SPORT AND PERFORMANCE NUTRITION FOR THE COMPETITIVE ADOLESCENT ATHLETE

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INTRODUCTION

Adolescence generally refers to a period of life in young adults between 12 and 18 years.

Recent interest in young athletes has led to more research efforts in this field. However, sports nutrition research in adolescent athletes remains in its infancy. Despite the limited scientific literature, key principles are well established as general best practice. Adopting a food first approach, structuring good nutrition support around the physiological demands of the sport and consideration of sport specific nuances are principles valid for both adults and junior athletes. However, direct application of certain adult practices to the adolescent athlete is generally not appropriate. This is due to younger athletes undergoing many anatomical, physiological and metabolic changes during growth that require specific considerations.

A recent position statement defined two categories of adolescent athletes in the context of sports nutrition: active and competitive[1]. The competitive adolescent athlete "*demonstrate gifts talents in the physical, physiological, or movement domains which may indicate future potential in high performance sport*". They are set apart from the wider 'active' population, who, may be engaged in formal competition and regular training, however are unlikely to have the same physical demands as their "competitive" peers.

This article considers the latest nutritional recommendations and research in the context of competitive adolescent athletes including how nutrition can change during periods of injury and rehabilitation.

WORKING WITH COMPETITIVE ADOLESCENT ATHLETES

Physiologically, growth and maturation are complex processes influenced by the interaction of genes, hormones, nutrients and the environment in which an individual lives. Differences between chronological and biological age have been well documented in the same age groups across different sports[2]. Due to the challenges in obtaining accurate energy intake and expenditure in this population, monitoring rate of growth (e.g. stature and body mass) and maturation (such as somatic maturation, e.g. maturity offset, i.e. time from PHV) regularly to track an individual's progress remains key.

Modern-day pressures have a significant impact on young athletes' eating behaviours. Peers, team mates, professional athletes, coaches and the media all have significant effects which can cause vulnerability, the spectrum of which is wide from poor oral health, restrictive eating, unhealthy eating practices to disordered eating. The focus when working with adolescent athletes should be on achieving nutritional requirements for optimal growth, maturation and physical development as well as making sure adequate energy and macronutrient intake can support training loads.

ENERGY AND THE ADOLESCENT ATHLETE: HOW MUCH IS ENOUGH?

The energy intake of each adolescent athlete should be based on their total daily energy expenditure (TEE) (i.e. their energy requirements) to optimise not only growth and maturation but also stimulate training adaptations, promote recovery and sport performance. Before giving specific macronutrient recommendations it is first essential to understand the energy expenditures of adolescent athletes.

The highly variable rates of growth amongst adolescent athletes, particularly around peak height velocity (the maximum rate of growth in stature during adolescence), influence an individual's energy requirements, particularly their resting metabolic rate (RMR). These increases in RMR are coincided with increases in stature, body mass (BM), fat-free mass (FFM) and maturity status[3,4].

Activity energy expenditure is the most variable contributor to TEE and in adolescent athletes often the greatest contributor to TEE. Exercise type, duration and intensity as well as an athlete's anthropometric profile will all influence activity energy expenditure (and thus total energy expenditure), leading to a large inter-individual variability in TEE between adolescent athletes. Even within the same sport, differences in training and competition loads and anthropometric profiles amongst different age-groups can lead to differences in total energy expenditure and subsequent energy requirements.

For example, the TEE of academy soccer players was recently established in three different age-groups. U18 players presented with a TEE (3586 ± 487 kcal·day-1; range: 2542-5172 kcal·day-1) that was approximately 600 and 700 kcal·day-1 higher than both the U15 (3029 ± 262 kcal·day-1; range: 2738-3726 kcal·day-1) and U12/13 (2859 ± 265 kcal·day-1; range: 2275-3903 kcal·day-1) age-groups respectively[5]. There was also large individual variation in TEE within each age-group with individual variation of approximately 1600, 1000 and 2600 kcal·day-1 in the U12/13, U15 and U18 squads, respectively within the same week. This highlights the importance of adopting an individualised and sport-specific approach to energy intake based on energy expenditure.

In addition to the standard components making up TEE, adolescent athletes also have a small but important amount of energy required for tissue growth (~5 kcal per gram of weight increase)[6].

