WORLD AQUATICS

NUTRITION FOR AQUATIC ATHLETES

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INTRODUCTION

Aquatic athletes need specific nutrients which they should eat at different times because their athletic activities produce shifting nutritional requirements. Aquatic athletes must handle extended training periods and elevated competition requirements.

The current situation makes nutrition a Key Factor which determines the sport performance, the recovery and the health status. It also extends the duration of an athlete's career.

This 2nd Edition of the Nutrition for Aquatic Athletes Brochure, developed under the authority of the World Aquatics Sports Medicine Committee, provides an evidence-based update to the 2013's publication. The document shows present worldwide agreements based on scientific research conducted from 2020 to 2025. The document serves as a scientific guide which medical researchers and clinical nutrition experts developed to help coaches and athletes and sports dietitians and physicians and national federations with their work.

The guide contains five distinct sections and provides specific guidelines which athletes can use throughout their entire competitive year. The key to remember is: Food = Fuel.

Part 1 – Core Nutrition Principles

New information about energy availability and macronutrient consumption, hydration requirements, micronutrient needs and evidence-based dietary supplement recommendations.

Part 2 – Specialised Populations & Medical Conditions

Female athletes, Youth and Master's athletes, plant-based diets, chronic medical conditions, RED S, eating disorders and religious fasting.

Part 3 – Recovery and Performance

How important is the recovery (3 Rs' approach). How technology may help the athletes to create their dietary plan.

Part 4 – Travel & Challenging environments

Travel nutrition and fuelling in challenging environments such as hot, cold, high altitude, and polluted waters, including integration of modern wearables and monitoring

Part 5 – Sport specific Nutrition

Specific nutrition information for each aquatic sport.

Important Notice:

Always consult your doctor, team physician, or a nutritionist before adjusting your nutrition plan. They will provide personalised advice based on your health, medical history, and medication.

ACRONYMS

REDs:	Relative Energy Deficiency in Sport
EA:	Energy Availability
LEA:	Low Energy Availability
ROS:	Reactive Oxygen Species
DASH:	Dietary Approach to Stop Hypertension

WORLD AQUATICS

PART 1

CORE NUTRITION PRINCIPLES

ENERGY NEEDS AND AVAILABILITY

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)
- physical activity (both aerobic or anaerobic or a combination).

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.

Energy Balance

The training requirements of aquatic athletes need energy consumption that fulfils their short-term exercise needs and their body's permanent responses to exercise, keeping in mind fuel required to repair old and build new muscle.

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. 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. Yet it does not take into account the fuel requirements of building new muscle, regardless of age or sport.

Total Energy Expenditure (TEE) shows the complete energy usage of the body which stems from three essential components:

BMR – Basal Metabolic Rate

The human body requires energy to maintain its basic operations when someone stays motionless because it needs to operate the heart and lungs and control body temperature.

TEF – Thermic Effect of Food

The body requires energy to perform three main functions which include nutrient digestion and absorption and metabolic processing.

TEA – Thermic Effect of Activity

The body uses energy from three sources which include structured training sessions and competitive events and daily non-exercise activities.

TEE = BMR + TEF + TEA

The total dietary energy intake (TEI) equals TEE in energy balance. Athletes in high performance sports use specific time-based methods to achieve muscle growth through brief periods of excess calories and fat reduction through brief periods of calorie restriction while maintaining their health.

Athletes who compete in aquatic sports face a major threat from their ongoing practice of eating insufficient calories.

Signs include:

- Increased fatigue or irritability
- Plateau or decline in performance
- Recurrent illness or injury
- Sleep disruption and low mood

Healthcare providers need to assess both the level of training intensity and dietary food consumption when they notice these symptoms.

Energy Availability (EA)

The body requires more than energy balance to ensure it has sufficient energy for its essential physiological functions. The Energy Availability (EA) provides an element to measure this factor.

EA = (Energy Intake – Exercise Energy Expenditure) / kg Fat Free Mass

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 caloric threshold is set at 30 kcal (125 kJ) per kg FFM.

Sport science professionals use the following standard measurement points in their work.

- >45 kcal/kg FFM/day – Optimal
- 30–45 kcal/kg FFM/day – Reduced
- <30 kcal/kg FFM/day – Low; associated with physiological dysfunction, muscle loss and REDs

Low EA over weeks to months can lead to:

- Menstrual dysfunction in females (oligo/amenorrhea)
- Decreased testosterone in males
- Reduced immune function and delayed recovery
- Mood changes and reduced training adaptation
- Impaired performance
- Loss of muscle adaptation and growth

The bone formation process weakens, leading to an increased susceptibility to bone fractures (a condition known as osteopenia/osteoporosis)

High risk groups include:

- Adolescents in heavy training
- Athletes who want to achieve a lean body shape.
- Athletes who need to perform double sessions while their food access remains restricted.
- Athletes who follow restrictive or unbalanced eating patterns including poorly organised vegan dietary plans.

Monitoring and Managing EA

Monitoring

Measuring EA is not easy. Different methods and indicators can be used by a healthcare professional to estimate EA or to identify potential signals of Low Energy Availability (LEA).

Food Records:

Analyse 3–7-day food logs maintained by athletes to assess energy intake and macronutrient distribution, with particular focus on the nutrient intake relative to training times as well as fuel (usually liquid) consumed during training.

Body Mass and Composition Trends

Regular review of body weight and composition

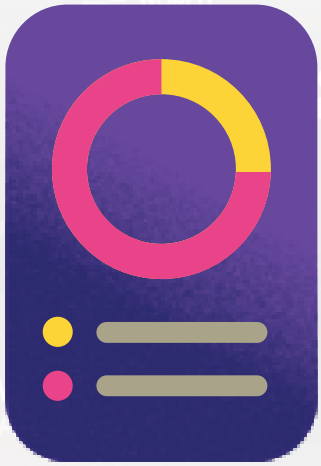
Tracking changes

Does the athlete is regularly sick? Do you observe regular injuries, overuse injuries or changes in training tolerance and performance? All of these may indicate LEA or Relative Energy Deficiency in Sport (REDs).

Self-monitoring

The athletes should observe and report:

- Fatigue and mood fluctuations
- Sleep quality and duration
- Hunger levels
- Training quality and recovery
- Menstrual Cycle (Female Athletes).



If LEA is suspected, the athlete's physician should conduct tests to identify deficiencies or abnormal hormones profile.

Managing

Adjust Energy Intake (EI) based on training load

- High-Volume Training Days: Increase total energy intake to match elevated expenditure, including fuel intake during practice + timing of calories following practice.
- Recovery Days: reduce slightly protein intake while ensuring energy needs are met.

Meal timing and distribution

- Distribute meals and snacks throughout the day (4–6 times).
- Prioritise intake before and after main training sessions to optimise fuelling and recovery.
- Focus on nutrient-dense foods: dairy products (e.g., Greek yogurt, milk), nuts and seeds, dried fruits, healthy oils (e.g., olive oil, avocado), whole-grain starches (e.g., quinoa, brown rice)
- Focus on timing of food/nutrient intake following training
    - nutrient/ fuel intake is best within 90 minutes following training.

Avoiding dangerous practices

- Avoid aggressive weight loss methods (e.g., extreme dieting, intermittent fasting) unless medically supervised. If weight loss is desired strength training needs to be increased to maintain muscle while burning off fat.
- Educate athletes on the risks of low EA, including decreased performance, increased injury risk, hormonal imbalances, long-term health consequences (e.g., osteoporosis).

MACRONUTRIENTS FOR AQUATIC ATHLETES

Carbohydrates

Carbohydrate provides an important fuel source for the brain and muscle during exercise. 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.

Role in aquatic performance

Carbohydrates are the primary substrate for the different aquatic activities :

- Interval sets and race pace training
- Sprints, starts, and turns
- Explosive movements (e.g., starts, turns, and sprints)
- Prolonged, high-demand routines (artistic swimming)
- High intensity phases in water polo and open water swim

When the body fails to obtain sufficient carbohydrates, the athletes experience:

- A rapid glycogen depletion, leading to premature fatigue and reduced power output.
- Increased perceived exertion, making training and competition feel significantly harder.
- Muscle loss noting that the muscle fibers that are lost/compromised first are the ones that are under the most stress i.e. the most important ones for performance
- Impaired decision-making and coordination, as the brain relies on glucose for optimal cognitive function.
- Incomplete recovery between sessions, compromising performance over multi-day competitions.

Daily Carbohydrate Needs

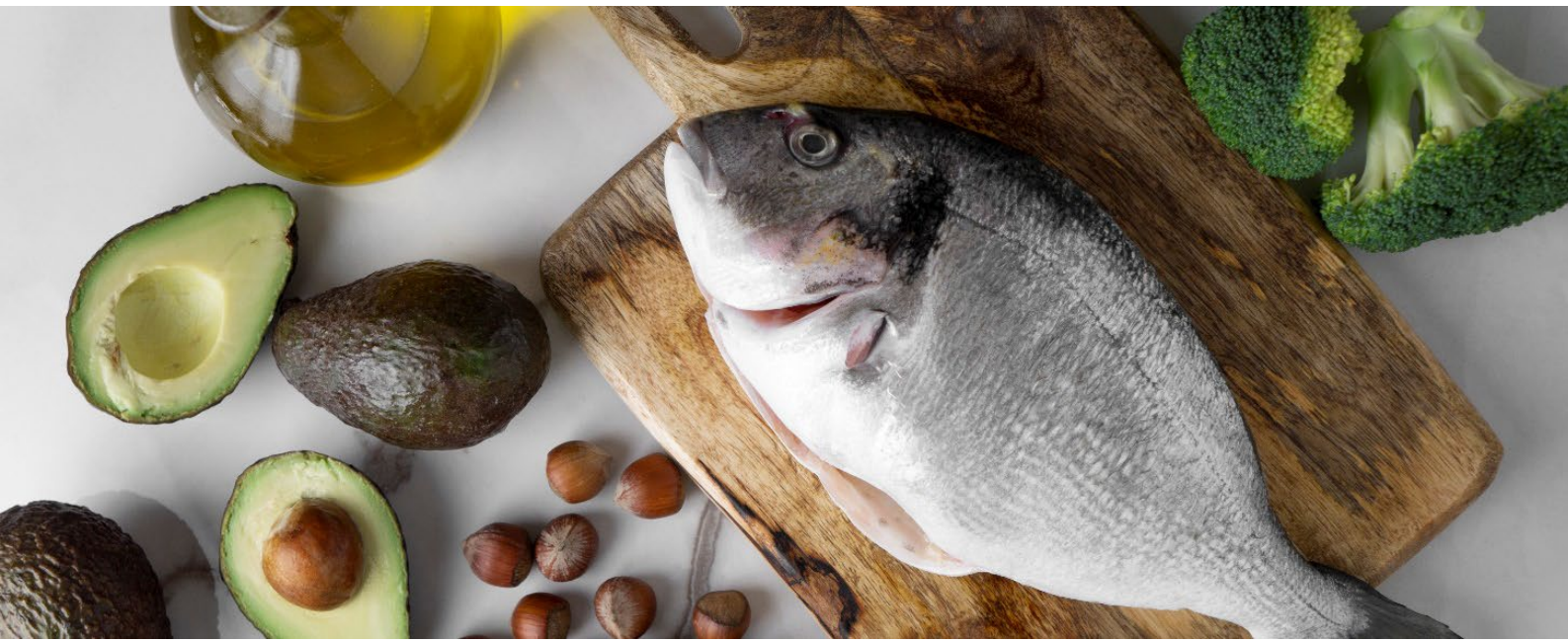
Athletes should determine their carbohydrate needs through training fuel requirements instead of following specific high-carb or low-carb dietary rules. The training intensity level determines the amount of carbohydrates that should be consumed by athletes.

