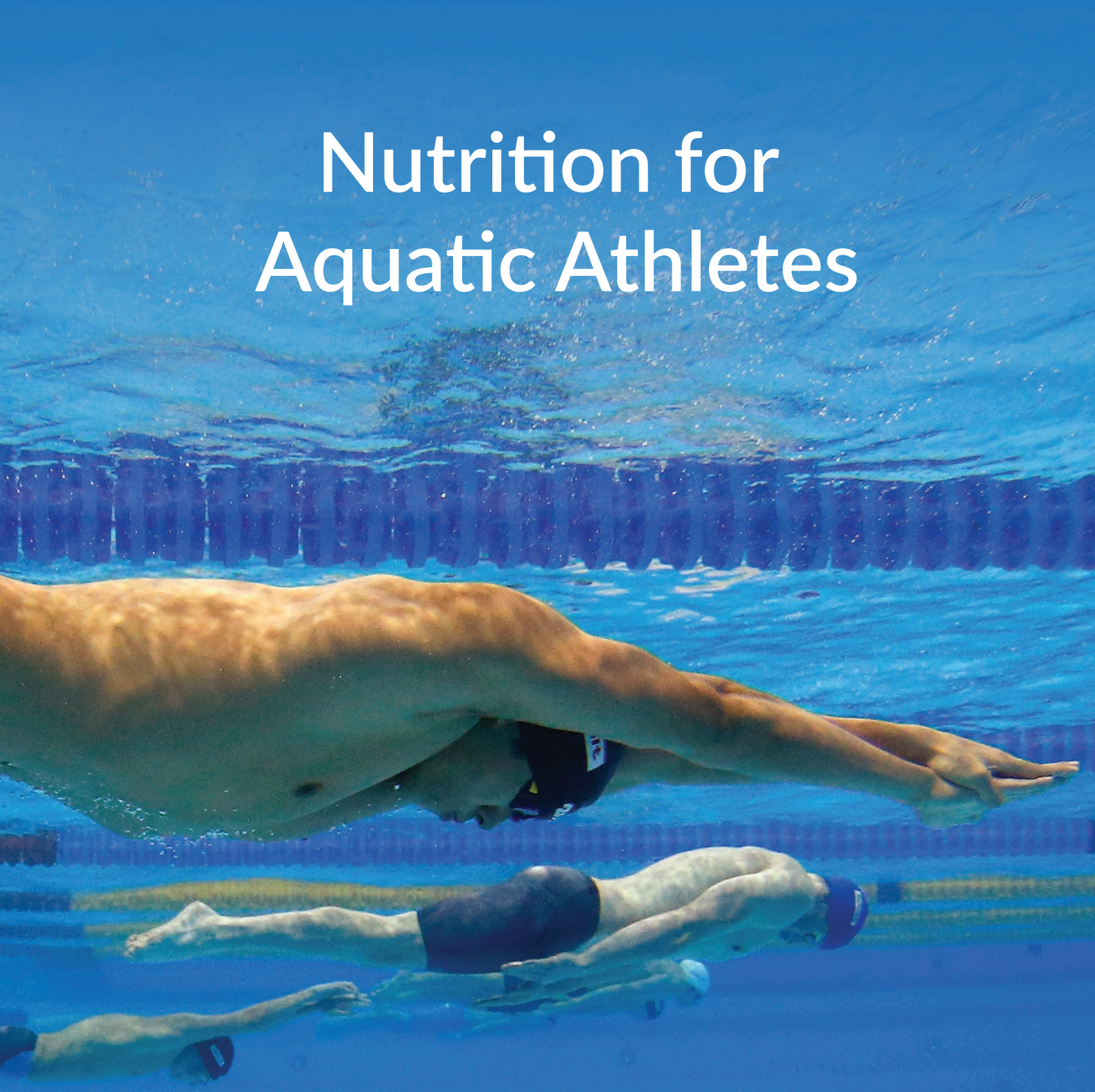
Nutrition for Aquatic Athletes



A practical guide to eating for health and performance

Fina
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Introduction

FINA President' message

It is my great pleasure to introduce the *FINA-Yakult Nutrition Brochure*, a very useful publication aiming at giving practical information on an important matter: the nutritional needs of our aquatic athletes.

FINA is fortunate to have great Stars in our six aquatic disciplines and much has been said and written about their meticulous and demanding preparation for our major competitions. The technique, the biomechanics, the dry-land training, or the prevention of injuries are recurrent themes in the specialised literature, but I believe that the specific theme of nutrition also deserves a thorough work like the one presented in this brochure.

Based on a specific Conference hosted by FINA and Yakult in London (GBR), in 2013, this publication details all the aspects related to a healthy strategy in this field, highlighting the specific needs in each of our sports. It has also in consideration different groups (young athletes, female competitors…) and multiple situations (training, travelling, competition…).

Our FINA Sports Medicine Committee has been very active in researching and publicising all matters related with the health of our athletes. The organisation of the FINA World Sports Medicine Congress, every two years, is a concrete example of this effort and is already a fundamental rendezvous for all the experts in this domain.

I am sure that this brochure will, once more, be a powerful tool to disseminate this message in such an important matter.

I take this opportunity to sincerely thank all those responsible for its publication and I also express my gratitude to the experts that gave their contribution on athletes' nutrition.

Finally, I address my appreciation and recognition to our partner Yakult for its involvement and support to this project.

The best reward to this valuable work will be given by our Stars. Thanks to these guidelines, their preparation will improve and, in consequence, their performances will be even better. This will continue bringing additional value to Aquatics in the five continents!

Message from Yakult

Yakult

For 80 years, Yakult has continued to conduct business activities as heirs to the passionate spirit of our founder Dr. Minoru Shirota to deliver good health to as many people as possible.

His philosophy includes the ideas of "preventive medicine," "a healthy intestinal tract leads to a long life," and "a price anyone can afford." All three, together with "sincerity" and "harmony among people," form the foundation upon which we have built our businesses, and we refer to them collectively as "Shirota-ism." Shirota-ism has been the root of our business since our founding, and it has continued to be cherished to this day, without being swayed by the changing times.

Yakult is working to expand its business based on Shirota-ism and our corporate philosophy of "We contribute to the health and happiness of people around the world through pursuit of excellence in life science in general and our research and experience in microorganisms in particular" in the aim to become a global company embraced by people throughout the world.

FINA official partner
Yakult had for some time been looking for a partner that understood our philosophy. The result of this search was FINA, whose philosophy of "contributing to the creation of rich lifestyles for people throughout the world by promoting good health through aquatics" matched well with our corporate philosophy. This led to us becoming a sponsor in 2005, which marked the 70th anniversary of our founding. Since then we have been sponsoring the FINA World Championships and the FINA World Swimming Championships (25m) as a FINA official partner, and are supporting the development of aquatics worldwide.

Yakult will continue to work with FINA to further support the development of aquatic sports around the globe.

Key Messages

Many factors contribute to success in sport, including talent, training, motivation and resistance to injury and illness. When highly talented, motivated and well trained athletes gather for competition, the margin between victory and defeat is usually small. Attention to every detail can make that vital difference, and nutrition is a key element of the serious athlete's preparation.

Diet affects performance in all events, and the foods that we choose in training and competition will affect how well we train and compete. Athletes need to be aware of their nutritional goals and of how they can select an eating strategy to meet those goals.

Diet may have its biggest impact during training, and a good diet will help support consistent intensive training while reducing the risk of illness or injury. Good food choices can also optimise the adaptations in muscle and other tissues in response to the training stimulus.

Athletes are all different, and there is no single diet that meets the needs of all athletes at all times. Individual needs also change across the season and athletes must be flexible to accommodate this.

Getting the right amount of energy to stay healthy and to tolerate the often large training volumes is a key goal of the everyday diet. Consume too much energy and body fat increases: too little and performance falls and illness results. Developing the perfect physique requires careful integration of training and diet.

Carbohydrate is a key nutrient for energy supply, but carbohydrate needs will depend on the training load and therefore vary from day to day and across the season. Athletes must be aware of foods that are good sources of carbohydrate and make these a focus of their diet.

Protein foods are important for building and repairing muscles, but a varied diet containing everyday foods will generally supply more than enough protein. The timing and type of protein are as important as the amount of protein in the diet. Well-chosen vegetarian diets can meet an athlete's protein needs.

A varied and wholesome nutrient-rich diet that meets energy needs and is based largely on vegetables, fruits, beans, legumes, grains, lean animal meats, dairy produce and oils should ensure an adequate intake of all essential vitamins and minerals.

Maintaining hydration is important for performance. An adequate intake of fluid before, during (where appropriate), and after exercise is especially important in hot climates. Salt (sodium) replacement is important when sweat losses are high, but needs vary between athletes.

Athletes are cautioned against the indiscriminate use of dietary supplements, but careful and strategic use of a small number of supplements and sports foods, ideally in consultation with a sports nutrition expert, may benefit some athletes.

Food is an important part of life, and athletes should enjoy the foods that they eat, confident in the knowledge that they have made wise choices.

This booklet contains information that will help all athletes in aquatics sports to make informed choices to meet their nutritional needs in different situations. It is no substitute for individual advice from a qualified professional, but tries to give practical information that will be of use to the serious athlete.

