encouraged to weigh themselves before and after exercise to ensure proper fluid replacement is maintained (22). For every

Table 4.
Postmatch nutrition.

Do	Don't
Compare pre and post match weights. Drink 3 cups of water for every pound lost after exercise.	Forget to consume adequate amounts of protein to help with protein synthesis muscle recovery
Start replacing carbohydrates within 30 min of match	Drink alcohol
Focus on carbohydrates with high glycemic index during the first 2 h of recovery phase	

pound of weight lost after activity, the athlete should consume 24 oz of fluid (28). Dehydration is best avoided when the athlete begins practice or competition in the euhydrated state (38).

Micronutrients: Vitamins and Minerals

Vitamins are organic compounds that help regulate several metabolic and neurological processes, assist with energy synthesis, and help prevent the destruction of cells. The fat-soluble vitamins (A, D, E, and K) are stored by the body, and excess intake may result in toxicity. The water-soluble vitamins (vitamins B and C) are for the most part eliminated in excess by the urine. Several vitamins have been shown to have direct ergogenic effects on performance, but most are not included in a standard recommendation for the athlete's diet. Vitamin D has been shown to promote bone growth and mineralization by enhancing calcium absorption, but no performance-enhancing effect has been seen with supplementation (25). Vitamins E and C have been found to reduce oxidative damage and therefore may help athletes tolerate stressful training sessions more efficiently (10). Vitamin C has been shown to support a healthy immune system, which can be beneficial for the competitive rugby player (32). In general though, unless an athlete has a nutrient deficiency or specific dietary restrictions, there is little need for vitamin supplementation in rugby players. The fact that athletes have such increased energy needs usually provides them with more than enough opportunity to obtain these vitamin sources through a balanced diet.

Minerals are inorganic compounds that assist in a wide variety of metabolic processes. They are the building blocks of tissue, enzymes, and hormones. Minerals can become depleted in athletes who undergo prolonged periods of training but usually are replaced easily by ingesting a balanced diet (25). Some athletes may have concomitant health issues that would put them at higher risk for mineral deficiency and therefore may benefit from supplementation. For example, calcium supplementation may be indicated for any athlete who either has or is at risk for osteoporosis such as those with female athlete triad or with low bone mineral density (15,25). Supplementation of sodium chloride during the initial days of training in the heat has been shown to maintain hydration (36) in athletes susceptible to dehydration. Athletes with iron deficiency or other types of anemia have demonstrated increased exercise capacity after iron supplementation (4). Also zinc supplementation during training has been shown to decrease changes in immune function after exercise (31). However the majority of athletes will not derive any performance benefit from daily mineral supplementation.

Dietary Supplements — Creatine Monohydrate

The goals of any good sports nutrition program should be to educate the athlete and their coaches about the proper way to structure and time their meals to optimize performance and recovery. Dietary supplements can play a role in helping these athletes achieve these goals, but the emphasis must remain on these substances as supplements and not replacements for a balanced diet. Most dietary supplements on the market have little or no sound scientific data to prove their efficacy. However there are few nutritional supplements like creatine monohydrate that have been shown to increase high-intensity exercise capacity and increase lean muscle mass (25).

Creatine monohydrate is a very popular and apparently effective dietary supplement used amongst athletes. Studies have shown a significant increase in muscle mass during training when creatine monohydrate is used as a supplement (23). One study has shown that during a 4- to 12-wk training program, athletes taking creatine monohydrate demonstrated a 2- to 5-lb greater gain as compared to controls (23). The proposed mechanism for this increased weight gain is that athletes taking creatine monohydrate are able to engage in higher intensity activity and therefore promote better training adaptations and greater muscle hypertrophy (33). The most common reported adverse effect has been weight gain (23,24), but recent long-term studies have supported the overall safety of this supplement (24,39). There even has been evidence showing that the use of creatine monohydrate can decrease the incidence of injury during training (13,48). The recommended dose of creatine monohydrate is $0.3\ g{\cdot}kg^{-1}{\cdot}d^{-1}$ for at least 3 d followed by 3 to $5\ g{\cdot}d^{-1}$ to maintain stores (25). The International Society of Sports Nutrition maintains that with proper supervision, the use of creatine monohydrate in competitive athletes is acceptable and may provide an alternative to potentially dangerous and illegal anabolic drugs (25).

