

Nutritional Practices, Interventions and Recommendations for Junior Rugby League Players

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Abstract

Rugby league is an intermittent, collision team sport played at amateur and professional levels across junior and senior age categories worldwide. A paucity of literature exists with regard to research on nutrition for junior rugby league players. This lack of research makes the development of specific nutritional recommendations for players problematic. There is a concern that players may adopt the latest fad diet or supplement to augment their performance at a risk to their performance, training adaptation, recovery, injury susceptibility and health. Youth culture, social media, socio-economic status, behavioural and educational issues may contribute to the poor dietary practices of players. To maintain health, optimise growth and enhance athletic performance and recovery, junior rugby league players need to consume an appropriate diet. Junior rugby league players should periodise their nutritional intake according to the training and competition phase. 1.5-1.7 g.kg⁻¹ day⁻¹ of protein is recommended with equally spaced meals throughout the day to maximise protein synthesis. During phases where skeletal muscle tissue is prioritised this recommendation should be towards the higher end, 1.7 g.kg⁻¹ day⁻¹. Carbohydrate ingestion between 4-8 g.kg⁻¹ day⁻¹ should be adjusted daily according to the daily exercise needs of the player. A food first policy should be adopted basing food intake on primarily whole and minimally processed sources from a variety of foods will help players meet their micronutrient intake. Implementation of a nutrition education programme should be undertaken with players improve the nutritional knowledge and dietary practice. This paper reviews the current scientific data related to the energy needs of junior rugby league players, special nutrient needs during training and competition and the use of supplements.

Keywords: Rugby league; Development; Performance; Recovery

Introduction

Rugby league

Rugby league football is played at junior (Under 12-Under 20) and senior levels in several countries worldwide [1]. For players over 13 years, the game is played under the international rules. It is a physical contact sport lasting between 60-80 minutes (depending on the standard of competition), during which players are subjected to high impact collisions, frequent intense bouts of running and tackling interspersed with short bouts of recovery [2,3]. Players are required to have a highly developed level of strength, power, speed and agility, as well as both aerobic and anaerobic endurance; the levels of which increase with the level of competition [1]. Further, the coordination of neuromuscular tasks including power, speed, strength into functional movements with appropriate psychological skills including pattern recognition, decision-making, dual-task and anticipation within the game are the key factors underpinning success [4,5].

Differences exist between the physical demands of junior and senior rugby league matches. Gabbett [6] investigated the physical demands between National Rugby League (NRL, senior players) and National Youth Competition (NYC, elite U20s) match-play measuring the activity cycles (i.e., ball-in-play periods) during the game. NRL matches had longer ball-in-play periods, a smaller proportion of short

duration activity cycles, and a larger proportion of longer duration activity cycles. The total time the ball was in play for NRL and NYC matches was approximately 55 minutes and 50 minutes, respectively, indicating that 30-40% of match time comprises stoppages (i.e., for scrums, penalties, line drop-outs, tries, and video referee decisions). Despite these differences a well-developed aerobic capacity is the strongest discriminator between playing rank for junior players [7]. High-intensity running and repeated-high intensity effort are typically lower for junior rugby league performance compared to elite players [8]. The musculoskeletal system is still developing in junior rugby league players and, as a consequence, they have significantly lesser maximal strength and power when compared to professional rugby league players [9]. However, similar to professional level, junior rugby league forwards have significantly greater body mass and skinfold thickness than the backs [10]. These attributes are advantageous for forwards who are frequently exposed to tackling and collisions [11].

In the pursuit of sporting excellence, the emphasis on identifying and developing talented youth athletes within respective contexts has increased dramatically in recent years [12]. National governing bodies and professional clubs invest resources to identify outstanding youngsters at an early age in order to accelerate their development into senior levels [13]. These youngsters are encouraged to engage in increasingly strenuous training and competition, fast track programmes and or early specialization requiring higher levels of investment of players' adaptation reserves in this unique time of growth and development. In England, talented junior (Under 16s)

players train and compete in approximately 8 matches per season for a professional club alongside training and competing for their community club, school and representative teams, in addition to potential participation in other sports. Within the United Kingdom a talented player pathway was established in 2008 to provide a defined pathway that sets out clear progressions from school to club, to professional club that players move through to elite level. Junior teams (U12-U17) contribute significantly to part of this process having the highest overlap of activities within the pathway.

