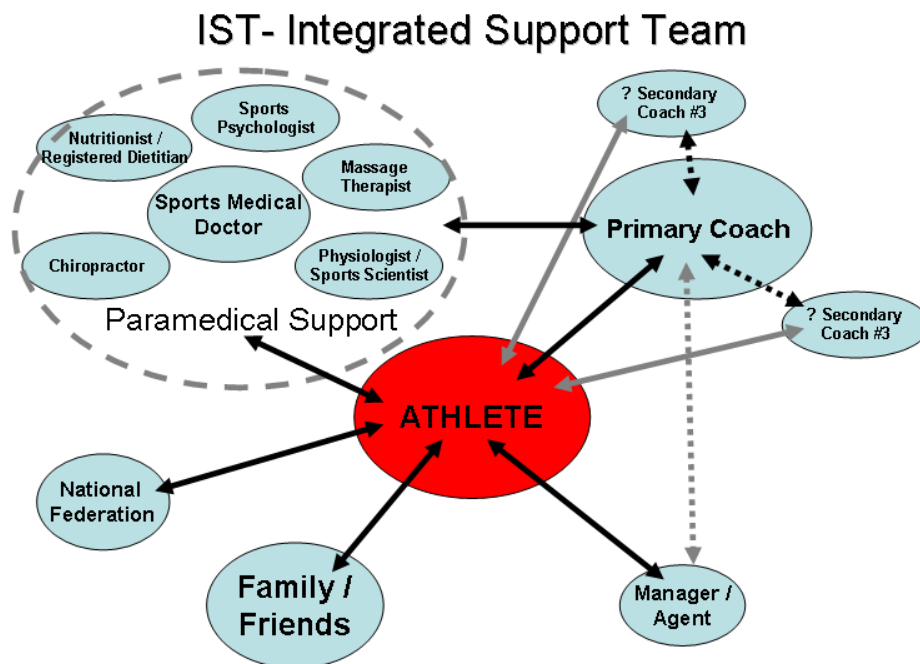


# Sport Nutrition Assessment: Questions, analysis and tools to consider

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Gaining the right information is imperative to be a highly effective sport dietician- whether you are working with a newcomer or an Olympian. For a young or new athlete, a standard three-day dietary record, emphasizing nutritional basics and some recovery nutrition tips, will provide the majority of the support they may need. On the other side of the continuum, Sport Canada has identified the need for elite Olympic level athletes to develop an 'Integrated Support Team' (IST) with their coaches- of which you, as a Registered Dietician (RD) or Nutritionist, may be apart of. An IST is a coach-driven group of professionals (doctors, physiotherapist, massage therapist, dietician/nutritionist, physiologist, sport psychologist, biomechanist etc.) who directly support and assist an athlete throughout the periodized yearly training program in their respective areas of expertise to allow the athlete to realize their fullest potential during a planned championship peak (Fig 1).

**Figure 1.** Schematic representation of members and interaction of an IST



With elite athletes, it is important that the level of support and expertise that a Registered Dietician (RD) / Nutritionist brings be developed and specialized. An appreciation of the individual athlete's periodized training program and how nutrition can be periodized around that program need to be considered. Knowing general human physiology and metabolism will allow you to better assess the types of energy/fuels that athletes are using in training, and thus, be more in tune with the potential shift in macro and micronutrients that may need to occur to support their training and competition load. Dr. Powers and Howley have a great and easy-to-read textbook covering the basics in this area called *Exercise Physiology: Theory*

and *Application to Fitness and Performance – 7<sup>th</sup> edition* (Powers & Howley, 2008). Two other great textbook resources for any RD specializing in exercise and sport performance are both either written or edited by Dr. Louise Burke (PhD, RD), Australian Institute of Sport Head RD for the past 20 years: 1) *Practical Sports Nutrition* (Burke, 2007) and 2) *Clinical Sports Nutrition- 3<sup>rd</sup> Edition* (Burke & Deakin, 2007).

The following short-review will highlight some of the best sport related questions to potentially ask, as well as the right tools you might consider utilizing, to optimize your approach with the varying types of athletes that you deal with in your practice.

### ***“Other” sport specific questions: appreciating physiology’s impact on nutrition***

Below is an outline of the many sport and nutrition questions/themes that you may consider using as part of your normal practice in relation to the types of individualized issues an athlete may be experiencing. Where applicable I have tried to include a good reference for the theme of the question below.