AVOIDING LOW ENERGY AVAILABILITY (LEA)

Energy availability is the amount of energy left for homeostatic physiological functions, thermoregulation and growth. Low energy availability can increase the risk of overreaching[7] and is associated with iron deficiency which may exacerbate some of the outcomes of low-energy availability such as fatigue[8]. Not only is low-energy availability likely to have a negative effect on an adolescent athlete's sporting performance and development it may also affect their long-term health.

Energy Availability = (energy intake – physical activity energy expenditure) / FFM).

Due to day to day variation in contributing factors, it is difficult to prescribe exact energy requirements for adolescent athletes[10]. Instead, it is strongly recommended to avoid low energy availability and ensure adequate energy availability (EA) for growth.

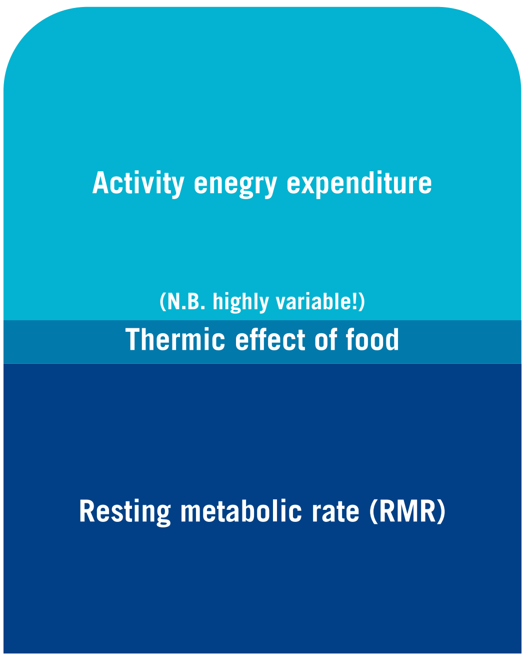
Chronic low-energy availability (defined as <30 kcal·kg FFM-1·day-1 in adults) may lead to relative energy deficit in sport (RED-S)[9]. Considering adolescent athletes have greater relative energy demands than adults[5], ≥45 kcal·kg FFM-1·day-1 is likely to be the minimum energy availability an adolescent athlete would require. Difficulties in accurately quantifying energy availability have resulted in few studies reporting this in adolescent athletes. Studies have reported mean energy availabilities of ~ 29 kcal·kg FFM-1·day-1 in young male and female athletes (11-25 years old), that competed in a range of sports at national or international level[8] to 69 ± 10 kcal·kg FFM-1·day-1, 51 ± 9 kcal·kg FFM-1·day-1 and 41 ± 15 kcal·kg FFM-1·day-1 in U12/13, U15 and U18 respectively in English Premier League academy soccer players[5].

Whilst under-reporting of energy intake does occur in adolescent athletes, available data would still suggest that low EA is common particularly in adolescent basketball players[11] and swimmers[12].

MACRONUTRIENT AND HYDRATION REQUIREMENTS

Owing to the limited data on the typical total energy expenditures (Table 1), it is currently difficult to accurately recommend specific macronutrient requirements for adolescent athletes training and competing in different sports. This is reflected in recent position statements on adolescent athletes,

COMPONENTS OF TOTAL ENERGY EXPENDITURE



TEE comprises of three main components:

1. Resting metabolic rate (RMR); the energy required to maintain homeostatic physiology at rest);
2. Thermic effect of food / diet induced thermogenesis (the energy costs of digestion, absorption, transport, metabolism and storage of food and drink), and
3. Energy expenditure from planned physical activity and non-exercise activity thermogenesis.

Figure 1: Components of total energy expenditure.