Despite the era of professionalism and the restructuring of the player pathway, it could be suggested from the literature and from conversations with a number of practitioners in the field of applied rugby league that a greater emphasis may need to be placed on education regarding junior players' nutritional intake and training [7,14]. Nutrition and performance are topics of a paramount importance for junior rugby league players, yet there is a paucity of nutritional information for this group of athletes. Within a professional sporting environment players are more likely to achieve appropriate nutritional intakes as a result of the support and the nutritional strategies the clubs put in place. Junior rugby league players have greater responsibility for their own dietary intakes. There is evidence within the sport science literature that research can have a direct and real impact to the applied practitioner and thus the player [15]. It could be suggested that the case study approach adopted and presented by Sanctuary et al. [15] needs to be replicated at a Junior Level, to further support the development of applied/real life rugby league literature. The purpose of this paper is to review the current literature regarding junior rugby league players nutritional practices and provide appropriate recommendations for junior rugby league players to enhance adaptation responses during this unique and "sensitive/developmental window" of time.

Nutrition issues for junior rugby league players

Nutrition plays a fundamental role in three aspects of training and development for junior rugby league players: 1) fuelling of game and training related performance, 2) recovery from competition and training, and 3) the promotion of training adaptations, including skeletal muscle hypertrophy and to support optimal growth and maturation of the player [16]. Unfortunately, limited information is available concerning the nutritional practices of junior rugby league players. Generally, it has been reported that young rugby players have an inadequate understanding of sports nutrition and do not adhere to dietary practices appropriate to their sport as they are largely unaware of their nutritional needs, the importance of meeting these needs, and also how to meet these needs [17]. Athletes, in general, rarely have the opportunity to consult dietary specialists and players generally do not adhere to dietary recommendations appropriate for their sport leading to potential nutrient deficiencies or excesses in specific areas [18]. Empirical observations that are supported by unpublished data from our research within a professional Rugby League Club revealed that poor dietary practices were prevalent amongst Junior (U15s and U16s) and Academy (U20s) players. Findings were similar to those of Cole et al. [19] including limited fruit, vegetable, fibre intake and high in both saturated/trans fats and sugar, in addition to altered eating patterns and poor meal macronutrient distributions. At the senior professional level, Tooley et al. [20] found that the dietary practices of the players sampled were inadequate to meet nutritional recommendations including an elevated portion of energy derived from fat, lower fibre intake compared to the Reference Nutrient Intake and lower carbohydrate consumption. In a group of 203 male rugby union

players age 15–18 years competing at Senior School's Cup level in Leinster Walsh et al. [17] found that poor nutritional knowledge was evident regarding the foods required for refueling, use of sports drinks and the role of protein.

The determinants of food choice are complex and are shaped by social, cultural and economic forces [21]. Indeed, a number of interrelated challenges influence nutritional practices of junior players within the United Kingdom. Rugby league players are typically from areas of low socio-economic status with limited economic means, education and demographic areas with poor dietary intakes [22]. It could be speculated that these factors are rooted in rugby league's traditional ties and historical foundations. More affluent population subgroups are not only healthier and thinner, but they also consume higher-quality diets than do lower income families [23]. Families and players with limited finances are under pressure to buy foods that are higher in energy, high in both fat and sugar that cost less per unit of energy when compared to less fattening but nutritionally much richer foods, such as fruits and vegetables. Poor dietary practices have become integrated into adolescence culture and are normative [24]. This is attributed by the contemporary environment which encourages indulgent consumption of energy-rich foods, the promotion of such foods and supplements by the media and commercial entities, and their increasing centrality in a variety of social contexts [25]. For the aspiring junior rugby league player the high level of competitiveness and physique orientated culture also leaves players vulnerable to the latest fad diet or supplement to augment their athletic performance. As with many adolescents players may strive to achieve independence and they are highly influenced by the beliefs and behaviours of peers. Thus achieving and maintaining optimal player performance and health is a challenge for the players themselves alongside parents, coaches, nutritionists, sport scientists and for all those who are involved in the development of junior rugby league players. Specific nutritional areas and recommendations are discussed in further detail below:

Energy and nutrient intakes

A paucity of literature concerning the energy expenditure of rugby league players exists during competitive matches and training possibly due to the difficulty in accurately estimating energy expenditure in high-intensity intermittent sports [26] or the gross underestimation of energy expenditure from "metabolic power" equations that fail to take into account the contact and wrestling demands of the game. Coutts et al. [27] estimated energy expenditure was approximately 7.9 millijoules (MJ) during a competitive match of rugby league; heart rate recordings were taken to estimate the 'internal cost' of the match. Kempton et al. [28] investigated metabolic-power parameters of elite rugby league players utilising global positioning system (GPS) data. The estimated energy expenditure of varied between positional groups 25.7–43.5 kJ/kg⁻¹ during competitive matches.