#### *Dietary and training questions to consider:*

- Desire to reduce body fat and body mass to enhance performance via enhanced power-to-mass relationship (O'Connor *et al.*, 2007)
- Risk of dietary extremes, disordered eating, and inadequate nutrition attributable to overemphasis on low body mass and body fat level (Nattiv *et al.*, 2007)
- Changes in physique during maturation and adolescence (Bar-Or, 2001)
- Negative effects of chronic energy restriction and long-term growth during maturation (Bar-Or, 2001; Nattiv *et al.*, 2007)
- Practical difficulties in consuming sufficient energy and CHO intake in a busy day (Burke *et al.*, 2001)
- Optimal recovery between multiple daily training sessions (Tarnopolsky, 1999; Jentjens & Jeukendrup, 2003; Burke *et al.*, 2004; Tipton & Wolfe, 2004; Stellingwerff *et al.*, 2007a)
- Timing of training and timing of recovery nutrition in relation to the rest of the athletes day (Tarnopolsky, 1999; Jentjens & Jeukendrup, 2003; Burke *et al.*, 2004; Tipton & Wolfe, 2004; Stellingwerff *et al.*, 2007a)
- Specific nutrition plan right after training for recovery nutrition (Tarnopolsky, 1999; Jentjens & Jeukendrup, 2003; Burke *et al.*, 2004; Tipton & Wolfe, 2004; Stellingwerff *et al.*, 2007a)
- Length of time it takes to eat after training (Include travel time etc.)
- Adequate fuel and fluid intakes during prolonged training sessions (Sawka *et al.*, 2007; Stellingwerff *et al.*, 2007b)
- Risk of low iron status, especially in female and vegetarian athletes
- Risk of menstrual disturbances in female athletes, female athlete triad, low bone mineral density (Nattiv *et al.*, 2007)
- Periodizing nutrition to meeting periodized training (Stellingwerff *et al.*, 2007a)
- High level of interest and/ or use of supplements (Maughan *et al.*, 2007)

- Compromise in achieving fuel requirements and adequate protein and micronutrient intakes when trying to achieve body weight and body fat goals (Nattiv *et al.*, 2007; O'Connor *et al.*, 2007)
- Mismatch between training energy expenditure and low energy intake to try and achieve very low body fat (Nattiv *et al.*, 2007; O'Connor *et al.*, 2007)
- Adequate protein intake to promote muscle mass gain during resistance training and to repair damaged muscle for recovery (Tarnopolsky, 1999; Tipton & Wolfe, 2004)
- Minimizing gastrointestinal issues before and during competition
- Consideration of caffeine to enhance performance (Tarnopolsky, 1994; Maughan *et al.*, 2007)
- Aggressive short-term recovery strategies needed (Jentjens & Jeukendrup, 2003)
- Travel-- life on the road and circuit
- Adjusting energy intake during taper to prevent excessive weight and fat gain (O'Connor *et al.*, 2007)

## Energy calculations

Obviously different athletes expend varying amounts of energy during their diverse activities. However, even the same athlete might expend incredibly different amounts of energy during training at unique parts of the periodized training year. For example, figure 2 below highlights that there might be as much as a 30 to 50% difference in daily energy expenditure between altered training loads from the early season endurance training phase (General Prep Phase) to the late season Competition Phase.

**Figure 2.** Documented overview of two male middle-distance athletes (1500m runners) and how their training and energy expenditure varies throughout the periodized training year.

### General Prep Phase: Jim Ryun- teenage middle-distance phenom



- Weekly mileage as high as 190km/week
  - Cover up to 20km in a single interval session
  - 12 to 14 running sessions per week
- (Nelson & Quercetani: *The Milers, Jafnews*, 1985)

**Huge energy daily/weekly aerobic energy expenditures (~3400 kcals/day) = greater fat and CHO based energy needs, with PRO**

### Competition Phase: Sebastian Coe- at 1984 LA Olympics



- 7 races in 9 days
  - Olympic 1500m gold and 800m silver
  - average weekly running: only ~32km/week
- (Martin & Coe: *Training Distance Runners*, Leisure Press, 1991)

**Smaller daily/weekly anaerobic based energy expenditure (~2200 kcals/day) + championship body comp = lower energy intakes, but emphasis on CHO + PRO**

Clearly, having an appreciation and understanding of these energy differences throughout the training week, months and year are important in guiding nutrition recommendations. There are several scientific laboratory methods that can be used to assess what an athlete's energy outputs are during rest or exercise, the main one being indirect calorimetry (having athletes breathe into a metabolic cart during rest and exercise to measure exercise energy expenditure (EEE)). But, this method is completely impractical for non-research settings.