Daily Carbohydrate Needs (Burke et al., 2011):

Training Load	g/kg/day
Light	3–5 g
Moderate	5–7 g
High Intensity	6–10 g
Ultra Endurance	8–12 g

Note: g/kg/day = g / kg of body mass / day

Fats in aquatic athletes



Key roles

Fats are not just a source of stored energy but are essential for various physiological functions:

- Energy production. During low to moderate exercise fat provides more energy per gram than carbohydrates
- Hormonal system: Fats are needed to produce hormones that support muscle growth and repair, like testosterone and cortisol
- Cellular health: Fats are key components of cell membranes and play a role in protecting and repairing cells.
- Nutrient absorption: body absorbs fat-soluble vitamins which include A, D, E and K
- Modulation of inflammation and immune function

The consumption of extremely low-fat diets which occur with low EA levels leads to endocrine disruption and immune system weakness and menstrual cycles disorders.

Practical recommendations

The total fat content needs to amount to 25–35% of the total energy value.

- Minimum: 0.8–1.0 g/kg/day
    - Prioritise unsaturated fats:
    - Extra virgin olive oil, canola oil
    - Avocado, nuts, seeds
- Oily fish (salmon, sardines, mackerel)
- Limiting factors:
    - Industrial trans fats and saturated fats in processed foods exceed the recommended amounts.

Omega 3 Fatty Acids (EPA/DHA)

Omega-3 fatty acids, particularly EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid), play a unique role in sports nutrition. They have anti-inflammatory benefits reducing muscle soreness and accelerating recovery.

Dose range 1.5–3 g/day from food and/or supplements. They may:

- Reduce Delayed Onset Muscle Soreness (DOMS)
- Support joint health and recovery

Food first approach:

- 2–3 servings/week of oily fish
- The general health benefits of ALA plants include chia seeds and flaxseed and walnuts, but people should take marine omega 3 supplements when their dietary omega 3 levels are insufficient.

Proteins

Roles

Protein supports:

- Repair of exercise induced microtrauma
- Muscle remodelling/building and strength development
- Immune defence and wound healing
- Hormone and enzyme synthesis

Given the high frequency of training (often 2 sessions/day), aquatic athletes benefit most from adequate daily intake and optimal distribution rather than very high single doses.

Daily requirements

The recommended daily protein intake for general athletes should be between 1.2 and 2.0 grams per kilogram of body weight.

Higher end (1.6–2.0 g/kg/day) for:

- Sprinters and strength focused swimmers
- Masters athletes (due to anabolic resistance)
- Energy restricted phases (fat loss)

Timing and distribution

The daily protein intake needs to be consumed every 3–4 hours through 4–6 meals/snacks.

The recommended post training intake should be ~0.3 g/kg body weight during the 30–60 minute period following exercise while consuming carbohydrates.

Athletes who train heavily and masters athletes should consume 20–40 grams of casein-rich protein before sleep as this helps their bodies repair during rest time.

Protein Sources

Animal based (complete proteins):

Eggs, dairy, lean meat, poultry, fish

Plant based:

Soy (tofu, tempeh), quinoa, buckwheat, seitan, legumes + grains in combination

Supplements:

Whey, casein, or plant-based protein powders and bars can be used where food is impractical (e.g., travel, late night sessions) but should complement a food first approach.

MICRONUTRIENTS & 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 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, and routine high-dose antioxidant supplementation should generally be avoided.

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.

Iron

Human body requires iron to perform its essential functions in haemoglobin, myoglobin and mitochondrial enzyme operations. In food there are two forms of irons:

1) heme iron, found in animal products like red meat and poultry and
2) non-heme iron, which is found in plant-based sources (legumes and leafy greens).

Heme iron is absorbed more efficiently.

The condition of iron deficiency which results in anaemia or without anaemia, affects numerous female and adolescent swimmers who experience decreased endurance and reduced training performance associated with extended recovery times.

Key points:

The preferred choice for heme iron consumption should be red meat, poultry and fish.

People should eat vitamin C rich foods like fruits and vegetables during their non-heme iron containing meals to enhance iron absorption.

- The consumption of tea, coffee and high calcium foods should be restricted when eating foods that are rich in iron, they reduce iron absorption.
- Use iron supplements only under medical supervision, guided by blood tests and hepcidin levels where possible.

Iodine

The body requires iodine for thyroid hormone production, which regulate metabolism, energy production, and body temperature.

Chronical exposure to chlorinated pool may interfere with iodine uptake and the thyroid gland activity.

Recommendations:

- Recommended daily intake for adults and adolescents should be 150 µg.
- Recommended daily intake for pregnant and lactating athletes should be between 220–290 µg.
- Recommended intake should be directed by blood levels or iron and stored iron (Ferritin)

Main food sources for iodine include iodised salt, dairy products, eggs, seafood and specific types of seaweed. However, people should stay away from taking too much iodine through supplement that contains kelp or seaweed because these products lack proper regulation.

Vitamin D

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.

Risks:

Different factors connected to sun exposure may increase chances of developing low vitamin D levels. Indoor training, living in high latitudes, darker skin or permanent sunscreen protection are known to affect the production of Vitamin D. Regular blood screening is necessary for such athletes.

Target:

Serum concentration ≥75 nmol/L

People who need vitamin D supplements should take 1,000–2,000 IU/day under medical supervision and may consider judicious sunshine exposure.

Calcium

Calcium also deserves attention, especially in adolescents and in female athletes, due to its role in bone mineralisation, nerve transmission, and muscle contraction.

Moreover, the low-impact nature of aquatic sports provides a weaker bone-building stimulus compared to other sports. Essential minerals for bones must be obtained through diet and additional exercise that includes higher-impact or resistance activities. Land based strength programs help support healthy bone production.

For most adults, the recommended daily calcium intake is around 1,000–1,200 mg per day, depending on age and sex.

For adolescents, the daily intake is around 1,300 mg.

Sources:

- Dairy and fortified plant milks
- Hard cheeses, yogurt
- Calcium set tofu, leafy greens (kale, bok choy), almonds

Antioxidants and Phytochemicals

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. Reactive Oxygen Species (ROS) as a typical response to extreme physical exercise.

The use of high-dose antioxidant supplements which include large amounts of vitamins C and E does not support training progress and should be avoided as a standard practice.

Instead, dietary sources should be considered.

- Vitamin C: citrus fruits, berries, kiwi, peppers.
- Vitamin E: nuts, seeds and plant oils.
- Polyphenol: berries, grapes, green tea and cocoa.
- Carotenoids: carrots, sweet potatoes and spinach.

HYDRATION STRATEGIES

Hydration in aquatic environment

An aquatic environment does not mean that hydration is not important. At contrary, we often observe that hydration is underestimated. There is an important fluid loss due to sweat and respiration event in the water.

Consequently, 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.

Consequences of hypohydration:

- The swimming technique produces less power and becomes less efficient in its stroke execution. The heart beats faster at a constant speed.
- Concentration declines and may impair decision-making.
- Thermoregulatory capacity decreases.

Consequences of overhydration:

The condition known as hyponatremia exists when plasma sodium levels fall below 135 mmol/L which leads to various symptoms starting from nausea and confusion and progressing to seizures.

Therefore, the following questions should be considered:

- when may it be helpful to drink during a workout or event?
- how much to drink?
- what type of drinks are best?

- what modifications should be made in hot or cold environments, especially in the case of open water swimmers?

Sports drinks vs Energy drinks

It is crucial for the athletes and their support staff that the difference between the two drinks is made.

Feature	Sports Drink	Energy Drink
Primary purpose	Hydration + electrolytes + CHO	CNS stimulation (caffeine) + sugar
Typical contents	Water, sodium, potassium, 4–8% CHO	High caffeine (80–300 mg), sugar, additives
Use during sport	Yes – for longer/intense sessions	Generally, not recommended during event
Doping risk	Low (if third-party tested)	Higher (unregulated stimulants possible)

For hydration and fuelling, prefer:

- Water (it remains a good resource)
- Sports drinks that can be consumed during sessions which last more than 60 minutes and when athletes compete in hot environments.

The use of "energy drinks" should be prohibited from becoming a standard practice during both training sessions and competitive events.

Homemade Sports Drinks

The use of basic homemade solutions becomes essential due to budget constraints and anti-doping regulations.

For 1 liter:

- 30–60 g sugar / maltodextrin
- 250 mL fruit juice
- The recommended amount of table salt for this recipe should be teaspoon and 1/2 teaspoon which contains 500–1,000 mg of sodium.

- Top up with water (filtered or boiled & cooled) to reach 1 L

The process results in a 6–7% carbohydrate solution which contains electrolytes at levels found in various commercial beverages. Athletes need to modify their concentration levels between 4–8% based on their body temperature and their ability to tolerate gastrointestinal issues.

Individualised Hydration

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 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.It is key to develop a drinking plan for training and competition that is right for each athlete. The main points to be taken into consideration are : typical sweat losses, opportunities to drink in their sport, and feedback from comfort and thirst.

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: wet hair and swimming costume are likely to be carrying water weight, even after you 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%

Team support should perform measurements of sweat rate by tracking body mass changes between the start and the end of each workout session.

If an athlete experiences recurring muscle cramps and produces excessive sweat, a sodium level test needs to be conducted.

Rehydration guideline:

- Drink 1.2–1.5 L per kg of body mass lost over the subsequent 4–6 hours.
- The hydration strategy should include sodium addition to fluids and salty foods at amounts of 20–50 mmol/L which equals 460–1,150 mg/L after the session.

Monitoring hydration status

Urine color is a good indicator. A pale straw appearance of urine indicates that the body maintains euhydration (=an adequate hydration).

The following symptoms may appear when someone develops dehydration: thirst, dry mouth, headache, dizziness and poor concentration, decrease in muscle performance.

SUPPLEMENTS

Many athletes in the aquatic disciplines look to sports foods and dietary supplements for health and performance benefits, including:

- modifying physique – gaining muscle mass or losing body fat
- providing a fuel supply for the workout or race
- allowing more consistent and intensive training by increasing vigour during a workout or promoting recovery between sessions
- promoting adaptations to training
- maintaining good health and reducing interruptions to training due to chronic fatigue, illness or injury
- enhancing competitive performance
- addressing a nutrient deficiency
- Providing a convenient source of nutrients that is easy to consume when everyday foods are unavailable or impractical to eat. This is most often the case just prior to, during, or after an exercise session, or sometimes when travelling.

Some of these products may have benefits for some aquatic athletes, but this will depend very much on the discipline, the performance level, the training status and also on the biochemistry and physiology of the individual.

Sports foods are generally manufactured to achieve the last of these goals, and by providing a practical way to meet special nutrition needs they may indirectly assist the athlete to achieve some of the benefits on the list.

Examples of sports foods that might be useful include:

- sports drinks (providing fluid and carbohydrate during exercise)
- sports gels (additional carbohydrate intake, especially during exercise)
- liquid meals (carbohydrate, protein, vitamins and minerals for a pre-event meal, post-exercise recovery or a high-energy diet)
- sports bars (carbohydrate, protein, vitamins and minerals – often a solid form of the liquid meal)
- protein powders (high quality protein source that can be mixed with water into a drink or added to other fluids such as milk or fruit smoothies to boost the protein content)

Of course, the cost of these sports foods must be taken into account when deciding to use them. Furthermore, the athlete should recognise that the sports food market includes products that are carefully manufactured to provide nutrients to meet well documented goals right through to gimmicky items that have a poor composition or the addition of ingredients with no evidence base.

The use of pills, potions, powders and other sports supplements is widespread, but few products are supported by robust research, and some may even be harmful to the athlete.

Athletes should look carefully at the risks and rewards of individual supplements before trying them.

Where there is a demonstrated deficiency of an essential vitamin or mineral, and an appropriate intake from food is not possible, a supplement may be helpful. For example, other sections of this document have noted that athletes with a diagnosed deficiency of iron or Vitamin D may benefit from a course of supplements, but this should be done only if a blood test shows it to be necessary.

The use of supplements, however, does not compensate for poor food choices and an inadequate diet. A much better option is to develop the knowledge and skills to ensure that all your nutritional needs are met from a variety of well-chosen foods.

Caffeine

It has an ergogenic effect for many aquatic events as it does reduce perception of effort and enhance alertness and neuromuscular function.