However, no data exists concerning the energy expenditure of junior rugby league players. Junior rugby league players are faced with the complex challenge of consuming adequate energy to fuel sport performance, training activities as well as growth and development. Nutrient needs are higher during adolescence than any other time in the life cycle, regardless of activity level [29,30]. This is largely a result of hormonal changes adolescents experience resulting in considerable changes of growth and maturation alongside significant physiological, cognitive and psychosocial changes [31]. Rapid growth of new tissue (i.e., muscle) and other widespread changes (e.g., bone, organs) occur and many adult patterns are established. Furthermore, junior rugby

league players often expend a significant amount of energy participating in more than one sport and usually more than one team within the same sport including for school and local clubs, adding to the demands placed upon them [32], loads exceeding those typically prescribed to elite adult athletes [33].

Tooley et al. [20] investigated the nutritional and activity habits of professional Rugby League players during a competitive week including four training days (pre-match), a match day (match), and two rest days (recovery) concluding that the players mean daily energy deficit of 947 ± 214 kcal was estimated when compared to estimated energy expenditure. A mid-season study on professional Rugby League determined that mean daily energy intakes of the forwards and backs were 4309 ± 947 and 4142 ± 822 kcal, (carbohydrate 51%, protein 18%, fat 25%, alcohol 4%) with 6 and 2.0 $\text{g/kg}^{-1}/\text{d}^{-1}$ from carbohydrate and protein respectively [34]. Lundy et al. [34] did not measure or estimate energy expenditure to determine whether the players were in an energy deficit, surplus or balance.

Energy substrates intake

Protein - Both players and coaches favor increases in muscle mass as it has been suggested that higher percentage lean body tissue may act as means of protection from impact injuries and are associated with higher levels of strength and power [9]. Furthermore, players are increasingly concerned with their level of muscularity attributed by contemporary culture and by exposure to unrealistic cultural ideals of muscular physiques through varying media outlets [35]. It could be suggested that these factors lead to junior players being confused as to the appropriate intake of protein, possibly at the expense of other essential nutrients. However, over emphasis on protein intake may hinder athletic performance at the expense of other important nutrients including carbohydrates [36]. Protein provides only a minimal amount of dietary energy; body weight maintenance and energy provision is determined predominantly by the intake and utilisation of CHO and fat [37]. Optimisation should precede overconsumption; the human body has saturation, threshold point of processing specific nutrients including protein and muscle tissue. Junior rugby league players need realistic expectations for gains of muscle mass from qualified staff.

Certainly, greater protein needs per kilogram of body weight are required to satisfy both training requirements including the novelty to

newer training stimuli and to maintain a positive nitrogen balance [38]. Players regularly use varying training modalities including resistance training and sport specific training to improve, or maintain, peak physical performance stimulating repair and remodelling of structural proteins [39]. Additional dietary protein may be needed to facilitate training adaptations but may not be required to support the growth spurt of junior rugby league players. Aerenhouts et al. [40] found that a mean protein intake around $1.5 \text{ g/kg}^{-1} \text{ day}^{-1}$ was adequate to stay in a positive nitrogen balance during periods of peak growth in adolescent sprint athletes. Adequate intake of protein of $1.5\text{-}1.7 \text{ g/kg}^{-1} \text{ day}^{-1}$ are recommended with equally spaced meals throughout the day to maximise protein synthesis (0.3 g/kg/serving) for junior rugby league players [29]. As protein intake is an important consideration for optimal training adaptations players may opt towards the higher end of the recommendation ($1.6\text{-}1.8 \text{ g/kg/day}$) during the off season or pre-season. The timing of protein intake is as fundamental as the amount consumed; ingestion of protein after exercise or prior to sleep may optimise the adaptive processes and thus is recommended [41].