Instead, there are a couple of easy to use equations to get a general appraisal of the amount of daily energy an individual may be expending, which is:

***exercise energy expenditure (EEE) + basal metabolic rate (BMR) + thermic effect of food (TEF)***

Estimate of basal metabolic rate (BMR): One can roughly estimate a person's BMR by the following equation:  **$BMR = 70 \times \text{weight}^{0.75}$** ; where weight is in kg

Thermic Effect of Food (TEF): One can roughly estimate the TEF, as calculating:

**TEF = ~10% of total daily energy intake**

Exercise energy expenditure (EEE): The need to express the energy cost of exercise in simple units has led to the development of the term metabolic equivalent (MET), and one MET is equal to a person's resting VO<sub>2</sub> (resting oxygen consumption ~ basal metabolic rate (BMR)) (Powers & Howley, 2008). You can find in textbooks or online entire tables of MET's for almost every activity imaginable (Juggling: 4.0 METs; Running 6min/mile: 16 METs).

**Energy expenditure (kcal/min) = 0.0175 kcal x MET x kg BW**

There is also another very simple equation that can be used as a rough estimate for energy expenditure during walking or running over level surface:

**Energy expenditure of walking or running (kcal) = 1kcal x kg BW x 1km distance**

An example: a 65kg male goes for a 20km run in 75min. Estimate his EEE and daily energy expenditure.

*Estimate the energy expenditure of the run:*

20km in 75min = ~6min/mile = 16 METs

0.0175 kcal/min X 16 METS x 65kg = 18.2 kcal/min x 75min = 1365 kcal for his run

OR

1 kcal/kg/kilometer = 65kg x 20km = 1300 kcal

*Estimate his BMR:*

$BMR = 70 \times \text{weight}^{0.75} = \sim 1600 \text{kcal}$

*Estimate is TEF (he consumes about 2900kcal/day)*

~10% of daily energy intake = 290 kcal

*Therefore his daily energy expenditure is:*

$1300 \text{kcal} (\text{run}) + 1600 \text{kcal} (\text{BMR}) + 290 \text{kcal} (\text{TEF}) = \sim 3200 \text{kcal}$

## **Body composition**

All specialized sports have an ideal height, weight and body composition (O'Connor *et al.*, 2007), which are dictated by individual dietary and exercise habits, but also to a large degree by genetics. However, beyond this 'ideal' or normal height, weight and body composition, there are always athletes that excel who do not exactly fit within this mold.

A number of athletes (primarily female) are over-mindful of the benefit that low body weight brings to performance, and many believe that post-exercise protein consumption may bring unwanted gains in muscle mass, ultimately leading to weight gain (Nattiv *et al.*, 2007; O'Connor *et al.*, 2007). However, recent evidence has suggested that the specific exercise stimulus (resistance vs. endurance), rather than the nutrition intervention, plays a more dominant role in the divergent signaling pathways and the types of proteins that are synthesized after exercise, which explains the adaptive response and divergent phenotypes (Coffey & Hawley, 2007). Thus, protein intake should not be avoided on the premise that it might lead to unwanted muscle mass, and weight.

