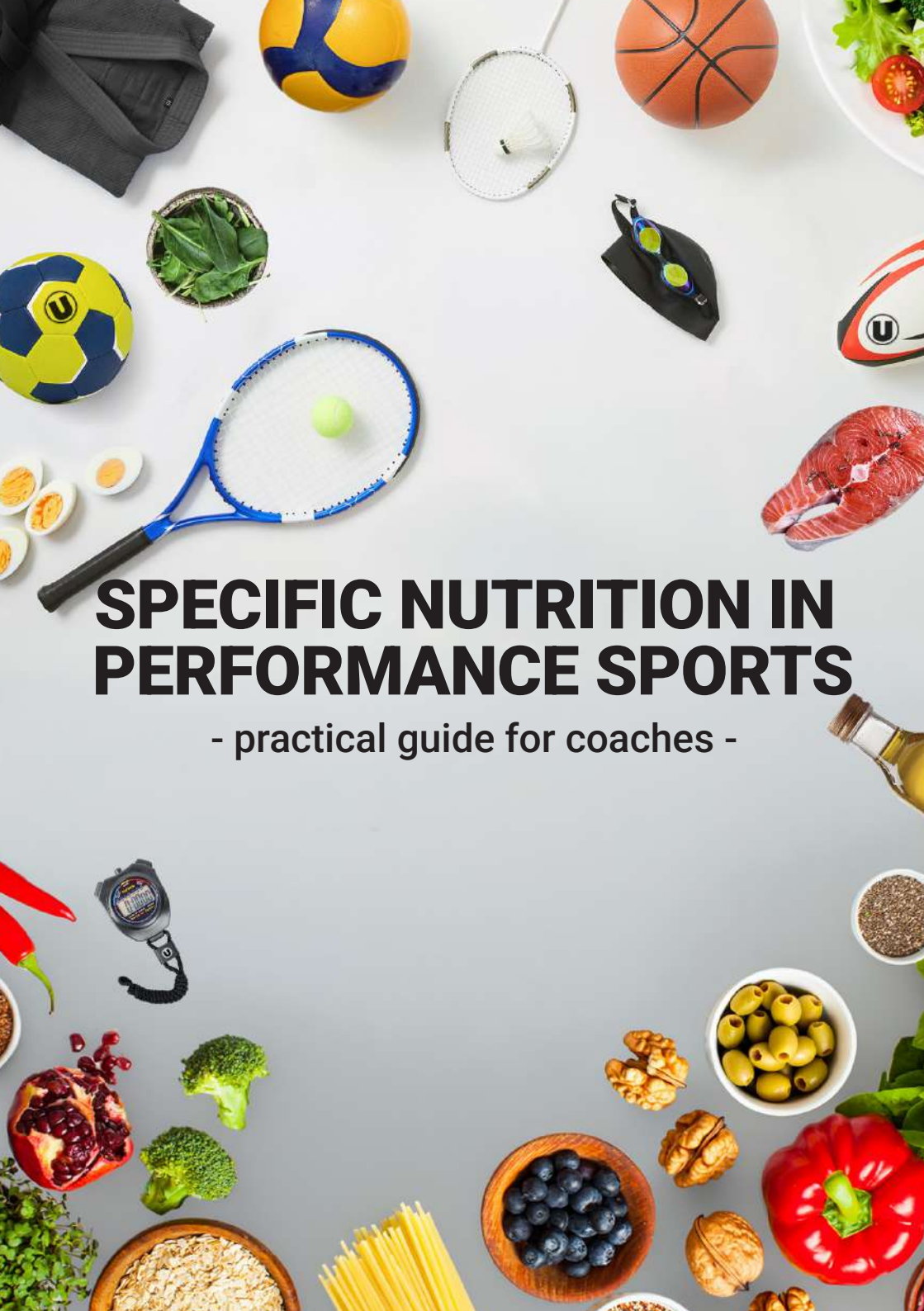

SPECIFIC NUTRITION IN PERFORMANCE SPORTS

- practical guide for coaches -

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SPECIFIC NUTRITION IN PERFORMANCE SPORTS

PRACTICAL GUIDE FOR COACHES

NUTRIȚIA SPECIFICĂ ÎN SPORTUL DE PERFORMANȚĂ

GHID PRACTIC PENTRU ANTRENORI

Cluj-Napoca
2026

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Chapter 1

INTRODUCTION

Chapter 1 **INTRODUCTION**

1.1. About the GUIDE

This material was developed within the cooperation project "New Skills and Educational Tools for Coaches regarding Specific Nutrition in Performance Sports" no. 2024-1-RO01-KA220-VET-000243958, co-funded by the European Union through the Erasmus+ Programme.

This Guide is primarily intended for performance sports coaches from the "U" Cluj Sports Club (Romania), OFI Sports Club (Greece), and Volleyball club Deya Sport (Bulgaria). However, it can be successfully used by any coach, regardless of their sport discipline, performance level, or the sport organisation they belong to.

Why a Nutrition Guide for Coaches?

Nutrition is an important component of sports performance and physical recovery, yet access to correct, applicable, and context-adapted information remains a challenge.

Most existing nutrition guides or specialised materials are either aimed at the general public ("how to eat healthy"), targeted directly at athletes ("your performance nutrition plan"), or written for nutrition professionals (using technical language or offering general recommendations that are difficult to apply in the practical reality of performance sports).

The purpose of this guide is to provide coaches with a practical resource that complements the existing tools and practices within the partner sports clubs, enriches their knowledge of performance-specific sports nutrition, and enables them to actively contribute to the quality of athletes' preparation by guiding them towards correct, balanced, and effort-adapted nutrition.

The objectives of the Guide are:

- ✔ Increasing coaches' knowledge regarding the principles of sports nutrition and the impact of diet on performance and physical recovery;
- ✔ Developing coaches' competencies in identifying and differentiating athletes' nutritional needs according to age, sex, performance objectives, and training phases;
- ✔ Preventing and correcting ineffective nutritional strategies by applying evidence-based recommendations and collaborating with nutrition specialists and parents (for junior athletes);
- ✔ Improving the quality of athletes' preparation through the application of good practices in nutrition, with clear recommendations on meals, hydration, and menus, also useful for parents and sports canteen staff;

✔ **Integrated approach to training and nutrition:** rather than treating nutrition as separate from physical preparation, this guide provides coaches with concrete reference points for aligning the nutritional plan with the stages of training, competition, and recovery;

✔ **Accessible and action-oriented language:** provides clear, simplified, evidence-based recommendations that are easy to apply and communicate to athletes, and can be integrated into training plans;

✔ **Relevance across all sports disciplines:** the content is structured transversally, with examples and case studies applicable to team sports and individual sports alike, as well as to strength and endurance disciplines;

✔ **Focus on continuous professional training and education:** proposes a modern approach, offering coaches practical resources and tools to support ongoing development of their knowledge in sports nutrition, including through digital support and dedicated applications (U-NutriCoach App);

✔ **Inclusive and responsible approach:** incorporates perspectives related to cultural diversity, special needs, and ethical and sustainability considerations in athletes' nutrition;

✔ **Support for junior athletes and parents:** acknowledging that junior teams require at-home guidance to adopt sport-specific nutrition, the Guide includes practical information for parents as well;

✔ **Recommendations for collective meal provision for athletes:** provides practical guidelines for planning and organizing meals in athlete canteens, as well as in situations involving travel, training camps, or temporary locations.

The content of the Guide follows a logical and progressive structure: from fundamental concepts about nutrients and hydration, to applied recommendations for different types of physical effort and athletes' individual characteristics, and finally to practical solutions for the use of technology in sports nutrition and for meal planning.

Through this structure, a clear transition is ensured from the "**why**" (the importance of nutrition) to the "**how**" (its concrete application depending on sport, situation, age) and to the "**where and with what resources**" (canteens, family, technology).

What this Guide is NOT?

✘ It is not a nutrition manual and does not replace the advice of a physician or a licensed dietitian in cases of specific health conditions or medical pathologies!

✘ It does not provide personalized diet plans for each athlete; the Guide offers general recommendations and good practices, which must be individually adapted!

✘ It is not a physical training program; it focuses exclusively on nutritional aspects related to sports performance and physical recovery!

✘ It does not guarantee immediate or uniform results for all athletes, as the effectiveness of nutrition depends on several individual factors!

✖ It does not substitute the decisions of the medical team or the nutrition specialist in the case of athletes with special needs, allergies, or food intolerances!

This guide provides a **framework for understanding and action**, adapted to the language and reality on the ground. Its purpose is to help coaches leverage the benefits of proper nutrition as part of the training process, without turning it into an additional task or into a domain of exclusive expertise.

The coach is not and should not become a dietitian — but is a **key factor** in the correct application of sports nutrition principles, contributing decisively to the performance, health, and balance of the athletes they train.

1.2. Diversity, inclusion, and responsibility in sports nutrition

A proper diet is more than a combination of nutrients — it is a component of personal balance, respect for diversity, and responsibility towards the community and the environment.

In performance sports, **nutritional recommendations** must take into account not only physiological and scientific aspects, but also the **social, cultural, and individual context of athletes**.

This Guide proposes an integrated approach that values cultural differences, promotes inclusion, and supports sustainability as part of nutritional education in sports.

The Principles of the Guide

1. **Athletes' nutrition must reflect local culinary traditions and personal preferences, as long as they adhere to the principles of a healthy and balanced diet.**
   It is recommended to make use of traditional ingredients and dishes — such as legumes, whole grains, or local protein sources — to create menus adapted to the cultural and economic context of each team. In this way, meal plans become not only healthy, but also relevant and accessible.

2. **The guide addresses the specific nutritional needs of all athletes, regardless of age, gender, religion, income level, social status, or functional abilities.**
   Equal access to information and healthy meals is promoted, while also respecting individual needs and beliefs — such as vegetarian diets, lactose/gluten-free diets, or halal and kosher menus.

3. **Sports nutrition must be approached in a responsible manner, without emphasizing pressures related to body weight or physical appearance.**
   The athlete's/team's coaches and staff must convey balanced messages, based on scientific evidence, that prevent eating disorders and support long-term health.

4. **The guide encourages the adoption of sustainable eating practices.**
   It is recommended to plan portions according to effort and age, reduce food waste, creatively reuse leftovers, and choose local and seasonal ingredients with a low environmental impact.

5. **The coach has a key role in shaping athletes' attitudes towards nutrition.**
   Through the way they communicate, through personal example, and through the atmosphere created within the team, the coach can turn athletes' diversity into a strength. It is important that the messages conveyed are clear, positive, and adapted to the athletes' level of understanding, avoiding generalizations and stereotypes.

This cultural, inclusive, and responsible approach provides the ethical and psychosocial framework within which the practical recommendations of the Guide are applied — from meal planning and simple recipes to organizing collective meals and education for sustainability.

1.3. The importance of nutrition in performance sports

Performance sports have evolved significantly over time, an evolution reflected in increasingly higher records and results, both in individual disciplines and in team sports. The level of competitions, from local events to major international tournaments, has reached standards that, in the past, seemed difficult to imagine.