Carbohydrates - Junior rugby league players should achieve an energy intake that provides sufficient carbohydrate to fuel their training and competition. Muscle glycogen availability during training and competition can influence work output, distance covered and sprinting frequency, particularly in the later stages of exercise [42]. For the adult population of rugby league players, an intake target of 5-9 g of carbohydrate per kg of body mass should meet the requirements of most players given the high glycolytic demands of the sport [43]. However, the level of maturation of the adolescent may influence the glycogen content of muscle; the content increasing with maturation. Indeed the glycogen content muscle within children may be 50 to 60% of that of adults leading to an earlier depletion during exercise than is seen in adults [44,45]. Boisseau et al. [46] also speculate that there is greater utilisation of fat stores in young individuals. During junior rugby league players cover lower relative distances than elite players ($88 \text{ vs. } 95 \text{ m min}^{-1}$) possibly due to lower skill level or physical abilities [11]. It would seem prudent to lower the recommendation of 5-9 g/kg/day to 4-8 g/kg/day . Needless to say, players should learn to adjust and periodise their daily intake of carbohydrate based on feedback about his or her performance and recovery, the duration and intensity of exercise, for example, on game days and heavy training sessions consume more carbohydrate and on light days less carbohydrates (Table 1) [47].

Situation Daily Need For Fuel and Recovery		CHO Target Per/kg Body weight
Minimal	Light Training Program (low intensity or skill based)	2-4 g per kg/day
Moderate	Moderate Exercise Program (~1 hour/day)	4-6 g per kg/day
High	Endurance Program (1-3 hr per day of moderate to high intensity exercise)	5-9 g per kg/day
Very High	Extreme Exercise (4-5 hr per day of moderate to high intensity exercise)	9-11 g per kg/day
Maximum Daily Refueling	Post-Event Recovery or aggressive fueling ("carbohydrate loading") before the game	6-11 g per kg/day
Speedy Refueling	Less than 8 hours recovery between two demanding workouts	1-1.2 g per kg/hr after 1st session – Repeat each hour until normal meal schedule is resumed
Pre-Game Fueling	Before the game	1-4 g/kg – 1-4 hr before exercise

During Game	Short games or small fuel demands	Small amounts – or rinse
During Game	Moderate game demands (60 – 90 min)	30-60 g/hr
During Game	Large game fuel demands (>2 hr) or poorly fueled	Up to 80-90 g/hr

Table 1: Daily carbohydrate intakes for junior rugby league players should be adjusted based on the activities performed [47].

Fat – Historically, dietary fat has been among the lifestyle factors most often claimed to be responsible for increases in adiposity and has been stigmatised with various health related issues. Junior rugby league players may overly restrict dietary fat intake for the sake of losing body fat percentage with little appreciation of the benefits of adequate fat intake. Diets rich in trans fats and saturated are more common in rugby league due to their accessibility, low cost, flavour and palatability [20]. Lundy et al. [34] found during the competitive season that professional rugby league player's fat intake was low but 48% came from saturated fatty acids ($10.1 \pm 3.2\%$ of total energy intake, ratio of saturated fat to polyunsaturated fat 2.43).

Certainly, different types of fats have different characteristics and different effects on both performance and health. Omega-3 (n-3) fatty acids have also been shown to stimulate protein anabolism and attenuate catabolism relevant to the player involved in resistance training and high impact collisional activities [48]. Dietary fat intake has been found to influence anabolic hormone concentrations including testosterone which is particularly relevant to rugby league players attempting to augment their lean body tissue [49,50]. Daily intake of $0.6\text{-}1.2 \text{ g/kg}^{-1}\text{/day}^{-1}$ of fat is recommended, depending on individual preference, tolerance and goal. Player's should be encouraged to eat a variety of different fats including saturated, monounsaturated, polyunsaturated and avoid the over-consumption and -emphasis of one type. Basing food intake on primarily whole and minimally processed sources will encourage players to consume healthier fats.

Micronutrient Intakes

Physical growth and maturation lead to increased need for nutrients and micronutrients like vitamins A, B12, C, folic acid, calcium and iron. Rodriguez et al. [51] also identified calcium, vitamin D, B vitamins, iron, antioxidants such as vitamins C and E, β -carotene, and selenium as most deficient in athletic populations. Unfortunately, limited research has been carried out regarding micronutrient intake of junior rugby league players. At the professional level, Tooley et al. [20] and Lundy et al. [34] found during the competitive season that players attained adequate micronutrient intake. However, in a group of Japanese male collegiate (aged 19.5 ± 0.9 years) rugby union players the mean intakes of calcium, magnesium, and vitamins A, B1, B2, and C were lower than the respective recommended dietary allowances (RDA) or adequate dietary intakes (ADI) [52]. A possible explanation for the differences reported between these studies is that Lundy et al. [34] and Tooley et al. [20] investigated the dietary intakes of professional players.