Nutrition for the Elite Athlete

Competitive athletes may train 300-600 times each year, but most will eat 1200-1600 times in the same period. Therefore, well-chosen eating practices have much to offer the athlete:

- Fuel to train and perform at a competitive level
- Optimum gains from the training program
- Enhanced recovery between workouts and between events
- Achievement and maintenance of an ideal body weight and physique
- Benefits from the many health-promoting components of food
- A reduced risk of injury, overtraining fatigue and illness
- Sustained concentration and mental skills over the day
- Confidence in being well-prepared to face competition
- Achievement of consistent high-level competition performances
- Enjoyment of food and social eating occasions at home and during travel

Despite these advantages, many athletes do not meet their nutrition goals. Common problems and challenges include

- Poor knowledge of foods and inadequate cooking skills
- Poor or outdated knowledge of sports nutrition
- Lack of access to dietitians /nutrition professionals or other credible resources
- Inadequate finances
- Busy lifestyle leading to inadequate time to obtain or consume appropriate foods
- Poor availability of good food choices
- Frequent travel
- Indiscriminate use of large amounts of supplements or failure to use evidence-based supplements and sports foods in the appropriate way

The information in this booklet is designed to provide coaches and athletes with an overview of the latest guidelines in sports nutrition. While there is no such thing as a magic diet or food, there are many ways in which eating well can allow athletes at all levels of performance to achieve the specific goals of their training and competition programs.

It makes no sense to train hard and ignore the benefits that good food choices offer to maximise training and performance.

The information is based on a conference hosted by FINA in London in December 2013.

This booklet is based on the scientific contributions to the FINA conference of: Margo Mountjoy (FINA Bureau), Ron Maughan, Louise Burke, Dan Benardot, Dave Costill, Greg Cox, Wim Derave, Anu Koivsto, Anna Melin, Iñigo Mujika, David Pyne, Sherry Robertson, Rick Sharpe, Greg Shaw, Trent Stellingwerff, Kevin Tipton, Evert Verhagen, Wes Zimmermann, Cees-Rein van den Hoogenband, Saul Marks, David Gerrard, Kevin Boyd, and James Miller.

Part 1 General Principles: Nutrition Goals & Eating Strategies

Energy needs

An athlete's self-selected energy intake sets the *"budget"* from which an athlete must meet their needs for carbohydrate, protein and fat, as well as the range of foods that provide vitamins, minerals and other health-promoting dietary factors.
An athlete's energy requirements are made up of several components:

- **baseline metabolic needs** (such as the energy required to support cellular maintenance, temperature regulation and immune health),
- **growth** (including an increase in muscle mass) and,
- **physical activity**.

Energy expended in one of these processes is not available for others, so the diet must provide sufficient energy to meet the needs of all essential functions. Physical activity – or in the case of an athlete, the intensity, duration and frequency of training sessions and competitions - will play a strong role in determining daily energy requirements.

When daily intake of food energy from carbohydrate, fat, protein (and alcohol) is equal to energy expenditure, the athlete is said to be in ***energy balance***.

Energy balance = Energy intake – energy expenditure

This means there is neither a net loss nor gain from the body's energy stores of fat, protein and carbohydrate, and is the desirable state for much of our lives. These energy stores play a number of important roles related to exercise performance, contributing to:

- an athlete's size and physique (e.g. body fat stores and muscle mass)
- function (e.g. muscle mass)
- fuel for exercise (e.g. muscle and liver glycogen stores)

Athletes often want to change their energy balance, either to produce an energy deficit (principally to reduce the size of body fat stores and therefore, body mass) or to achieve an energy surplus (principally to support growth or support the gain of muscle mass). This can be done either by altering energy intake, energy expenditure or both components.

However, an important new concept is that of ***energy availability***. This is defined as the energy that is available to the body after the energy cost of physical activity has been deducted from daily energy intake. Energy availability is therefore, the amount of energy that can be expended to look after the body's physiological needs.

Energy availability = Energy intake – Energy cost of training/competition*

(* = total energy expenditure during the exercise minus the background cost of being sedentary during this period)

The body can cope with a small drop in energy availability, but if it becomes too great, this will compromise its ability to undertake the processes needed for optimum health and function, and ultimately, training.

We now recognise that many health problems commonly seen in athletes are associated with low energy availability - these include menstrual disturbances in female athletes, reduced basal metabolic rate, compromised immunity, poor hormonal function and impaired bone density. Importantly, there is mounting

evidence, that low energy availability directly reduces performance. For example, a study of a swimming squad showed that swimmers whose diets were found to be energy deficient suffered a decrease in race speed after a lengthy training block while their teammates gained a substantial improvement in their swimming speed with the same workouts. Unfortunately, low energy availability may be not always be easily visible since it often occurs in athletes who are weight stable and not necessarily lean/light.

Although any reduction in energy availability has some effect on the body, researchers have identified a threshold below which the consequences are particularly harmful. This is usually discussed in terms of an athlete's Fat Free Mass (FFM) – i.e. Body mass minus Body fat. This threshold is set at 30 kcal (125 kJ) per kg FFM. Examples of adequate and low energy availability are provided below.

There are three situations that are typically associated with low energy availability.

- Disordered eating and eating disorders. We used to think this was the main cause of energy deficiencies, causing some stigma to the athletes involved. Disordered eating requires early intervention and specialist help, but we now know that many athletes can get into situations of low energy availability without this backdrop
- Restricted eating for weight control or loss or body fat. Many athletes undertake such campaigns with the best of intentions and, often, good reasons. However, the degree of energy deficit achieved by reduced energy intake or increased exercise may be too severe for good health or to support training. Even when weight loss is undertaken without any problem behaviour or undue stress, trying to achieve it at too fast a rate is likely to lead to unnecessary compromises of health and performance. In some cases, low energy availability causes such a reduction in metabolic rate that the athlete's energy needs drop to the point that they no longer lose weight on an energy restricted diet
- Inadvertent failure to increase energy intake sufficiently during periods of training or competition that are high in volume and/or intensity. Some athletes undertake extremely strenuous training or competition programs. Appetite, time for preparing and eating food, and awareness of intake are just some of the factors influencing our food intake that may not always keep pace, especially when there is a sudden increase in exercise load. The practicality of eating a high energy intake day after day can be challenging for many athletes. Some may be unaware that they are falling behind in meeting their energy needs, or that it is problematic

Tips for maintaining adequate energy availability

- ✓ Be aware of energy needs and how these might vary over time. Be prepared to scale energy intake up and down according to the changing energy costs of daily training or competition. Be aware also of additional needs for growth. Ideas for achieving a high energy intake are found in the next section
- ✓ Take care when there is a change in your food environment – particularly when travelling or when changing your home situation. It can take time and a conscious effort to re-establish new eating patterns when opportunities to eat or access to suitable foods are altered
- ✓ Do not embark on drastic diets that limit energy intake or food variety. Even when loss of weight or body fat is likely to achieve better health and performance, severe energy restriction is associated with unnecessary consequences of low energy availability. Where possible, plan weight loss programs so that they can be undertaken at a slower and less harmful pace
- ✓ If you are developing stress related to food and body image, seek expert help at an early stage
- ✓ Female athletes should treat an interruption to a normal menstrual cycle as a problem that also needs early assessment and intervention
- ✓ If you are unsure about your energy needs and how to achieve them, consult a sports nutrition expert
- ✓ Note that the consequences of low energy availability include irreversible loss of bone, as well as impairment of hormone, immune and metabolic function. It's not worth it!

Examples of different levels of energy availability

1. High energy availability for growth or gain of body mass

Energy availability	Example
> 45 kcal (> 189 kJ) per kg fat free mass (FFM)	Athlete A: 65 kg and 20% body fat FFM = 80% x 65 kg = 52 kg Weekly training = 5600 kcal (23.5 MJ) Daily energy intake = 3520 kcal (14.7 MJ) Energy availability = (3520-800)/52 = 52 kcal/kg FFM (219 kJ)

2. Adequate energy availability for weight maintenance

Energy availability	Example
~ 45 kcal (~ 189 kJ) per kg fat free mass (FFM)	Athlete B: 65 kg and 15% body fat FFM = 85% x 65 kg = 55 kg Weekly training = 5600 kcal (23.5 MJ) Daily energy intake = 3285 kcal (13.8 MJ) Energy availability = (3285-800)/55 = 45 kcal/kg FFM (189 kJ)

3. Reduced energy availability but still adequate for healthy weight loss (or weight maintenance at reduced metabolic rate

Energy availability	Example
30-45 kcal (125-189 kJ) per kg fat free mass (FFM)	Athlete C: 55 kg and 20% body fat FFM = 80% x 55 kg = 44 kg Weekly training = 5600 kcal (23.5 MJ) Daily energy intake = 2340 kcal (9.8 MJ) Energy availability = (2340-800)/44 = 35 kcal/kg FFM (164 kJ)

4. Low energy availability – health implications

Energy availability	Example
< 30 kcal (< 125 kJ) per kg fat free mass	Athlete D: 55 kg and 25% body fat FFM = 75% x 55 kg = 41 kg Weekly training = 5600 kcal (2.35 MJ) Daily energy intake = 1980 kcal (8.3 MJ) Energy availability = (1980-800)/41 = 29 kcal/kg FFM (120 kJ)

Carbohydrates

For training and recovery

Carbohydrate provides an important fuel source for the brain and muscle during exercise. A long history of studies shows that the performance of sports involving prolonged activity, high intensity efforts, skill and concentration, or a combination of these factors, is enhanced when body carbohydrate stores can keep pace with fuel needs.
The body's carbohydrate supplies come from glycogen stored inside the muscle and from blood glucose which is topped up by liver glycogen stores or by carbohydrates consumed just before and during exercise. These stores can be turned over by a single exercise session of sufficient length and intensity (e.g. 60-90 min of high intensity training), so daily carbohydrate intake determines how much carbohydrate fuel is available for each training and competition session in the athlete's program.

Twenty years ago, sports nutrition guidelines promoted a universal message that all athletes should eat diets highly focussed on carbohydrate-rich foods at all times. These messages have changed in the light of new evidence, new understandings and new terminology.