This evolution is the result of simultaneous progress in several areas: the refinement of training methods, the development of game tactics, the strengthening of psychological performance capacity, the improvement of strategies that support the body in coping with increasingly intense stimuli, and the advancement of digital technologies. In this context, nutrition has become an essential pillar, with multiple benefits.

The assessment of athletes' eating habits suggests that they:

- Tend to consume certain nutrients in excess while ignoring the overall picture of the diet. For the body to function at maximum capacity, the intake of all nutrients is necessary, not just a few considered “key.”
- Focus on meeting energy, carbohydrate, and protein intake targets without considering food quality. Foods in their natural or minimally processed form, simply cooked, provide—beyond macronutrients—vitamins, minerals, and other natural bioactive compounds.
- Concentrate on nutrition around competition or on consuming the most innovative supplements. However, the diet during the training period has the greatest potential to positively influence performance.

A suitable diet for athletes:
- supports the adaptations targeted through training: strength, speed, or endurance;
- provides the energy required for the intensity of the effort;
- restores energy stores (glycogen);
- promotes the development and maintenance of muscle mass;
- reduces inflammation and helps repair the micro lesions caused by effort;
- accelerates recovery after injuries;
- helps manage common issues faced by athletes (fatigue, muscle cramps, digestive disturbances, weight fluctuations, low immunity, mental fog);
- provides the body with all nutrients, in the right amounts, to function optimally and maintain health.

In addition to a training plan, the athlete also needs a nutritional plan. Just as the training is structured and adapted over time, nutrition must support these stages to allow the achievement of performance goals.
Training periodization involves modifying the intensity, volume, and specificity of the effort according to each athlete's objectives. It is essential that, in parallel, there is a periodized nutritional plan adapted to these changes.

The nutrition plan must:
- be aligned with the structure of the training;
- take into account the athlete's individual dietary needs;
- support the requirements of each phase of preparation.

Thus, except for particular situations:
- weight loss will be planned in the off season or at the beginning of the preparation period;
- caloric restrictions will be avoided during periods of high training volume or in the competitive season;
- during competition, only strategies that have already been tested, are known and well tolerated, and have proven effective in training will be applied.

1.4. The role of the coach in the nutritional education of athletes

The role of the coach in the training of athletes is complex, combining pedagogical, psychological, strategic, theoretical, and practical functions. The modern coach is the main coordinator of the training process, having the responsibility to integrate the contributions of the multidisciplinary team into a unified, coherent, and functional program for the athlete.

For a significant impact and an organized approach, the coach should:
- know the basic nutritional principles, in order to understand the connection between nutrition, effort, recovery, and performance;
- integrate the recommendations of all specialists (dietitian, doctor, physiologist, psychologist) into a unified training program;

- monitor whether nutritional interventions produce the desired results, in relation to training and competition objectives;
- observe the emergence of athlete related issues (decreased exercise capacity, persistent fatigue, poor recovery, digestive disturbances) that may be addressed through nutritional interventions;
- monitor the athlete's adherence to sports nutrition principles;
- guide and educate the athlete, using pedagogical methods adapted to their level of understanding and experience;
- provide specific advice aligned with the recommendations of specialists.

The coach may initiate:
- group discussions with athletes, aimed at conveying general objectives, ensuring team cohesion, and clarifying the importance of appropriate nutrition in sports preparation;
- individual discussions that allow the message to be adapted to each athlete's particularities, offering specific feedback and personalized solutions;
- meetings with athletes' families, to align lifestyle and nutrition outside training with the requirements of performance preparation;
- seminars, aimed at updating athletes' knowledge and integrating new scientific and methodological guidelines into the training routine.

1.5. The role of the dietitian in the nutritional education of athletes

A dietitian is a healthcare professional with university-level training and a professional license to practice in the field of nutrition. Dietitians possess an in-depth understanding of how the human body works, the role of nutrients, and the ways in which nutrition can be strategically applied to achieve specific health and performance goals. Their recommendations are evidence-based, adaptable to real-life situations, and tailored to individual needs. Although the term "nutritionist" is also commonly used in sports settings, it is a broad term that is often unregulated and does not necessarily imply standardized education or professional qualifications. In performance sports, the dietitian serves as a bridge between nutritional science, the specific demands of the sport, and the individual needs of the athlete.

The dietitian works closely with the coach to gain a comprehensive understanding of:
- the physiological demands of the sport;
- the structure of the competitive season;
- the training periodization and the desired adaptations;
- the established performance goals.

In direct collaboration with the athlete, the dietitian assesses:
- dietary habits and food preferences;
- body composition and nutritional status;
- relevant medical history;

- symptoms associated with intense physical effort (fatigue, digestive problems, concentration difficulties, frequent injuries, sleep disorders, etc.);
- the athlete's practical ability to purchase and prepare food.

Based on all this information, the nutritional recommendations are formulated so that they:

- correctly cover the energy and nutrient requirements in relation to the type of effort, the training plan, and the performance objectives;
- prevent or alleviate symptoms associated with intense physical effort;
- are clear, realistic, and easy to apply in daily life.

The recommendations are implemented:

- in the form of concrete meal plans, either individualized or at canteen level;
- through individual or group educational sessions.

Nutritional education plays an essential role. It allows the athlete to understand their own needs and reactions, to be flexible in food choices, to identify practical alternatives, and to make informed decisions regarding their own body.

Nutrition in performance sports is a dynamic process, influenced by numerous factors. Therefore, the dietitian adjusts recommendations periodically, depending on the context, objectives, and the athlete's response to the proposed interventions. Continuous feedback from the athlete and the coach is essential for optimizing results.

Chapter 2

THEORETICAL FOUNDATIONS FOR UNDERSTANDING NUTRITION IN PERFORMANCE SPORTS

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2.1. Physiology and metabolism in sports activity

Physiology is the science that studies how the human body works: from the cellular level, up to tissues, organs and the interactions between them. Exercise physiology focuses on how the body responds and adapts to physical activity and how these processes influence athletic performance.

To sustain life, the body maintains its internal environment in relatively constant balance, known as homeostasis. Intense or prolonged physical effort disturbs this balance, causing changes in:

- energy needs;
- tissue oxygenation;
- blood volume and pressure;
- body temperature;
- acid-base balance;
- hydration status.

When physical exertion becomes too intense and the body can no longer maintain its internal balance, fatigue sets in. Fatigue acts as a protective mechanism, limiting effort and preventing harm to the body.

Understanding these mechanisms allows for the development of training and nutrition plans that promote strategic adaptations, aiming to delay the onset of fatigue and optimize athletic performance.

Acute metabolic responses to exercise

Any form of physical exercise involves an increased energy demand at the level of the active muscles. Fatigue occurs when energy supply can no longer meet this demand, either in very intense efforts or in prolonged exercise.

To produce energy during physical effort, the body primarily uses carbohydrates and fats, and to a lesser extent proteins. These come from the diet and from the body's own energy stores. Although micronutrients do not provide energy directly, they are essential for the metabolic processes involved in energy production.

At rest, the body produces the energy required for vital functions through aerobic metabolism, using oxygen to oxidise mainly fats and, to a lesser extent, carbohydrates. The rate of energy production is low but efficient, and internal balance (homeostasis) is easily maintained.

Once exercise begins, the demand for energy progressively increases, and

production is ensured by three energy systems that operate simultaneously but contribute differently depending on the intensity and duration of the effort. As long as oxygen supply is sufficient, energy is produced predominantly through aerobic metabolism, with oxidation of fats and carbohydrates.

As exercise intensity increases, the body favors the oxidation of carbohydrates, as they provide more energy for the same amount of oxygen available compared to fats. This allows athletes to sustain higher levels of performance when oxygen delivery to the muscles becomes a limiting factor.

During very high-intensity activities, when oxygen supply and the rate of energy production using oxygen can no longer meet the body's needs, the body turns to producing energy by breaking down glucose without oxygen. This energy system is associated with lactate accumulation and increased muscle acidity, factors that contribute to the development of fatigue.

Although for a long time the focus was on "sparing" carbohydrates by increasing fat oxidation, in high-intensity sports it is often more efficient to ensure a higher availability of carbohydrates, in order to maximise performance.

A carbohydrate-rich diet increases glycogen stores and favours their use during exercise. Conversely, high-fat diets or fasting periods shift metabolism towards fat oxidation. Endurance training increases the oxidative capacity of the muscles and their ability to use fats; however, at high intensities, the absence of glucose becomes a limiting factor.

Muscular system

The muscle is a highly adaptable tissue that changes its mass, fiber structure, and function in response to the training stimulus. Each sport imposes different demands in terms of strength, speed, or endurance, and these demands determine which types of muscle fibers are predominantly used:

- **Type I fibers** (slow oxidative) are specialized for endurance efforts. They have a high resistance to fatigue and efficiently use aerobic metabolism, which relies on oxygen.
- **Type IIa fibres** (fast oxidative) support repeated efforts of moderate to high intensity. They can produce force more rapidly than type I fibres and rely mainly on the use of carbohydrates.
- **Type IIx fibres** (fast glycolytic) are adapted for explosive efforts and maximal force production. They rapidly use carbohydrates, but fatigue quickly and can sustain effort only for short durations.

Sports that predominantly require fast fibres need strategies that ensure high carbohydrate availability and efficient glycogen replenishment. Endurance sports benefit from strategies that support aerobic metabolism, carbohydrate availability and oxidative adaptations. In all cases, adequate protein intake is essential for maintaining and adapting muscle mass.

Respiratory system

A key element of performance in most sports is VO_2max, which reflects the body's capacity to use oxygen for energy production during exercise. In general, a higher VO_2max allows athletes to sustain higher intensities of effort for longer periods. When exercise intensity exceeds this capacity, the body relies more heavily on anaerobic metabolism, which accelerates the onset of fatigue and reduces the duration of effort. A higher VO_2max is also associated with good overall health.

At high intensities, carbohydrates become the preferred fuel because they allow more energy to be produced using the same amount of oxygen. For this reason, carbohydrate availability is essential for sustaining intense and repeated efforts.

The ability to reach and sustain a high VO_2max depends on several factors:

- delivery of oxygen to the muscles, which can be affected by anaemia, insufficient iron intake or reduced blood volume due to dehydration;
- oxygen utilization at the muscle level, largely determined by mitochondrial density and efficiency, adaptations that are directly influenced by aerobic training;
- efficiency of the cardiovascular system, responsible for oxygen transport;
- respiratory function, through the lungs' capacity for gas exchange;
- environmental conditions, such as altitude or high temperatures, which can reduce oxygen availability.

Cardiovascular system

The cardiovascular system is essential for athetic performance and for maintaining the body's internal balance through:

- the transport of oxygen and nutrients to all tissues;
- the removal of metabolic waste products;
- the regulation of body temperature;
- and the transport of hormones from their site of production to the site of action.

The transport capacity depends on both hemoglobin concentration and total blood volume, as well as on the muscle capillary network, which develops through endurance training and enhances the exchange of oxygen and nutrients.

On average, men have higher haemoglobin concentrations than women, which translates into an approximately 15% greater oxygen-carrying capacity, partially contributing to the observed differences in aerobic capacity.