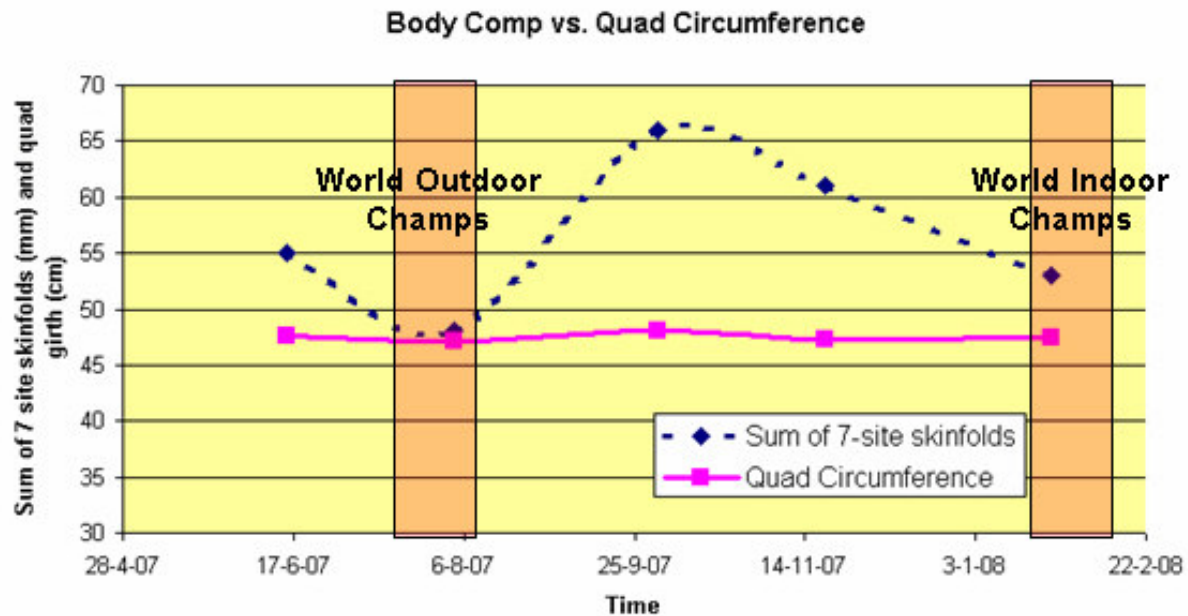
In line with this, several recent studies have shown that higher-protein intakes spare muscle protein and enhance fat loss during periods of energy restriction (Phillips, 2006). Given this, it might be advantageous for athletes looking to lose weight, while maintaining muscle mass, to slightly increase protein intake up to ~35% E, as this may result in a metabolic advantage in changing body composition during situations of energy restriction

In already lean athletes, and/or young athletes who are looking to lose further weight, it is also wise to only undertake body fat and weight reduction via negative energy balance under the supervision of an expert dietician/physiologist. In many circumstances, further weight loss in already lean athletes actually can cause a loss of muscular power and strength, an increased risk for stress fractures, a decreased immune function and circumstances leading to female athlete triad (Loucks & Thuma, 2003; Ihle & Loucks, 2004; Nattiv *et al.*, 2007), which all lead to a decrease in performance and a compromised healthy situation. For example, a runner or cyclist who is already very lean would not enhance performance by losing another 3% of body weight and fat if at the same time he or she also lost significant leg muscle mass (quad girth). By measuring and assessing this over time, one can truly see if they are making ideal periodized changes in their body weight, body fat percentage and in their muscle girths. Like training and nutrition, body composition should also be periodized over time and athletes should only aspire to be truly at competition 'performance weight' for short periods of time throughout the year (Fig. 3). Too many athletes aspire to be at competition weight year round—this can be both physically and emotionally difficult and can lead to risk of injury, sickness and health issues.

A common question RDs/physiologists face is what is the lowest percent body fat that males and females should seek to optimize performance? This is a very difficult question to answer, as each individual will have a differing metabolism, which will support a differing lowest % body fat, while still being healthy. Some female athletes can be as low as 8 to 10% body fat and still have a normal and function menstrual cycle and all normal and healthy blood parameters, while the next elite female athlete might lose her menstrual cycle once she drops below 15% body fat.

In the end, optimizing body composition can also involve a high degree of emotional and psychological body image stress, which needs to be properly and positively addressed by a nutritional expert, along with the coach, family and sometimes a psychologist to ensure no disordered eating arises.

**Figure 3:** Body composition measurements made of a weight-dependant track and field athlete throughout a training year.



Techniques to measure and monitor body composition changes over time:

There are several ways to non-invasively measure body composition over time that include:

- body weight, body height, girths (easy, inexpensive, practical, limited information, accurate information)
- skinfolds (ISAK method) (more technical, need someone trained, inexpensive, less practical, more information, but lower accuracy)
- bio-impedance analysis (BIA) scales (ie. TANITA etc.-- easy to use, less expensive, practical for home use, more information, but even lower accuracy)
- underwater weighing (very technical, expensive upkeep, impractical, Gold standard for accuracy)
- iDEXA (technical- but easy to use, VERY expensive, very accurate, 'new' gold standard?)