TABLE 1

Sport	Sex	Age (years)	Stature (cm)	Body Mass (kg)	Training & Competition Load	Study Duration	TEE (kcal.day-1)
Basketball (9)	M & F	M: 17.0 ± 0.7 F: 16.9 ± 0.7	M: 192.5 ± 6.4 F: 173.1 ± 3.3	M: 80.9 ± 7.7 F: 64.0 ± 5.4	>10 hours per 7 days	7 days	M: 4626 ± 682 F: 3497 ± 242
Rugby League (11)	M	U16: 15.2 ± 0.8 U20: 17.6 ± 1.1	U16: 180.8 ± 7.0 U20: 176.8 ± 3.8	U16: 79.3 ± 17.1 U20: 87.6 ± 8.8	-	14 days	U16: 4186 ± 946 U20: 4475 ± 748
Rugby Union (11)	M	U16: 15.6 ± 0.5 U20: 18.3 ± 0.5	U16: 182.1 ± 7.5 U20: 178.1 ± 3.5	U16: 85.4 ± 17.3 U20: 85.1 ± 8.3	-	14 days	U16: 3834 ± 521 U20: 4338 ± 709
Soccer (4)	M	U12: 12.2 ± 0.4 U15: 15.0 ± 0.2 U18: 17.5 ± 0.4	U12: 157.1 ± 4.1 U15: 173.9 ± 5.6 U18: 181.2 ± 5.2	U12: 43.0 ± 4.8 U15: 56.8 ± 6.2 U18: 73.1 ± 8.1	(Per 14 days) U12: 659 ± 81 min U15: 869 ± 72 min U18: 846 ± 39 min U12: 38.3 ± 5.1 km U15: 53.7 ± 4.5 km U18: 54.4 ± 7.1 km	14 days	U12: 2859 ± 265 (range: 2738 – 3726) U15: 3029 ± 262 (range: 2275 – 3903) U18: 3586 ± 488 (range: 2806 – 5172)
Speed Skating (12)	M	18.2 ± 1.3	179.0 ± 3.0	75.7 ± 7.0	918 ± 42 min per 10 days	10 days	4013 ± 908 (range: 3057 – 5971)
Gymnastics (13)	M & F	7.6 ± 0.7	116.3 ± 2.4	20.0 ± 1.7	4 hours per day	10 days	2004 ± 258
Swimmers (10)	F	19 ± 1	178.3 ± 2.2	65.4 ± 1.6	~5-6 hours per day	5 days	5589 ± 502
Table Tennis (14)	M	20 ± 1	168.7 ± 4.1	58.9 ± 7.9	~3 hours per day	14 days	3695 ± 449

M=males. F=females. TEE=total energy expenditure.

Table 1: Total energy expenditures of adolescent athletes from different sports (assessed via the doubly labelled water technique).

where little evidence exists to suggest that carbohydrates, protein and fat needs differ from adults athletes. However, these needs should enable a young athlete to "fuel for the work required" for carbohydrate and/or heightened protein needs during periods of increased strength training or unique periods of activity reduction such as injury or off-season.

Despite the importance of hydration to human health (and performance), there remains a noticeable lack of any current guidelines specific to adolescents on fluid guidelines and replacement. Heat loss through sweat will result in fluid and electrolyte loss in adolescents just as adults. However, there are differences in sweat rates between adults and adolescents, but it appears reduced sweat rate does not impair heat loss during exercise in the young. Therefore, the recommendations on fluid replacement for adolescent athletes can be similar to the ones for adults.

Young athletes under consume fluids required during prolonged exercise. Simple strategies especially in hot and humid conditions should be used. These can include, the addition of flavourings water, use of ice slushies and planned fluid breaks during training/competition. The use of sports drinks should be avoided for shorter exercise periods, and when they are used, good oral health practices after 30 minutes of finishing exercise should be encouraged to reduce the risk of dental decay.

MICRONUTRIENTS

Whilst it is essential that adolescent athletes consume adequate amounts of all micronutrients, iron, calcium and vitamin D continue to receive the greatest attention.

CALCIUM AND VITAMIN D

As a key regulator of calcium homeostasis, Vitamin D is required in adequate levels for calcium absorption. Sufficient vitamin D levels and calcium are therefore crucial to ensure maximal bone mineral accumulation in developing adolescent athletes. Around 95% of adult bone mineral content is achieved by the end of adolescence, with ~26% of this accruing during peak bone mineral content velocity (~12.5 and ~14 years old in girls and boys respectively)[13]. During peak bone mineral content velocity skeletal calcium accretion is ~300mg per day[14]. Ensuring maximal bone mineral content accrual is of paramount importance for adolescent athletes, to maximise peak bone mass and help reduce the risk of skeletal injuries (e.g. stress fractures) and osteoporosis in adulthood.

Historically, adolescent athletes across multiple sports fail to meet their daily calcium requirements[15]. Various strategies are proposed as triggers to mitigate issues. For youth athletes, this includes consumption of a calcium rich snack/ meal prior to exercise to attenuate bone resorption (i.e. bone breakdown)[16].