In elite endurance athletes, cardiac output can exceed 40 L/min, compared with about 20 L/min in sedentary individuals. This increased amount of blood pumped by the heart with each beat also explains the low resting heart rate characteristic of endurance athletes.

Thermoregulation

In most forms of exercise, the efficiency of converting metabolic energy into mechanical work is just over 20%, which means that nearly 80% of the released

energy is transformed into heat. In cold environments, this heat helps maintain body temperature and muscle function. In contrast, during prolonged exercise performed in hot and humid environments, heat dissipation becomes difficult, and its accumulation represents a major challenge for performance.

An increase in core and skin temperature is associated with a higher perception of effort. An often-underestimated aspect is that, in hot conditions or when exercise begins in a dehydrated state, effort is perceived as more difficult even from the early stages of activity.

Redirecting blood flow to the skin to facilitate heat loss through sweating reduces central blood volume, impairing oxygen delivery and energy production.

Evaporation of sweat is the primary mechanism of heat loss, but it is accompanied by losses of water and electrolytes, especially sodium. The reduction in blood volume leads to an increase in heart rate, and the effort is perceived as more demanding.

Both hypohydration and hyperthermia, when sufficiently severe, impair physical and cognitive performance. In most sports situations, small fluid losses have limited impact; however, the development of hypohydration exceeding 2–3% of body mass can compromise performance.

Fatigue

Regardless of the type of effort, the environment in which it takes place or the athlete's level of training, fatigue inevitably occurs if exercise is sufficiently intense or prolonged. However, understanding the underlying mechanisms of fatigue allows the implementation of training and nutrition strategies that can delay its onset and improve performance.

Table 1. Physiological causes of fatigue and recommendations

Cause	Solution
Rapid decrease of phosphocreatine in very intense efforts (1–10 seconds)	Development of anaerobic capacity through specific training; in certain situations, creatine supplementation, under supervision, may help delay fatigue.
Accumulation of acidic metabolites and a decrease in muscle pH during high-intensity efforts lasting 1–10 minutes	Training that increases tolerance to high-intensity effort; nutritional strategies that support buffering capacity and recovery
Low glycogen stores during prolonged efforts of 1–3 hours	Ensuring adequate carbohydrate intake before and during exercise; glycogen replenishment after training
Excessive increase in body temperature in hot environments	Adequate hydration, pre-cooling strategies, and gradual heat acclimatization
Dehydration and reduced plasma volume	Planning fluid intake before, during, and after exercise
Increased perception of effort and protective mechanisms of the central nervous system	Pacing strategies, adequate recovery, sufficient sleep, and appropriate nutrition
Low energy availability	Dietary intake adapted to training volume and monitoring for signs of persistent fatigue

Adaptations to training

The aim of training is to increase functional capacity and to achieve

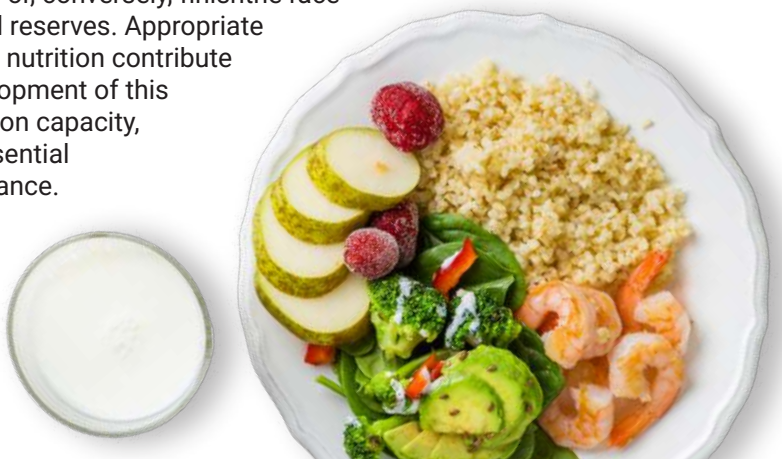
performance improvements specific to the event or sport practised. Training influences all organs and tissues of the body, but adaptations are specific to the stimulus applied and to the muscles involved. In general, progress is proportional to the training load (intensity, duration and frequency); however, there is a threshold beyond which increasing volume or intensity leads to a decline in performance, known as overtraining syndrome. This manifests as poor performance, chronic fatigue, difficulty in sustaining the training programme and increased risk of illness.

For a long time, nutrition was considered mainly a means of supporting recovery between training sessions. Today, we know that its role is much broader: nutrition directly influences the adaptations that occur after each training session. Training activates the genes responsible to produce functional proteins, while the nutritional, metabolic, and hormonal environment determines how efficiently this adaptation takes place. Nutrient intake before, during, and after exercise can enhance—or, conversely, limit—these responses.

In strength training, initial increases in performance occur rapidly, often after only a few sessions, before any visible structural changes in the muscle, and are primarily driven by neural adaptations. In contrast, endurance training produces complex adaptations increases in cardiac pumping capacity, blood volume and red cell mass, muscle capillary density, mitochondrial mass and the activity of enzymes involved in the oxidation of carbohydrates and fats.

One of the key adaptations to endurance training is the increased capacity to oxidise fats, which reduces dependence on carbohydrates during effort. This adaptation may be useful when carbohydrate availability is limited; however, in high-intensity efforts, it can increase the energy cost of movement and accelerate the onset of fatigue. Adaptations are also reversible: periods of inactivity lead to the loss of training-induced gains.

Training influences not only the body, but also the brain. One important aspect is learning to control pacing, so that energy is distributed efficiently over the duration of an event. Beginner athletes often start too fast and fatigue prematurely or, conversely, finishthe race with unused reserves. Appropriate training and nutrition contribute to the development of this self-regulation capacity, which is essential for performance.



2.2. Energy for performance: balance, requirements, and availability

Energy

Sports performance depends on eating enough food that provides both the right nutrients and enough energy. This helps athletes delay fatigue, recover better, and reduce the risk of injury and illness.

We get energy from the foods and drinks we consume, and it is measured in kilocalories (kcal). The body needs energy all the time to keep basic functions working (like breathing, blood circulation, and brain function), to support training and movement, to grow and develop, and to digest and absorb nutrients.

Energy balance

The energy we get from food and drinks (carbohydrates, proteins, and fats) is called energy intake.

The body uses energy for:

- resting metabolic rate (RMR) – energy needed to maintain basic body functions at rest (e.g. breathing, circulation, brain function);
- physical activity – energy used for daily activities (walking, work, chores) and training;
- thermic effect of food – energy used to digest and absorb nutrients.

Energy balance describes the dynamic relationship between the energy we take (energy intake from food and drinks) in and the energy we use (energy expenditure):

ENERGY BALANCE = ENERGY INTAKE – ENERGY EXPENDITURE

When

- intake = expenditure -> weight stays stable;
- intake > expenditure -> weight increases (energy surplus);
- intake < expenditure -> weight decreases (energy deficit) (Figure 1).

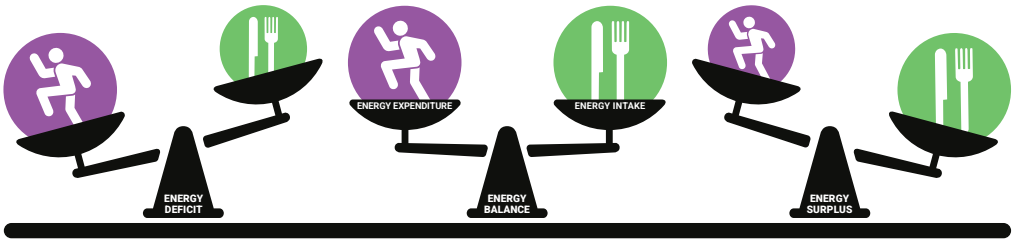


Figure 1. Energy balance

Energy requirements

Energy requirements represent the amount of energy (kcal) that ensures a stable weight and helps maintain health and optimal physical condition. An athlete's energy requirements depend on the training structure (periodization) and the cycle within the annual training plan, varying according to the volume and intensity of training. The daily energy requirement for most athletes ranges between 1,500 and 6,000 kcal. For a 70-kg athlete the energy requirements can vary between ~2,000 and 5,000 kcal/day.

In practice, energy requirements are often estimated based on energy expenditure, which includes resting metabolic rate, physical activity, and the thermic effect of food.

1. Estimating resting energy expenditure (RMR)

The Cunningham equation estimates RMR based on fat-free mass (muscle, organs, bones, and blood), which requires knowledge of body fat percentage.

RMR = 500 + (22 × fat-free mass in kilograms)

2. Physical activity

Energy expenditure from physical activity is added to RMR using a physical activity coefficient; this includes both daily activities (e.g., housework) and planned exercise (e.g., training) (Table 2).

Energy requirement = RMR × PAL

Table 2. Physical activity level (PAL)

Exercise level	Coefficient
Sedentary (little or no exercise)	1,2
Slightly active (30 min. of moderate-intensity physical exercise, 1–3 times/week)	1,375
Moderately active (45 min. of moderate-intensity physical activity, 3–5 times/week)	1,55
Very active (1 h of physical activity 6–7 times/week)	1,725
Extremely active (exercise of increased intensity and frequency)	≥1,9

3.Thermic effect of food (TEF)

Finally, the energy required for the digestion of food is added, representing approximately 10% of the value obtained from RMR and physical activity.

Energy requirement = (RMR × PAL) + TEF

Daily energy requirements example

Athlete, 60 kg, 170 cm, 13% body fat, 2 trainings/day

a.Calculate the RMR

- Determine first the fat-free body mass
- Body fat = 60 x 0.13 = 7.8 kg
- Fat-free body mass (weight – body fat) = 60 kg – 7.8 kg = 52.2 kg
- RMR = 500 + (22 x 52.2) = 1650 kcal

b.Apply PAL (according to the physical activity level)

- RMR x PAL coefficient = 1650 x 1.9 = 3135 kcal

c.Adăugarea ETA

- Total kcal (RMR x PAL) x 10% = 3135 x 0.1 = 314 kcal

d.Necesarul energetic zilnic:

- Total kcal (RMR x PAL) + TEF = 3135 + 314 = 3450 kcal

Energy availability

Energy availability (EA) is the amount of energy available to the body after accounting for energy expended through exercise from dietary intake.

EA = energy intake – energy cost of exercise

- energy intake = kcal consumed through food and drinks;
- energy cost of exercise = kcal used during planned exercise/training.

In certain sports (e.g., high jump, marathon), a lower body weight can provide a competitive advantage, while in others, weight categories are imposed by regulations. To reduce body weight, athletes may deliberately restrict their food intake below requirements or increase training volume to expend more energy. In both cases, an energy deficit is created, leading to weight loss; however, in the long term, this may result in low EA. This means that, after subtracting the energy expended during training from daily energy intake, insufficient energy remains available for physiological processes. Under these conditions, the body may slow down or suppress certain energy-demanding functions, such as growth or reproduction. Low EA may result from intentional dietary restriction or may occur unintentionally when the athlete does not adjust food intake to training load.

Low EA can occur in athletes of both sexes. In women, it is associated with menstrual dysfunction (irregular cycles or amenorrhea), and in men with reduced testosterone levels (erectile dysfunction, low libido). In the long term, low EA leads

to Relative Energy Deficiency in Sport (RED-S), which affects multiple body systems, leading to reduced bone strength, increased injury risk, impaired immunity, cardiac rhythm disturbances, or mood disorders.