Unfortunately, not all athletes and coaches have heard of these changes. Further confusion is provided by the current best-selling diets in the general community – for example Paleo, Atkins, Real Meal Revolution (high fat, low carb) and Zone – which are reduced carbohydrate, carb-restricted or entirely anti-carbs. This creates the need for some new and clear messages about carbohydrate and the athlete.

New concepts in carbohydrate guidelines for the everyday diet

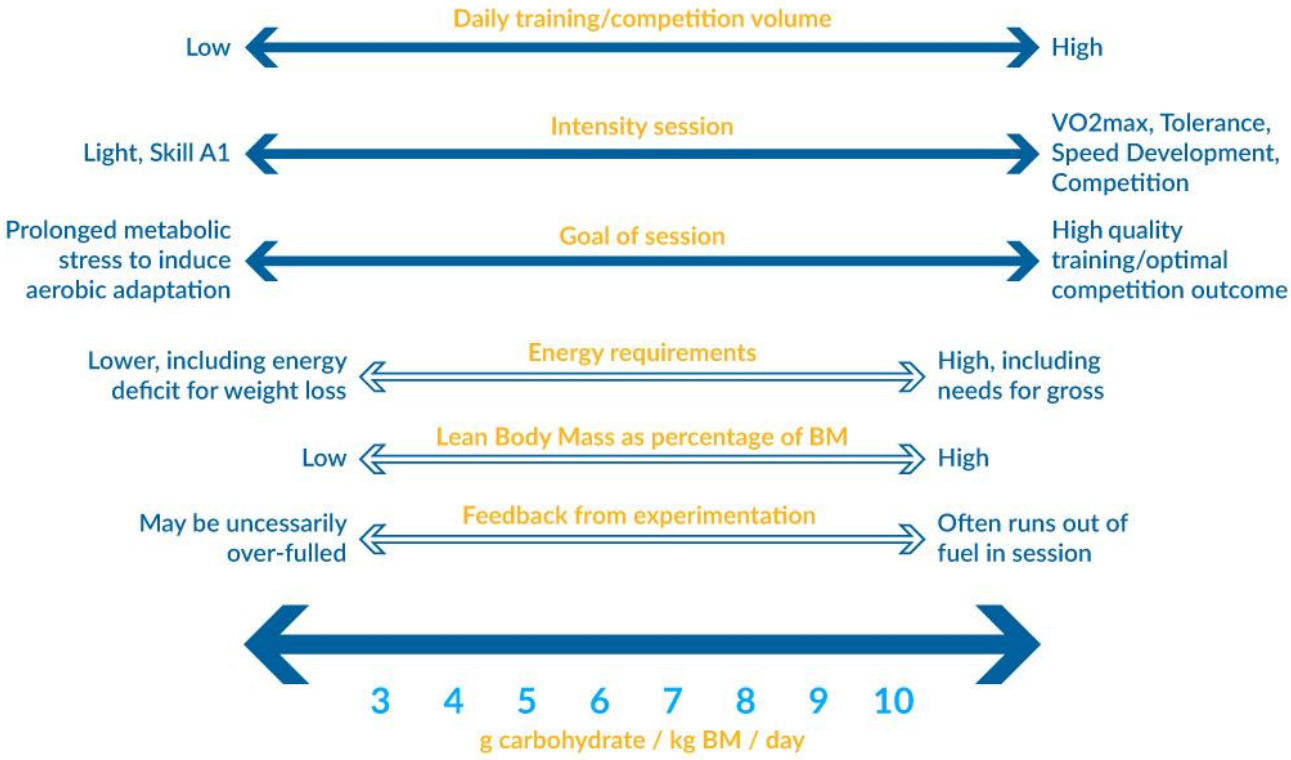
A pictorial summary of guidelines for carbohydrate intake is provided in *Figure 1*, while the features of the updated guidelines are explained below:

1. We no longer promote a *"one size fits all"* approach to dietary carbohydrate targets. Instead, the athlete's carbohydrate intake should be individualised to suit the demands and goals of their training program. The frequency, duration and intensity of training will largely determine the muscle's carbohydrate needs, and that will vary between athletes.
2. We use different language and concepts to discuss carbohydrate intake goals. Targets for carbohydrate are provided in terms of grams relative to the athlete's size (body mass) rather than as a percentage of total energy intake. Furthermore, rather than simply talk about *"high carbohydrate diets"* and *"low carbohydrate diets"*, we should consider carbohydrate intake in comparison to the muscle's fuel needs on a daily basis. We should consider whether the total intake and timing of the day's intake able to meet the fuel demands of a workout (= high carbohydrate availability), or are carbohydrate stores depleted or sub-optimal in comparison to the muscle fuel demand (= low carbohydrate availability). Because each athlete's fuel needs can be different, any given carbohydrate intake might provide high carbohydrate availability for one athlete but low for another.
3. A fundamental principle of training is that the load and goals change from day to day, over the various microcycles and macrocycles in the periodised training calendar, and at different points of the athlete's career. Therefore, rather than having a static dietary intake, athletes should vary their carbohydrate intake from day to day according to the rise and fall in muscle fuel needs.
4. The central idea that carbohydrate is a key fuel for sports performance remains a constant. In many types of sport, the depletion of carbohydrate stores is associated with fatigue, an increased feeling of effort to sustain a given workload and reduced performance. Therefore, when it is important to train hard, at high intensity or with high quality, athletes should follow a range of dietary strategies that match their body's carbohydrate supplies to the fuel needs of their exercise program. This is obviously important in competition scenarios, but should also be implemented for key training sessions or important training phases where high volume workload is in place and/or high quality performance is required.

5. On other occasions, it may not be as important to train with high carbohydrate availability. Many athletes do some of their training sessions with low carbohydrate availability. Sometimes this is because of practicality – for example, swimmers often do their early morning training sessions without anything to eat. Sometimes, it is deliberate - the athlete may be reducing their carbohydrate and energy intake to reduce body fat levels. This may not be a problem during the base phase of training or on days of light training, when training intensity and quality is low. In fact, some studies suggest that doing some training sessions in this way provides a good stimulus to the muscle to help it adapt to training. Of course, such strategies need to be periodised into the training program so that they don't interfere with training intensity.

6. Even though daily carbohydrate targets (see Figure 1) can be developed from the features above, it is always important to fine-tune based on further individual considerations. Feedback from training should be considered (how am I performing? How am I feeling during a workout? Am I recovering sufficiently between sessions? Is illness or general fatigue a problem?). The athlete's energy budget is also important – there may be more room or need to increase carbohydrate during periods of growth or other high energy demand, but scenarios of reduced energy demand may require a tightening of carbohydrate targets.

Considerations in setting daily carbohydrate intake targets for aquatic athletes



Muscle glycogen less limiting for completion of session
Less need for carbohydrate intake over total day or around sessions
Some sessions may be deliberately done with low carbohydrate availability

High muscle glycogen requirement for completion of training or optimal competition performance

Promote opportunities for carbyhydrate intake in total day and around session.

Practical suggestions for planning meals and snacks to assist with carbohydrate targets

- Many nutritious carbohydrate-rich foods can be included in meals and snacks to meet carbohydrate intake goals as well as contribute to overall diet quality
  - ✓ Wholegrain forms of breakfast cereals, oats, breads and crackers
  - ✓ Grain-based foods such as rice, pasta, quinoa, noodles
  - ✓ Fruits, legumes and starchy vegetables
  - ✓ Sweetened dairy products (flavoured milk, yoghurts etc)

- A great way to track carbohydrate intake with muscle fuel needs is to include additional carbohydrate in meals or snacks eaten before and after a workout. This means when training needs increase, so does carbohydrate intake. Consuming carbohydrate before and during lengthy pool sessions will also add to the day's carbohydrate target as well as specifically provide fuel for the workout. Open water swimmers should particularly take this opportunity to practise their strategies for eating and drinking during their races

- When athletes train more than once per day and sessions are close together, speedy recovery of the muscle carbohydrate stores may be important. Consuming carbohydrate-rich foods and drinks soon after the session helps with rapid refueling – a target of 1 g per kg of body mass per hour for the first 4 hours will optimize glycogen storage. The type of carbohydrate is generally less important than the amount, and athletes should make choices based on convenience, palatability, cost, and the contribution these foods can make to other nutritional goals
- When it isn't possible to meet these carbohydrate targets during the early hours of recovery, or when the recovery period is short, the presence of protein in recovery snacks is likely to promote higher rates of glycogen storage than carbohydrate alone. This is useful since post-workout protein intake addresses other goals of recovery eating. Some protein-carbohydrate combinations are found in the section on Protein
- During longer recovery periods (24 hours), the pattern and timing of carbohydrate-rich meals and snacks does not appear to be critical, and can be organised according to what is practical and comfortable for each athlete

Carbohydrates

For competition

The high-intensity nature of most pool events, as well as the whole body (arms and legs) contribution to performance, means that effort should be directed to preparing muscle glycogen stores to fuel good performances.
In pool swimming, synchronised swimming, water polo and diving, well-chosen eating strategies can prepare the needed fuel supplies for each session, although it may be challenging to refuel between several sessions in a multi-day program, or between several races within the same session.

In open water races of longer than 1 hour, the depletion of muscle glycogen stores within the race poses a performance challenge, and nutrition strategies before and during the race will be needed to provide additional carbohydrate to keep the brain and muscles working optimally.

Strategies for competition eating include the intake of carbohydrate in the hours or days prior to an event to ensure muscle and liver glycogen stores are appropriately stocked for the fuel needs of the event, consuming additional carbohydrate during longer evens, and proactive refuelling in the period between multiple events.