In addition to its involvement in calcium homeostasis, vitamin D is also involved in supporting immune function and skeletal muscle regeneration[17]. Although a blanket approach to vitamin D3 supplementation is not advised, a common approach is to supplement athletes with during winter months when sun exposure is limited even without testing vitamin D status[18]. Particular attention should be given to adolescent athletes that train and compete indoors all year round[19].There is limited evidence for vitamin D3 supplementation having an ergogenic effect on athletic performance. Conversely, deficiency impairs musculoskeletal health and increases the risk of injury in adolescent athletes[20]. This may also extend to reduced power and force output in adolescent females [21].

IRON

During childhood and adolescence, iron requirements are increased as a result of growth in tissues. The onset of menstruation in females results in iron losses, increasing their requirements further[22]. Exercise can result in iron loss through haemolysis, as well as in urine, stool and sweat. Iron deficiency is highly prevalent amongst adolescent athletes (up to 50% in females), with inadequate dietary iron intake (often concomitant with inadequate energy intake and/or a vegetarian diet) often the main cause of iron deficiency[23].

Symptoms such as fatigue sensation and decreased performance can be associated to iron deficiency with or without anaemia. Improving iron status in deficient individuals can improve exercise efficiency[24] and reduce fatigue[25]. Thus, testing of adolescent athletes who present symptoms associated with iron deficiency (e.g. during regular medical check-up) will inform appropriate treatment strategies. Iron supplementation should only be taken following advice from a qualified professional.

PERFORMANCE NUTRITION AND THE COMPETITIVE ADOLESCENT

Supplement use in competitive adolescent athletes is wide spread. Recent surveys highlight 82.2% of athletes aged 15-18 years, competing at international level, in different sports are taking sports supplements, with protein powders being the most prevalent (54%)[26].

Recommended sports nutrition principles of using a food first approach i.e. eating the right amounts of the right types of food at the right times remains, in many cases, enough for the competitive adolescent athlete to meet their needs. This approach is supported by the latest expert consensus groups respective statements on nutrition in sport[1,28,29,30]. Sports drinks, sports foods and in some instances, carbohydrate gels remain the only supplements of potential value for competitive adolescents together with supplementation based on clinical needs. These can include iron, vitamin D and omega 3.

Certain supplements e.g. creatine, beta alanine, beetroot juice, caffeine may have an ergogenic effect in specific sporting situations in adult athletes as part of a well-planned approach. However, these supplements should be sparingly used with adolescent athletes. The use of creatine is common in the latter years of academy development programs (17-18 years) despite the lack of data on its safe use in young athletes. However, use amongst this population appears to be well-tolerated and holds ergogenic effects, including improved sprinting capacity, and lower body power

TABLE 2

Type of Session	*Description*	*U13 (number of sessions)*	*U14*	*U15*	*U16*	*U18*
Pitch-based	*Technical and tactical soccer specific training 60-90 minutes Age adapted volume & intensities*	*5*	*5*	*5*	*5*	*6*
Gym-based	*U13: BM movement 30 minutes 4-6 exercices x 3 sets x 8-10 repe-titions U14-U18 : external load inclusion 45 minutes 6-8 exercices x 2-4 sets x 5-10 re-petitions*	*3*	*3*	*3*	*3*	*4*
Yoga-based	*Active recovery and regeneration Stretching and movement competency 30 minutes*	*1*	*1*	*1*	*1*	*1*
Competitive match-play		*1*	*1*	*1*	*1*	*1*

U: under- Adapted from Hannon, Carney, et al., 2020

Table 2: Typical week in-season schedule for Premier League male Category 1 adolescent players.

output[27]. Creatine supplementation should be considered on an individual basis and not as a blanket approach. The use of protein powders is another example, where use may be justified as part of additional energy/ macronutrient needs in some athletes and to support muscle protein synthesis as they move towards adulthood.

Adolescence athletes' and their coaches and parents/guardians should have a long-term commitment to optimising the diet which alongside an appropriate training programme will provide the foundation for their athletic development. Supplements should not be seen as a quick fix method of bypassing the natural development process and the gains that come with that.

CLINICAL SPORT NUTRITION, THE INJURED ADOLESCENT ATHLETE AND AN ELITE SOCCER ACADEMY

Injury is an inevitable part of playing sport at a competitive level. Yet, research on nutritional support for sport related injuries in young athletes remains scant. In fact, the "energy cost" of rehabilitation in adolescents has yet to be established. In practice, requirements have to be adapted from adult parameters using experience, and knowledge of the rehabilitation process itself (Table 4).