How is EA calculated?

EA represents the energy available to the body after subtracting exercise energy expenditure from daily energy intake. It is expressed relative to fat-free mass (kcal/kg fat-free mass), i.e., metabolically active tissue (organs and muscles).

Female athlete, 165 cm, 55 kg, 15% body fat, daily energy intake 2400 kcal, exercise energy expenditure 4900 kcal/week.

a.Determine the fat-free mass

- Body fat = 55 × 0.15 = 8.25 kg
- Fat-free mass (weight-body fat) = 55-8.25 = 46.75 kg

b.Determine the daily exercise energy expenditure

- 4900 kcal/7 = 700 kcal/zi

c.Determine EA

- EA = (2400 – 700) / 46.75 = 36 kcal/kg fat-free mass

EA interpretation:

45 kcal/kg fat-free mass = high EA (weight gain/increasing muscular mass)

~45 kcal/kg fat-free mass = optimal EA

30–45 kcal/kg fat-free mass = low EA (weight loss/decreasing body fat)

<30 kcal/kg fat-free mass = very low EA (impaired health status)

Note: The lower the EA, the less energy remains for normal body functions after exercise.

Warning signs of insufficient energy intake:

- constant fatigue and reduced performance;
- increased frequency of injuries or illness (colds, infections, stress fractures);
- excessive concern about food and body weight (eating in secret, repetitive/rigid eating behaviour; compulsive eating/excessive exercise; frequent weighing/refusal to be weighed);
- history of mental health vulnerability (e.g., depression);
- the tendency to over-exercise (training outside the planned program / despite an injury or medical restriction);
- self-criticism and social withdrawal (self-criticism particularly about body image);
- physical signs (weight fluctuations; menstrual disturbances in women; signs of low testosterone – low libido, erectile dysfunction in men).

Consequences of low EA

Performance depends not only on training load but also on the athlete's ability to adapt to training. However, the capacity to adapt to training is much more difficult

to measure than the training load itself. Low energy availability (LEA) impairs this capacity to adapt to training and therefore reduces performance (Table 3). Coaches must be aware that training load and adequate nutrition are two inseparable components of athletic performance.

Table 3. The effects of low energy availability on exercise capacity and mental state

Physical consequences	Psychological consequences
Reduced adaptation to training	Reduced concentration capacity
Decreased muscular strength and resistance	Impaired mental clarity
Reduced endurance exercise capacity	Irritability
Impaired coordination	Depression

Strategies for preventing low EA (LEA) / RED-S

Prevention primarily requires that both coaches and athletes understand the risks and consequences of long-term inadequate nutrition and can recognize the warning signs. The following strategies applied consistently by coaches can help reduce the risk of LEA/RED-S in athletes:

1. Promote proper nutrition

Help athletes understand that nutrition is no less important than training; support regular eating before and after training to keep energy stores topped up.

2. Prioritise health and performance, not appearance

Value improvements in skills and performance instead of a specific body shape. Reinforce that an athlete's performance and well-being are more important than physical appearance.

3. Encourage communication

Create an environment where athletes feel comfortable discussing nutrition, fatigue, and health concerns. In conversations with female athletes, topics related to the menstrual cycle may be addressed, with any changes requiring medical evaluation. In male athletes, discussions should focus on energy levels and recovery, as signs of low energy availability are often less obvious.

4. Address weight/body composition responsibly

Discuss any concerns related to body weight and composition directly with the athlete, in a private setting, never in front of the team. Frequent weigh-ins (especially in junior athletes) and comments about athletes' physical appearance should be avoided.

5. Manage training load

Athletes identified as being at risk should have their training load adjusted — either by reducing volume or intensity, or by incorporating extra rest days — in parallel with appropriate dietary modifications. Monitor for any improvement in and mood. If no improvement is observed, a more detailed assessment is required.

6. Promote a team-based approach

Addressing RED-S effectively requires a coordinated team effort. Collaborate with dietitians, physicians, and mental health specialists who are familiar with the specific needs of athletes. Athletes should be referred to specialists whenever signs of concern arise.

2.3. Energy systems and adaptations to training

Physical activities and sports can place very different demands on the body: some require large amounts of energy over long durations (e.g., the marathon), whereas others require an extremely high rate of energy production over short periods (sprints, weightlifting). Regardless of the type of effort, the immediate source of energy for muscle contraction and relaxation is adenosine triphosphate (ATP).

The three main energy systems involved in ATP resynthesis are:

- **the phosphocreatine system (ATP–CP);**
- **anaerobic glycolysis,**
- **oxidative phosphorylation (aerobic metabolism).**

All three energy systems are always active, but depending on the type and intensity of exercise, one becomes the main source of energy. Nutrition directly influences the availability of the fuels required by each energy system and, consequently, the body's ability to adapt to training and maintain performance.

The phosphocreatine energy system (ATP–CP)

- ☑ involves a very rapid, single-step reaction;
- ☑ operates anaerobically (does not require oxygen during its use);
- ☑ provides energy over a short duration (~10 seconds);
- ☑ produces 1 molecule of ATP per molecule of phosphogreatine (CrP);
- ☑ fatigue occurs once CrP is depleted;
- ☑ is predominant in explosive, high-power efforts.

The phosphocreatine system supports explosive efforts but depends on aerobic recovery between repetitions. Training strategies, rest intervals and, in some cases, creatine supplementation can influence the capacity to sustain the power and the quality of high-intensity training sessions.

The anaerobic glycolytic energy system (lactate system)

- ☑ uses carbohydrates exclusively;
- ☑ operates anaerobically (does not require oxygen);
- ☑ has a high rate of ATP production, but slower than the ATP–CP system;
- ☑ provides energy for approximately 1–2 minutes;
- ☑ produces 2 ATP from glucose and 3 ATP from glycogen;
- ☑ fatigue is associated with a decrease in muscle pH;
- ☑ is predominant in intense, sustained or repeated efforts (for example, repeated sprints).

The anaerobic glycolytic system is essential for performance in intense and repeated efforts. Carbohydrate availability, the structure of rest intervals and nutritional strategies directly influence the athlete's capacity to sustain this type of effort.

Lactate – an aerobic fuel, not a "waste product"

Contrary to the traditional beliefs, lactate is not a useless waste product, but a valuable metabolic intermediate.

Once in circulation, lactate can be taken up by tissues with high oxidative capacity and used as an aerobic energy source. The greater the amount of lactate produced, the greater the need for aerobic activity to metabolize it. Thus, anaerobic glycolysis is closely linked to aerobic metabolism, which is responsible for lactate oxidation.

Lactate is a reusable fuel and a marker of effort intensity, not the direct cause of fatigue. The body's capacity to produce, transport and oxidise lactate depends on the level of aerobic fitness and can be improved through training and appropriate nutrition.

The oxidative phosphorylation energy system (aerobic system)

- ☑ uses both fats and carbohydrates;
- ☑ operates aerobically (requires oxygen);
- ☑ is much slower than anaerobic systems, involving many reactions;
- ☑ has a high energy yield (≈30 ATP from glucose / ≈113 ATP from palmitic fatty acid);
- ☑ can be sustained for a virtually unlimited duration;
- ☑ fatigue occurs through the depletion of fuels: carbohydrates or fats;
- ☑ is the predominant energy system in endurance sports (long-distance running, cycling, long-distance swimming).

Proteins as an energy source

Proteins are not stored in the body as an energy reserve, unlike carbohydrates (stored as glycogen) or fats (stored as triglycerides). Their primary role is structural and functional, contributing to muscles, enzymes, hormones, and other essential components.

Nonetheless, amino acids derived from proteins can be metabolised aerobically for

energy production, but this requires an additional step: removal of the amino group. The resulting nitrogen is converted into urea and eliminated via urine. This process makes the use of proteins as an energy source slower and metabolically more costly.

Among all macronutrients, proteins are the least preferred energy source. They are not stored for rapid access and are used for energy mainly when other sources are limited. Therefore, their contribution to energy production during exercise is typically low, especially when carbohydrate and fat intake is adequate.

Under conditions of metabolic stress, such as fasting periods, severe energy restriction or exercise performed with low glycogen reserves (for example, the final stages of a marathon), proteins may contribute to a greater extent to energy production. Even in these situations, their contribution rarely exceeds 10% of total energy, and their use for energy is a sign that the nutritional strategy is not optimal.

Proteins should be preserved for their structural and functional roles. An appropriate nutritional strategy ensures sufficient carbohydrate and fat intake, preventing the body from using muscle mass as an energy source.

2.4. Macronutrients: carbohydrates, proteins, and fats

Carbohydrates

What are carbohydrates (CHO)?

CHO are the primary source of energy for working muscles during moderate- and high-intensity exercise, as well as for the brain. They are made up of carbon, hydrogen, and oxygen — hence the abbreviation CHO. In the body, CHO are stored as glucose (in the blood) and glycogen (in the liver and muscles). Liver glycogen is responsible for maintaining normal blood glucose levels, while muscle glycogen serves as a direct fuel source for muscle contraction. Glycogen stores are depleted through physical activity and must therefore be replenished appropriately. CHO are important nutrients before exercise, during exercise (in certain situations), and after exercise. In food, they are found in the form of sugars (simple CHO), starch (complex CHO), and fibre (non-digestible CHO). One gram of CHO provides 4 kcal.

Roles:

- ☑ energy source;
- ☑ maintaining blood sugar levels;
- ☑ influencing how fat is used and stored;
- ☑ supporting gut health.

Digestion, absorption, and metabolism

After consumption, CHO are broken down into glucose through digestion. This process begins in the mouth and takes place largely in the small intestine. Complex CHO (polysaccharides) are broken down by enzymes into simpler sugars and then into monosaccharides — glucose, galactose, and fructose — which are absorbed into the bloodstream. Glucose is the most abundant and is absorbed via a specific transport mechanism as is galactose. Fructose, however, is absorbed through a different pathway. These differences in absorption allow the body to take up several types of sugar simultaneously. Following digestion and absorption, CHO are transported in the blood primarily as glucose. Some of this glucose is used immediately for energy, while the surplus is stored as glycogen in the liver and muscles. Insulin is the hormone that helps the body use and store glucose.

Types

Simple vs. complex CHO

Based on their structure and the speed at which they can be converted into energy, CHO are classified as simple or complex, respectively as fast- and slow-absorbing CHO.
Simple CHO consist of one or two sugar molecules (mono- and disaccharides).
Monosaccharides: glucose, fructose, galactose.
Disaccharides: sucrose (table sugar), lactose, maltose.

Key features:

- ☑ digested and absorbed quickly;
- ☑ cause a rapid rise in blood sugar;
- ☑ provide immediate energy.

Complex CHO are made up of longer sugar chains (polysaccharides) and include starchy foods and fibre.

Key features:
- digested and absorbed more slowly;
- cause a gradual rise in blood sugar;
- provide sustained energy.

Starchy foods represent the body's primary energy source, supporting both physical performance and recovery by replenishing glycogen stores.