**Blood work**

Another nutrition assessment tool to consider is a standard blood analysis. However, unlike some other more non-invasive and inexpensive tools, a blood work analysis only provides a periodic snap-shot at a given time. Unfortunately, to date there is no single key blood parameter that can acutely indicate something as simple as over-training. The human organism is much too adaptable and diverse for the majority of blood parameters to be useful for a single given analysis. However, there are some blood measures, particularly iron assessment, which if the athlete is deficient on can certainly have negative impacts on performance.

However, if an athlete is closely tracked over time (almost monthly or even bi-monthly) with a series of blood and other practical measurements, and in close contact with the coach and IST, an individual profile can be established over time. Then there are certain individual blood measurements that may indicate over-reaching, over-training, or conversely, optimal and peak performance- but this type of analysis is accomplished from an individualized baseline and tracking over time.

One of the most important blood measurements to get is iron status (Table 1). Iron deficiency anemia is much more prevalent than most people realize. It is estimated that 20% of women, 50% of pregnant women and 5% of men are iron deficient. Therefore, since iron stores are so vital to healthy and viable RBCs, and ultimately to an athlete’s performance, I would recommend at least a yearly blood iron analysis.

**Table 1:** Common iron blood parameters

Parameter	Females	Males
hematocrit	36.1 to 44.3%	40.7 to 50.3%
hemoglobin	12.1 to 15.1 g/dl	13.8 to 18.2 g/dl
serum ferritin	12 to 150 ng/ml	12 to 300 ng/ml
serum iron	iron: 60 to 170 mcg/dl TIBC: 240-450 mcg/dl transferrin saturation: 20-50%	

(note: for ferritin units ng/ml = ug/L)

Again, I would recommend that all serious athletes (regardless of whether athletes have had issues before or whether altitude training is planned or not) get their blood checked for these parameters at least yearly (females should be checked several times per year and especially if already at risk). It should also be noted that there is a range that is considered “normal,” but elite level athletes are anything but normal humans, due to the daily strain of training and racing placed on their entire body. So if an athlete’s blood iron values are on the low-end of the normal range (Table 1), it would probably be good to start an iron supplement and it would also not be wise to undertake any altitude training, since this will place the athlete at a greater risk for iron deficiency anaemia.

If you have the opportunity to measure and track many blood parameters, and you are dealing with at least an international level athlete, you might consider some of the following. Again, unless extremely over or under normal parameters, many of these measurements need to be individually base lined and tracked over time to better assess trends with athletes.

General health (maybe measured once per year)

HDL-Cholesterol, LDL-Cholesterol, Triglycerides

Thyroid Function: Free T3, Total T3, Free T4, Total T4

Inflammation: C-reactive protein (also potentially linked to over-training)

Vitamins/Minerals: Vit. D, Vit. A, B-Vitamins (vegetarian), Zinc, Magnesium, Calcium

Iron status and anaemia: The following biomarkers relate to the breakdown and formation of red blood cells and the ability to transport oxygen which is closely linked with performance.