The recommended intake should be between 3–6 mg/kg that athletes should take at least 60 minutes before their most important event. The dosage of 2–3 mg/kg will produce similar effects to the full dose but with less potential adverse reactions.

Larger doses of caffeine do not seem to be more effective, and may have negative outcomes such as anxiety, gastrointestinal distress, over-arousal and poor sleep patterns after an event. This is likely to be a problem in multi-day events and in sports involving heats and finals. Please remember that caffeine is also a diuretic and promotes dehydration with the negative impact that has on sports performance.

Creatine

Supplementation with creatine monohydrate can increase the amount of high energy phosphocreatine stored in the muscles, and may improve performance in single or multiple sprints.

Creatine is normally found in meat and fish, but the effective doses are more than is found in normal foods.

- Loading phase: 20 g/day (4 x 5 g) for 5–7 days, or
- Maintenance phase: 3 –5 g/day over several weeks

As with all supplements, exceeding the maximum effective dose is not helpful.

Beta-alanine

During very hard exercise, the muscles produce lactate and hydrogen ions (acidity). This is both good (giving energy to allow hard efforts) and bad (causing pain and interfering with muscle function).

Beta-alanine intake (4–6 grams per day) over 4-8 weeks has been shown to increase levels of carnosine, an important buffer, in the muscles.

This buffering effect delays muscle fatigue, allowing for longer or more intense sessions.

Dietary nitrates

Supplementation of the dietary nitrates has been shown to reduce the amount of oxygen required to do a set amount of work.

Beetroot juice, spinach, arugula, and other leafy greens are rich in nitrates that the body converts to nitric oxide, improving blood flow and oxygen delivery to muscles.

More research is needed to confirm the efficacy of beetroot juice/nitrate supplementation in well-trained aquatic athletes. It seems that there is a small, effect in endurance event of less than 30 minutes. It seems however that these effects vary from one individual to another.

Tart cherry and other polyphenol rich foods

Polyphenols are now well known for their antioxidant effect. They will help faster recovery times and reduce the muscle pain after exercise.

Polyphenols can be found in tart cherries and berries for instance.

Supplements and safety

It is strongly recommended to only use supplements that have been certified by recognised third party organisations to avoid any contamination risks that could lead to anti-doping rule violations.

WORLD AQUATICS

PART 2

SPECIALISED POPULATIONS & MEDICAL CONDITIONS

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 in some cases a lower total training load)
- Greater risk at developing disordered eating/eating disorders

The section 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 availability, 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.

Menstrual Cycle: Performance and Fuelling

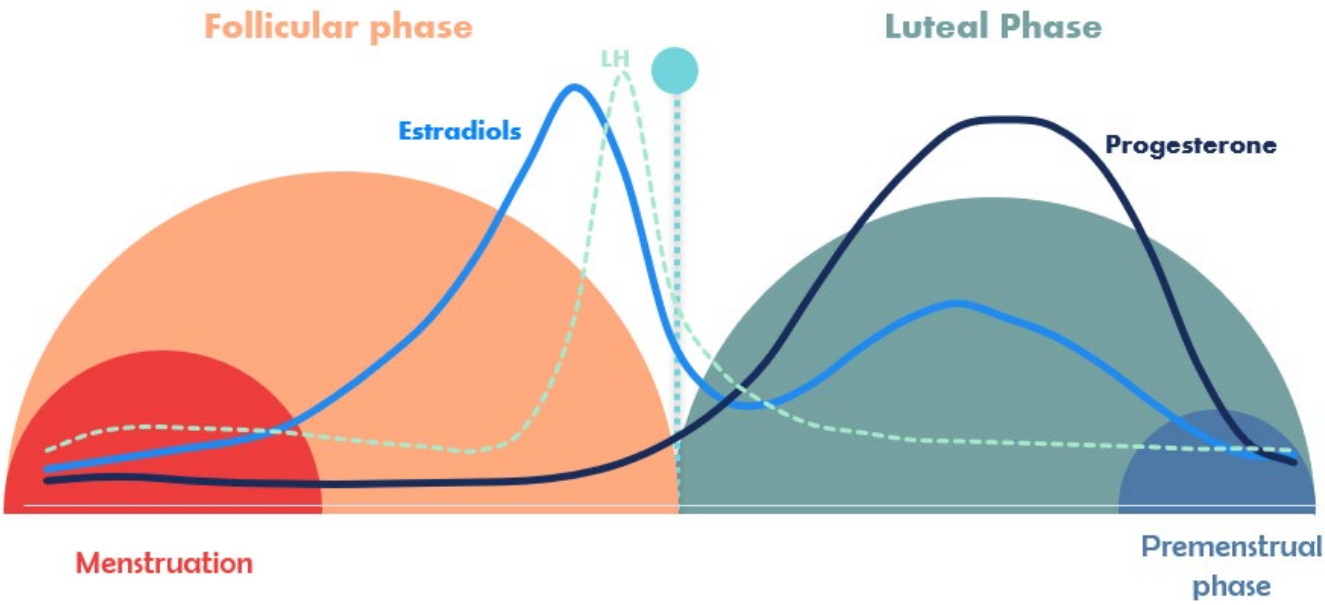
The ovarian hormones control different systems of the female body and affect sport performance through their influence on the metabolism.

Every woman, every athlete is different.

Athletes should know about their menstrual cycle and should be encouraged to keep a menstrual health journal, logging symptoms, moods, sleep, and performance impacts during each cycle, to help in understanding personal patterns and planning around potential disruptions.

Aquatic sports often involve an early specialisation, coupled with intense training sessions and high energy expenditure, especially at a young age. Due to these demanding conditions, athletes are at an increased risk of experiencing menstrual cycle irregularities. The combination of demanding physical activity, high training volumes, and the pressure to maintain peak performance can disrupt the hormonal balance, leading to a higher prevalence of cycle disorders (primary amenorrhea, secondary amenorrhea, and oligomenorrhea) among athletes in aquatic sports. These menstrual cycle disturbances can be partly due to a Low Energy Availability (LEA)/Relative Energy Deficiency in Sport (REDs).

Typical cycle phases



(Source : Dupuit, Marine – INSEP)

- Menstrual Phase (Day 1-5): Physical and mental energy may be lower, and symptoms like abdominal cramps are common.
- Follicular Phase (Day 6-14): Estrogen level begins to rise and peaks just before ovulation day. (Day 14), which can boost energy. This phase may be ideal for incorporating higher-intensity training, as it can maximize strength gains and enhance muscle recovery.
- Luteal Phase (Day 15-28): Both progesterone and estrogen increase with higher progesterone levels. The drop of hormonal concentration at the end of this phase can lead to various symptoms. The body experiences elevated core temperature and elevated heart rate and excessive sweating, possible fluid accumulation in the body, gastrointestinal problems or changes in mood.

Practical cycle aware strategies

Across the cycle

- Athletes need to track their menstrual cycles by using apps or journals.
- Collected data should enables support staff to develop individualised training programs and dietary plans instead of using it to limit athlete performance.

Follicular phase

- The body improves its ability to process insulin and uses carbohydrates as its main energy source.

Luteal phase

- Daily protein intake should be slightly higher than 1.8–2.0 g/kg/day because it will supports muscle repair and prevent muscle tissue deterioration.
- Athlete should eat carbohydrates at a steady pace by using low glycemic index foods and scheduled snacks to manage blood sugar fluctuations and stop hunger.
- Increase water and electrolytes to compensate high body temperature and excessive sweating.
- Athletes need to track their gastrointestinal comfort so they can modify their fiber and fat consumption before their competition when needed.

Key strategy for coaches and support staff:

Menstrual Cycle is a topic that is not much discussed within the athletic community. Over 81% of athletes considered menstrual cycle as a taboo. There is often a lack of open communication between athletes, coaches, and medical staff regarding menstrual health.

Adapted nutrition strategies can help to reduce the symptoms of physiological stress. For instance, encourage a balanced diet rich in whole foods, omega-3 fatty acids, and hydration, which can reduce discomfort and menstrual pain.

Minimize caffeine, additive sugar, salty and processed foods, as they can exacerbate symptoms like cramps and bloating.

Key nutrients and REDs' risk in female athletes

High volume training, aesthetic or leanness pressures, associated with mismatched energy intake, place female aquatic athletes at high risk of LEA and REDs.

Iron

The screening process should be performed regularly for all female athletes but women that experience heavy bleeding during menstruation and adolescents need more frequent checks.

The body should receive heme sources which include red meat and poultry and fish while non-heme sources need to be consumed with vitamin C.

The medical team should monitor who receive supplements to validate specific timing based on hepcidin levels.

Calcium and Vitamin D

The body needs Calcium to maintain bone strength and prevent stress fractures. Vitamin D is critical in calcium metabolism for healthy bones as well as important in maintaining a healthy immune system.

Red flags that may mean REDs

- Menstrual irregularity or amenorrhoea
- Recurrent stress fractures or low bone density
- Athlete shows unintentional weight loss together with fatigue and persistent cold intolerance.
- Food rigidity, weight preoccupation, or anxiety around eating

The process of early identification requires sports physicians to work with dietitians and psychologists as well as coaches for proper management of the condition.

Pregnancy

Some aquatic athletes will train and occasionally compete during their pregnancy period. They must receive first an appropriate obstetric clearance and monitoring but can safely perform swimming activities with low impact conditioning exercises.

Energy and macronutrients

Pregnancy requires additional calories, especially in the second and third trimesters (about 300–500 extra kcal/day). The body weight and training level may help to adjust the daily intake.

Proteins are essential for the growth of the foetus. The target is at least 1.1 g/kg of body mass of daily protein which should be distributed throughout the day in equal portions.

The athletes should follow standard athlete nutrition recommendations which need to be modified based on their current training intensity and their ability to consume food because of nausea. Maintaining a healthy hydration status is even more critical with pregnancy. Remember: Pay attention to urine color as an indicator of hydration status.

Key micronutrients

Iron deficiency and anemia are especially common in pregnant athletes. Pregnancy increases the need of several micronutrients like folic acid, iron, iodine, calcium, vitamin D, Omega-3, etc.

Any adjustment should be done under the close supervision of the athlete's doctor.

Lactation and postpartum training

Lactating athletes can safely resume training and competing with a proper fuel & fluid first approach. However, the return to sport elite activities should be done with the approval of the athletes' physician, to tailor the quantity and intensity of their workouts sessions to avoid injury. A gradual approach is recommended.

Energy and hydration

The energy requirements during training should be 450–600 kcal/day higher than a typical practice. It could be adjusted t based on the athlete's specific training needs.

An extra daily fluid intake is also necessary during lactation (if breastfeeding), reaching a total of 3 L/day plus exercise replacements with careful attention to urine color.

Athletes should maintain adequate carbohydrate and protein to support both milk production and maternal recovery.

Nutrient focus

Nutrients adjustment may be required based on the athlete' diet especially for daily intake of calcium, vitamins D and B12, and iron. Iron screening might be necessary to address postpartum anemia.

Practical tips

The training workout should start with either breast milk consumption or expression to minimise breast swelling which causes pain to the mother.

Athletes who consume enough energy and fluids while exercising at high intensity will in principle not experience any changes in their milk production or quality.

YOUTH 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

Growth, energy needs, and training

Youth aquatic athletes undergo fast changes in their body composition and neuromuscular development while performing high-volume of trainings and maintaining their academic duties.

Consequences of under-fuelling include:

- Growth curves below expected levels or delayed puberty
- Continuous fatigue that prevents from concentrating (e.g at school and practice).
- Recurrent illness and slow recovery from injury
- Loss of enthusiasm or early sport drop out

Practical principles:

Youth athletes should receive their food supply through three (3) daily meals and 2 to 3 snack portions which should be based on their training schedule.

- The recommended food choices include milk, yogurt, cheese, nuts, nut butters, dried fruit and granola.
- Adult weight loss methods which include fasting and low carb diets or weight reduction through "cutting" should be prevented for adolescents.