Fast- vs. slow-absorbing CHO

This classification is linked to the concept of the glycaemic index (GI), which indicates how quickly blood sugar rises after consuming a CHO-containing food. The higher a food's GI, the greater its impact on blood glucose. Based on their ability to raise blood sugar, CHO foods can be divided into low, medium, and high GI categories.

Table 3. Examples of low, medium, and high GI CHO foods

Low GI (0–55)	Medium GI (56–69)	High GI (70–100)
Apples (~36-44)	Pasta (~50-65)	White bread (~70-85)
Whole milk (~27-34)	Oats (~55-69)	White rice (~70-90)
Lentils (~21-26)	Sweetcorn (~55-60)	Potatoes (~70-90)
Beans (~30-40)	Kiwi (~50-60)	Crisps (~70)
Peanuts (~15-20)	Ice cream (~55-65)	Pretzels (~80)
Bananas (~45-60)	Honey (~58-65)	Watermelon (~72-80)

GI in practice

GI was initially developed for people with diabetes, but it is also used in sports nutrition. However, its role in optimising sports performance is not fully clear. In theory, consuming low-GI foods before prolonged exercise may help preserve glycogen stores and increase the use of fat as a source of energy. This could potentially delay the onset of fatigue. However, during high-intensity exercise, the body requires rapidly available energy, and CHO are the preferred fuel source. High-GI foods may be more useful after exercise, when rapid glycogen replenishment is important. Nevertheless, research findings do not clearly

support the superiority of either low- or high-GI foods for sports performance.In addition, when athletes consume CHO during exercise, the type of CHO consumed before training matter less.

In practice, athletes should choose the type of CHO according to the demands of the activity (e.g. need for rapidly available energy), timing of intake, digestive tolerance, and food preferences, rather than relying exclusively on GI. It is important to remember that low-GI foods generally contain more fibre. A diet rich in whole grains, vegetables, and fruits provides health benefits and may help reduce inflammation.

Fibre

What is fibre?

Fibre encompasses several plant-based compounds — such as cellulose, pectins, and resistant starch — that cannot be digested by the body. It can be divided into two broad categories: soluble and insoluble, each with distinct effects on digestive health. The large intestine (colon) is home to a vast community of microorganisms known as the gut microbiota. Fermentable soluble fibre acts as nourishment for the beneficial bacteria in the gut, with positive effects on athletic performance and recovery. Athletes with a balanced gut microbiota tend to experience fewer gastrointestinal symptoms — such as bloating, cramping, and diarrhoea — during exercise.

Roles:

- slowing carbohydrate absorption (helping to maintain steady energy levels);
- adding bulk to stool and supporting regular bowel movements;
- acting as a prebiotic — feeding beneficial gut bacteria;
- producing compounds that support gut and metabolic health.

Types

Fibre can be classified according to several criteria, including:

- solubility in water;
- degree of fermentation (the extent to which they can be used by gut bacteria).

Insoluble fibre passes through the digestive system largely unchanged. It adds bulk to stool and speeds up transit through the intestines, reducing the risk of constipation.

Soluble fibre – dissolves in water and forms a gel-like substance that slows the digestion and absorption of carbohydrates, preventing sharp spikes in blood sugar.

Most plant foods contain a mixture of fibres, not a single type.

Some soluble fibres are fermentable, meaning they can be used by gut bacteria as a source of energy, resulting in the production of beneficial compounds as well as gases. Certain compounds help maintain the integrity of the intestinal lining and reduce inflammation, thereby supporting recovery after exercise. Research suggests that beta-glucan fibres found in oats and barley may improve endurance capacity and muscular strength in athletes.

However, the gases produced during fermentation can cause digestive discomfort, such as bloating and cramping, especially when produced rapidly or in large amounts. In other words, although fermentable fibres provide clear benefits, they may also lead to undesirable side effects. Individual tolerance varies depending on the composition of the gut microbiota and its fermentation capacity.

In contrast, low- or non-fermentable fibres are less likely to cause gastrointestinal discomfort, which is an important consideration for athletes involved in endurance or high-intensity exercise.

Proteins

What are proteins?

Proteins are made of chains of amino acids that contain carbon, hydrogen, oxygen, and nitrogen. The body uses 20 different amino acids to build proteins: 9 are essential (they must come from food), and 11 are non-essential (the body can produce them). Six of the non-essential amino acids are considered conditionally essential — they need to come from the diet when the body cannot produce enough, such as during illness or high physiological stress. To build proteins, the body needs all 20 amino acids to be available at the same time. In the body, amino acids are mainly used to build and repair tissues, but they can also provide energy when needed. One gram of protein provides 4 kcal.

For most amino acids to be used as fuel by the muscles, they first need to be converted into glucose in the liver. An exception is the group of branched-chain amino acids (leucine, isoleucine, and valine), which go directly to the muscles and can be used both for building and as a source of energy. However, their main role is to support muscle growth and repair.

Roles:

- building and repairing tissue;
- producing essential molecules such as enzymes and hormones;
- transporting substances around the body: oxygen, nutrients, hormones;
- maintaining internal balance (fluid distribution in blood and tissues, pH regulation);
- communication between cells;
- energy.

Digestion, absorption, and metabolism

Protein digestion begins in the stomach and continues in the small intestine. Proteins are broken down into small fragments (di- and tripeptides) and individual amino acids, which are then absorbed in the small intestine. Some protein supplements contain hydrolysed protein (protein that has been partially pre-digested) allowing for faster absorption. Casein is often processed in this way to bring its absorption rate closer to that of whey protein. Once absorbed, amino acids are transported either to the liver or directly into circulation. Depending on the body's needs, the liver determines whether:

- amino acids are used for protein synthesis and the production of other compounds;
- directed to other tissues;
- used to generate energy.

Branched-chain amino acids are transported directly to the muscles, where they can be used either for protein synthesis or as an energy source.

Types

Complete and incomplete proteins

Proteins differ depending on which amino acids they provide to the body:

- complete (provide essential amino acids in adequate amounts and proportions, e.g. animal-based proteins);
- incomplete (provide essential amino acids in lower amounts or in less balanced proportions, e.g. many plant-based proteins).

Complete proteins are considered high-quality protein sources, providing essential amino acids in adequate proportions and being more easily utilised by the body. However, some of these protein sources are also high in „bad" (saturated) fat - e.g. fatty meat, sausages, processed meats, lard, bacon, certain full-fat dairy products etc. Therefore, consuming these foods in large amounts may have negative effects on health. It is important to mention that plant-based proteins can meet essential amino acid requirements if the diet is varied.

Fast- and slow-acting proteins

Milk is a particularly valuable source of protein after resistance exercise, as it contains both whey and casein. Whey protein is absorbed rapidly, causing a sharp rise in blood amino acid levels followed by an equally sharp decline. For this reason, whey is considered a fast-acting protein that stimulates muscle growth effectively. Casein, by contrast, produces a slower but more sustained and stable increase in amino acid levels, which helps to limit muscle protein breakdown.

Soy protein is a complete protein and a suitable post-exercise option for athletes who do not consume animal products. Like whey, soy proteins are absorbed relatively quickly.

Fats

What are fats?

Fats are molecules made up of carbon, hydrogen, and oxygen; some also contain phosphorus in their structure. Unlike carbohydrates and proteins, fats do not dissolve in water — they are soluble only in certain substances such as alcohol or ether. The main types of dietary fat are:

- triglycerides;
- cholesterol;
- phospholipids.

All types of fat play essential roles in normal bodily function.

Triglycerides are the main form in which fat is both consumed and stored in the body. Cholesterol is naturally produced by the liver from fatty acids, glucose, and amino acids and is found exclusively in animal-based foods. Phospholipids are a type of fat that forms part of the structure of cell membranes. The body can produce phospholipids, but they are also found in food — for example in egg yolk, liver, soya, nuts, and seeds. Fat is the most energy-dense macronutrient, providing 9 kcal per gram.

Roles:

- providing energy;
- storing energy;
- enabling the absorption of fat-soluble vitamins;
- supplying essential fatty acids;
- increasing satiety;
- protecting internal organs;
- insulating the body and providing protection against cold;
- contributing to hormone production.

Digestion, absorption, and metabolism

Fat digestion takes place predominantly in the small intestine. Because fat does not dissolve in water, its digestion requires both bile and digestive enzymes. Bile prepares fat for digestion by breaking it down into smaller droplets, which enzymes then break down further into fatty acids, glycerol, cholesterol, and phospholipids. After absorption, these molecules are packaged into particles called chylomicrons, which enter the circulation and are transported to the muscles and adipose tissue. In the muscles, fat is either used as an energy source or stored temporarily as intramuscular triglycerides. In adipose tissue, fat is stored as energy reserves. Fat digestion and chylomicron formation are slow processes, and the absorption of a high-fat meal can take several hours.

Types

Dietary fats can be classified as unsaturated (mono- and polyunsaturated), saturated, and trans fats.

Unsaturated fats

- Monounsaturated fats are generally liquid at room temperature and are associated with benefits for cardiovascular health.
- Polyunsaturated fats include the essential fatty acids omega-3 and omega-6, which must be obtained through food because the body cannot produce them. Polyunsaturated fats support cardiovascular health, particularly when consumed in place of saturated fats. Also, omega-3 fatty acids may also support recovery from exercise.

Saturated fats

Are generally solid at room temperature. Intake should be kept moderate, as excessive consumption is associated with increased cardiovascular risk.

Trans fats

Are artificially produced through the industrial processing of vegetable oils. Their consumption is associated with negative effects on cardiovascular health and should be avoided as much as possible.

2.5. Micronutrients: vitamins and minerals

Micronutrients, namely vitamins and minerals, do not provide a direct source of energy, but the roles they perform make them indispensable.

Vitamins are involved in numerous processes in the body, making possible the use of energy from carbohydrates, fats, and proteins; the regulation of metabolism (= the biochemical and energy transformations that take place in the tissues of a living organism); the formation of substances needed by the body; other specific functions.

Based on their properties, vitamins can be either fat-soluble or water-soluble.

Fat-soluble vitamins (A, D, E, K) dissolve in fats and are stored in body fat tissue. Daily intake is not mandatory, and excessive intake can be toxic.

Water-soluble vitamins (vitamin C and B vitamins) dissolve in water and are not stored in the body. They require daily intake, while excess intake rarely occurs.

Due to their complex structure, vitamins can be destroyed by:

- prolonged storage;
- prolonged exposure to air (oxygen);
- high humidity;
- light exposure;
- high temperatures during cooking;
- dissolving in water during washing, soaking, or boiling.