Iron - Iron requirements are highest in males during peak pubertal development because of a greater increase in blood volume, muscle mass and myoglobin [53]. Junior rugby league players have risk factors for iron depletion which include hemolysis caused by tissue trauma from repeated foot strikes and physical contact occurring during both training and competitive games, as well as iron loss through

gastrointestinal and urinary tracts, and sweating [52,54]. Furthermore, hepcidin, a 'master regulator' of iron homeostasis, may be elevated due to the physical stressors involved in both the training and competition of rugby league [55]. Shimoda et al. [55] studied hepcidin and iron metabolism in rugby union players and concluded that iron decreases as hepcidin increases especially during stressful heavy training and during the season. Hepcidin is elevated for approximately 24 hours post-exercise as a result of heightened inflammation processes, promoting a negative iron balance in athletes [56]. Junior rugby league players may require iron up to 11 mg/day for males and 15 mg/day for females [30].

Calcium – The skeleton is a metabolically active organ that undergoes continuous remodelling influenced by a range of factors including genetics, mechanical loading and nutrition [57]. During adolescence, adequate calcium intake is required to support bone accretion, to optimise the development of peak bone mass within a player's genetic potential and to prevent bone related issues including stress fractures [58]. According to Bell [59] 14.2 ± 0.9 years peak growth velocity (PGV) in the skeleton occurs at age 14 years for males coinciding with peak calcium accretion rates. Calcium intake below the recommended level and peak bone mass may not be achieved [60] and thus may cause potential problems for the players later on in life. Furthermore, given the degree of mechanical loading players are exposed to due to various training modalities such as resistance training, plyometrics, wrestling and sprint training higher calcium requirements may be required to support the increased bone formation [61]. Diets that provide adequate calcium, ranging from intakes between 1200 and 1500 mg/day, during the adolescent years should be encouraged.

Vitamin D - Low vitamin D is a common deficiency in athletes especially if exposure to natural sunlight is limited; when training in the winter months or when training mostly indoors [62]. Within the United Kingdom (UK) the majority of training and general physical preparation for junior rugby league players takes place from November to December either indoors or under artificial lights. Furthermore, the majority of teams are based within the North of England in Lancashire and Yorkshire with limited sunlight in the winter months exposing players to a higher risk of vitamin D deficiency. In the UK between October and March, synthesis of vitamin D may be almost impossible and therefore, the majority of the UK population may be vitamin D deficient during the winter months [63]. Few studies have assessed the impact of Vitamin D deficiency on skeletal muscle function in young athletes. Ward et al. [64] found that optimal vitamin D levels were found to correlate positively with jump height, jump velocity and power. Adequate vitamin D consumption is essential for health and athletic endeavours of the rugby league player. A positive relationship between Vitamin D status and muscle mass, immune, cardiovascular and physical function also exists [65]. Inadequate Vitamin D intake has been shown to negatively impact bone health [66], suppressed immune function and increased risk for stress related injuries and upper-respiratory tract infections [65]. Poor vitamin D status coupled with

the type of training and the increasing competition demands of junior rugby league players places them at a higher risk of illness and injury. In the absence of adequate sun exposure including over the winter training period, players are recommended to take ≥ 800 –1000 IU vitamin D/d from dietary and supplemental sources [67]. Players should also ensure they meet RDA for calcium to facilitate the absorption of Vitamin D [68].

Nutritional Strategies for Competition and Training

Nutrient timing is a strategy in which precise amounts of nutrients are delivered at precise time points, relative to exercise, in order to enhance performance or training effects inducing a variety of favourable metabolic, genetic and morphological changes to optimize adaptation and or performance [69]. Junior rugby league players

would significantly benefit from implementing appropriate nutritional guidelines during the pre-training and match period, 3 to 4 hours prior to exercise, in addition, to the acute recovery period, in the first 2-hrs post-exercise. Empirical observations support the concept of “nutrient timing” primarily pre (<3 hr) exercise and post (<2 hr) exercise within the training or competition environment for psychological, social and educational reasons. These periods may be particularly important for junior rugby league players, who may have challenges consuming the appropriate foods due to travel related issues, time or financial constraints, school or work commitments. It is during this period when coaches, support staff and the club can support positive behaviour change reinforcing good nutritional practices that meet the players’ immediate requirements. Pre- and post-exercise nutrition recommendations can be seen in Tables 2 and 3.