Psychosocial environment and body image

There are different issues that young athletes could face early in their career.

- Coach may provide feedback focused on body weight and physical body shape. In judged or weight sensitive sports (diving, artistic swimming) this pressure is magnified.

- Learning beauty standards through social media.
- Peer comparisons

Entourage should offer a healthy culture

- Emphasise performance, skill, and resilience over aesthetics.
- Ban any team body weight measurements or publication.
- Offer early access to sports dietitians and psychologists as education resources, not when there is problems.

Early warning signs:

- Skipping meals or hiding food
- Rapid weight changes
- Obsessive body checking
- Social withdrawal

The screening process for disordered eating and REDs should begin at an early stage because healthcare providers need to make immediate referrals when they identify any eating disorders symptoms.

MASTERS ATHLETES

Physiological changes

Starting around the age of 50, the human body experiences sarcopenia which causes progressive loss of muscle mass and a decrease of strength.

The body shows anabolic resistance as it does not perform muscle protein synthesis when consuming standard protein amounts during training activities.

Aging is associated with various musculoskeletal changes. First, bone demineralization that can lead to osteopenia and osteoporosis which mainly affects postmenopausal women because they develop higher chances of getting these conditions. And secondly joint degeneration like osteoarthritis that reduced the masters athlete's ability to train due to pain and stiffness in knee and hip.

The body requires less energy at rest which results in decreased overall energy consumption.

The human body fails to recognize thirst signals effectively that can create difficulties to maintain proper hydration levels.

Masters population shows higher rates of hypertension, prediabetes and dyslipidaemia, along with pre-cancerous and cancerous developments. Personal habits (smoking and similar activities/exposures) and family history are critical to consider when screening. Aerobic fitness and healthy dietary habits reduce the risks for developing cancer.

Protein needs and muscle maintenance

To manage sarcopenia and anabolic resistance in masters athletes, it is recommended to increase the daily intake of protein associated with regular resistance training.

The daily protein intake should be between 1.6–2.0 g/kg/day. It represents 0.4 g/kg (30–40 g) per meal which should be taken three to five times daily. The daily intake should contain leucine rich proteins which include whey. Dairy, eggs or soy.

A pre sleep dose of ~40 g casein dominant protein (e.g., cottage cheese, casein shake) will help support muscle protein synthesis during the night.

Bones, joints, and cardiometabolic health

Bone health

Calcium: 1,000–1,200 mg/day from diet and/or supplements.

Vitamin D: the recommended daily intake of Vitamin D should be between 800 IU and 2000 IU to have levels above 75 nmol/L, while taking into account serum blood levels of Vitamin D.

Joint health

Omega 3 fatty acids (1–3 g/day from food or supplements) may reduce joint pain and inflammation.

The combination of collagen peptides (10–15 g with vitamin C) taken before exercise loading serves as an additional support measure.

Cardiometabolic health

The recommended dietary pattern should follow a Mediterranean style that includes vegetables, fruits, whole grains, legumes, nuts, olive oil and fish.

Masters athletes need to monitor their sodium intake and body fluid status through their blood pressure checks.

Recovery and immune function

Masters athletes show delayed recovery times and become more prone to getting sick.

Recovery nutrition priorities:

The recommended post exercise intake should include 20–40 grams of protein together with 1.0–1.2 grams of carbohydrate per kilogram of body weight during the first 30–60 minutes after exercise. Nutrient intake during practice (usually liquid) also supports muscle health.

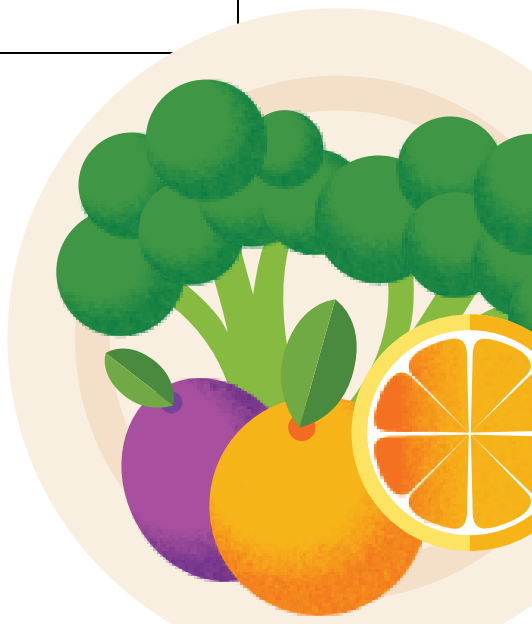
Support immune function with:

Zinc, vitamins C and D, vitamin A and E.

A diet rich in colourful plant foods and fermented products (e.g., yogurt, kefir).

Example of daily menu – Masters Athlete

Timing	Example Meal / Strategy
Breakfast	Eggs + wholegrain toast + berries + coffee
Snack	Greek yogurt + walnuts + honey
Lunch	Grilled salmon + quinoa + spinach + olive oil
Pre-training	Banana + whey or soy protein shake
Post-training	Milk-based smoothie with whey + oats + berries
Dinner	Lentil soup + chicken breast + roasted vegetables
Pre-bed	Cottage cheese or casein shake



SPECIAL DIETS

Vegetarian and vegan Athletes

Plant based diets have become more popular among athletes as they choose to follow this diet for ethical reasons, environmental concerns or health benefits.

Key challenges and solutions:

Nutrient	Risk / Issue	Strategies
Protein	Lower leucine & digestibility	Combine legumes + grains; include soy, tofu, tempeh, seitan
Iron	Lower bioavailability (non-heme)	Pair with vitamin C; avoid tea/coffee during meals
Vitamin B12	Absent in unfortified plant foods	Use supplements or fortified foods
Zinc	Phytate interference	Soak/sprout legumes/grains; consider low-dose supplement
Calcium	Lower intake without dairy	Use fortified plant milks, tofu, almonds, leafy greens
Omega-3 (EPA/DHA)	Only Alpha-Linolenic Acid in plants	Microalgae-based EPA/DHA supplements (250–500 mg/day)
Creatine	Absent in plant foods	Consider creatine monohydrate 3–5 g/day if appropriate

Additional considerations:

The high fiber content in this diet may restrict the ability to consume enough calories so the athlete should use smoothies, oils and nut butters together with fortified foods to reach the daily energy needs.

Athletes should regularly consult with a dietitian to identify any nutritional deficiencies and develop a complete new eating plan.

Religious Fasting – Example: Ramadan

The practice of fasting during Ramadan requires people to abstain from food and water throughout the entire day which creates major problems for their energy needs and their body fluid levels particularly when they train at high levels or live in hot environments.

Key risks:

- The body receives insufficient energy while its glycogen stores remain at subpar levels during both training and competitive competition hours.
- The human body loses excessive amounts of water during sports activities which become either long or require high levels of physical exertion.

During the Ramadan period, the athlete faces three other challenges: disrupted sleep patterns, shifts in circadian rhythm, and reduced recovery time.

Performance supportive strategies:

Training timing:

- The primary training session needs to occur immediately following iftar (evening meal) because this period enables athletes to consume food and liquids for optimal performance.
- The training process should continue during fasting but athletes should decrease their workout intensity and time when needed.

Suhoor (pre-dawn meal):

- The nutrition strategy needs to offer athletes slow-burning carbohydrates together with high-quality protein and electrolyte-rich fluids.
- The meal should contain some healthy fats (nuts, seeds and avocado) to help with feeling full.

Iftar (sunset meal):

- The first foods should include fluids together with simple carbohydrates (e.g dates, fruits and soups).
- Athlete should eat a balanced meal containing carbohydrates together associated with lean protein, vegetables and healthy fats.

Post-iftar snacks:

- The window between iftar and suhoor should be used to provide additional snacks and recovery drinks which will help athletes to meet their energy and nutrient requirements.

Recovery and sleep:

- Athletes should focus on taking short naps while following good sleep practices to reduce the impact of broken nighttime rest.

MEDICAL CONDITIONS

Each athlete, each man, each woman are different. Therefore, support staff and medical professional needs to create personalised nutrition plans adapted to the current medical treatments and protocols. It is important that sports physicians work together with endocrinologists and dietitians for the best of the athletes.

REDs and Eating Disorders

Relative Energy deficiency in Sport (REDs) is *a syndrome of impaired physiological and/or psychological functioning experienced by female and male athletes that is caused by exposure to problematic (prolonged and/or severe) LEA. The detrimental outcomes include, but are not limited to, decreases in energy metabolism, reproductive function, musculoskeletal health, immunity, glycogen synthesis and cardiovascular and haematological health, which can all individually and synergistically lead to impaired well-being, increased injury risk and decreased sports performance*. [Mountjoy M, Sundgot-Borgen J, Burke L, et al. 2014]

The following groups face increased risk:

- Artistic swimmers and divers (aesthetic emphasis)
- Youth athletes who perform heavy training without sufficient nutrition support.
- Athletes who display perfectionistic behaviour
- Athletes who excessively focus on their body weight and appearance.

Clinical red flags

- Menstrual irregularities or amenorrhoea in females
- Men develop reduced sexual interest, their regular morning erections occur less often.
- Recurrent stress fractures or low bone density
- Persistent fatigue, mood changes, or impaired concentration
- Rigid food rules, secretive eating, or compensatory behaviours

Management framework

The assessment process includes using LEAF-Q and REDs CAT screening tools when these tools are accessible.

The first step needs to increase energy supply through two methods: eating more food or/and reducing training intensity i.e. achieving balance between fuel need and fuel supply

Shift goals from weight to health and performance metrics.

Management of such conditions will require participation from multiple healthcare professionals: physicians, dietitians, mental health specialists and coaches. Initiating the treatment early will give better outcomes and may prevent permanent damages to both the bones and the endocrine system.

Diabetes Mellitus

The types of diabetes generally encounter in aquatic sports are type 1 (T1DM) or type 2 (T2DM). They require complex treatment approaches that could be challenging in the practice of aquatic sports.

Type 1 Diabetes (T1DM)

Athletes who have T1DM need to take external insulin and perform regular blood glucose tests. Regular physical activity can improve insulin sensitivity, reducing the amount of insulin needed to manage blood sugar. However, it also increases the risk of low blood sugar, especially during prolonged or intense exercise.

Nutrition strategies (to be implemented together with medical insulin adjustments):

Pre training:

- Avoid fasted high intensity sessions.
- Athlete needs to receive 15–30 grams of low glycemic index carbohydrates while healthcare staff need to check glucose levels to determine the correct insulin dosage.

During training/competition (>60 min):

- The recommended carbohydrate intake should be between 30–60 grams per hour which should come from liquid or gel sources for fast absorption.

Post training:

- Plan needs to include 1.0–1.2 g/kg of rapid acting carbohydrates together with 0.3 g/kg of protein to help the body recover glycogen stores and repair tissues.

CGM technology enables individuals to detect their glucose patterns and maintain safety, but proper monitoring by qualified healthcare provider is necessary.

Type 2 Diabetes (T2DM)

Physical activity helps T2DM athletes to better use insulin while simultaneously enhancing their heart health and metabolic function. Many Masters athletes fall into this category.

Nutritional focus:

The diet plan should focus on consuming low glycemic index high fibre carbohydrates which should be spread out throughout the entire day. It needs to contain sufficient protein to help repairing muscles and ensure a feeling of fullness.

The athletes need to receive constant monitoring of their blood sugar response to oral hypoglycemic medications because hypoglycemia becomes more likely during high-intensity physical activity.

Replace saturated and trans fats with unsaturated fats (olive oil, nuts, seeds, avocado).

Hypertension

The risk of cardiovascular events rises when someone has hypertension, so they need close monitoring during both high intensity activities and hot weather conditions.

Nutrition considerations

Sodium

The general recommendation for sodium should be around 1,5 g/day without exceeding 2,3 g per day (individuals need to check with their treating physician).

Diet pattern

A DASH style or Mediterranean pattern includes vegetables, fruits, whole grains and low fat dairy products as main components.

Fats

The diet needs to include unsaturated fats instead of saturated fats and trans.