Table 4. Vitamins – roles and food sources

Vitamin	Essential role in athletes	Main food sources	Reference Intake (general population)
Vitamin A	Supports immunity, vision, and tissue integrity	Liver, dairy products, eggs, carrots, pumpkin, spinach	700–900 µg
Vitamin D	Bone health, muscle function, immunity	Sun exposure, oily fish, eggs, fortified dairy products	600–800 UI (15–20 µg)
Vitamin E	Antioxidant, protection of muscle cells	Nuts, seeds, vegetable oils, avocado	15 mg
Vitamin K	Blood clotting, bone health	Green vegetables (spinach, broccoli), cabbage	90–120 µg
VitaminC	Antioxidant, collagen production, immunity, iron absorption	Citrus fruits, peppers, berries, kiwi, sea buckthorn	75–90 mg
VitaminB1 (Thiamine)	Carbohydrate metabolism, energy production	Whole grains, pork, legumes	1.1–1.2 mg
Vitamin B2 (Riboflavin)	Energy production, cellular function	Dairy, eggs, meat, almonds	1.1–1.3 mg
Vitamin B3 (Niacin)	Energy metabolism, nervous system function	Meat, fish, whole grains, peanuts	14–16 mg
Vitamin B5 (Pantothenic acid)	Energy metabolism, hormone synthesis	Meat, eggs, legumes, whole grains	5 mg
Vitamin B6	Protein metabolism, haemoglobin formation	Meat, bananas, potatoes, whole grains	1.3–1.7 mg
Vitamin B7 (Biotin)	Carbohydrate, fat, and protein metabolism	Eggs, nuts, seeds	30 µg
Vitamin B9 (Folate)	Red blood cell formation, DNA synthesis	Green vegetables, legumes, citrus fruits	400 µg
Vitamin B12	Red blood cell formation, nervous system function	Meat, fish, eggs, dairy products	2.4 µg

B vitamins

Because energy use increases during physical activity, athletes need higher amounts of certain vitamins involved in energy production — especially vitamin B1 (thiamine), B2 (riboflavin), and B3 (niacin). In simple terms: the more energy (kcal) an athlete uses, the more of B vitamins they need. In most cases, if food intake matches the training load, these higher vitamin needs are covered by eating more food (Table 6).

Table 6. Estimated daily requirements for vitamins B1, B2 and B3

Energy intake (kcal/day)	Body weight (kg)	Vitamin B_1 (mg/day)	Vitamin B_2 (mg/day)	Vitamin B_3 (mg/day)
2000	60	1,1	1,2	13,2
2500	70	1,4	1,5	16,5
3500	80	1,9	2,1	32,1

Vitamins A, C, and E

During exercise, the muscles produce more free radicals — unstable molecules that, in excess, can lead to oxidative stress. This can affect muscle function, increase inflammation, and slow down recovery after exercise.

The body has its own antioxidant defense systems to neutralize free radicals. Training helps strengthen these systems, improving the muscles' ability to cope with oxidative stress and recover more efficiently. These are important training adaptations, but they can be reduced if:

- oxidative stress becomes too high;
- large doses of antioxidant supplements are used.

It is important to note that a low to moderate level of oxidative stress is normal and beneficial for training adaptations.

The main micronutrients with antioxidant roles are:

- vitamin C;
- vitamin E;
- beta-carotene (vitamin A).

It is recommended that most antioxidants come from food sources, such as:

- fruits (berries, dark grapes);
- vegetables (red cabbage, eggplant, carrots, tomatoes, sweet potatoes, spinach, kale);
- whole grains;
- nuts and seeds;
- tea and coffee;
- vegetable oils.

Antioxidant supplements are recommended particularly in cases of deficiency, insufficient dietary intake, or during periods of increased stress.

Vitamin D

Vitamin D is produced mainly in the skin through exposure to sunlight. Diet plays a smaller role, as foods rich in vitamin D (cod liver oil, trout, salmon, sardines, tuna, eggs) are usually eaten in limited amounts. Vitamin D is important for bone health, muscle function, immune function, and various metabolic processes. It may also support recovery after injuries and help reduce the risk of infections in athletes.

Stress fractures can account for up to 20% of all sports injuries. While the role of vitamin D in maintaining bone mineral density is well established, its role in healing these fractures is still unclear. Some studies suggest that vitamin D supplementation is associated with better physical performance, including improvements in aerobic capacity. It may also support recovery by helping increase strength, power, and muscle mass. Resistance training may increase vitamin D levels in the blood, possibly due to increases in bone mass associated with this type of exercise.

Athletes should ensure adequate vitamin D levels either through controlled sun exposure or supplementation. Low vitamin D levels are common in athletes across many sports, especially during the winter. Therefore, regular testing and correcting any deficiency are recommended.

Minerals have a structural role, being part of the composition of bones, teeth, hormones, haemoglobin, etc. They are involved in muscle contraction, the formation of clotting factors, the transmission of nerve impulses, blood pressure control, immune function, cellular metabolism or nutrient metabolism, etc.

Minerals have a simple structure, which generally makes them resistant. They may be lost through dissolution in water or through the formation of bonds with other elements that cannot be broken during digestion.

Table 5. Minerals - roles and food sources

Mineral	Essential role for athletes	Main food sources	Reference Intake (general population)
Calcium	Muscle contraction, bone health, nerve transmission	Milk, yogurt, cheese, fish with bones, tofu, green vegetables, almonds, fortified products	1000–1200 mg
Phosphorus	ATP production, energy metabolism, bone structure	Meat, fish, eggs, dairy products, nuts, legumes	700 mg
Magnesium	Energy production, muscle and nerve function, cramp prevention	Nuts, seeds, whole grains, legumes, green vegetables	300–400 mg
Sodium	Fluid balance, nerve transmission, muscle function	Salt, common foods, sports drinks	1500 mg (higher with heavy sweating)
Potassium	Muscle contraction, electrolyte balance	Bananas, potatoes, legumes, fruit, yogurt	~3500 mg
Chloride	Fluid and acid-base balance, digestion	Table salt, salty foods	~2300 mg (usually covered through salt intake)
Iron	Oxygen transport, aerobic capacity	Red meat, liver, eggs, legumes, spinach, dried fruit	8–10 mg men; 15–18 mg women
Zinc	Immunity, tissue repair, protein synthesis	Meat, dairy products, nuts, seeds	8–11 mg
Copper	Iron metabolism, collagen formation	Nuts, seeds, seafood, whole grains	~0.9 mg
Manganese	Energy metabolism, bone health	Whole grains, nuts, tea, vegetables	1.8–2.3 mg
Iodine	Energy metabolism, bone health	Iodized salt, fish, dairy products, eggs	150 µg
Selenium	Antioxidant, muscle protection, thyroid function	Brazil nuts, fish, eggs	55 µg
Fluoride	Teeth and bone health	Drinking water, tea, fish	3–4 mg

Iron

Iron is essential for oxygen transport (through hemoglobin) and energy metabolism. Iron deficiency limits oxygen delivery to working muscles, which can reduce sports performance.

Both diet and training itself can affect iron status. Athletes at higher risk of iron deficiency include those in endurance sports, aesthetic sports, and vegetarians.

Iron deficiency can lead to iron-deficiency anemia, which develops when there is an imbalance between:

- intake (low intake, restrictive or low-calorie diets);
- absorption (affected by dietary inhibitors – Table 7.A);
- losses (sweating, menstruation, etc.);
- requirements (high training volume and intensity).

Athletes may need about 70% more iron than non-athletes. Signs and symptoms of iron deficiency are shown in Figure 2.

In the early stage, iron deficiency may not yet appear as anemia. Iron stores are low (low serum ferritin), but hemoglobin can still be normal. Even at this stage, performance may be affected, and without intervention, it can progress to iron-deficiency anemia.

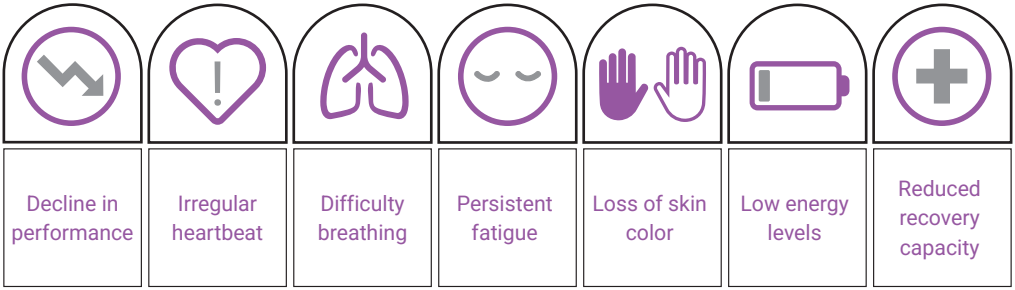


Figure 2. Signs and symptoms of iron deficiency

What should be done first?

The first step is to improve the diet by increasing intake of iron-rich foods and optimizing iron absorption (Table 7, B).

Recommended intake is around 14 mg iron/day, and for female long-distance runners, it may increase to 18 mg/day.

In general, it is recommended to regularly include:

- meat, fish, and organ meats (liver) ~5 times per week;
- legumes (beans, chickpeas, lentils);
- green leafy vegetables (kale, arugula, beet greens);
- seeds (pumpkin seeds).

Types of iron

There are two types of iron in food:

- heme iron -> found in animal foods;
- non-heme iron -> found in plant foods.

Types of iron

There are two types of iron in food:

- heme iron -> found in animal foods;
- non-heme iron -> found in plant foods.

Heme iron is absorbed more efficiently than non-heme iron. However, the absorption of non-heme iron can be significantly enhanced by consuming it together with foods rich in vitamin C.

Iron absorption is also influenced by the body's iron stores:

- when stores are low -> absorption increases;
- when stores are adequate -> absorption decreases.

Important for coaches

Although diet plays a key role in maintaining iron balance, iron-deficiency anemia cannot be corrected through diet alone. This would require consuming very large amounts of iron-rich foods (even kilograms). Depending on medical advice, treatment may include oral iron supplements, or intravenous iron, in some cases. Iron supplements should not be taken without medical advice and blood tests. Excess iron intake can cause digestive issues and, over time, lead to ironoverload with health risks.

Table 7. Dietary factors that influence iron absorption

Factors that reduce iron absorption (A)	Factors that increase iron absorption (B)
☒ Phytates: found in whole grains, wheat bran, legumes, nuts, peanut butter, seeds, soy products, soy protein, and spinach	☑ Foods rich in vitamin C (ascorbic acid): salads, lightly cooked green vegetables, some fruits, citrus fruits, and fruit juices (including vitamin C–fortified juices)
☒ Polyphenols: found in black tea, coffee, herbal teas, cocoa, red wine, and some spices (e.g., oregano)	☑ Some fermented foods: miso, certain types of soy sauce
☒ Calcium: reduces the absorption of both heme and non-heme iron by competing with iron in the intestine (milk, cheese, and other dairy products)	☑ Meat factor: beef, liver, lamb, chicken, and fish
☒ Peptides from partially digested plant proteins: found in soy protein isolates and soy-based products	☑ Alcohol and some organic acids: foods with a very low pH that contain citric or tartaric acid, such as citrus fruits
	☑ Vitamin A and beta-carotene: liver, animal fats, carrots, sweet potatoes

Calcium

Calcium (Ca) is a key nutrient for building and maintaining bone mass. It also plays an essential role in muscle contraction, protecting bones and joints from the stress of physical activity, and energy metabolism, helping convert carbohydrates and fats into energy. In addition, calcium contributes to reducing injury risk, improving recovery time, reducing fatigue, and delaying muscle soreness after exercise.