In the absence of muscle damage, the aquatic athlete can normalise their muscle glycogen stores with as little as 24 hours of carbohydrate-rich eating and exercise taper. The targets identified in the previous figure can be used to guide pre-event preparation. It should be remembered that many aquatic athletes undertake a pronounced taper in the pre-competition phase – carbohydrate targets should be based on real competition needs (the fuel demands of the event and continued training within the competition phase) rather than on previous patterns of high volume training.

'Carbohydrate-loading'

Open water swimmers who compete in races of 10 km and longer may benefit from *'carbohydrate-loading'* for a few days prior to the competition. This strategy involves consuming carbohydrate at intakes known to maximise glycogen storage (9-12 g/kg/d) for 24-48 hours while exercise is reduced to an easy taper. This strategy allows muscle glycogen stores to be super-compensated above normal levels to fuel the lengthy demands of their race. It can sometimes be challenging to re-load between races when the swimmer competes in both 10 and 25 km races on a competition program.

Pre-event meal

(1-6 h period before competition)

Athletes should try to find a range of foods to eat in the hours prior to competition that not only provide extra energy during the event, but also feel *'right'* in terms of curbing hunger, maintaining gut comfort, and being convenient as well as practical. In aquatic sports that do not cause carbohydrate depletion (e.g. diving), the pre-event meal need not be carbohydrate-focussed. However, in events involving greater muscle fuel demands, athletes are advised to use the pre-event meal to top up carbohydrate stores. This is especially important if recovering muscle glycogen from a previous competition session, or in the case of morning events, to top up liver glycogen stores after fasting overnight.

The effect of eating carbohydrate in the hours before exercise is to increase the muscle's rate of carbohydrate use. Therefore, the pre-event meal should contain enough carbohydrate to compensate for this *"priming"* of greater carbohydrate reliance. A carbohydrate intake greater than 1 g/kg should achieve this goal, and pre-event meals which enhance performance in longer events are generally in the range of 1-4 g/kg carbohydrate. Continuing to consume carbohydrate during a longer event, such as a water polo game or open water race helps to sustain fuel availability.

Depending on the time of day, the athlete's preferences and the availability of food, an athlete may choose a range of carbohydrate-rich foods and drinks to make up their pre-event meal. The type, timing and amount of foods should be practiced until a successful plan is developed.

Carbohydrate intake during exercise

During water polo and open water swimming, there is both opportunity and a potential benefit from consuming extra carbohydrate during the event. We have long recognised that consuming carbohydrate during exercise enhances performance - with benefits seen in terms of sustaining optimum pace, allowing more time at high intensities, and maintaining mental skills and concentration. A variety of mechanisms seem to explain this, ranging from providing high rates of an additional fuel to the muscle to making the brain feel happy so that it feels able to make us work harder.

Until recently, we have provided a generic recommendation for carbohydrate intake during exercise. However, there is now good evidence that exercise of different duration and intensities requires a different carbohydrate feeding approach (*see Table A below*). A range of carbohydrate-containing drinks and foods may be able to supply these targets, as well as other needs such as fluid. These include special sports products such as sports drinks, gels and bars. Many everyday foods and drinks such as fruit, juices and soft drinks and confectionery may also be suitable. The athlete should practice in training to develop a race or event fuelling plan. This plan will need to take into account the opportunities provided in the athlete's event to consume drinks or foods.

Refuelling between events

The competition schedule in many aquatic sports involves multi-events in the same day or multi-date competition. Therefore, some preparation will be needed to ensure that the athlete has adequate access to carbohydrate-rich snacks and meals to appropriately refuel between their events. Having well-chosen snacks and specialised sports drinks/foods at the pool may be an important part of the plan, particularly if the athlete's timetable at the pool needs to include warm-downs, media appearances, drug testing and other activities. Again, the athlete should refuel according to their real needs rather than adopting either over-zealous or lazy (unplanned) approaches.

Event	Duration	Carbohydrate target	Comments
During sustained high intensity exercise (e.g. water polo game or 5 km open water race)	45-75 min	Small amounts (including simply swilling carbohydrate around the mouth)	✓ Opportunities to consume carbohydrate-rich foods and drinks vary according to the event – from feeding pontoons or choices carried by the swimmer during open water races, to pool-side supplies for game breaks and substitutions during water polo ✓ A range of everyday dietary choices and specialised sports products ranging in form from liquid to solid may be useful
During endurance exercise (e.g. 10 km open water race)	1-2.5 h	30-60 g/h	✓ Higher intakes of carbohydrate are associated with better performance and swimmers should make use of feeding pontoons to gain supplies ✓ The athlete should practice to find a refuelling plan that suits their individual goals including hydration needs and gut comfort ✓ Practice with the choice of carbohydrate and feeding strategies is important
During ultra-endurance exercise (25 km race)	> 2.5-3 h	Up to 90 g/h	✓ As above. ✓ Products providing multiple transportable carbohydrates (Glucose:fructose mixtures) will achieve high rates of oxidation of carbohydrate consumed during exercise

Table A

Dietary protein for athletes

From requirements to optimum

Protein needs in sport are another area in which knowledge and practice have evolved.

For many years there has been debate about the total protein requirements of athletes, with many experts believing that daily needs are elevated above those of sedentary people. Protein intake targets for both strength and endurance training have been set at about 1.3-1.8 g/kg body mass per day.

Most dietary surveys show that most athletes following *"western"* diets easily meet these goals, even without the intake of expensive supplements. Athletes who are most at risk of failing to meet these targets are those who restrict their energy intake and food variety.

The new way to consider protein needs, however, is to consider the role of protein in achieving the desired outcomes of each training session, since each session ultimately promotes the building of new proteins in response to the specific type of training.
Dietary protein plays an important role in this response to exercise. The amino acids that make up the proteins in the foods that we eat are used as the building blocks for the manufacture of new tissue, including muscle, and for the repair of damaged tissue. They are also the building blocks for hormones and enzymes that regulate metabolism, support the immune system and other body functions.Protein provides only a small source of fuel for the exercising muscle but does increase when muscle carbohydrate stores are low.
When this approach to protein needs is taken, the focus becomes how to promote optimum protein synthesis in the period of recovery and adaptation from each workout.

The following ideas have emerged:

- Eating a source of high quality protein soon after exercise is part of the process of promoting muscle protein synthesis. High quality protein, particularly from animal sources (e.g. dairy, meats, eggs etc), is especially valuable
- The amount of protein required to maximise this response to exercise is quite modest – about 0.3 g per kg Body mass (typically, 20-25 g)
- It may help to choose a protein source that is rapidly digested and provides a good source of leucine as the post-workout protein boost. Whey protein fits this profile, which explains its popularity for post-workout recovery. This can easily be found in everyday dairy foods and drinks. Nevertheless, sometimes there can be value in using a more compact form that is easy to carry and prepare around the exercise session – such as a liquid meal supplement or a simple protein powder. There is no justification for the more expensive protein powders or amino acid formulations with extra ingredients and fancy claims
- We know that the muscle is stimulated to increase its protein synthetic rates for up to 24 hours after a workout. The best way to take advantage of this is to spread protein serves (20-25 g) over meals and snacks consumed 4-6 times over the day. This is not something that our traditional eating patterns always achieve, since most people eat the majority of their protein intake at the evening meal. It may be more sensible to redistribute protein intake to other meals in the day
- When high volume training, growth and an aggressive approach to gain of muscle mass is required, it can help to have an extra serve of protein in the day, just before bed

Protein rich foods – 10 g protein is provided by each choice

- ✓ 2 small eggs
- ✓ 300 ml cows milk
- ✓ 30 g cheese
- ✓ 200 g yoghurt
- ✓ 35-50 g meat, fish or chicken
- ✓ 400 ml soy milk
- ✓ 60 g nuts or seeds
- ✓ 120 g tofu or soy meat
- ✓ 150 g legumes or lentils
- ✓ 150 ml fruit smoothie/liquid meal

Examples of nutrient-rich carbohydrate and protein combinations for refuelling and rebuilding after key sessions

- ✓ Breakfast cereal with low fat milk
- ✓ Baked beans on toast or on a baked potato
- ✓ Fruit salad with fruit-flavoured yogurt
- ✓ Bagel with peanut butter + low fat milk
- ✓ Fruit smoothie or liquid meal supplement
- ✓ Low Fat chocolate milk
- ✓ Lean meat and veggie pizza
- ✓ Sandwich with meat and salad filling
- ✓ Meat and vegetable stir fry with noodles or rice

Vitamins, minerals and antioxidants

Vitamins are chemicals that help the body to function smoothly by supporting metabolism. The essential minerals (sodium, potassium, iron, magnesium, etc) also play a range of roles to ensure a stable environment for the body to function, in muscle contraction, nerve conduction, oxygen transport and all of the other processes that keep us alive.

Other minerals form important tissues such as the calcium in bones.

Some vitamins and minerals and other nutrients also have a role as anti-oxidants to mop up the free oxygen radical chemicals that are formed as a by-product of metabolism. In short, they are important for maintaining optimum health and function.

Athletes often want to know if their training programs create special needs for additional intakes of vitamins and minerals. It is likely that this might be the case for at least some nutrients, but that a well-chosen and varied diet based on adequate energy intake is easily able to meet any increased demands.

Athletes who are training hard and who eat enough foods to meet their increased energy needs will generally achieve high intakes of all of the essential nutrients from the foods that they eat. Dietary surveys show that most athletes are well able to meet the recommended intakes for vitamins and minerals by eating everyday foods. Those at risk of sub-optimal intakes of these micronutrients include:

- athletes who restrict their energy intake, especially over long periods, especially to meet weight loss goals
- athletes who follow eating patterns with restricted food variety and reliance on foods with a poor nutrient-density

The best way to correct this situation is to seek advice from a sports nutrition expert such as a sports dietitian. When food intake cannot be adequately improved – for example, when the athlete is travelling in a country with a limited food supply - or if an individual is found to be suffering from a lack of a particular vitamin or mineral, then short-term supplementation might be appropriate. This should be undertaken with the advice of a qualified sports nutrition expert. In general, a broad-range multivitamin/mineral supplement is the best choice to support a restricted food intake, although targeted nutrient supplements may be necessary to correct an established nutrient deficiency.