Hydration

Appropriate fluid intake but it needs sodium amounts to correspond to the prescribed medication and blood pressure measurements.

Athletes need to avoid consuming high caffeine pre workout products and unregulated stimulants because these substances lead to elevated blood pressure and dangerous side effects with prescribed medications.

Hypotension

The combination of chronic low blood pressure and orthostatic intolerance produces dizziness and syncope while it decreases exercise performance during and after high-intensity workouts or when standing for long periods (such as post-race ceremonies).

Nutritional strategies (under physician guidance):

Allow athlete to consume sodium at levels between 3–5 grams per day when the doctor approves this amount.

Athlete should drink at least 3 liters of fluid spread throughout the day and remembering to observe urine color. The body should receive electrolytes containing fluids both before starting training and while training.

The diet plan needs to include several small meals during the day as eating causes blood pressure to decrease due to digestion.

Avoid high caffeine consumption and big sugar consumption.

Thyroid Disorders

Thyroid hormones regulate metabolism, energy production, and body temperature.

Hypothyroidism

The condition produces symptoms like fatigue, weight gain, cold intolerance, constipation or irregular menstrual cycles for women. The standard treatment for this condition requires to take thyroid supplementation such as levothyroxine as medication.

Diet support:

Iodine

The recommended daily iodine intake for adults should be 150 µg but people should stay away from taking unregulated supplements or consuming seaweed products that contain high amounts of iodine.

Selenium

The body requires 55–70 µg of selenium each day to perform T4→T3 conversion (e.g Brazil nuts, seafood and eggs are potential sources).

Other micronutrients

Avoid high dose of iron and calcium supplements when taking the medications. The substances may interfere with each other's absorption.

The healthcare provider needs to check athlete's blood levels of vitamin D and B12.

Hyperthyroidism

Main symptoms of hyperthyroidism are : weight loss during excessive hunger, heat intolerance, fast heart rate and anxiety.

Nutritional focus:

Individuals need sufficient energy and protein intake to stop muscle deterioration from occurring. The body needs calcium and vitamin D to maintain bone health.

Regular monitoring of the water intake, especially in warm pool environments.

Avoid all caffeine products and stimulants that will exacerbate tachycardia and anxiety symptoms, typical of elevated thyroid levels.

WORLD AQUATICS

PART 3

RECOVERY & PERFORMANCE

RECOVERY NUTRITION

The process of recovery stands as an absolute necessity because it enables athletes to achieve training adaptation and maintain their immune system and prevents injuries from occurring.

The 3 R's of Recovery should be applied following essential training sessions. The body needs three essential elements for recovery which include **Refuel** (carbohydrate), **Repair** (protein) and **Rehydrate** (fluids + electrolytes).

Athletes who train twice daily or compete in multiple-day events need to focus their recovery activities on the initial 2–4 hours that follow their training session/race.

The 3 R's of recovery

Refuel – Restore muscle glycogen

The body uses up most of its glycogen stores when performing high-intensity sets, during dryland training and competitive events.

Recommendation:

Advised carbohydrate intake should be between 1.0–1.2 g/kg/hour during the first 1–4 hours following intense exercise particularly when training is intense or when athletes compete in multiple races throughout the day.

The first priority should be to consume high glycemic index foods which digest easily such as sports drinks, white rice, pasta, bread, potatoes, fruit or flavoured dairy products.

Repair – Support muscle protein synthesis

The body experiences microtrauma during workouts and competitions. A regular supply of high quality protein is required for repair and adaptation.

Recommendation:

Advised protein intake should be between 20–40 grams which equals 0.3 grams per kilogram body weight and should be consumed within 30–60 minutes after exercise.

Repeat the intake every 3–4 hours throughout the day.

Masters athletes and heavy trainers should consume 1.6–2.0 g/kg/day.

Prioritise leucine-rich foods like dairy, whey, eggs, soy, and combinations of plant-based proteins.

Rehydrate – Replace fluids and electrolytes

The goal is to concentrate on restoring plasma volume and electrolytes instead of depending on water intake alone.

Recommendation:

Drink 1.2–1.5 L per kg of body mass lost over the subsequent 4–6 hours and include sodium addition to fluids and salty foods after the session.

The practice of consuming only plain water in big amounts following extended work periods should be avoided because it will lower plasma sodium levels which will extend the time needed for complete rehydration as well as not providing the critical fuel to exercising muscles

What is an effective recovery meal?

The 3 R's need to be combined into one functional system which provides recovery meals.

Goals	Carbohydrate (g/kg)	Protein (g/kg)	Fat
Rapid glycogen restoration	1.0–1.2	~0.3	Minimal
Muscle gain / strength block	0.8–1.0	0.3–0.4	Moderate
Between competition sessions	1.0–1.2	~0.3	Low–moderate

Include colourful, antioxidant rich foods to support recovery without blunting adaptation: berries, cherries, pomegranate, kiwi, citrus, leafy greens, extra virgin olive oil, nuts and seeds.

Timing considerations

Fast track recovery (next session the same day)

The athlete needs to begin refuelling right away by consuming food and drinks before taking a shower, followed by a complete meal during the next 1-2 hours.

The athlete should receive liquid or semi solid foods when their appetite remains low (milk-based shakes, smoothies and drinkable yogurts).

Next session >24 hours away

Prioritise the total daily amount.

The goal remains to maintain protein distribution throughout the day while preventing any single period of more than five hours without eating.

11.3.3 Evening training

The athletes need to receive their first recovery meal immediately following their training session. A pre sleep snack containing 20–40 grams of casein rich protein together with carbohydrates should be consumed to help the body repair itself during sleep.

Immunonutrition

Immunonutrition is a dietary approach aiming to reinforce the immune system through a specific diet, mainly used in medical context (before/after surgery or to support patient undergoing cancer treatments). It is based on specific intake of micronutrients to regulate the immune response and reduce inflammation.

Athletes become more prone to upper respiratory tract infections as they experience both intense training, travel activities and disrupted sleep patterns. It is therefore pertinent to consider this approach in sport. Immunonutrition in elite sport may help to optimise the recovery, reduce post-effort inflammation, strengthen the immune system (generally affected by intense training) and improve performance.

Key considerations

- Reduce the risk of infection (running nose, influenza) connected to the immune tiredness
- Accelerate/increase the muscular and articular recovery following heavy workouts
- Limit chronical inflammation due to repeated microtraumas
- Support the protein synthesis for the muscular reparation and growth

Key nutrients and micronutrients

- Omega-3 fatty acids (EPA/DHA): anti-inflammatory benefits (2.2.3).
- Arginine : amino acid helping to heal the body and support immune function.
- Glutamine : amino acid essential for immune cells and to manage metabolic stress
- Vitamins and antioxidants: C, D, E, zinc, and selenium to support immune system.
- Probiotics : to balance the health gut

Foods to avoid

- Refined sugars: promote inflammation.
- Alcohol: disrupts recovery and weakens the immune system.
- Ultra-processed foods: lack of essential nutrients.

Practical recovery examples

The first thirty minutes after the workout session/competition (0–30 minutes) are critical as during that period the muscles are more receptive to nutrient absorption.

Associate carbohydrates and protein will improve the recovery by stimulating the muscle protein synthesis.

An example of good post-workout snack should be a balance of carbohydrates (to refill glycogen store), protein (muscles repair) and healthy fats (energy and recovery).

Few examples:

- Greek yogurt with berries and few nuts
- turkey/chicken sandwich with fruit
- recovery smoothie
- rice bowl with lean protein and vegetables

How to monitor recovery?

Focus on key parameters measured over the year and listen to the feedback from the athlete: workouts loads, heart rate, heart rate variability, sleep tracking, strength and asymmetry tests, wellbeing assessment (mood, appetite, injury, illness), session feedback (pain, soreness, etc).

NUTRITION & APNEA PERFORMANCE

First of all, the nutritional recommendations related to apnea comes from physiological principles and related sports nutrition literature. Most of the recent research were on free diving athletes. There is lack of evidence based for World Aquatics' sport.

Apart free diving (a non-World Aquatics discipline), artistic swimming is the sport that immediately comes to mind when you think of apnea and physical exertion.

An artistic swimming routine is composed of several apnea periods mixed with synchronised and acrobatic movements.

In swimming, the repetitive underwater phases offer apnea times associated with high intensity effort. These phases could be a key element of the race.

Apnea is associated with various physiological demands. It involves energy metabolism (aerobic and anaerobic). It will depend on each individual's ability to tolerate hypoxia and how the body performs in low-oxygen conditions.

Potential element to consider:

- To improve blood flow and muscle oxygenation. Consider food rich in nitrates (see #5.4).
- To improve buffering: Beta-alanine is recommended (see #5.3)
- Creatine to support the phosphocreatine system.
- To keep a good hydration to maintain blood plasma

TECHNOLOGY & MONITORING

Digital tools and wearable devices may assist athletes in their nutrition choices, but they should not replace medical professionals' expertise and assessment.

Several performance indicators are accessible to athletes through technological devices: training intensity, sleep patterns, HRV measurements, menstrual cycle, etc.

Key Biometrics Relevant to Nutrition

Common biometrics in aquatic sport are:

Heart Rate (HR) & Heart Rate Variability (HRV)

The body shows signs of under recovery through high resting heart rate and low heart rate variability which also indicate illness or insufficient energy intake.

Sleep duration and quality

Short periods of sleep fragmentation lead to changes in appetite hormones while making physical tasks seem more difficult and preventing the body from recovering properly.

Estimated Energy Expenditure (EE)

Modern devices use swim session data to calculate TEE but these estimates do not provide accurate results for tracking purposes.

Core or skin temperature

Body temperature sensors may provide benefits for athletes who need to handle heat or cold temperatures and for athletes who train in open water environments.

It also exists reusable high-precision sensors for elite athletes to measure sweat range or accessible single-use patches for casual monitoring.

Translating data into nutrition decisions

Training Load & EE	→	Fuel Planning
Sweat Data	→	Personalised Hydration
Sleep & Travel Data	→	Jet Lag and Meal Timing

Practical framework for practitioners

Wearables track calories burned, HRV, sleep, and hydration, which are information to help athletes' physician to tailor caloric intake, recovery nutrition, and hydration plans.

The data collected can flag energy deficits, an overtraining, or a metabolic stress, so the practitioner can quickly correct by adjusting the nutrition and hydration plans (e.g., more protein, electrolytes, or anti-inflammatory foods).

On the other side, some data can alert the athletes to consult their doctor to correct abnormalities. For instance:

- Resting HR spikes or irregular rhythms (possible infection/cardiac issue)
- Low HRV or poor sleep for more than 1 week (stress, illness, or overtraining)

WORLD AQUATICS

PART 4

PRACTICAL APPLICATIONS: TRAVEL & CHALLENGING ENVIRONMENTS

EATING WHILE TRAVELING

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.

Pre -travel preparation

The travel schedule needs to be mapped by showing both flights or drive times, training sessions availability and the predicted time between meals. Caterers and food organizers should be contacted well ahead of the trip to let them know about meal timing and menu needs.

The pre-travel assessment needs to show hotel dining options and nearby grocery stores and all guest dietary restrictions.

A travel nutrition kit requires these fundamental items for its composition.

- Individual protein powder sachets or ready to drink cartons
- Oats/instant porridge cups
- Mixed nuts and dried fruit
- Whole grain crackers or rice cakes
- Portable fruit (apples, bananas) where permitted (please check customs restrictions)

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 recognised, and a drinking plan should be organized to keep the athlete well hydrated. Fluid choices should be appropriate to the athlete’s energy requirements.

Examples of strategies:

- Carry a refillable bottle and drink regularly (small, frequent sips).
- Electrolyte tablets and oral rehydration sachets serve as essential items for travellers to consume during their long flights and after they arrive at their hot weather vacation spots.
- The consumption of alcohol together with high caffeine amounts should be restricted when traveling.

Airport and in-transit eating

The athletes need to keep their blood sugar levels constant and stay away from large fatty foods which trigger stomach problems.