Iron, Ferritin, Haematocrit, Haemoglobin

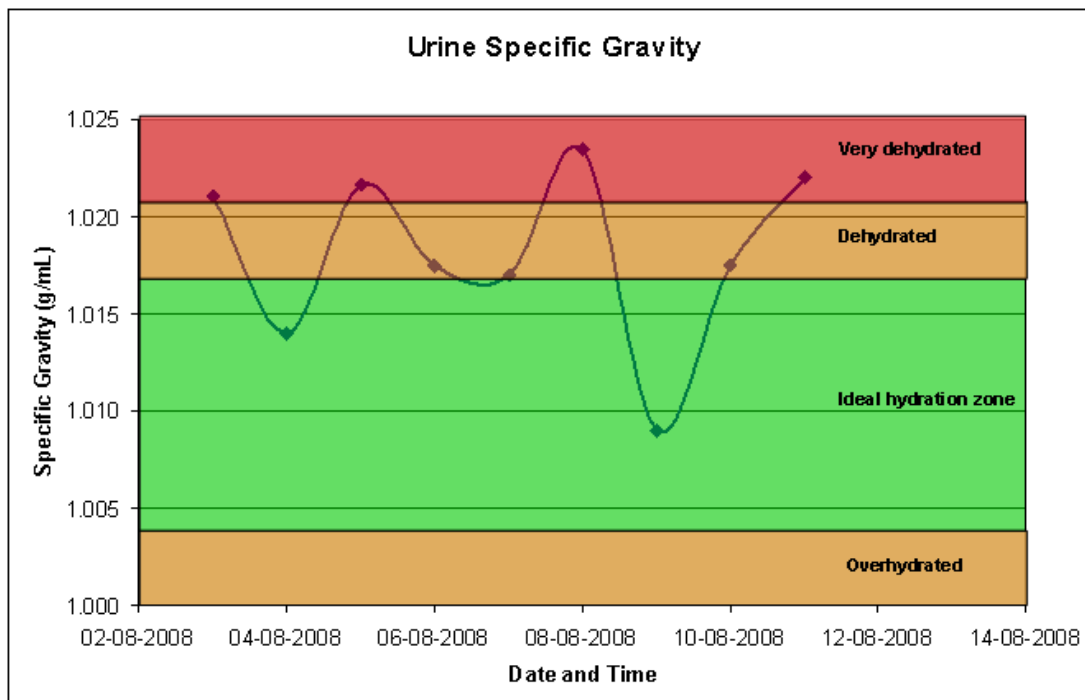
Training stress: The following biomarkers can be used to assess training stress, by assessing sensitive markers of muscle, bone and connective tissue breakdown on an individual basis. Excessive muscle and connective tissue breakdown results in overuse related muscle injury and these biomarkers can potentially be used to modify training load and reduce injury risk. .  
Muscle: Creatine kinase  
Hormonal: Cortisol, Testosterone

## Hydration

The most recent American College of Sports Medicine (ACSM) Position Stand on hydration and fluids (Sawka *et al.*, 2007) took a different perspective on hydration than previous expert recommendations in that the advice was much more individualized, instead of generalized. This most recent position stand takes into account the robust data showing that very similar individuals (in height, weight and body composition, ethnicity and training status) can have very different sweat fluid and electrolyte losses. At the cornerstone of this recent position stand was the need for athletes to assess their own individual fluid losses in differing weather conditions, to come up with their own individualized drinking recommendations.

There are several easy and practical tools that an RD/nutritionist can implement in the assessment of hydration status (Sawka *et al.*, 2007). The easiest way is to assess pre and post-exercise body weight (in kg), and subtract the amount of fluid intake in liters to determine the total body sweat rate (in liters, note 1 liter = 1 kg of weight). Athletes can very quickly calculate their individual sweat rates in different weather conditions, and adjust drinking schedules accordingly to try to stay within 2 to 3% of BW fluid losses. Also, in team camp situations, daily hydration status can be monitored by a simple assessment via a morning urine sample and measured by the hand refractometer that measures urine specific gravity (USG). Below (Figure 4) is the data of a given athlete at the 2008 Olympic Games and his/her hydration status during the pre-training camp.

**Figure 4.** Urine specific gravity measures for athlete X at the pre-2008 Olympic camp.



### ***Being a recovery expert beyond just a nutrition expert***

Optimizing recovery via individualized nutritional recommendations and protocols can have a large impact in training load, quality and ultimately performance for a given athlete. Hard training is catabolic in nature. It is only during recovery, of which nutrition is one of the cornerstones, that the benefits of the hard work are realized through the recovery of muscle energy stores (primarily glycogen) and the synthesis of new proteins. All athletes across different sports utilize an incredibly diverse and varied exercise stimulus. Therefore, depending on the previous exercise mode, intensity and duration, the acute recovery nutritional recommendations will also vary. Table 2 below gives general recovery nutrition recommendations based on the type, intensity and volume of training that can be applied to any individual athlete (per kg basis) and any individual sport.