Some special micronutrients and other food chemicals will now be discussed.

Anti-oxidant nutrients

We know that free oxygen radicals are produced during normal metabolism, and that our bodies develop anti-oxidant defence systems to neutralise these chemicals and the damage they cause to body tissues. We also know that exercise causes an increased production of these oxygen radicals, and many athletes feel that anti-oxidant supplements may help to protect them against this elevated level of harm. Vitamins C and E supplements have been popularly used for this purpose.

More recently, however, there have been changes to such thinking. It seems unnecessary to provide large doses of a few anti-oxidant chemicals when the body has its own mechanisms to increase a more complex antioxidant defence system. In fact, it may simply unbalance the system and cause more harm than good. There may be some benefits associated with the production of free oxygen radicals – new evidence shows that they function as signals to promote important adaptations to training. It is possible that the use of antioxidant supplements may actually neutralise some of the signalling that underpins recovery and adaptation to a workout, meaning that antioxidant supplementation could reduce the effectiveness of a training program.

Foods contain a large variety of health promoting chemicals in addition to vitamins and minerals. These products – usually called phytochemicals or phytonutrients – promote function and health in our bodies as antioxidants, anti-cancer agents, and many other roles. The names of some of the chemicals include quercetin and ECGC, and new studies are continually investigating whether supplemental forms of these products could be useful for health and performance. To date, these studies haven't been able to translate the benefits known about these products into a functional

output. Therefore, at present, the most effective way to approach these chemicals is though eating them in plentiful amounts in food.

Ideas for promoting dietary variety and nutrient-rich eating to achieve a plentiful intake of vitamins, minerals and phytochemicals

- ✓ Be open to trying new foods and new recipes
- ✓ Make the most of foods in season
- ✓ Explore all the varieties of different foods
- ✓ Mix and match foods at meals
- ✓ Think carefully before banishing a food or group of foods from your eating plans
- ✓ Find substitution foods that have similar nutrients when excluding a food group
- ✓ Include fruits and/or vegetables at every meal and snack. The strong and bright colours of many fruits and vegetables are a sign of a high content of various vitamins and other food anti-oxidants. Aim to fill your plate with a rainbow of highly coloured foods to ensure a good intake of the range of these health-promoting dietary compounds

Vitamin D

Vitamin D is classified as a fat-soluble vitamin which acts as a hormone. It has important functions in the body including maintenance of good bone health, muscle function and immunity. Vitamin D is found in some foods, but our major source comes from sunshine exposure. Vitamin D deficiency can lead to several health issues including increased risk of bone injuries, chronic musculoskeletal pain and viral respiratory tract infections. Reversal of sub-optimal Vitamin D status in athletes may have beneficial effects on athletic performance and health.

Athletes at risk of Vitamin D deficiency include those who:

- train indoors
- have dark skin
- live further away from the equator
- wear clothing that covers most or all of their body
- regularly use sunscreen or consciously avoid the sun

Such athletes should be screened and if Vitamin D levels are sub-optimal, a course of Vitamin D supplementation, and perhaps judicious sunshine exposure should be undertaken under medical supervision.

Iron

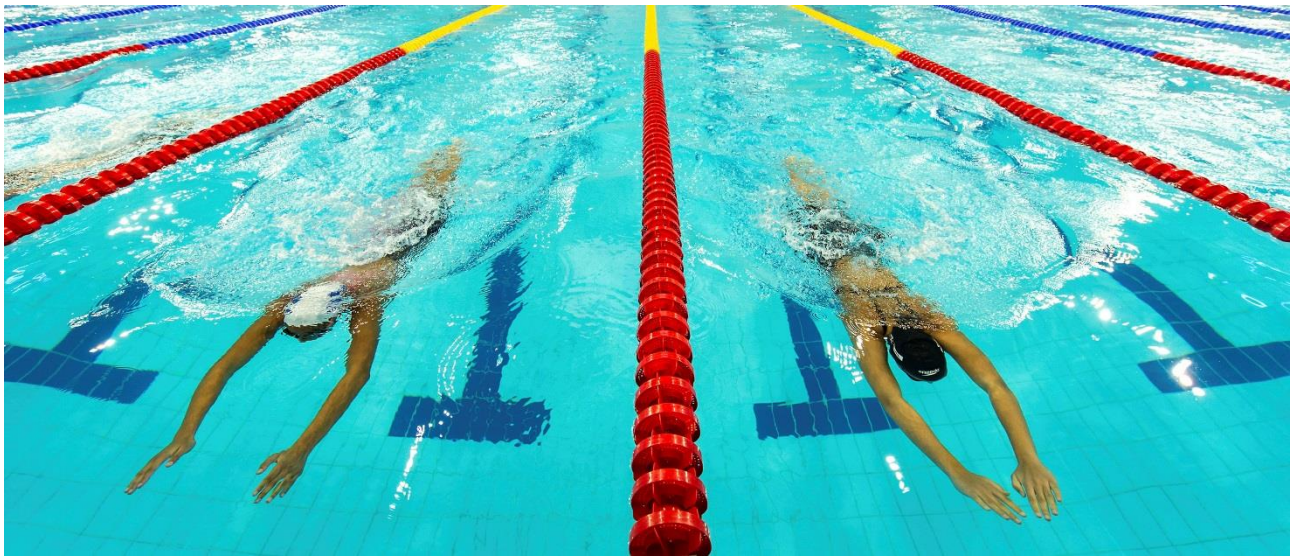
Iron plays an important role in the transport of oxygen in the blood (as haemoglobin) and muscle (as myoglobin), and inadequate iron status can obviously impair performance and recovery. There is some evidence that an athlete's iron requirements may be elevated due to increased levels of loss due to their training load. However, most athletes who become iron deficient or anaemic do so because of poor iron intake.

Athletes who are at high risk of such problems are those who restrict energy intake and dietary variety. Since meats are a major source of well absorbed iron, vegetarian eaters will need to plan their meals carefully to find alternative iron sources. Females are also at risk because of increased iron requirements due to menstrual blood losses matched against a smaller food intake. Iron-rich eating will help to reduce this risk.

Athletes who are at risk of poor iron status should have this monitored periodically. Athletes who are undertaking altitude training often like to do this too, to ensure that they have sufficient iron stores to allow the adaptations to their specialised training demands. Routine use of iron supplements is not wise: too much is just as harmful as too little. Self-medication with iron supplements may not address the real causes of an athlete's fatigue or other issues of poor eating and may do more harm than good.

Calcium

Calcium is important for healthy bones, especially in adolescents and in female athletes, so it is important to ensure adequate calcium intake. The best sources are dairy foods, including low fat varieties.



Iron-rich eating strategies

- ✓ Consume moderate servings of red meats (well-absorbed iron) in 3-5 meals per week
- ✓ Choose iron-fortified cereal products such as breakfast cereals
- ✓ Combine plant and non-meat sources of iron (e.g. legumes, cereals, eggs, green leafy vegetables) with food factors that enhance iron absorption. These include vitamin C and a factor found in meat/fish/chicken. Examples of clever matching include fruit juice or fruit with breakfast cereal, or chilli con carne (meat and beans)
- ✓ Avoid combining non-meat source of iron with food factors that inhibit iron absorption such as phenolic compounds (e.g. team and coffee), phytates (e.g. bran), or calcium (e.g. dairy)

Calcium

- Each athlete should aim to include at least 3 servings of these foods in their daily eating plans such as:
  - ✓ glass of milk
  - ✓ slice of cheese
  - ✓ carton of yoghurt
- Additional daily servings are required during growth spurts in childhood and adolescence, and for pregnancy and lactation
- Fortified soy foods may provide a useful substitute where athletes cannot consume dairy foods

Hydration:

Water and salt needs for training, competition and recovery

The water and salt needs of athletes are dictated primarily by three factors:

1. The normal losses of daily living, including losses in urine, faeces, breath and through the skin
2. Increased losses caused by training (in the water and on land) as a result of increases sweat and respiratory losses
3. The environment: there are increased losses during periods of warm weather and at altitude

Aquatic athletes are unique in relation to fluid needs.

Undertaking most of your training immersed in water causes some interesting features related to hydration issues. First, sweat losses are highly variable and are greatly influenced by the temperature of the water in which the activity is undertaken. When the water is cool, as dictated by the FINA temperature requirements for competition pools (25-28°C), a lot of the body heat produced during exercise can be dissipated by convection in the water, reducing the need to sweat. Thus the sweat losses typically incurred by aquatic athletes are lower than those seen in land-based sports of a similar intensity/duration.
However, open water swimming has more variable water temperatures (16-31°C; as dictated by FINA rules) and can have a greater impact on hydration status.

Nevertheless, the second point is that being in and out of the water, as occurs in many aquatic activities, can camouflage actual sweat losses since it can be difficult to distinguish where the water on skin, costumes and hair is coming from. Therefore, some aquatic athletes are not aware of fluid as an issue of general interest and can under-estimate their true sweat losses during a workout or race. Many may not be aware that significant losses can occur during sessions that are high in intensity, undertaken in a hot indoor or outdoor environment, undertaken in a hot pool or waterway or combined with dry-land training.

Finally, as we will explore later, some of the features associated with aquatic sport challenge the accuracy and practicality of implementing the simple measurement used by many athletes to assess fluid losses over the session: monitoring weight changes over the workout and the volume of fluid consumed from a personal drink bottle.