Examples of suitable travel foods

- breakfast cereal and cereal bars
- Sandwich or wrap containing lean protein along with salad makes up this option.
- Sushi or rice bowl with fish/chicken and vegetables
- Powdered milk and liquid meals
- Sports drinks and protein powders
- Juice concentrates
- Dried fruit and nuts
- Crackers and nut butters

Adapting to Time Zones

On arrival:

- Eat according to local time as soon as feasible (e.g., breakfast at local morning).
- Eat light, carbohydrate-rich foods and spend time in daylight to help the body adjust faster.
- The largest meal should occur during the local evening hours, it may help to sleep better.
- Caffeine can be used strategically to support wakefulness but should be avoided late in the local day.

Eating at destination and adhering to a food plan

The home pattern should be recreated through three daily meals and two to three snack times which should include local food options.

<u>For buffet meals:</u>

- First step is to choose a lean protein portion on the plate.
- The dish requires two different vegetables and either one or two carbohydrate options which include rice, pasta, potatoes and bread.

At restaurants:

- Prefer grilled/steamed over fried.
- Order your sauces as separate items while choosing water or low sugar drinks from the menu.
- Avoid new or very spicy dishes in the 48 hours before key races.

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.

Gastrointestinal safety and food 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 when applicable. 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. Avoid raw/undercooked meat, fish, or eggs, as well as salads or unpeeled fruit or unpasteurised dairy.

Hand hygiene through soap or sanitizer needs to take place before eating.

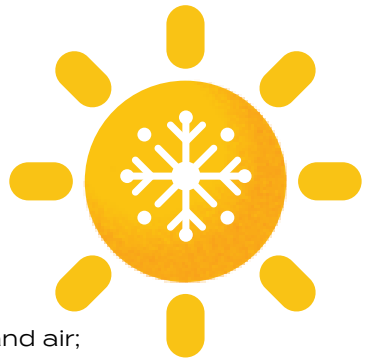
Athlete who experiences gastrointestinal symptoms should transition to eating simple foods which are low in fibre and fat content (white rice, toast, bananas, soups) while they focus on rehydrating their body. The athlete should receive regular medical evaluation and be isolated in a single room to avoid further contamination to the rest of the team until a diagnosis is done.

Gastroenteritis is often caused by viruses that are highly contagious.

Travel nutrition checklist

- planned eating times which are part of the schedule.
- snacks and supplements packed (within customs rules)
- hydration strategy for flights and arrival
- support staff to identify potential dining areas.

CHALLENGING ENVIRONMENTS



Aquatic athletes, especially open-water swimmers (OWS), can be challenged by difficult and changing environmental conditions.

Environmental challenges include:

1) impaired temperature regulation in hot or cold water and air;
2) altitude; and
3) environmental pollution.

Such challenges can add significant undesired stress that may compromise an athlete's energy balance, recovery, immune function, optimal training adaptation and ultimately performance. There are a variety of different strategies to address these challenges.

Environmental stressors which include heat and cold and altitude and pollution create extra physical demands on the body. Nutrition needs to make changes based on these developments.

Hot water, Heat and Humidity

World Aquatics rules state that water temperature for open water events must be between 16.0°C to 31.0°C, with some races lasting up to 2 hours.

Hypothermic events happen more frequently during open water events and are more of a concern than hyperthermia – but both are equally detrimental to performance and health.

A high body fat level can limit an athlete's ability to dissipate heat in warm water conditions and place them at a higher risk for heat-stress or heat stroke.

Cold Water and cold environments

Human body thermal conductivity is approximately 25-times greater in the water than air. Even in water at the same temperature as air, athletes feel colder because heat is conducted away so efficiently.

So water that is even marginally colder than body temperature (~37°C) is a significant "heat sink" and has the potential to cause hypothermia.

Optimal pre-race fuelling (glycogen stores) and in-race carbohydrate and fluid intake appears to combat shivering.

Nutrition strategies:

As participants will consume slightly more energy throughout their race in cold water, the diet should contain healthy fats such as oily fish, nuts, seeds, avocado and olive oil. These will help maintain energy levels and body heat.

Immediately after session, the consumption of warm carbohydrate-rich foods (e.g soups with bread and pasta and rice dishes together with protein sources) is recommended.

Hot drinks like tea, or cocoa should also be given to the athletes after the race.

Altitude

Altitude training is a common tool used by athletes to prepare for international competitions.

A positive effect is the stimulation of the hypoxic erythropoiesis which, under ideal conditions, will increase red blood cells and oxygen carrying capacity (oxygen delivery).

However, training or competing in altitude may come with different challenges.

- Increase energy expenditures/appetite suppression
- Body experiences a higher oxidative stress
- Increase risk for dehydration
- A stimulated erythropoiesis means a higher iron requirement

Iron

The diet needs to contain sufficient amounts of red meat, poultry, fish, legumes and cereals.

Concerning iron supplementation, the current literature does not provide sufficient scientifically-based evidence. However, depending on the pre-altitude serum ferritin concentrations, some recommendations may be considered by the medical team (see table hereafter from "*Nutrition and altitude: strategies to enhance adaptation, improve performance and maintain health: a narrative review, T. Stellingwerff, P.Peeling, L. Garvican-Lewis, R. Hall, A. Koivisto, I.Heikura & L.Burke, 2019*".)

Pre-Altitude
~4 to 6 weeks prior

Baseline blood health screen
Essential:
- Full blood count including Hb concentration and red cell indices (MCV, MCHC)
- Iron profile including, serum ferritin, soluble iron, iron saturation & total iron-binding

Consider
- Hbmass measurement via CO rebreathing (independent on PV shifts)
- CRP, as ferritin is an acute phase reactant concentration

Aim to have blood work completed when rested (i.e., >24 hours after a hard workout) and healthy > 24h post-last iron supplement.

If ferritin <35 µg/L:
- Consult sports physician, nutrition and/or physiology expert
- Consider starting supplemental iron *immediately*, aiming for 100mg of *elemental* iron per day as a single daily dose*.

If iron deficiency is severe (ferritin <15 ng/mL) and/or iron deficiency anemia is suspected
Consult sports physician, parenteral iron (IV) may be indicated

During-Altitude
~2 weeks prior & throughout

If ferritin <100 ng/mL at pre-altitude blood check and not taking iron:
- Start with 100mg of elemental iron/day for ~2 weeks prior to altitude as a single daily dose
- Progress to 200mg of elemental iron/day in~1 week prior to altitude and continue throughout the altitude camp as a single daily dose*
- If GI issues present for more than 7 days, lower the dose to 100-150mg of elemental iron daily (or highest dose tolerated) and contact a nutrition expert to review your supplementation strategy.

If ferritin is between 100 and 130 ng/mL at pre-altitude blood check:
- 2 weeks prior to and throughout the altitude camp, supplement with 100mg elemental iron/day as a single daily dose*

If ferritin >130 ng/mL at pre-altitude blood check:
- Please contact a medical, nutrition or physiology expert for individual advice, but potentially an iron supplement may not be indicated, or only a lower daily dose (e.g <50mg of elemental iron/daily)

Post-Altitude
~several days / weeks post

Post blood health screen:
Essential:
- Full blood count including Hb concentration and red cell indices (MCV, MCHC)
- Iron profile including, serum ferritin, soluble iron, iron saturation, total iron binding

Consider
- Hbmass measurement via CO rebreathing (independent of PV shifts)
- CRP, as ferritin is an acute phase reactant concentration.

Aim to have blood work completed when rested (i.e., >24h after a hard workout) and healthy (no recent illness) >24h post-last iron supplement.

Adjust se-level daily iron intake according to expert advice and post-altitude values.

***Increasing Iron Bioavailability Considerations:**
- Consume iron with a vitamin C source (e.g. combined iron and Vit C supplement)
- Menstrual cycles cause only small blood (iron) losses per month in females and normal female sex hormone levels actually decrease total hepcidin release, potentially increasing the amount of iron that can be absorbed.
- Single daily dosing protocols have been shown to minimize iron induced hepcidin release, allowing for increased bioavailability on subsequent iron intake.

***Decreasing Iron Bioavailability Considerations:**
- Calcium, tannins in black tea / red wine, polyphenols in coffee, antacids, vitamin E, tetracycline have all shown to decrease iron bioavailability to varying degrees-avid iron intake in combination with these substances with at least a few hours of separation.
- High intensity/prolonged exercise causes inflammation and the release of the hormone hepcidin, which has been shown to block iron absorption. It is best to periodise the iron supplement intake at least 4 to 6 hours after, and at least 2 hours prior to, hard exercise bouts.
- Sports that involve running on surfaces increase foot strike hemolysis (micro-bleeding) and a greater chance of decreasing iron stores.

Note that there are several forms of iron supplements and they are tolerated differently by different individuals. So if one iron supplement is poorly tolerated (usually gastric) then changes to a different formulation.

Energy density

To compensate the higher energy requirement and the decreased appetite, athletes should increase their energy intake and for instance, consider energy-dense foods like nuts, dried fruit, granola and smoothies to prevent weight loss and low EA.

Antioxidants

The diet should focus on consuming fruits-berries and leafy greens (in smoothies for example) together with healthy fats and nuts to help maintain redox balance.

Hydration

At altitudes, dry air and increased respiration/ventilation raise body water loss, making adequate fluid intake essential for compensation. Proactive intake strategy is essential.

Remember the importance of observing urine color to help detect dehydration.

Polluted or poor quality waters

There is very little research on the impact of air and water pollution on athlete health and performance. However, some aquatic athletes experience periodic respiratory issues related to chlorination of pool water and poor air quality.

Since air and/or water pollution may cause an impairment of the immune system, nutrition interventions that support the immune system may be beneficial.

Nutrition and health strategies

- Adequate carbohydrate intake during and after training
- Adequate energy availability
- Sufficient protein (1.4–1.8 g/kg/day)
- Micronutrients: vitamins A, C, E, D, zinc, selenium
- Consume probiotic foods to maintain gut barrier function and microbiota health, including yogurt, kefir and fermented foods.

Practical recommendations to minimize adverse effects of water pollution during open water races include choosing clean water venues for all training to minimize total pollution exposure and rehearsing feed-zone practices to limit inadvertent consumption of polluted water.

Practical Checklist

Hot / warm water

- Consume water with electrolytes before beginning workout session or race.
- Sports drink/water available at poolside or on feeding pontoon
- Define post-session rehydration plan and cooling strategies

Cold water

- Extra snacks on cold exposure days
- Warm carbohydrate rich post session meals

Altitude

- Iron status checked pre camp and monitored
- Dietary plan to include energy-dense meals and snacks
- Antioxidant-rich foods

Polluted waters

- Robust hygiene protocol post session
- Diet to include immune-enhancing compounds together with probiotics
- Safe food and water practices during camps/meets.

WORLD AQUATICS

PART 5

SPORT-SPECIFIC NUTRITION

SWIMMING

Swimmers need to have a strategic nutrition plan to manage busy schedules during trainings (e.g workouts and studies) or events.

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 1'500 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.

High-level swimmers need to consume 5'500–7'000 kcal/day of energy because their training is extremely demanding.

Training

Committed swimmers usually train 2-6 hours each day, often combining two sessions in the pool with an additional land-based workout (e.g. resistance training, core training or running).

This pattern generates:

- Very high total energy expenditure
- Substantial glycogen turnover

Matching energy needs is key to support training and maintain/achieve optimal body health.

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.

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.

Tactics, 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

Energy

The heavy training phases of elite swimmers require them to consume at least 45 kcal/kg/day but their youth status and tall height may demand them to consume much higher amounts.

Recommended intakes

- Carbohydrate: 6 – 12 g/kg/day.
- Protein: 1.4 – 2.0 g/kg/day (distributed throughout 4–6 meals and snacks).
- Fat: the total energy intake should also include unsaturated fats which make up 25–35% of the total energy consumption.

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

Training Day Structure

Early Morning Sessions

The swimmer should consume a small amount of food which is easy to digest regardless of their current appetite level (banana, cereal bar, liquid breakfast, or small yogurt + fruit).