Another way to track the effectiveness of your nutritional interventions over time, or identify at risk athletes for over-reaching or over-training, are through simple questionnaire based approaches. Here are 3 different established and scientifically verified questionnaires that can be utilized:

- ❑ **DALDA - Daily Analysis of Life Demands in Athletes.** This 1 page, 34 question analysis can be used daily to track not only training stress, but life stress, in athletes. (Rushall, 1990)
- ❑ **TQR – Total Quality Recovery.** Total quality recovery (TQR) is a concept that looks at recovery as a combination of recovery actions and the athlete's perceptions of recovery. It gives coaches and athletes a simple yet effective checklist of actions that lead to TQR without using more complicated or invasive tests. It is so simple that it can be done daily and it is easily assessed by the coach. Should recovery not be occurring as planned, the lacking action is easily identifiable. (Kenntta & Hassmen, 1998)
- ❑ **POMS – Profile of Mood States.** A test designed to measure certain psychological traits. Profile Of Mood States (POMS) is a popular tool among sport psychologists who have used it to compare the prevailing moods of elite athletes and non-athletes and to identify over-reaching and over-training symptoms. (Morgan, 1980)

**Table 2:** Summary of acute post-exercise dietary recommendations in respect to specific type of training.

Type of Training	Examples of Training Sessions	Fuels Utilized	Acute Nutrition Recommendations
<b>Aerobic capacity &amp; power-oxidative &amp; glycolytic enzymes / VO2max / AT</b>	1) >2hrs cycling 2) >75min running 3) >75min swimming	Mainly FATS	<b>during aerobic training:</b> CHO: $\sim 1-1.4 \text{ g}\cdot\text{kg}^{-1}\cdot\text{hr}^{-1}$ sports drink  <i>exp: <math>\sim 800</math> to <math>1000\text{ml}</math> sports drink per hr</i>
<b>Anaerobic capacity &amp; power-glycolytic enzymes / CHO metabolism / muscular strength / running economy</b>	(Note: all of the described training sessions below could be applied to cycling, swimming and running) 1) 30sec reps on 1min recov. 2) 10x1min on 2min recov. 3) hill runs of 15-30sec 4) 90sec reps on 5min recov.	FATS/CHO	<b>short term (&lt;4hrs) recov:</b> in small repeated doses over first 2hrs post-exerc CHO: $1.2-1.5 \text{ g}\cdot\text{kg}^{-1}\cdot\text{hr}^{-1}$  <i>exp: <math>\sim 800</math> to <math>1200\text{ml}</math> sports drink per hr</i>
		CHO	<b>longer term (&gt;20hrs) recov:</b> over first 2hrs post-exerc CHO: $\sim 1\text{g}\cdot\text{kg}^{-1}\cdot\text{hr}^{-1}$ total PRO: $\sim 0.3 \text{ g}\cdot\text{kg}^{-1}\cdot\text{hr}^{-1}$ FAT: $\sim 0.1 \text{ g}\cdot\text{kg}^{-1}\cdot\text{hr}^{-1}$ <i>exp: 1) whole-wheat bagel + peanut butter 2) 750ml sports drink + protein bar 3) 2 cups cereal + milk + banana 4) tuna on whole wheat + 500ml juice 5) chocolate milk + low-fat fruit yogurt</i>
<b>Explosive training and technical work-maximal contraction ability / muscular hypertrophy / technique &amp; economy</b>	1) weight training 2) plyometric jump training 3) sprint & speed drills 4) hill sprints	CHO & ATP/CP	<b>during and 2hrs post-resistance exerc:</b>  CHO: $\sim 0.5 \text{ g}\cdot\text{kg}^{-1}\cdot\text{hr}^{-1}$ total PRO: $\sim 0.3 \text{ g}\cdot\text{kg}^{-1}\cdot\text{hr}^{-1}$ EAA: $\sim 0.1 \text{ g}\cdot\text{kg}^{-1}\cdot\text{hr}^{-1}$ <i>exp: 1) 500ml sports drink + protein bar 2) 250ml of milk + piece of fruit</i>

AT, anaerobic or lactate threshold; CHO, carbohydrate; CP, creatine phosphate; EAA, essential amino acids; exerc, exercise; exp, example; PRO, protein; recov, recovery.

Nutrition recommendations adapted from (Tarnopolsky, 1999; Jentjens & Jeukendrup, 2003; Burke *et al.*, 2004; Tipton & Wolfe, 2004; Stellingwerff *et al.*, 2007a).

Collectively, these approaches and tools can offer a RD/nutritionist a further individualized dimension to their recovery approaches with athletes. Nearly all elite athletes and coaches readily agree that with all types of training, there is an ideal time, place, duration and intensity that should be carefully planned for optimal performance. This same type of rigorous and comprehensive approach needs to be implemented when considering acute and chronic nutrition interventions. At the elite level, nutrition, training and racing interactions need to be highly monitored and continually altered and individualized.

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