All these features may challenge the athlete's ability to look after their hydration needs around exercise, with the capacity both to overhydrate and under-drink. Doing a better job means learning the practical aspects of:

- when it may be helpful to drink during a workout or event
- how much to drink
- what type of drinks are best, and
- what modifications should be made in hot or cold environments, especially in the case of open water swimmers

Just as general training and competition strategies should be tailored for individual athletes in accordance with their unique needs and preferences, so should their drinking and eating choices during exercise. Athletes, coaches and trainers should *'fine tune'* the following recommendations to identify their own winning formula.

When is it helpful to drink during exercise?

Fluids consumed during exercise can play a number of roles. These include making the athlete feel more comfortable, replacing a body fluid deficit, and providing a means to consume other ingredients such as carbohydrate. The importance of each of these roles will vary according to the situation.
It is seldom necessary to replace fluid losses during exercise that lasts less than about 40 minutes, but even in some short workouts or competitive events, some athletes feel better after having a drink and this should do no harm.
During training or competition sessions lasting longer than about 40 minutes, however, there may be advantages to drinking during the session. When it is not

possible to drink during such sessions, an alternative is to hydrate well just before starting the session. To do this, the athlete should practise drinking during the 15 minutes before exercise and find how much is initially filling but comfortable once exercise begins (e.g., 300-800 ml).

How much to drink?

How much you should drink during exercise depends on a number of factors including the size of the fluid deficit that your sweat losses are contributing to as well as the comfort and practicality of your opportunities to drink.
A small fluid deficit (e.g. < 2% Body Mass) has no effect on performance, but severe dehydration (e.g. > 5% BM) impairs exercise intensity and quality as well as mental skills.
There is no clear evidence on the point at which performance begins to be affected and this almost certainly varies between individuals as well as depending on the type and duration of exercise and on the environmental conditions.

Athletes are often advised to drink only when thirsty, but this may not always be a reliable guide. Furthermore, the rules and opportunities to drink fluids in many sports may not coincide with the times that thirst hits.

A more targeted option is to develop a fluid plan to fit the event, the individual and other nutritional needs. As a starting point, the athlete should try to drink at a rate that replaces enough of their sweat losses so that the overall fluid deficit for a training session or competition is kept to no more than about a 2% loss of body weight (i.e. 1.0 kg for 50 kg person, 1.5 kg for a 75 kg person, and 2 kg for a 100 kg person). This is usually achievable in aquatic sports.
The exception may be in open-water or distance swimming over long duration sessions in warm water/environments when sweat rates are high and it is difficult to get access to fluid. When it isn't practical to drink enough to keep fluid deficits below this target, a more feasible alternative is simply to try to minimize dehydration.

In some situations, athletes over-hydrate during exercise – drinking more than their sweat losses. There may be some reasons when this is justified; for example, the case of the athlete who starts a workout or event already dehydrated. However, problems can occur when the fluid intake is excessive, leading to a serious problem called hyponatraemia (dilution of blood sodium concentrations). This is most often seen in recreational exercisers who work at low intensities but drink large volumes of fluid in the belief that they are doing the right thing.

In all of these situations, it can help for an athlete to have a feel for their typical sweat rates and how hard or easy it is to drink to keep pace with these. The guide below provides some ideas on to how to check this.

When do you need more than water?

Although hydration is a key focus of nutrition strategies during exercise, fluids consumed during exercise can contain a range of ingredients. In terms of proven performance benefits, no nutrients match water and/or carbohydrate.

During exercise lasting longer than 1 hour and which elicits fatigue, athletes are advised to consume a source of carbohydrate that is rapidly converted to blood glucose. This generally improves performance – allowing the athlete to maintain pace, skills and concentration instead of succumbing to fatigue. As outlined in the earlier section on Carbohydrates in competition, the targets for carbohydrate during exercise will vary according to the athlete's preparation (how well fuelled), the fuel needs of the event (duration and intensity of the session) and individual tolerance.

The use of commercial sports drinks with a carbohydrate content of about 4-8% (4-8 g/100 ml) allows carbohydrate and fluid needs to be met simultaneously in many events. The small electrolyte content of these drinks preserves thirst and acknowledges that sweat is also a source of body electrolyte loss. As previously outlined, in other events where sweat losses may be lower but muscle fuel needs are still high, more concentrated carbohydrate choices (e.g. gels and confectionary) may be useful to fuel without overhydrating. Typically, when carbohydrate is consumed during exercise, it is best consumed in a pattern of frequent and continued intake. This will provide a constant stimulation of the brain and central nervous system, or when needed, a constant source of additional fuel for the muscle.

Caffeine contained in commonly available beverages and foods can enhance endurance or performance during the later stages of prolonged exercise.

This benefit can be obtained with relatively small doses of caffeine (about 2-3 mg/kg bodyweight or 100-200 mg caffeine). This is equivalent to 1-2 cups of brewed coffee or 750-1500 ml of a cola beverages as commonly consumed by people of various cultures.

Various sports products (gels, drinks etc) may also provide a convenient low dose serve of caffeine. Contrary to popular belief, when caffeine is consumed in these amounts it has little effect on urine losses or hydration.

Rehydration after exercise

Replacement of water and the salts lost in sweat is an essential part of the recovery process that prepares an athlete for their next exercise session. Since sweat and urine losses continue to occur during recovery, the athlete will need to drink about 1.2-1.5 litres of fluid for each kg of weight loss in training or competition to compensate and fully restore fluid losses. This may not be an issue for sessions when sweat losses were moderate and there was plenty of opportunity to drink during the session. However, in hot weather and after prolonged high-intensity training sessions, a rehydration plan may be useful.

Sodium, the main salt lost in sweat, also needs to be replaced. Sodium replacement can be achieved via sodium-containing fluids such as sports drinks and pharmacy oral rehydration solutions. However, a well-chosen meal or snack can supply the salt that is needed. This may be because the foods are salt-containing (e.g. breads, breakfast cereals, cheese, processed meats) or because salt is added in the preparation or serving of the meal.

Practical ways to assess and manage hydration

Every athlete is different because they have different sweat losses and different opportunities to drink fluid during their workouts and events. The goal is to develop hydration plans that are individualised to specific situations, and avoid excessive levels of both over- and under-hydration. Strategies that can be used periodically to assess sweat losses and hydration levels provide a valuable role in developing such plans.

Two simple steps may help to guide your hydration practices

1. In scenarios or environments where sweat losses are high, aim to start each exercise session well hydrated. If you are passing urine less often than normal, you may be dehydrated. If urine colour becomes darker than what is normal for you, then you may not be drinking enough. Check your urine colour against the chart.

   Note that the aim should NOT be for your urine to be as pale as possible. Drinking too much can be uncomfortable and, if excessive, possible harmful. The aim is to develop fluid practices over the day whicht keep pace with regular fluid needs and special losses from exercise or hot environments. As losses change, so should drinking practices. It makes since to spread fluid intake over the day rather than trying to play catch up at the end. Drinking more than you need in the late part of the day can mean interrupted sleep due to toilet breaks.

2. Develop a drinking plan for training and competition that is right for you. This should be based on several pieces of information including your typical sweat losses, the opportunities to drink in your sport, and feedback from comfort and thirst.

   Monitor your sweat losses and the success of your drinking plan during training sessions in different situations (see box). How did you feel? How did you perform? What was your weight loss over the session? This should generally not exceed about 2% of body mass. If you lost more than this, you probably did not drink enough. Drink more next time. If you lost less, you might have drunk too much. Did it make you feel uncomfortable? Did you take time out to drink that was unnecessary?

   Drinking so much that you gain weight during competition is never likely to be a good idea. The only time you might need to do this is when you have been dehydrated at the start of the event.

How to estimate sweat losses and sweat rates:

1. Measure body weight both before and after at least one hour of exercise under conditions similar to competition or a hard workout.

2. Take these body weight measurements wearing minimal clothing and while bare footed. Take the “Before” exercise measurement just before commencing the session, and after going to the toilet. For the “After” measurement, towel dry after exercise and obtain body weight as soon as is practical (e.g. less than 10 min after the session, and before eating, drinking or going to the toilet).

Note: your wet hair and swimming costume are likely to be carrying water weight, even after your have towelled yourself. This will vary according to the individual, but tends to be more of a problem for female athletes. Greater accuracy can be gained if the pre-training weight is also measured under the same conditions – that is, shower before the session or dive in the pool and get wet then towel-dry.

Example: Pre-exercise weight = 74.5 kg
Post-exercise weight = 72.8 kg
Fluid deficit = 1.7 kg

3. Estimate the weight of any fluid or foods you have consumed during the workout

Example: 800 ml of fluid = 800 g or 0.8 kg

Note: it may not always be possible to account for all fluid consumed during the session since water may be accidentally swallowed from the pool. This error will underestimate fluid losses and sweat rates from the calculation guidelines provided here

4. Sweat loss (Litres) = Body weight before exercise (in kg) - Body weight after exercise (kg), + weight of fluids/foods consumed (kg).

Example: 74.5 kg – 72.8 kg = 1.7 kg deficit
+ 0.80 kg (800 ml fluid) = sweat loss of 2.5 kg or 2500 ml.

Note: various characteristics of swimming tend to promote urine production – most aquatic athletes know of the urge to visit the bathroom during a workout. If this occurs, you should try to estimate the volume of urine lost – either, weigh yourself before and after the bathroom visit, or in the case of a research protocol where extra accuracy is required, collect the urine in a container so that you can measure the volume. This volume/weight should be subtracted from the pre-post session weight change to correct it to reflect sweat losses more accurately.

5. To convert sweat loss over the session to a sweat rate per hour, divide by the exercise time in minutes and multiply by 60.