- Fasted high intensity sessions should be the exception, not the norm.

During long or intense sessions (>60–75 min), the recommended carbohydrate intake should come from sports drinks, gels and soft fruits at a rate of 30–60 grams per hour. Athletes should be taught about sodium consumption during sessions which last more than one hour or take place in hot weather or when they do land training activities.

Recovery - Post Session (within 60 minutes)

The daily carbohydrate intake recommendation should be between 1.0–1.2 g/kg body weight.

The recommended daily protein intake should be 0.3 grams per kilogram of body weight which equals 20 to 40 grams.

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.

Taper nutrition

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
- Remember that every athlete/team training routine is different. While distance swum may be less, intensity will be greater affecting each athlete differently. Watch carefully for signs of undernutrition (cramping, muscle weakness) also during a taper.

The recommended daily protein consumption should reach 1.4 grams per kilogram of body weight to support the preservation of lean body mass.

Competition Fuelling

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 yogurt, pasta salad, fruit) are recommended during longer breaks

Swimmers should 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)

Nutrition plan

Pre race (2–4 hours before first event)

High carbohydrate, low fibre, low fat meal:

The examples include oats with banana and honey and white rice with eggs and toast with jam and yogurt.

Between races

<60 min between starts:

Small fast-acting carbohydrates together with fluids (sports drinks, diluted juice, fruit and yogurt drinks).

1–3 hours between starts:

A light meal or substantial snack (wrap/sandwiches, rice/pasta bowls together with fluids and electrolytes).

Post day recovery (for multi day meets)

Athletes should consume carbohydrates with protein during the 30–60 minute period following their last race before eating their complete meal.

ARTISTIC SWIMMING

Artistic Swimming is unique among aquatic sports, combining speed, power and endurance with precise synchronised movements and high-risk acrobatic manoeuvres.

Athletes spend a great amount of time upside down, underwater and undertaking exercise while breath-holding.

The nutritional demands of the Artistic swimming athlete are complex due to the intense training demands and aesthetic nature of the sport.

Several special challenges are faced by Artistic swimmers:

- The nature of training favours lengthy sessions in a variety of exercise modalities with limited breaks. Such a structure makes it difficult to consume adequate energy and fluid during the session.
- Furthermore, the underwater and upside-down manoeuvres may cause discomfort following food/drink intake
- Artistic swimming is an aesthetically judged sport—making appearance and body composition a prime focus for coaches and athletes. Individuals may develop eating disorders and restrictive eating patterns.

Apnea performance and nutrition is covered earlier in this document.

Performance & Risks

Artistic swimming involves key risks:

- Low energy availability and REDs
- Iron deficiency and menstrual dysfunction

Training

Artistic swimmers should aim for a well-chosen diet that is adequate in energy, carbohydrate and protein to optimise training and performance.

Achieving an ideal physique and adequate energy availability

The obsessive restriction of energy intake to achieve weight loss goals can sacrifice bone health, performance, menstrual function and other health issues.

The artistic swimmer should achieve her physique goals according to a safe and well-organised plan.

Energy and fuelling

- Carbohydrate: 4 – 7 g/kg/ day adjusted to the level of training intensity.
- Protein: 1.4 – 1.8 g/kg/day to help muscles recovery and building, and prevent injuries.
- Fat: the total energy intake should also include unsaturated fats which make up 25–35% of the total energy consumption.

The consumption of small meals and snacks every 3-4 hours serves to:

- Maintain energy
- Support mood and concentration
- Consumption of big weighty meals should be prevented (➔ discomfort).

Coaches should allow sufficient breaks during workouts to support adequate fueling and hydration

Pre routine and Competition Day

2–3 hours pre routine

The meal consists of low fat and low fibre carbohydrates with moderate protein content.

- white rice with eggs; pasta with light sauce; sandwich with lean protein + fruit.

30–60 minutes pre routine

20–30 grams of carbohydrates through a small snack.

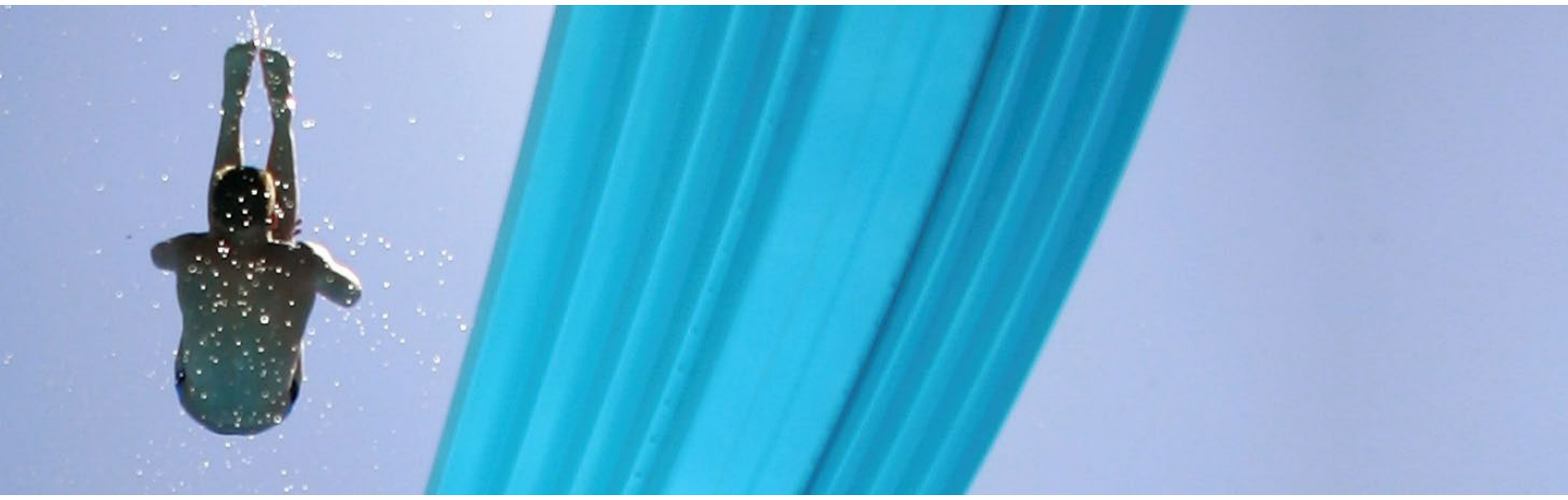
- Fruit, small cereal bar, sports drink.

Again, coaches should allow sufficient breaks during workouts to support adequate fueling and hydration

Health monitoring

Regular screening should be performed to identify iron deficiency, to monitor menstrual health, detect REDs and disordered eating (especially in teenage athletes).

DIVING AND HIGH DIVING



Due to the biomechanics of this acrobatic and aesthetic sport, the diver must be short, well-muscled and lean. As the increasing difficulty of dives has increased the physical and mental demands of the sport, divers and coaches have become more interested in strategies that can support high level training and conditioning.

Nutrition is important to support skill and concentration during long practices, to promote adaptation and reduce the risk of illness and injury, and to allow the diver to compete in peak shape.

A multi-disciplinary sports medicine team should be integral to the daily training environment and suitable foods and fluids should always be available during prolonged practices and competitions.

The physical requirements of diving together with body image issues create conditions which lead divers to develop LEA and REDs, and bone stress injuries.

The diet needs to protect bones and muscles, and enable growth in children and teenage divers.

Performance & Risk Profile

Diving demands:

- Explosive power and fine motor control
- The training program includes extensive technical development of dryland skills through trampoline and platform exercises and conditioning work.
- The athlete shows extreme sensitivity to stomach discomfort and bloating which causes him to stop performing before competitions start.

Risks:

People who practice this behavior consume fewer calories than their bodies require to stay at their desired weight.

- The body lacks sufficient calcium and vitamin D and protein to maintain proper bone structure.
- The delayed growth and puberty of adolescent divers who have chronic low EA occurs.

Energy and macronutrient targets

- Carbohydrate: 3 – 5 g/kg/ day (5–6 g/kg/day during power training)
- Protein: 1.2 – 1.7 g/kg/day to help muscles recovery and protect tendons and joints.
- Fat: the total energy intake should also include unsaturated fats which make up 25–35% of total energy while selecting omega 3 foods because these nutrients help protect joints and aid in recovery.

While divers typically train for at least 5 hours each day, specific knowledge of the training and competition demands is essential to interpret current carbohydrate intake guidelines. Divers do not need to practice carbohydrate loading strategies that maximize glycogen stores ; indeed, over-storage in the muscle could compromise flexibility.

Since total energy intake may need to be carefully managed to meet physique goals, the focus of the training diet should be on nutrient-dense carbohydrate-rich foods. The exception to this may be around lengthy training sessions where more practical forms of carbohydrate are useful to maintain muscle and brain supplies.

Since blood sugar fluxes in 3-hour units, the pre-training meal should be followed with foods and beverages that can sustain normal blood sugar over the duration of the session.

Recommended protein intake can generally be met through diet alone, although the use of protein drinks (i.e. whey protein isolate) and related packaged foods may assist in the timely intake of protein immediately following training or competition.

Slightly higher protein intakes may be required for athletes striving to lose (fat) weight so as to better maintain lean muscle mass. Ideally, the diver should maintain energy balance and a regular meal pattern, providing 20-30 grams/meal of high-quality protein to maintain and/or increase muscle mass and bone density.

Fat is a source of energy, fat-soluble vitamins, and the essential fatty acids. While high-fat diets are not recommended for athletes, extreme restriction of fat intake is also unwise.

Micronutrient, Bone health and injury prevention

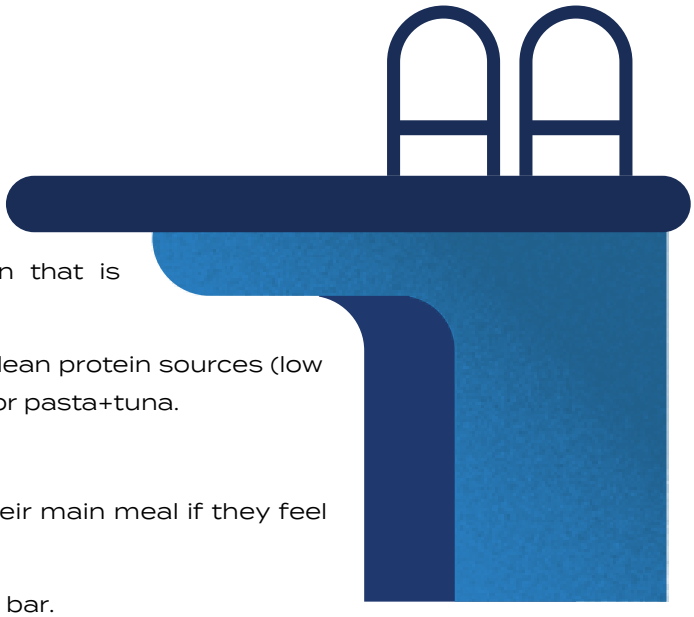
The combination of high impact entries associated with dryland work and low EA values creates an environment that could lead to higher stress fracture occurrence.

To ensure sufficient intake of micronutrients (i.e., vitamins and minerals), divers are encouraged to consume nutrient dense foods.

Calcium, zinc and iron are micronutrients that vegetarians may lack (please refer to the previous sections). Vegetarian athletes should ensure that their regular foods contain adequate amounts of these micronutrients.

Focusing on nutrient-rich wholefoods to meet energy needs should provide adequate intake of micronutrients, and alleviate the need for supplements.

Pre-dive



The athletes should eat their main meal between 3 to 4 hours before their session or competition while consuming a portion that is neither too large nor too small.

The diet should include carbohydrates with lean protein sources (low fat) and fiber content such as rice+chicken or pasta+tuna.

The athlete may eat a light snack before their main meal if they feel hungry.

- Fruit, small yogurt, or a simple cereal bar.

The consumption of big meals together with carbonated beverages should be avoided during the time leading up to diving.