Nutritional intake can affect the rehabilitation process. Nutritional needs may be assessed according to degree of immobilization, extent of physical activity reduction, and degree of lean mass loss. An injured athlete can go through two main stages starting at inflammation, immobilization, and muscle atrophy, leading to second stage of rehabilitation and return-to-play[31].

Comparable to adults, muscle strength loss and atrophy are markedly apparent within 5 days of immobilization, due to increased muscle protein breakdown in conjunction with reduced muscle-protein-synthesis (MPS). In adults, it has been estimated 150g of muscle mass is lost per day, or equivalent of 1Kg per week during injury and immobilization[32].

PRACTICAL CONSIDERATIONS

1. Busy schedules, often with limited feeding opportunities, requiring early morning training sessions and finishing with late evening matches or travel (Table 2).
2. Large variation in body composition (FFM) between U12 (31.6 ± 4.2Kg) and U16 squads (56.3 ± 5.3Kg) [4].
3. RMR progressively increases from under 12-16 age-groups after which there is limited increase in RMR[4].
4. Elite adolescent athletes may be at risk of poor nutrition and unhealthy eating habits.
5. Youth players approaching adult professional transition are more at risk of injuries and that time lost due to injury can prevent players achieving maximum match skills[33,34].
6. Injury rates during match exposure are higher than during training[34].
7. Half of adolescent soccer injuries are mild resulting in 1-week time loss, one third moderate with 1-4 weeks only, 10-15% were severe with time loss above 30 days. Average time loss for injury is 15 days[35].

NUTRITIONAL STRATEGIES: FROM THEORY TO PRACTICE

Nutritional support strategies during injury should be focused on minimizing the detrimental impact of the injury on muscle, tendon, ligament and bone, and enhancing the recovery process by increasing anabolic stimuli. During rehabilitation, nutritional support switches focus to supporting muscle hypertrophy and limb strengthening

Strategy #1 Initiate Early Athlete Contact

A typical athlete's reaction when injured is usually to reduce food intake. This may be accidental through the loss of a routine or a conscious one for fear of gaining weight through lower activity. The opposite may also occur because of anxiety triggered by the injury.

Nutritional support specifically during injury of adolescent athletes should not only focus on preventing unwanted fat gain. It should also avoid inappropriate eating behaviours in search of muscle gains and definition[36]. Adolescent athletes' parents and supporting staff should encourage positive body image attitudes and support a healthy relationship with food. Since recovery from injury is connected to performance, dietary education should be provided to limit loss of muscle and gain of fat during injury/rehabilitation. If meals preparation/access to food is of concern, the use of home delivery solutions with specific caloric content may be beneficial.

Strategy #2 Set realistic energy intake goals

Caloric restrictions during inflammation, immobilization and active rehabilitation phases may compromise healing. Ten

TABLE 3

Source	*RMR (Kcal/day)*	*Population*
Hannon, Carney, et al. (2020)	*FFM: 1315 + (11.1 x FFM in Kg)* *Body Mass: 1254 + (9.5 x body mass in Kg)*	*Male adolescent soccer players*
Reale et al. (2020)	*Male:* *11.1 x body mass (kg) + 8.4 x height (cm) – 340* *Female:* *11.1 x body mass (kg) + 8.4 x height (cm) – 537*	*Adolescent athletes, both genders*

RMR=Resting Metabolic Rate, FFM=Fat free Mass

Table 3: Typical week in-season schedule for Premier League male Category 1 adolescent players.