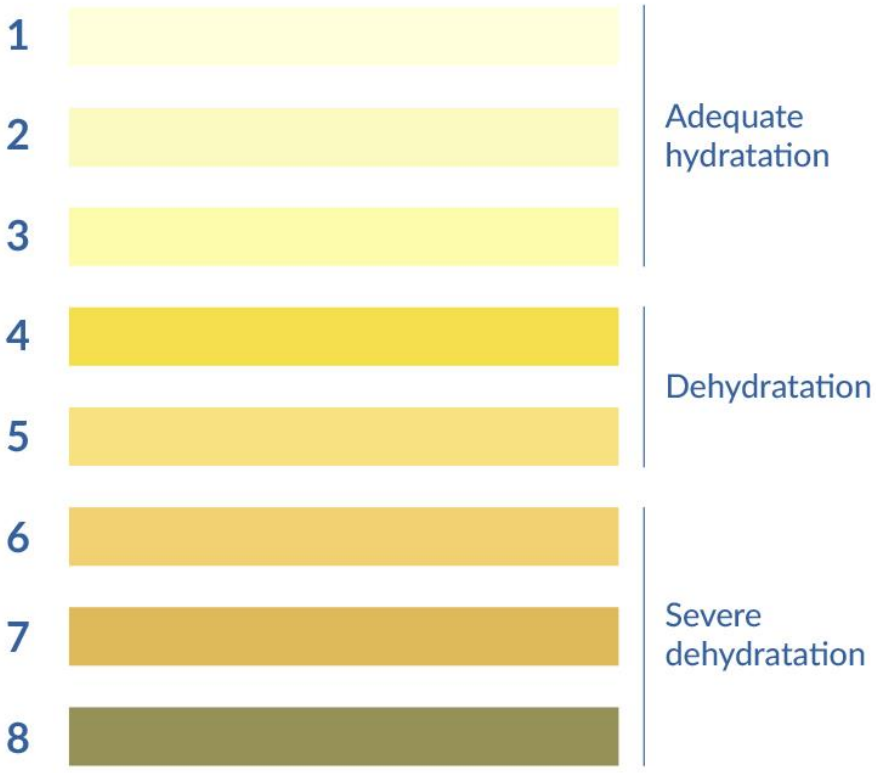
Example: sweat loss of 2500 ml in 100 min session = 2500/100 x 60 = 1500 ml/hour

6. Your weight deficit at the end of the session provides a guide to how well you hydrated during the session, and how much you need to rehydrate afterwards.
To convert kg to % body weight, divide the weight deficit by starting body weight and multiply by 100:

Example: 1.7 kg/74.5 X 100 = 2.3%

Note: 2.2 pounds equals 1.0 kg and converts to a volume of 1.0 litre or 1,000 ml or 34 ounces of water

Chart on urine colours



Special Populations

Youth + Female Athletes

Young athletes

Aquatic sports can require a serious commitment from their participants at a young age. For example, swimmers and divers can reach elite levels of performance in their early-mid teen years with many years of prior training supporting this effort. The implications of the commitment to daily training in young athletes include both the effect on energy and nutrient requirements, and the challenge of eating to achieve these requirements in a busy lifestyle.

The changing patterns of growth and development during childhood and early adulthood already raise special nutritional needs, while adolescence is a time of great social and psychological change which influences eating patterns and body image.

The needs of sport are superimposed on top of these features. Various challenges can be faced both by the athlete and his/her family:

- the need for flexible household meal choices and timetables to suit the athlete's training schedule and nutritional needs
- the search for portable foods and drinks to accompany the young athlete on their daily schedule
- the struggle to find a balance between sports nutrition requirements and the social eating patterns of childhood (e.g. parties, holidays)
- managing the often chaotic features of the eating patterns associated adolescence and its growing self-determination
- coping with the change in body composition associated with puberty which may either substantially change energy/nutrient needs (e.g. the increased needs for growth and development in adolescent male athletes superimposed on high volume training) or create a conflict in terms of the ideal physique for performance (e.g. the gain in body fat in adolescent female athletes)
- the need to learn nutrition knowledge and practical skills at an early age to allow the young athlete to assume responsibility for intake during competition travel or to leave home for an enhanced training environment

The sections in Part 2 of this booklet outline the specific nutritional and lifestyle needs associated with each of the aquatic disciplines. The recommendations in these sections should gradually become integrated into the eating patterns of the young athlete as they increase their training load and undertake regular competition

Some special comments are provided:

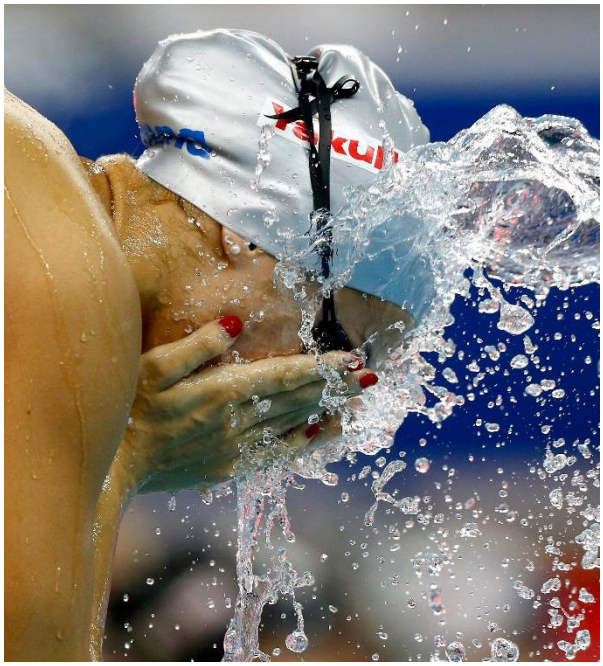
- Children and adolescents can face periods of significant growth and development which increase their requirements for energy and nutrients such as protein, iron and calcium. Various sections of this booklet deal with the eating strategies that secure adequate intakes of these key building blocks
- Children should develop lifelong good eating patterns and food knowledge via the family environment. From an early age they should be encouraged to join in family activities related to the choice, preparation and enjoyable consumption of wholesome foods. Sharing responsibiilty for the planning and organisation of food needs around training and competition will help them to gradually take responsibility for the special nutritional needs of an athletic career
- It is particularly useful for children and adolescents to develop habits around choosing wholesome snacks. A pattern of frequent intake of nutrient-rich foods and drinks is well suited to support growing bodies and other scenarios of high-energy needs. In addition, it is useful to address sports nutrition needs by adding extra food opportunities before, during and/or after a training session or competition. This strategy not only helps to provide nutritional support where it is most valued, but can teach the young athlete to naturally adjust total energy intake up and down according to the exercise load
- Adolescence can be a time of stress related to nutrition and body image unrelated to sport, and

further exacerbated by the demands of high level participation in sport. It is useful to provide education directed at the young athlete with positive messages about the role of sound eating practices in health, performance and enjoyment in life. Early detection and intervention around problem eating behaviours is encouraged

Female athletes

Female athletes can face some additional dietary challenges, which include:

- Having additional requirements for some nutrients (e.g. iron)
- Having lower energy requirements (due to a lower body mass and muscle mass and often a lower total training load)
- Pressure to achieve unrealistic body mass and body fat levels
- Greater risk at developing disordered eating/eating disorders



The section in this booklet on energy availability explained the importance of providing adequate energy intake to meet the energy cost of training/competition. Many female athletes are at risk of reducing energy availabiilty, usually in an attempt to achieve unrealistic body composition goals, to levels that are not able to sustain healthy body function.

Some problems seen in athletes associated with low energy availability include:

- menstrual disturbances
- reduced basal metabolic rate
- compromised immunity
- poor hormonal function
- impaired bone density (this can mean irreversible loss of bone)
- impaired training adaptation leading to reduced performance

Early indications of low energy availability disordered eating or poor body image should be treated seriously, with athletes being referred to an appropriate expert for further assessment and help.
In particular, female athletes should treat an interruption or irregularity to a normal menstrual cycle as a warning sign.
This is a problem that needs early assessment and intervention by a professional.

Nutrients of special concerns

Female athletes may be at risk of poor iron status because of increased iron requirements due to menstrual blood loses. They may also tend to restrict energy intake and limit certain foods, which can result in low iron intake.

An adequate calcium intake is also important for female athletes and may be compromised by inadequate energy intake or fat diets. Poor dietary calcium intake may exacerbate bone health problems associated with low energy availability.

See other sections of this booklet on Iron- and calcium-rich eating, and note that females must generally focus more carefully on these nutrients since they must meet their requirements from a smaller energy intake.

Part 2 Aquatic Discipline Specific Nutrition

Swimming

Committed swimmers usually train 2-6 h each day, often combining two sessions in the pool with an additional land-based workout (e.g. resistance training, core training or running). Contemporary nutritional strategies should be incorporated in the training program of swimmers to support such activity. Competition formats span single day meets up to the 8-day format on the Olympic and World Championship programs. Highly talented swimmers may compete in a range of strokes and distances in a single meet, with heats, semis and finals often being swum to determine the eventual winner of the most prestigious programs. Although muscle fuel stores are not challenged by a single event (with the longest event of 1500 m being completed in ~ 14-17 min at elite level), recovery between swims is important for the competitor who faces a busy race program with several races in a single session.

Training issues

Matching energy needs to support training and maintain/achieve optimal physique

Energy and carbohydrate needs vary according to the annual program, macro cycle, training week, training session and stage of development.