Strategies to Maximize Exercise Performance	<ul style="list-style-type: none"> • Pre-exercise meals should be eaten 3–4 hours prior to the exercise. The pre-exercise meal should consist of high carbohydrate foods (100-200 grams) and a moderate amount of protein (10-20 g). Meals containing low to moderate glycemic index (GI) carbohydrate foods that are provided as palatable meals are recommended. Low GI carbohydrates produces a more stable blood glucose concentration and results in feelings of satiety for longer than after a high-GI meal. • Liquid meal supplements or carbohydrate-containing sports bars that are easily digestible may be useful for players who suffer from pre-match nerves. • Attention should also be paid to fluid intake to ensure that the player is well hydrated.
Suitable Choices for Pre-exercise Nutrition	<p>Nutritious carbohydrate-rich selections include:</p> <ul style="list-style-type: none"> • Breads (including wraps) • Cereals (porridge, packaged cereals, and Bircher muesli) • Grains (rice, pasta, noodles, quinoa, and couscous) • Sweetened dairy (flavoured milk, flavoured yogurt, and custard) • Fruits, starchy vegetables (potatoes), and legumes (baked beans, kidney beans, and lentils) <p>Approximately 10grams of protein is provided by:</p> <ul style="list-style-type: none"> 2 small eggs 300 ml cow's milk 20 g skim milk powder 30 g cheese 200 g yoghurt 35-50 g meat, fish or chicken 400 ml soy milk 120 g tofu or soy meat 150 g legumes or lentils 200 g baked beans <p>Compact forms of carbohydrate (useful when appetites are low or players suffer from gastrointestinal problems from meals):</p> <ul style="list-style-type: none"> • Sports drinks (preferably a hypotonic (e.g. Lucozade Lite, Hydra 10)), liquid meals, gels, and bars • Flavoured milk drinks and smoothies, liquid meals
Unsuitable Choices for Pre-exercise Nutrition	<ul style="list-style-type: none"> • High fat (e.g. cheese, pastry, cream based sauces) • High protein (especially red fatty meats including steak and pork) • Fibrous foods (e.g. large portions of vegetables) should also be avoided due to potential digestive problems.
Benefits	<p>During this time period before heavy training sessions or competitive matches' carbohydrate intake should be optimised as it is the key energy providing nutrient that will ensure muscle and liver glycogen stores to be enhanced [94].</p>
When Should Proactive Pre-exercise Nutritional Strategies be Practiced?	<ul style="list-style-type: none"> • Before training sessions and matches.
Disadvantages	<ul style="list-style-type: none"> • Players may have their own beliefs and nutritional strategies that have worked well for them which do not coincide within evidenced based sports nutritional guidelines. In fact, it may be more beneficial to leave the player to their own strategies rather than upsetting their psychological status.

When is it Expendable?	<ul style="list-style-type: none"> • When sessions are light or low in intensity and muscle glycogen is not likely to become depleted or limit performance. • When the player(s) has periodized some train-low carbohydrate sessions to elicit greater stress to the organism.
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Table 2: Guidelines for pre-exercise nutrition [14].