Table 4

Situation	*Recommendations*	*Rehabilitation Practical Considerations*	*Reference*
Daily Requirements	*CHO: 5-10 g·Kg-1·day-1*	*Applied to early injury stage of inflammation and immobilization.* *Adjust to degree and duration of immobilization, injury severity, use of ambulatory aid and growth needs.*	*Burke et al., 2011*
	Protein: 1.4-2.0 g·Kg-1·day *0.22-0.33 g·Kg-1·meal-1*	*Middle to higher bracket for longer immobilization, athlete close/during peak height velocity stage.* *Spread starting from breakfast until pre-bed snack.*	*Jäger et al., 2017* *Hannon, Close, et al., 2020* *Volterman et al., 2017*
	Hydration: rehabilitation session should start in a euhydrated state; sufficient amounts before, during and after rehabilitation should be consumed to support health and performance – monitoring of first daily urine color may be used as an assessment tool of hydration		*Maughan & Shirreffs, 2008*
	Fat: 20-35% of total caloric intake of which not more than 10% is from saturated fats		*Rodriguez et al., 2009* *Desbrow et al., 2014*
Pre-Rehabilitation (and field rehabilitation sessions)	*CHO: 1-4 g/kg*	*Applied to second phase of rehabilitation focusing on muscle strengthening/ hypertrophy.* *Adjusted according to rehabilitation session intensity.*	*Balsom et al., 1999* *Burke et al., 2011*
	Protein: 0.25-0.4 g·Kg-1	*Higher range before rehabilitation resistance exercise.*	*Morton et al., 2015*
	Hydration: 3–5 mL·kg-1 – *2 hours before the event*	*Due to large differences in sweat rate among youth athletes, a general guideline is not practical; individual hydration strategies are encouraged. Early rehabilitation sessions in injury have low training load while later sessions may entail higher sweat losses; drinking practice should be relative to the rehabilitation session load.*	*Sawka et al., 2007*

Table continued on the next page.

During Rehabilitation session	CHO	Light training: not required, as long as pre-training CHO is met	Applied to last stages of rehabilitation where training volume and load are high, often in the return to play phase.	Russell & Kingsley, 2014 Burke et al., 2011
		Hard training/ 2 sessions/day: 30-60 g·hr-1	Highest bracket when timing between sessions is less than 8 hours.	
	Hydration: consumption of fluids should be enough to avoid body weight losses of > 2% and to avoid weight gain.		Addition of flavoring to water such as squash may encourage voluntary drinking during the session.	Sawka et al., 2007
After Rehabilitation session	CHO	Light training: follow usual food plan to ensure meeting daily requirements	Recovery meals/snacks within moments of completing a rehabilitation session.	Burke et al., 2017 Burke et al., 2011
		Hard training/ 2 sessions/day: 1.0-1.2g·Kg-1·hr-1	Recovery meal/snack immediately after a rehabilitation session in the last stages of injury.	
	Protein: 20-25 g			Moore et al., 2009
	Hydration: if recovery between sessions is > 12 hours, then consume ad libitum fluids. For recovery time < 12 hours, drink 1.5 L of fluid for each kg lost during the session.		Aggressive rehydration strategies can be applied to the last stages of rehabilitation where training volume and load are high with sport specific rehabilitation, combined with fitness training, often in the field at the return to play phase. It is common for an injured athlete to undergo 2 sessions of rehab per day when reaching the return to play phase. Electrolyte replacement should be considered as well as hydration; milk has been shown to provide good electrolyte replacement. Flavored milk may be more favorable for adolescents who do not rehydrate sufficiently.	Sawka et al., 2007
Bedtime	CHO: 15 g			Snijders et al., 2015
	Protein: 27.5 g			Snijders et al., 2015

Hydration is summarized in the context of low load training season. CHO: carbohydrate

Table 4: Recommended intakes for selected macronutrients practically applied to rehabilitation stages for adolescent athletes (adapted from adult recommendations).

days of energy intake at 80% of demands can reduce muscle protein synthesis by up to 19%[37]. Energy expenditure may also be affected by the use of ambulatory-aids, requiring the energy cost 2-3 folds as compared to regular walking[38].

Prescription of an accurate energy requirement is difficult and may require a progressive adjustment. To determine the total energy expenditure during rehabilitation phase, it is advisable to use accurate adolescent specific RMR predication equations (Table 3). The addition of the activity energy expenditure should consider the demands of the rehabilitation sessions, possibly through validated wearable technology estimating energy expenditure.

Strategy #3 "Fuel for the work required"

Low levels of muscle glycogen and endogenous carbohydrate lead to further protein degradation, increases in muscle protein breakdown, and reduction of net protein balance effectively impairing the muscle/tendon/bone remodelling process[39]. Therefore, there is a need for a periodized plan during injury with a focus on carbohydrate availability, prior to and after rehabilitation sessions.

Carbohydrate intake during and following rehabilitation sessions must be enough to cover rehabilitation needs, to support MPS and net muscle protein balance, as well as to reduce future bone injury risk. Carbohydrate requirements may be best determined according to a training session duration/intensity (Table 4). Adolescent athletes should be educated to modify carbohydrate intake according to their changing daily requirements, possibly by using colour coded days according to increased/decreased carbohydrate needs.