Athletes should aim for an intake of around 1500 mg of calcium per day as part of a balanced diet. Daily needs may vary depending on training level and body weight. In most cases, calcium can be obtained through food sources such as:

- milk and dairy products;
- green leafy vegetables;
- tofu;
- nuts;
- canned sardines with bones;
- fortified cereals.

Calcium absorption is regulated by vitamin D. If calcium intake is too low over time, the body will take calcium from the bones, leading to reduced bone density and a higher risk of fractures. Along with low calcium intake and aging, another important factor that can lead to bone loss is low estrogen levels. Estrogen helps regulate the menstrual cycle and protect bone health. Low estrogen levels are seen in:

- female athletes with low energy availability (irregular or absent menstrual cycles);
- women during menopause.

Magnesium

Magnesium (Mg) is involved in energy production and the regulation of muscle contraction. Higher magnesium levels in the blood are positively associated with better muscle performance in athletes. Low magnesium intake can lead to muscle cramps and reduced ability to sustain training volume, especially in athletes performing strength training. However, there is currently not enough evidence to show that magnesium supplements can prevent or reduce exercise-induced muscle cramps.

Athletes may need 10–20% more magnesium than sedentary adults due to losses through sweat and urine. Magnesium absorption is influenced by vitamin D levels - adequate or higher vitamin D levels can improve magnesium absorption. Magnesium, in turn, is essential for the synthesis, transport, and activation of vitamin D.

Food sources of magnesium:

- whole grains;
- spinach;
- cashew nuts;
- peanuts;
- almonds;
- avocado;
- milk;
- quinoa;
- black beans.

2.6 Water and electrolytes

Water

Water is essential for life and makes up about 60% of the human body. Proper hydration is important for many physiological processes. Both dehydration (too little water) and overhydration (too much water) can negatively affect sports performance.

Rapid loss of water and electrolytes through dehydration or diarrhoea can have serious, even life-threatening consequences. Athletes — especially those training in hot and humid environments — must pay close attention to proper rehydration during and after exercise. In addition to water intake, maintaining electrolyte balance is essential.

Roles:

- cell function: the medium where all biochemical reactions take place.
- body temperature regulation helps control body temperature through sweating and prevents overheating during exercise.
- digestion: supports digestion and nutrient absorption and helps prevent constipation.
- transport: carries nutrients, oxygen, and waste products throughout the body.
- joint and tissue health lubricates joints and protects organs and tissues.
- cognitive function: supports brain function and concentration.

Recommended water intake:

- adults: about 2–3 liters/day, depending on climate, activity level, and diet.
- athletes and active individuals: about 3–6 liters/day or more, depending on training intensity, duration, and environmental conditions.

Tips for staying well hydrated

- carry a water bottle and drink regularly throughout the day.
- include water-rich foods in your diet (e.g., watermelon, oranges, cucumbers, lettuce.
- avoid excessive intake of diuretics (caffeine, alcohol), which can increase fluid loss.

Electrolytes

Electrolytes are minerals essential for body function. They are involved in muscle contraction, nerve signalling, and energy metabolism.

Significant electrolyte losses can occur when the body loses fluids through vomiting, diarrhoea, or heavy sweating.

The main electrolytes are:

- sodium.
- potassium.
- calcium.
- magnesium.
- chloride.

Through sweating, athletes lose not only water but also electrolytes, especially sodium. Whenever possible, these losses should be replaced through food, rather than supplements. For example, water and salty foods can be used for rehydration when there is enough time to recover and when food can be consumed soon after exercise.

Water, isotonic drinks, and electrolyte products

Electrolytes are found both in isotonic drinks and in electrolyte products (gels, powders, etc.).

Isotonic drinks also contain carbohydrates (about 6–8%) and are useful as a source of energy, to help prevent dehydration and replace electrolytes. Recommended for: exercise lasting more than 1 hour; rehydration when body weight losses are modest.

Electrolyte drinks/products contain more sodium (about 4 times more) and much less sugar (energy) compared to isotonic drinks. These are useful for hydration before exercise in hot conditions or for rehydration when body weight losses are higher (Table 8).

Table 8. Hydration drinks: what to choose and when

Situation	Options
Before exercise in hot conditions	Electrolyte drink
Exercise < 1 hour	Water
Exercise 1-3 hours	Water/isotonic drink
Exercise > 3 hours	
Rehydration if body weight loss is < 2%	
Rehydration if body weight loss is > 2% or recovery time is short	Electrolyte drink

Why are electrolytes important?

Muscle cramps during or after exercise are among the most common problems athletes face. Their exact cause is not fully understood.

According to an older theory, cramps are caused by loss of water and electrolytes, which prevents the muscle from functioning properly. A more recent theory suggests that cramps are caused by fatigue and/or overuse, leading to increased

activity of the nerves that control muscle contraction. One argument supporting this theory is that cramps can often be quickly relieved by stretching the affected muscle, which reduces the activity of these nerves.

The roles of electrolytes in the body and how they can be lost are summarized in the table below.

Table 9. Electrolytes – roles and losses during exercise

Electrolyte	Role	Losses
Sodium	▪ fluid and electrolyte balance ▪ nerve signalling ▪ muscle contraction	▪ sweat, urine, stool
Potassium	▪ fluid and electrolyte balance ▪ nerve signalling ▪ muscle contraction ▪ keping heart rhythm normal	▪ sweat, urine, stool (modest losses) ▪ vomiting, medication that increase potassium loss
Calcium	▪ nerve signalling ▪ muscle contraction ▪ bone health	▪ sweat (modest losses) ▪ stool (higher losses – unabsorbed calcium)
Magnezium	▪ neuromuscular function ▪ energy production ▪ enzyme activity	▪ sweat and stool (modest losses) ▪ urine (higher losses; some medications can increase excretion)
Chloride	▪ fluid and electrolyte balance ▪ acid-base balance	▪ sweat (along with sodium)

As calcium and magnesium are covered in detail in the previous section (Micronutrients), we will focus here on sodium, potassium, and chloride.

Sodium

Sodium comes from foods, drinks, and supplements. Common sources include:

- salty foods (e.g., salted nuts, canned tuna, pretzels, olives, smoked salmon, pickled foods).
- drinks (e.g., pickle juice, electrolyte drinks).
- salt tablets or supplements.

In general, sodium intake from the diet is higher than recommended (about 2 g sodium/day, equivalent to 5 g of salt), and the excess is removed by the kidneys

through urine. Sodium is added to foods mainly as sodium chloride (NaCl), or table salt.

Most daily salt intake comes from:
- ultra-processed foods (~77%) (processed meats, chips, snacks, canned foods).
- added salt at the table (~11%).

The remaining of sodium intake (~12%) occurs naturally in foods (e.g., milk, cereals, vegetables) and water.

Under normal conditions, the body loses about 0.5 g of sodium per day through sweat and stool. However, in conditions of heavy sweating, sodium losses can become much higher.

Potassium

Potassium is found in many foods such as:
- fruits (bananas, avocado).
- vegetables (tomatoes, potatoes).
- legumes (beans).

To meet the recommended intake (about 3.5 g/day), a varied diet including these foods is recommended. Potassium supplements should not be used without medical advice, as excessive intake may increase blood potassium levels (hyperkalemia), potentially disrupting normal heart rhythm and leading to serious health complications. Although uncommon, cases of hyperkalemia have been reported in bodybuilders.

Potassium losses through sweat are usually low. However, significant losses can occur with:
- frequent vomiting (e.g., in athletes with eating disorders).
- severe diarrhoea.
- use of certain medications that increase potassium loss.

Chloride

Most dietary chloride comes from sodium chloride (salt). The recommended intake is about 3.1 g/day, which is equivalent to around 5 g of salt/day. Sodium and chloride are lost together through sweat, so the symptoms of chloride loss are like those of sodium loss.

Monitoring hydration status in athletes

Hydration status can be monitored using simple methods, such as:

- body weight (before and after exercise or in the morning).
- urine colour and volume.

Table 10. Practical methods for monitoring hydration status in athletes

Body weight measurement before and after exercise	Athletes are encouraged to weigh themselves (ideally in minimal clothing) before and after training to assess changes in body weight. For every 0.45 kg of body weight lost, it is recommended to drink 450–700 ml of fluids.
Morning body weight	During periods of intense training or hot and humid conditions, athletes may monitor body weight each morning. A reduction of >1% of body weight may suggest inadequate hydration.
Urine colour	Pale yellow urine generally suggests adequate hydration, whereas darker urine may indicate dehydration. However, some foods, supplements (e.g., B vitamins), and medications may also alter urine colour.
Urine volume	Regular urination throughout the day generally suggests adequate hydration. In practice, monitoring how often athletes urinate is often easier and more practical than measuring total urine volume.

Signs of dehydration:

- dry mouth and lips.
- fatigue and weakness.
- dizziness or feeling faint.
- low urine output or dark-coloured urine.
- headaches and difficulty concentrating.
- muscle cramps.
- heat-related illnesses during exercise.

- **Hydration strategies for athletes:**
- drink water before, during, and after training.
- include drinks with electrolytes during long or high-intensity exercise to replace

- sodium, potassium, and magnesium.
- adjust fluid intake based on environmental conditions (heat, humidity) and individual sweat rate.

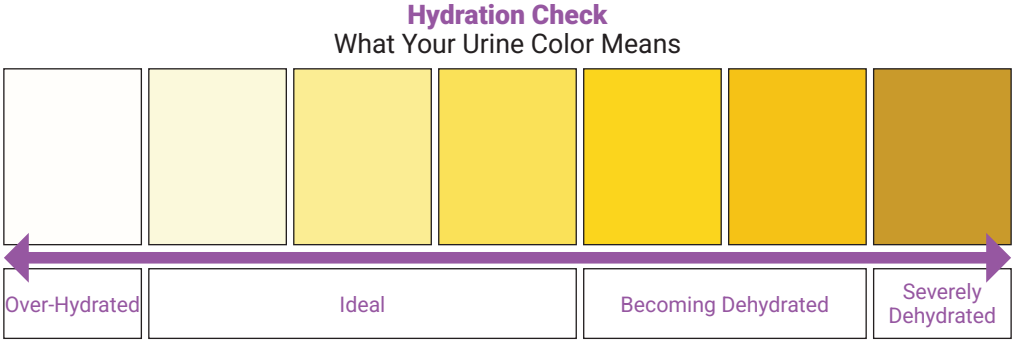


Figure 3. Urine colour as an indicator of hydration status

Biologically active compounds are another cathegory of natural substances found in foods that can provide important health benefits. They help protect cells from oxidative damage, reduce inflammation, support gut health, and contribute to disease prevention. To ensure an adequate intake of these compounds, it is recommended to consume a wide variety of fruits and vegetables of different types and colours.

Key messages:
- B-group vitamins are particularly important for energy production.
- vitamin D, iron and calcium are frequently involved in performance problems or injuries when a deficiency exists.
- in most situations, a varied diet covers requirements, and supplementation is carried out only based on an evaluation.
- supplementation in the absence of a deficiency does not confer additional benefits and increases the risk of toxicity.
- high doses of compounds with antioxidant and anti-inflammatory action may interfere with the body's adaptations to effort and may reduce performance.
- vitamins, minerals and bioactive compounds from foods act together and have more complex effects when consumed simultaneously, rather than individually.