The pre-event meal provides an opportunity to fine-tune carbohydrate and fluid levels, as well as to leave the diver with a feeling of comfort and confidence. The diver should experiment to find their own ideal routine. During a competition session, the diver should continue with fluid and fuel intake strategies that have been successfully developed during training

Hydration:

The body should receive water through small portions of water or light sports drinks but should stay away from drinking too much liquid before starting dives.

Divers should consume sufficient fluids through small portions of water or light sports drinks before, during, and after exercise to sustain health and performance.

Dehydration, defined as a body water deficit in excess of 2–3% body mass, decreases exercise performance in laboratory settings, and even a small threat to concentration and skills can have large consequences in a sport such as diving.

Of course, overhydration, leading to a weight gain can also be a problem and diver should stay away from drinking too much liquid before starting dives.

WATER POLO

Water polo is the only team sport sanctioned by World Aquatics, whereas Artistic Swimming has team, solo, dual, and mixed team.

Like most team sports, water polo is characterised by a high intensity, intermittent activity pattern coupled with aggressive physical contact with opposing players, which produce maximum energy expenditure.

Water polo players require endurance, strength, power, swimming speed, agility, tactical awareness, and specific technical skills, including ball control.

Water polo players are typically heavier and have higher body fat levels than other aquatic athletes. Physical characteristics are also observed to differ across positions, with center players being heavier and having higher body fat levels than perimeter players. This difference is likely to offer an advantage to the center player, since they are required to hold position close to goal while grappling and wrestling aggressively with opposition players. In contrast, perimeter players need to have speed and agility.

Unlike male water polo players, it is difficult for female players to maintain and or achieve a high body mass without increasing their body fat levels.

Daily Fuelling Targets

Carbohydrate: 6-10 g/kg/day during heavy training and match days, but 4-6 g/kg/day during lighter training days

Protein: 1.6–2.0 g/kg/day to help maintain muscle mass and support recovery processes

Fat: the total energy intake should also include unsaturated fats which make up 20–30% of the total energy consumption

Although it is not clear that carbohydrate-loading will benefit water polo performance, a player should commence match day with normalized or elevated muscle glycogen stores. This is particularly important in tournament settings where several games are played over a weekend.

A bench player or reserve goalkeeper who has little game time on match day should complete additional training as their dietary habits are likely to mirror those of starting players.

Pre-game meals are highly individual and will be heavily influenced by the scheduled game time. The player should include familiar, easily consumed carbohydrate foods and fluids in this meal. Liquid meal supplements provide a suitable alternative for the nervous athlete with a reduced appetite.

For afternoon or early evening games, the player should maintain their typical daytime meal pattern throughout the day, rather than sleep in and miss meals.

During the match, the player should consume carbohydrates in the form of sports drink or carbohydrate gels. Only small amounts of carbohydrate are needed since typical workloads are unlikely to stress muscle glycogen stores, and the benefits are most likely to be achieved via stimulation of the brain and central nervous system.

Although games at major international competitions are typically scheduled 48 hours apart, younger players may be involved in round-robin tournaments in which they are expected to play several games over a weekend. A well-organized, portable team recovery station, which may include sports drinks, liquid meal supplements (i.e., milk or soy-derived supplements), cereal bars, fruit, dried fruit and nut mixes, sports bars, and flavored milks will facilitate post-game recovery.

Muscle refueling can be delayed by contact injuries and excessive postgame alcohol intake. In the latter case, postgame celebrations will further hamper recovery due to the disruption to sleep and rest, as well as failure to follow other guidelines for eating. Perhaps a more significant issue relates to player safety and misconduct when team athletes engage in excessive postgame celebrations.

Training Day Structure

Pre training (2–3 hours before):

The recommended meal consists of carbohydrates with protein at a moderate level and minimal fat and fiber content.

During training (>75–90 minutes):

The recommended carbohydrate intake for athletes should be between 30–60 grams per hour through sports drinks/gels/soft fruits + fluids and sodium.

Post training:

1.0–1.2 g/kg of carbohydrates together with 0.3 g/kg of protein (to be taken within 60 minutes).

Rehydration guided by body mass change.

Game Day and Tournament Nutrition

2–4 hours pre game:

A well-known carbohydrate-rich food (pasta with light sauce. a rice bowl with lean protein).

30–60 minutes pre game:

Small snack if needed, which could also include fruit / small bar or sports drink.

During matches:

The team should use sports drinks during breaks and half time to consume fluids together with carbohydrates and sodium.

Between games (tournaments):

If <2 hours between games:

The first step should be to give fluids together with quick carbohydrates through sports drinks and fruit and yogurt drinks.

If time between games is 2–4 hours

Light meal consists of a sandwich and either a rice/pasta bowl or wrap together with fluids.

OPEN WATER SWIMMING

Open water swimmers train mostly in the pool with additional sessions in rivers, lakes and the ocean to acclimatize to a race environment.

Although the training volume of open water swimmers is similar to swimmers competing in the longest pool events (800 m, 1500 m), race distances in open water swimming are significantly longer (5 km, 10 km) and require specific nutritional strategies for optimal performance.

Training

Strategies recommended for pool swimming, particularly those practiced by distance swimmers are suited to open water swimmers.

Energy and carbohydrate needs will vary over the training program and should be periodized accordingly (see sections on energy availability and carbohydrate needs).

During periods of higher energy requirements, such as an intensive training camp, increased energy intake can be achieved by tactics including:

- Having an increased number of meals/snacks per day
- ensuring access to compact carbohydrate rich snacks (e.g. rolls with jam/honey, dried fruits, biscuits, sports bars, sweet dairy products, juice)
- adding oils and nuts to meals
- consuming high-energy fluids including milk drinks, juice and liquid meal supplements

Protein is important also for training adaptation, and is achieved by the good timing of intake of high quality protein (~ 20-25 g) regularly throughout the day. Examples of such foods can be found in the section on Protein.

Fluid intake during training should be adjusted according to the swimmer's individual sweat rates and environmental factors, particularly water and ambient temperature.

During training, the fluid may contain carbohydrate similar to recommendations for pool swimmers (30-60 g per hour), while race specific practice for longer events may require greater intake (up to 90 g/h from multiple transportable carbohydrate sources). Race nutrition strategies should be well-tested in training.

Pre Event Preparation

For events ≥10 km or >2–3 hours:

1–3 days pre-race:

Daily carbohydrate intake should reach 8 – 12 g/kg/day with less training activities (carb loading).

Protein intake should remain normal protein intake of 1.4 – 1.8 g/kg/day.

Race eve:

Dinner should consists of carbohydrate-based foods which contain both low and moderate levels of fiber and fat, while staying away from both fresh and hot spicy foods.

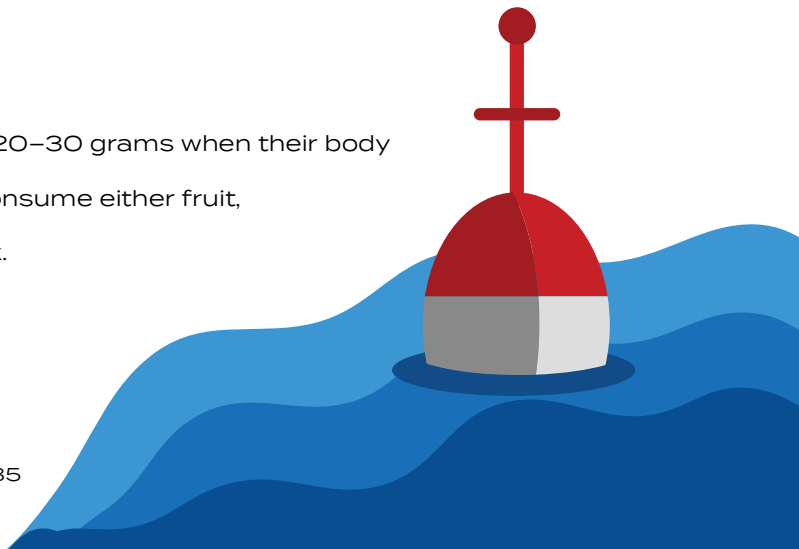
Race morning Fuelling

The pre-race meal (1-4 h prior to race) should be high carbohydrate, low fat, low fibre meal. It must continue to supply carbohydrate (1-4 g/kg) from foods that are easy to digest and familiar to the athlete.

Examples: oats with banana and honey; white toast with jam; rice with eggs; simple cereal + milk/yogurt

60 minutes prestart:

A small carbohydrate snack containing 20–30 grams when their body can handle it. The athlete may should consume either fruit, sports drink or a small bar as their snack.



Hydration:

The competition should begin with euhydration status.

When there is the potential for large sweat losses to lead to substantial fluid deficits during the race (e.g. high water temperatures and limited opportunities for fluid intake), some swimmers may consider pre race hyperhydration strategies. The intake of a salty beverage in the hours before the race (e.g. 10ml kg-1 of a 165 mmol/L sodium drink) will increase body fluid stores since the salt content temporarily increases fluid retention rather than urine production. The intake of similar amounts of icy beverages (e.g. 500 ml of a slushie) around 30 minutes before a race can pre-cool the swimmer and assist with temperature regulation during longer races swum in hot (e.g. 30°c) water.

In race fuelling

≤ 5 km races:

The need for nutritional support during short races is minimal but swimmers may benefit from the mouth-brain carbohydrate connection which has been shown to enhance performance.

For races >90 minutes

Swimmers should consume carbohydrate at rates of up to 60-90 g per hour to provide an additional source of muscle fuel. Carbohydrate choices include sports drink, gels, sports confectionary, or foods according to race practicality and swimmer preference. The absorption of carbohydrate at the highest rates of intake is aided by use of products containing mixtures of maltodextrin/glucose and fructose ("multiple transportable carbohydrates"). Feeding techniques should also be practiced to develop the skills that avoid spill of fluid/fuel and loss of time. Swimmers are encouraged to use the feeding pontoons and to consider carrying some of their own-supplies to allow for good race tactics.

Practical feeds:

- Sports drink (4–8% CHO) in bottles on feeding poles
- Diluted gels in bottles

Hydration

Though fluid needs of swimmers are lower than land based athletes, sweat rates can easily triple as water temperature increases (e.g. from 24°C to above 30°C, sweat rates may increase from ~0.4 L to 1.2 L/h).

Open water swimmers are recommended to establish hydration strategies that limit dehydration to 2 % of body weight, using information presented earlier in this brochure.

Post Race Recovery

Open water swimmers who compete in several distances in one meet should pay careful attention to recovery routines. Each of the World Aquatics Open Water Swimming distances will stress glycogen stores, thus proactive refuelling is required for fast recovery.

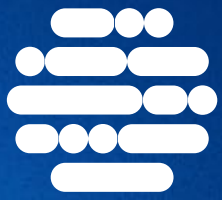
Within 30–60 minutes of finishing:

- Carbohydrate: 1.0–1.2 g/kg
- Protein: ~0.3 g/kg

In cold water environments, warm drinks and food are crucial after experiencing cold water events.

Quick-Reference Nutrition Guide for Aquatic Sports

Sport	**Carbohydrates**	**Proteins**	**Fat**
	g / kg / day	*g / kg / day*	*g / kg / day*
Swimming	6 - 12	1.4-2.0 (4-6 meals/snacks)	Unsaturated fat = 25 -35 % of total kcal
Artistic Swimming	4 – 7 (adjust to intensity)	1.4 - 1.8 (muscle repair & injury prevention)	Unsaturated fat = 25 -35 % of total kcal
Diving **High Diving**	3 – 5 *(5 - 6 for power sessions)*	1.2 - 1.7 (tendon & joint protection)	Unsaturated fat = 25 -35 % of total kcal (focus on omega-3)
Water Polo	6 – 10 (heavy training/match) 4 – 6 (lighter days)	1.6 - 2.0 (maintain muscle mass)	Unsaturated fat = 20 -30 % of total kcal
Open Water (1-3 days before race)	8 – 12 (Carb loading)	1.4 – 1.8	Moderate level of fat



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