Strategies to Maximize Recovery and Rebuilding Processes	<ul style="list-style-type: none"> • A high-quality protein-rich food providing 0.3g PRO / kg providing ~0.1 g EAA /kg (e.g., 25 g for a 85-kg player) should be consumed soon after the exercise session has finished. • Carbohydrate should be consumed soon after the training and match finishes. A recovery snack or meal providing carbohydrate equal to approximately 1 • kg BW-1• hr-1 (e.g., 85 g for an 85-kg male) preferably of high glycaemic index. <p>Target carbohydrate requirements according to fuel cost of training or competition can be seen in Table 1.</p> <ul style="list-style-type: none"> • Appetite can be suppressed through exercise, hence it is imperative that the food looks and smells appealing to the players to stimulate hunger or to use fluid forms of carbohydrate and protein including milk based fluids, fruit smoothies or liquid meals. • Whole foods such as milk, cheese or chicken sandwiches, yoghurts, fruits with complex mixtures of biochemical nutrients may allow numerous pathways / transporter mechanisms to be utilised, in addition, to the nutrients acting in a synergistic manner to optimise the adaptation-recovery process and modulate gene expression after exercise. • Consume fluids after the training or game. Preexercise and postexercise weight can be used as an indicator to the fluid deficit (approximately 1 kg = 1 L). Flavoured drinks will promote consumption. Aim to consume the target volume over the next 2–4 hr. • Electrolytes (e.g., salt and potassium) should be consumed at the same time as the fluid to replace those lost as sweat during the exercise. The electrolytes will maximize the retention of fluids. • Players should avoid the intake of alcohol as it may hinder glycogen replenishment and rehydration of fluids as it acts as a diuretic.
Suitable Choices Recovery and Rebuilding Processes	<p>Nutrient-rich carbohydrate and protein combinations (contains 50-75 g carbohydrate and 15-20 g protein) include:</p> <ul style="list-style-type: none"> 500-750 ml low fat flavoured milk 1 large bowl (2 cups) breakfast cereal with low fat milk 500-750 ml fruit smoothie or liquid meal supplement 1 large or 2 small cereal bars + 200 g fruit-flavoured yogurt 1 cup baked beans on 2 slices of toast or on a baked potato 1 bread roll with cheese or peanut butter + large banana 2 cups fruit salad with 200 g fruit flavoured yogurt 1 Bagel with thick spread peanut butter + 1-2 cups low fat milk 300 g (large) baked potato + low fat cottage cheese filling + 1-2 cups low fat milk 2-3 slices lean meat and veggie pizza 2 cups breakfast cereal with milk 400 g flavoured yoghurt Thick bread sandwich with meat and salad filling 2 cups stir-fry with rice or noodles and meat
Benefits	<ul style="list-style-type: none"> • Maximize glycogen re-synthesis and protein synthesis rates for the repair damaged muscle tissues (attenuate any muscle damage, perceived muscle soreness and immuno-suppression induced by the stress of the exercise). Players are also able to replace fluids and electrolytes lost in sweat and support their overall energy intake. Post-game or training nutrition also offer the players an additional opportunity to psychologically unwind and for players to consume nutrients that influence neurotransmitters associated with the promotion of sleep, which can be disrupted from evening matches, training and elevated neural stimulation.
When Should Post-exercise Nutritional Strategies be started?	<ul style="list-style-type: none"> • After matches or fuel-depleting training sessions.
Disadvantages	<ul style="list-style-type: none"> • May encourage the player to consume more energy than needed (leading to weight gain). • May encourage the player to choose inappropriate foods away from the exercising window. • May cause gastrointestinal discomfort or the need for urination if large volumes of fluid are consumed quickly.
When is it Expendable?	<ul style="list-style-type: none"> • When sessions are light or low in intensity and muscle glycogen is not likely to become depleted or limit performance. • When the available recovery eating choices are low in nutritional value, and it makes more sense to wait a little until the player can have a more nutritious meal or snack.

Table 3: Guidelines for post-exercise nutrition [14].

Special considerations - supplements

Nutritional supplement use is omnipresent in sport with athletes looking for performance gains or ways to cope with heightened training demands. The spectrum of available medical supplements, sports nutrition foods and performance supplements are vast [70], despite limited and tentative evidence supporting the efficacy of them, often stemming from poor methodological design of studies [71].

A worrying concern within rugby league is the prevalence of performance supplement use of junior players [14,72]. Reasons for consuming supplements are often complex, combining social, psychological, knowledge and economic factors [27]. Young athletes tend to be more 'performance focused' than 'health focussed' in their own use of supplements compared to their adult counterparts [73]. The attraction to supplementation is not surprising at the age of 13-17, youth culture, peer influence, limited knowledge and experimental behaviours, especially in an environment where physical prowess and sports performance is highly valued. Studies of adolescent athletes [74] show that a better sports performance is expected by nutritional supplement users. Unfortunately, supplement use, typically occurs without clinical guidance from trained dietitians and sports nutrition professionals or adequate product information [73]. Of 203 male rugby union players age 15-18 years competing at Senior School's Cup level in Leinster, Ireland almost 65% of players took some form of dietary supplement [17]. Players should be informed of the potential risks and benefits of supplementing with supplements. Players should be made aware that nutritional supplements have been found to be contaminated with undeclared substances prohibited by the World Anti-Doping Agency [75]. Over the last two years it was estimated that 40% of UK Anti-Doping Rule Violations (ADRVs), were a result of nutritional supplement use [76]. Empirical evidence suggests the most popular category of supplements within rugby league is caffeine and creatine.

Creatine (Cr) - Creatine has become one of the most popular performance supplements among athletes in recent times. Its use is considered to be legal and there is a significant amount of research published concerning the efficacy of creatine in team based sports [77]. A daily single dose of around 3 - 6 g for a period of 21-28 days can enhance performance of activities that are characteristic of the game of rugby league that are reliant on energy provision from high energy phosphates and the recovery of the phosphocreatine power system [78,79]. Creatine intake is an important consideration for optimal training adaptations as it augments adaptations at a cellular and sub-cellular level facilitating the physical prowess of the player [77]. The only clinical significant side effect of creatine usage is weight gain caused by the osmotic effect of creatine [80].