Strategy #4 Focus on the "What, when and how much"

Injury periods can be an ideal time to re-engage young athlete's beliefs on the importance of nutrition that can continue when they return to play. During injury, insufficient daily intake of protein may delay wound healing and increase inflammation[40]. Latest research[4] show that adolescent protein requirements are similar to adults (1.4-2.0 g·Kg-1·day-1). Athletes need to be educated on understanding different portion sizes of protein and when to increase portions to

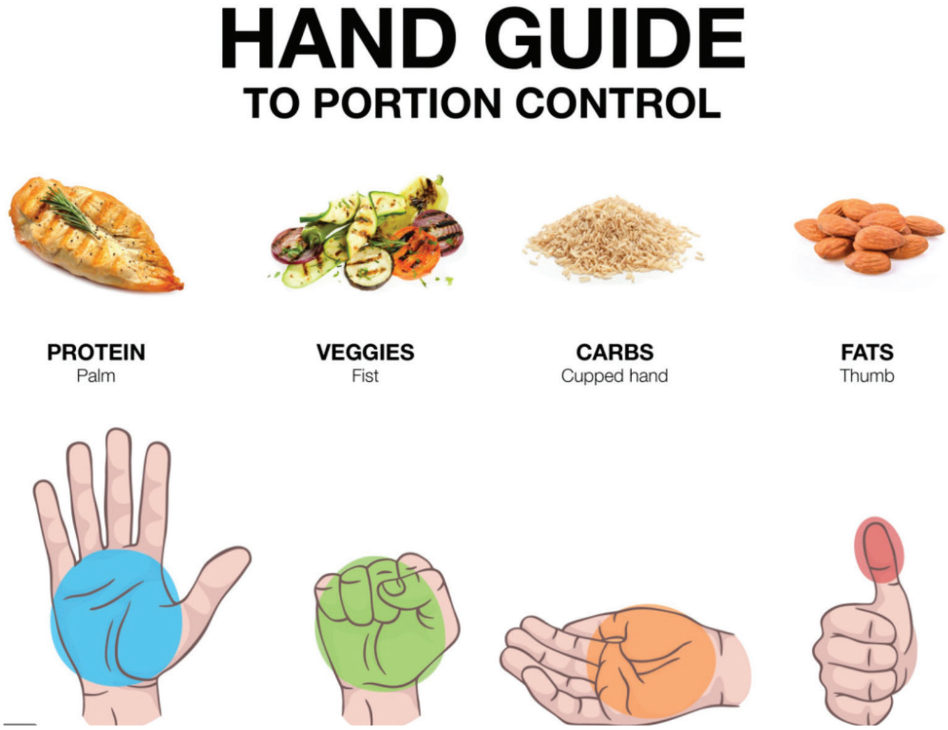


Figure 2: A simple Portion Control system using the hand. Differences in hand size do exist and this should be established when using this system with individuals to exclude any difficulty. Cupped hand for carbohydrate portions and thumb for fats are usually the key concerns.

meet a situational need. Key strategies linked to timing include:

1. Moderate doses of protein at 0.22-0.33g·Kg-1·meal-1, starting from breakfast should be consumed every 3-4hours throughout the day[41], including before/after exercise.
2. Focus on consuming a pre-bedtime protein meal/snack to promote muscle mass and strength increases[42].
3. Focused spread across the day of key essential amino acids containing-foods, known to influence MPS, such as dairy, eggs, meat, poultry, and seafood.
4. Use of hands to understand portion size (Figure 2).

Strategy #5 Unleash the power of food to support rehabilitation

Social media sources claim that many foods/supplements positively impact on health or a physiological process, many of which are unfounded. Emerging knowledge on the role of the gut, omega 3's, in addition to specific natural foods, such as curcumin and turmeric, suggest new avenues to supporting healing post-injury.

Recent evidence supports that using natural foods such as gelatin (including halal) may be beneficial for tendon/ligament injuries[43] and may be considered also for adolescent athletes.

Balancing ratios of omega-3 to omega-6 should be a focus point. Practically, this could be achieved by recommending the preferred foods containing high amounts of omega-3 and unsaturated fats and also encouraging avoidance of the more inflammatory trans-fat sources and processed foods.