Caffeine

Caffeine can be found in many of the drinks our rugby athletes enjoy. Coffee, tea, and energy drinks are seen commonly in the hands of our athletes as they come and go from class, work, practice, and so on. The amount of caffeine that is contained in these drinks varies greatly, and it is important for our athletes to be aware of how much caffeine they are consuming and how it may affect their performance and in some cases their eligibility.

In 2010, the International Society of Sports Nutrition released a position stand on caffeine and how it affects performance (11). The article concluded that caffeine can enhance sport performance when consumed in low to moderate doses (approximately 3 to $6\ mg{\cdot}kg^{-1}$) but does not result in further benefits when consumed at higher doses ($>9\ mg{\cdot}kg^{-1}$). Caffeine has been shown to be beneficial for high-intensity exercise of prolonged duration in team sports like rugby (40). Additionally in contrast to popular theory, current literature does not suggest that caffeine use during exercise results in diuresis (11). That being said, too much caffeine can be harmful and in some cases illegal. The National Collegiate Athletic Association has placed restrictions on the excess use of caffeine. If an athlete's urine contains caffeine at concentrations above $15\ \mu g{\cdot}mL^{-1}$, they are considered in violation (43). In addition, excessive caffeine use can put added strain on the cardiovascular system and cause tachycardia, palpitations, and a feeling of "jitteriness," which can be distracting for the athlete and ultimately affect performance.

Energy drinks are considered the second most popular dietary supplement in American adolescents and young adults (9). Recently energy shots have become popular and have been purported to increase mental focus and performance (49). Caffeine is the most common ingredient in energy drinks, and the concentration at which it is found in these drinks is unpredictable. Currently the Food and Drug Administration (FDA) limits the amount of caffeine in soft drinks to 0.02% of the product, but no such guidelines for energy drinks or shots exist. Along with caffeine, other stimulants like guarana, and yohimbine have been found in many energy drinks.

Reassurance that caffeine in small doses not only can be safe but also may improve performance should be included in any sport nutrition discussion with the rugby athlete. However, care must be taken to point out the potential adverse effects and negative training effects that excess caffeine can have on the athlete's performance. Athletes should be discouraged from consuming energy drinks because these are not subject to FDA regulations and therefore their true contents are unknown.

Alcohol

Alcohol remains the most common drug used by athletes, including rugby players. The use of alcohol before, during, and directly after athletic activity should be strongly discouraged. The acute consumption of alcohol has been shown to adversely affect psychomotor skills, decrease exercise capacity, and decrease performance (16). Alcohol use can impair an athlete's immune system, leaving them susceptible to infections (1). Drinking alcohol on the days leading up to competition can cause dehydration and put the athlete at risk once exercise begins. The consumption of alcohol during the recovery phase can inhibit the resynthesis of glycogen and impair protein synthesis after exercise (8,34). Athletes should be warned against the use of alcohol as part of the postmatch celebration.

Conclusion

Fueling the competitive rugby player both on and off the pitch can be a challenging task. The athlete must maintain energy balance by consuming a nutrient dense diet while participating in a solid training program. Carbohydrates, protein, and fat are the foundation of a balanced diet, and the timing of meals is crucial in maintaining energy balance. Therefore significant thought and preparation are required on behalf of the athlete to meet these goals and maximize performance. Proper hydration before, during, and after activity is fundamental and sets the framework for success. Dietary supplements are ubiquitous in today's society, and their use should be screened and closely monitored. Creatine monohydrate has been well studied and appears to be safe and effective as an ergogenic aid. Caffeine-containing energy drinks and shots should be discouraged as these are not subject to regulation by the FDA and may contain traces of prohibited substances. In addition, these supplements may contain ingredients whose effects have not been studied in athletes.

Vitamins and minerals are naturally occurring substances that most athletes consume as part of a well-balanced diet. The supplementation of vitamins and minerals is not recommended generally except in individualized circumstances. The rugby player armed with the knowledge of how to properly fuel their body will have a significant advantage over the competition. The education of athletes and coaches remains one of the most important aspects of a solid sports nutrition program.

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