Creatine supplementation in the under 18 population has not been investigated to any significant degree, especially in regards to rugby league performance. Despite this, creatine is being supplemented in young, <18 years old, athletes from a variety of team based sports [17]. In a group of 203 male rugby union players age 15-18 years competing at Senior School's Cup level in Leinster, Walsh et al. [17] found that creatine supplements were used by 28.6%, of which 16.8% of the 149 players younger than 18 years. Similar usage has been found in high school football players. Use of creatine by young athletes is significant and is inconsistent with dosages underpinned by scientific evidence [81]. Limited data exists regarding the prevalence of creatine usage in junior rugby league players.

One of the most promising areas of research with creatine concerns its neuroprotective capabilities against stressors to the brain [82]; particularly relevant to rugby league players. The head and neck is the most common site of match injuries in senior rugby league players [11]. Players are exposed to 20 to 40 physical "confrontations" per game causing serious structural and potential functional damage to the brain [83].

Younger athletes should consider a creatine supplement for its neuroprotective capability only if certain conditions are met including: puberty is past and he/she is involved in serious competitive training; the athlete is eating a well-balanced caloric adequate diet; he/she as well as the parents approve and understand the truth concerning the effects of creatine supplementation; supplement protocols are supervised by qualified professionals; recommended doses must not be exceeded; quality supplements are administered [84].

Caffeine - caffeine is a well-known neurostimulant shown to have ergogenic benefits critical for many performance related facets of a rugby league player enhancing intermittent sprint activity, acceleration, power and cognitive performance [85,86]. Caffeine ingestion is associated with a moderate hypoalgesic effect during high-intensity particularly relevant to junior rugby league players that are involved in multiple collisions and high intensity activities during the game or training [87]. Caffeinated energy drinks appear to be the most frequently consumed and are the most popular dietary supplement after multi vitamins in the young adult population [88]. According to self-report surveys, energy drinks are consumed by 30% to 50% by children, adolescents and young adults [89]. Energy drink manufacturers primarily target these groups using specific marketing techniques associating their products with themes related to music, sports, and risk-taking [90]; marketed to improve energy, weight loss, stamina, athletic performance, and concentration [89]. Energy drinks contain caffeine levels ranging from 50 mg (equivalent to a can of soda) to 500 mg (equivalent to 5 cups of coffee). Doses (<3 mg/kg bm, 200 mg) taken before exercise have been shown to increase athletic performance in adults [76]. It is speculated that lower doses may be required for younger athletes. In addition to caffeine energy drinks contain, taurine, vitamins, herbal supplements, and sugar or sweeteners potentially. Combinations of ingredients are used to enhance flavour, produce a synergistic, facilitating an increase in dependence and to produce a cross sensitization effect. Despite the prevalence of usage, our knowledge concerning caffeine and or energy drinks on the psychophysiology of under 18 year olds remains understudied and poorly understood. The majority of research has been conducted carried out on the adult population. However, it is well known caffeine disrupts sleep in adolescents [91]. Sleep dysfunction, has a complex association with vitally important physiological, cognitive, and psychological processes not only important for a junior rugby player's performance, recovery but for general health and well-being during adolescence and into adulthood [92]. Cardiac arrhythmias in adolescents related to high caffeine consumption have also been found [93]. Considering the potential performance benefits of caffeine and the long term developmental risks it may be prudent for junior rugby players to limit their intake [94-98].

Conclusion

Unfortunately, limited knowledge exists to guide best practice for junior rugby league players related to nutrition and further research is needed [99,100]. However, junior rugby league players are encouraged to consume nutrient-dense foods adopting a food first policy. Players

should be provided continued education on the risks and benefits associated with nutritional supplementation. Consideration should be given to educating the players with the appropriate elements regarding nutrition at certain stages of their long term development and sequentially steer them toward their ultimate performance target; at the same time teaching developmentally-appropriate content allowing fluency in the fundamental prerequisites of dietary practices first. Cooking classes or some practical element of "hands on" skills should feature in a player's curriculum, as there is little point in extolling the virtues of specific benefits of certain dietary approaches if they lack the practical cooking skills needed to be able to execute the change. Additional nutritional education strategies could include the development of fact sheets, delivery of small seminars and supermarket tours [100,101]. The information within this review has attempted to present both theoretical and practical knowledge to guide all those involved in the development of junior rugby league players who have specific nutritional needs.

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