- Energy needs are increased during growth, in heavy training periods and during training at high altitude. To avoid compromised training and an increased risk of illness in these settings, swimmers are recommended to follow eating strategies to match increased energy and carbohydrate intake to their increased needs. Tactics, also covered in other sections of this booklet include:
  - ✓ Increasing the number of meals and snacks in the day
  - ✓ Adding carbohydrate-rich snacks and fluids (juice, sports drink, flavored milk, smoothies, liquid meals) around training sessions
- During periods of reduced training load (e.g. taper and injury) energy intake should be adjusted to avoid unnecessary gain of body fat. Strategies to match lower energy requirements include:
  - ✓ Reducing intake of energy dense low-nutrient snacks
  - ✓ Focusing on foods high in volume and fiber (e.g. vegetables, fruits) and low-fat versions of protein-rich foods (e.g. low fat dairy, filets of fish/chicken)
  - ✓ Avoiding *"eating to boredom"* during sudden increase in leisure time
- A busy training schedule requires an eating plan rather than an ad hoc approach to nutrition. This plan should be underpinned by knowledge of food composition, and forethought to ensure that there is easy access to appropriate snacks in an "on the run" lifestyle
- Rapid body weight changes are discouraged. Swimmers should aim for modest improvements in dietary choices to achieve ideal physique over a period of time. Adequate energy availability is important for health and performance (see section at front of booklet)

Manipulating carbohydrate availability

Daily carbohydrate intake should reflect the metabolic needs of the muscle and/or the goal of the training. This may range from 3 - 10 g/kg/day according to the type and volume of training (see Carbohydrate needs for training). Meeting the muscle's carbohydrate needs (=high carbohydrate availaibity) will enhance recovery, delay fatigue and improve performance. Meanwhile occasional manipulations to achieve low carbohydrate availability around selected training sessions (≤ 1-2 session per week) may further enhance metabolic adaptation.

- *Strategies to achieve high carbohydrate availability:* Adding carbohydrate rich foods and snacks (e.g.

rolls, cereal, muesli, juice, dried fruit, sports drink, sports bar, and gel) around key sessions (pre, during, post) will permit high intensity training and reduce exercise induced stress on the immune system

- *Strategies to achieve low carbohydrate availability:* Training first thing in the morning prior to eating carbohydrate is an easy way to undertake a workout with low carbohydrate availability, and is commonly undertaken by swimmers without recognition of the tactic. Scientists are still investigating the pros and cons of deliberately undertaking sessions with low carbohydrate availability to promote training adaptations since the application of this strategy requires planning to periodise it to the right type of training sessions and to avoid any potential negative outcome (e.g. compromised immune function, overtraining)

Fluids and fuel during training

- Swimmers who train indoors in temperate water at low intensity have modest sweat losses (~0.3-0.5 L h^{-1}) which may be addressed by drinking to thirst. Workouts undertaken with higher intensity, in warm outdoor pools or involving land based activities incur greater fluid needs which may require an organized approach
- Carbohydrate intake during training should reflect the fuel needs and performance goals of the session
- Easy swim session < 90 min: water is usually appropriate and should be consumed in amounts that limit dehydration (< 2% of body weight)
- High intensity sessions with high carbohydrate availability: sports drink and/or gel providing 30 - 60g CHO h^{-1} and fluids according to individual sweat rate
- Sessions targeting low carbohydrate availability sessions: consume water to limit dehydration (< 2 % of body weight), consider mouthwash/candy in oral cavity to address fatigue without needing to ingest a fuel source

Recovery

Recovery strategies should be adjusted to the swimmer's individual needs based on 1) the physiological stress achieved by the first exercise bout 2) the period of recovery 3) the goals of the next workout 4) the swimmer's energy budget and need to manipulate physique.

- Swimmers should aim to consume carbohydrate (~1 g/kg) immediately after key workouts when recovery time is limited (<8 h) and the following session is glycogen dependent
- Swimmers should consume foods providing a modest serve of high quality protein (~20-25 g or 0.3 g/kg protein) soon after key pool sessions and resistance training. Similar protein serves should be spread regularly over the day in meals and snacks
- Less demanding training sessions or sessions with longer recovery periods may not need suchs aggressive recovery routines. In these situations or when the swimmer's energy budget is restricted, the normal meal routine may be used to achieve recovery goals
- While sports foods may provide practical recovery snacks, many whole foods are also suitable (e.g. muesli with milk/yoghurt, sandwich with egg/meat filling, flavored milk). Choices can be made based on food availabity, practicality, expense and individual preference

Competition issues

- Swimmers should recognise that their energy requirements are lower during the pre-competition taper due to the decreased training volume. Nevertheless, high-intensity sessions are

retained during this period and are highly glycogen dependent, requiring adequate carbohydrate availability

- A single race in the pool will not stress the fuel stores, but swimmers competing in several races over a session or meet should have a recovery plan similar to that used in training
- For whole day meets, swimmers should bring a suitable supply of carbohydrate-rich foods to the poolside. Easily digestible snacks and sports products can be consumed when there is < 60 min between races while nutritious whole foods (e.g. sandwich with egg/meat/cheese filling, cereal and yoghurt, pasta salad, fruit) are recommended during longer breaks
- Swimmersorshould adopt a race-day snack and fluid plan according to their real needs, avoiding over consumption due to an over-eager approach as well as inadequate intake due to poor preparation
- In championship meets, the usual routine is to consume a substantial lunch after the morning session (heats) and a light carbohydrate-rich snack before returning to the pool for the evening session (finals)

Performance enhancing supplements

There are a few supplements that may be beneficial for swimming performance when correctly applied – these include sodium bicarbonate, creatine, caffeine and possibly beta alanine and nitrate (see dietary supplements section)

These supplements may be appropriate for highly trained swimmers under the supervision of experienced sports nutrition/science professionals.

Part 3 Eating Strategies

Eating while travelling

High-level athletes in aquatic sports can face demanding training and competition schedules featuring extensive travel. For example, depending on the event, age and season, the elite swimmer may have between 30 to 100 races per year. Such a schedule will involve crossing multiple time zones in varying countries all with differing environmental, cultural, food and fluid choices. Frequent changes in location and the required travel demands create a number of potential challenges:

- Interruptions to normal training and lifestyle routine while traveling and recovering from travel
- Travel fatigue - physiological and psychological factors that build up during a single trip or accumulate throughout the season
- Jetlag - symptoms due to the time-phase shift to a new time zone
- Changes in environment (climate or altitude) requiring change to nutrition & hydration needs
- Differences in language and food culture which can result in inappropriate food choices including inadvertent exposure to food allergens and intolerances
- Varying catering arrangements with altered access to normal food choices or eating times
- Buffet style dining which may be associated with over-eating
- Different standards of food and water hygiene, including the water in which open water events are conducted

These challenges can be addressed with a variety of strategies

Planning ahead

- The athlete should investigate food issues on travel routes (e.g. airlines) and at the destination before leaving home. Caterers and food organizers should be contacted well ahead of the trip to let them know meal timing and menu needs

Supplies to supplement local food

- A supply of portable and non-perishable foods should be taken or sent to the destination to replace important items that might be missed.
  - ✓ The athlete should consider what is available in the new location versus the weight/convenience of traveling with extra food
  - ✓ They should also check with the local country's customs and quarantine to see what foods are permitted to be brought into the country of travel
- The athlete should be aware that many catering plans only cover meals. Since the athlete's nutrition goals are likely to include well-timed and well-chosen snacks and recovery nutrition, supplies should be taken to supplement meals en route, at the destination, and around competition

Examples of suitable travel foods

- ✓ breakfast cereal and cereal bars
- ✓ powdered milk and liquid meals
- ✓ sports drinks and protein powders
- ✓ juice concentrates
- ✓ dried fruit and nuts
- ✓ Crackers and nut butters
- ✓ Freeze-dried and canned meals.

Eating and drinking well en route

- The athlete should be aware of the risk of "*boredom eating*" when confined in a travel vehicle. Extra vigilance is needed to ensure that they eat according to their real needs, taking into account the forced rest while travelling
- When moving to a new time zone, the athlete should adopt eating patterns that suit their destination as soon as the trip starts. This will help the body clock to adapt
- Unseen fluid losses in air conditioned vehicles and pressurized plane cabins should be recognized and a drinking plan should be organized to keep the athlete well hydrated
  - ✓ Fluid choices should be appropriate to the athlete's energy requirements
  - ✓ Contrary to popular beliefs, caffeinated drinks such as tea, coffee and cola beverages have minimal effect on hydration and may even supply a substantial amount of fluid to the diets of habitual consumers. However the intake of caffeine should be considered in view of sleep patterns

Care with food/water hygiene

- A fundamental item of information to source is whether the local water supply is safe to drink. When this is not the case, the athlete should stick to beverages presented in sealed bottles from recognised manufacturers or to hot drinks made from well-boiled water
- Ice should be avoided in environments with unsafe water supplies since it is usually made from tap water
- In high-risk environments, the athlete should eat only at good hotels or well-known restaurants or from the athlete's village cafeteria. Food from local stalls and markets should be avoided, however tempting it is to have an "*authentic cultural experience*"
- The safest foods are those which have been well-cooked and served shortly after preparation.
- It is best to avoid salads or unpeeled fruit that has been in contact with local water or soil

Adhering to a food plan

- The athlete should choose the best of the local cuisine to meet their nutritional needs, supplementing with their own supplies where needed
- The athlete may even experiment with foreign cuisines and local dishes prior to undertaking their travel to become more accustomed to the food they are likely to encounter
- The athlete should be aware that their training and race/event schedules (e.g. pool time) may overlap with meal times, especially in countries with a different culture of eating patterns or in locations where catering options are inflexible. They may need to request special consideration, including boxed meals or snacks that can be kept or taken to the event venue
- The athlete should be assertive in asking for what they need at catering outlets – e.g. low fat cooking styles or an extra carbohydrate choice
- The challenges of "all-you-can-eat" dining should be recognized. The athlete should resist the temptation to eat *"what is there"* or *"what everyone else is eating"* in favor of their individualized, and optimal, meal plan