TAKE HOME MESSAGES

- The energy intake of each adolescent athlete should be adequate to optimise not only growth and maturation but also stimulate training adaptations, promote recovery and enhance sporting performance.
- Before specific macronutrient recommendations can be provided it is first essential to understand the total daily energy expenditures of adolescent athletes competing in different sports.
- There is currently a lack of evidence to suggest that adolescent athletes have additional micronutrient requirements compared to their non-athletic peers. Certain micronutrients including calcium, vitamin D and iron are of

paramount importance for the growing and developing athlete.

- Whilst dietary supplements are advocated to and consumed by many adolescent athletes, a 'food first' approach is strongly advised. Coaches, parents/guardians and practitioners should be made aware of potential health risks associated with consuming dietary supplements that are not part of a third-party testing program.

References

Available at www.aspetar.com/journal

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Table 5

Time	Type of Meal	Description	Macronutrient
7:00 am	Breakfast	3 Tbsp. Oats 1 ½ cup milk full fat 4 pieces dates 1 ½ Tbsp. honey 1 tsp. flax seeds	Kcal: 544 Kcal CHO: 79 g Protein: 17.7 g Fat: 17.4 g
10:00 am	AM snack	1 mid-morning smoothie 1 cup milk full fat ½ piece banana 3 slices pineapple Ice cubes 1 Tbsp. peanut butter	Kcal: 386 Kcal CHO: 55.9 g Protein: 12 g Fat: 13.4 g
12:30 noon	Lunch	½ plate mixed brown and white rice pilaf Palm size beef meat cubes 1 medium bowl season salad with avocado 500 ml Water with a dash of squash	Kcal: 911 Kcal CHO: 87 g Protein: 29.8 g Fat: 49 g
3:00 pm	50 minutes Pre-rehab snack	Gelatin and Vitamin C jelly bowl: 2 berry flavored gelatin packs (20 g) diluted with 1 Vitamin C tablet 500 mg and water 1 chopped apple	Kcal: 163 Kcal CHO: 22.5 g Protein: 15.1 g Fat: 1.4 g
4:00-5:00 pm	During low intensity rehabilitation session	500 ml water	Kcal: 0 CHO: 0 Protein: 0 Fat: 0
5:20 pm	Post rehabilitation session	1 small tub Greek yoghurt full fat (180 g) 1 tsp. honey	Kcal: 233 Kcal CHO: 12.2 g Protein: 17.7 g Fat: 12.6 g
7:30 pm	Dinner	½ plate mashed potato with skin Palm size grilled cod fish 1 medium bowl broccoli salad 500 ml Water with a dash of squash	Kcal: 521 Kcal CHO: 62 Kcal Protein: 32 g Fat: 15.8 g
9:00 pm	Bedtime snack	Fresh strawberry milkshake 250 ml milk full fat with 1 cup strawberries and 2 tsp honey	Kcal: 252 Kcal CHO: 31.5 g Protein: 9.5 g Fat: 9.8 g
		Total Macronutrients	Kcal: 3010 Kcal CHO: 349.7 g - 5.5 g·Kg-1 Protein: 134.1 g - 2.1 g·Kg-1 Fat: 119.4 g - 1.8 g·Kg-1 ≈ 35% of energy intake

Analysis Software: Nutritics, 2019. CHO: carbohydrate – Tbsp: tablespoon – tsp: teaspoon.
Meal plan based on 15 year old player undergoing low cost rehabilitation in third week with gradual loading 40-60 minutes; weight= 63 Kg; Height= 175 cm; 11% fat; fat mass= 6.93 Kg; FFM= 56 Kg; Estimated cost of rehabilitation session (low intensity) ≈ 400 kcal; Resting Metabolic Rate= 2000 kcal; EA= 46 Kcal/Kg FFM per day.

Table 5: A meal plan for an adolescent soccer midfield player with right medial collateral knee ligament strain grade II requiring 4-6 weeks rehabilitation: 3 weeks restriction of motion with use of brace, followed by gradual increase in load to preserve muscle strength/function of lower limbs muscle, and gradual increase in tissue loading at local level for ligament healing/remodelling. To support growth, maturation and the rehabilitation demands, this player is consuming a daily intake of 46Kcal/Kg FFM, 5.5 g·Kg-1 carbohydrate, 2.1 g·Kg-1 protein and 1.8 g·Kg-1 fat (35% of energy intake).