The most important micronutrients for athletes are those that support:
- energy production -> B vitamins.
- oxygen transport -> iron.
- muscle function -> calcium, magnesium.
- protection the body from damage (antioxidant) -> vitamins A, C, E.
- bone health and immune function -> vitamin D.

Chapter 3

THE HEALTHY PERFORMANCE PLATE. GENERAL NUTRITION GUIDELINES FOR ATHLETES

Chapter 3 THE HEALTHY PERFORMANCE PLATE. GENERAL NUTRITION GUIDELINES FOR ATHLETES

3.1 The healthy performance plate

The Healthy Performance Plate (Figure 4) is a visual tool designed to help coaches and athletes plan their main meals according to the level of exercise/training. It highlights the balance between nutrients that support training (carbohydrates), recovery (protein), overall body function (vitamins, minerals, and bioactive compounds), and protection (healthy fats). Proper hydration is essential for the effective use of these nutrients.

Moderate-intensity training

A balanced meal for a day with moderate-intensity training should include:

- 1/3 carbohydrates (energy);
- 1/3 protein (recovery);
- 1/3 vegetables + additional fruit (body function);
- healthy fats (1 tablespoon) (protection);
- fluids for proper hydration.

A moderate-intensity training day typically includes one or two training sessions, such as skills training and endurance/strength training. This plate (Figures 4-5) serves as a guide to adjust nutrient amounts based on the volume and intensity of training.

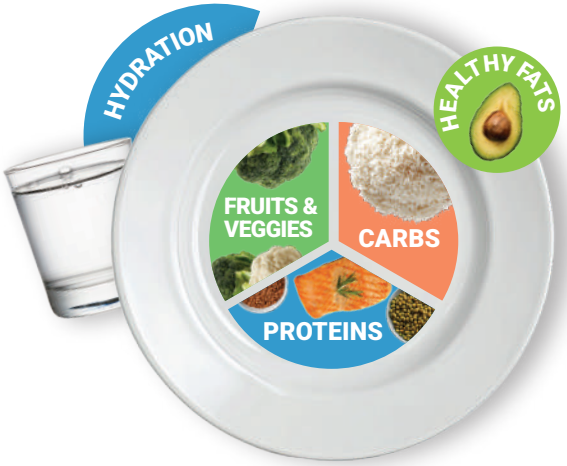


Figure 4. Recommended plate for a moderate-intensity training day

(A) *(B)*

Figure 5. Recommended plate for a high-intensity training/competition day – carbohydrates make up ½ of the plate (A). Recommended plate for a light training/rest day – carbohydrates make up ¼ of the plate

High-intensity training / competition

For a high-intensity training (at least two training sessions) or competition day (Figure 5 (A)), the plate should include:

- 1/2 carbohydrates (energy);
- 1/4 protein (recovery);
- 1/4 vegetables + additional fruit (body function);
- healthy fats (2 tablespoons) (protection);
- fluids for proper hydration.

Light training / rest day

For a light training or rest day (Figure 5 (B)), the plate should include:

- 1/4 carbohydrates (energy);
- 1/4 protein (recovery);
- 1/2 vegetables and fruit (body function);
- healthy fats (1 tablespoon) (protection);
- fluids for proper hydration.

Carbohydrates, the nutrients that fuel ENERGY

Athletes' diets should include an adequate intake of carbohydrates (CHO), adjusted to the volume and intensity of training and competition. During training and competition periods, carbohydrates should come mainly from grains and starchy foods, including high-fibre options (whole grains), depending on timing and digestive tolerance.

Foods high in simple carbohydrates (sugars) can be useful to help meet carbohydrate needs, especially in athletes with high energy demands. Outside of training, simple carbohydrates should preferably come from natural sources (e.g., fruit, milk, dairy products).

Simple carbohydrates

Natural sugars - glucose, fructose, lactose:

- food sources of natural sugars: fresh/dried fruits, fruit juices, some vegetables, milk and dairy products, honey, plum jam, syrups (e.g., maple, date syrup).

Added sugars - sugar, glucose syrup, fructose syrup:

- food sources of added sugars: jam, preserves, chocolate, sweets, sweetened cereals/drinks, sports drinks (isotonic), energy gels/bars.

Complex carbohydrates

Starchy foods

Grains and grain products: wheat, oats, rye, barley, rice, bulgur, quinoa, millet, corn, bread, pasta, rolls, flatbreads, polenta.
Starchy vegetables: potatoes, sweet potatoes.
Legumes: beans, chickpeas, lentils, dried peas.

Fibre

Fiber does not provide energy, but it influences digestion, blood sugar levels, and gut health, which can impact performance. It is recommended to reduce high-fiber foods around training.

High-fibre foods: whole grains (whole-grain bread, rice, pasta, oats), fruits and vegetables (especially with skin and raw), legumes (beans, chickpeas, lentils, dried peas).

Low-fibre foods: refined grains (white bread, rice, pasta), fruit juice, cornflakes, cooked vegetables, peeled fruits.

Proteins, the nutrients that power RECOVERY after exercise

Protein is essential for supporting growth and repairing damaged cells and tissues. Athletes should spread their protein intake throughout the day — across main meals, snacks, before/after training, and/or before bed — depending on their individual goals.

Food sources

The best protein sources are whole, minimally processed foods.

Animal-based proteins:

- fermented dairy (kefir, yogurt) and low-fat cheeses;
- eggs: chicken, quail;
- fish: salmon, mackerel, tuna, cod, trout, pikeperch, sardines;
- white meat (poultry): chicken, turkey;
- lean red meat: pork, beef, lamb (loin, tenderloin).

Plant-based proteins:

- legumes: beans, chickpeas, lentils, dried peas, edamame, soy;
- nuts, peanuts, and seeds.

Vitamins, minerals and bioactive compounds, the nutrients that support body's optimal FUNCTIONING

Fruits and vegetables supply the vitamins, minerals, and bioactive compounds the body needs to function optimally. Vitamins and minerals are involved in most of the body's chemical reactions. Bioactive compounds — such as polyphenols — work alongside certain vitamins and minerals (like vitamin C and selenium) to reduce the oxidative stress caused by exercise, supporting faster recovery. Athletes should eat fruits and vegetables of different colours every day to get the full spectrum of essential nutrients.

Food sources:

- tomatoes, red peppers, strawberries, cherries, raspberries, watermelon;
- carrots, pumpkin, apricots, mango, oranges;
- yellow peppers, zucchini, pineapple;
- spinach, broccoli, kale, avocado, cucumbers;
- blueberries, plums, grapes, eggplant, red cabbage;
- onion, garlic, cauliflower, mushrooms.

Fats, the nutrients that build body's PROTECTION

Fats are essential for the synthesis of certain hormones (e.g. steroid hormones — testosterone, progesterone, estrogen, cortisol), cell structure, and the absorption of fat-soluble vitamins A, D, E, and K. Certain types of polyunsaturated fats play an important role in recovery: omega-3 fatty acids, for example, have anti-inflammatory effects that can support muscle repair after intensive training; another type of fat found in dairy products and beef/lamb (conjugated linoleic acid) may help replenish muscle glycogen stores post-workout.

Food sources

Unsaturated fats:

a)monounsaturated — extra virgin olive oil, rapeseed oil, avocado, hazelnuts, pistachios, peanuts, cashews.

b)polyunsaturated — essential fatty acids:

- omega-3: fatty fish (mackerel, salmon, sardines), seeds (flaxseed, chia, walnuts);
- omega-6: seeds (sunflower, sesame); vegetable oils (sunflower, corn).

Saturated fats

- processed meats, red meat (pork, beef, lamb), lard, bacon, butter, cream, aged cheeses, coconut/palm oil.

Trans fats

- pastries, snacks, fried foods, margarine.

For athletes, unsaturated fats are preferred, particularly extra virgin olive oil, avocado, nuts, seeds, and fatty fish. Saturated fat intake should be limited and tailored to individual needs. Trans fats should be avoided as much as possible.

Hydration

Hydration plays a key role in performance, injury prevention, and recovery. Water is essential for maintaining blood volume, regulating body temperature, and muscle contraction. Hydration needs depend on various factors such as exercise intensity, body weight, sweat rate or environmental conditions. In addition to water, athletes can also drink milk or plant-based alternatives, fresh fruit juices (no added sugar), flavoured drinks (e.g. lemon water), tea, and coffee.

3.2. General nutrition guidelines for athletes

Nutrition and hydration during training

1.Carbohydrates

Carbohydrates (CHO) are the primary energy source for active muscles, particularly during high-intensity exercise. They are needed to fuel and replenish glycogen stores in the liver and muscles. Glycogen is the storage form of carbohydrates used during exercise — think of glycogen stores as "batteries" that power optimal performance when fully charged. A CHO-rich diet is essential for sustaining performance in both endurance and high-intensity, intermittent efforts.

Intake recommendations

Recommendations based on percentages of daily kcal intake have been replaced by those expressed in g/kg body weight/day (Table 10). This allows the optimal amount of carbohydrates to be established for athletes with either high or low food intake (e.g. during weight loss periods). The greater the intensity and duration of exercise, the higher the carbohydrate intake should be.

*Table 10. CHO intake according to the type and duration of exercise**

Training load	Exercise description	CHO intake	Observations on type and timing of CHO intake
Low	Low-intensity or skill-based activities (or <1 hour/day)	3–5 g/kg/day	Timing of CHO intake around training should support the main goal of each session. Factors such as athlete tolerance, individual preferences, ease of consumption, and logistics are essential. Nutrient-rich CHO sources, from food or fluids, should be prioritised to meet overall nutritional goals. Rapid consumption of a CHO-containing food or fluid immediately after training should be aligned with nutritional goals, timing of the next session, and the planned meal.
Moderate	Moderate-intensity exercise programme (approx. 1 hour/day)	5–7 g/kg/day	
High	Endurance programme (1–3 hours/day of moderate–high intensity effort)	6–10 g/kg/day	
Very High	Extremely high training volume (>4–5 hours/day of moderate–high intensity effort)	8–12 g/kg/day	

**Note: These recommendations should be tailored to the individual athlete, considering total energy needs, body composition, daily training load, and performance-related feedback.*

Adequate CHO intake is important for all athletes but is particularly important when multiple training sessions are performed in a single day, such as track and field events, swimming training, or competitions that include several events in one day. Consuming CHO at meals and snacks provides a consistent energy source for the muscles involved in exercise.

2. Fiber

Fibre intake in athletes' diets is often overlooked, despite its important role in performance, recovery, and gut health. In practice, fibre intake is frequently adjusted to improve either digestive comfort during physical effort, or body weight and composition. These interventions are often based on the specialist's experience as guidelines are currently lacking.

Intake recommendations

Current guidelines generally focus on limiting fibre intake before exercise to reduce

the risk of digestive issues, such as bloating, cramps, frequent bowel movements. Athletes are advised to choose easily digestible, low-fibre carbohydrates (e.g., white bread, pasta, rice, cornflakes, potatoes).

Too much fibre or poor timing can trigger digestive discomfort during training, but too little can compromise gut health and disrupt the balance of beneficial bacteria. For example, in athletes following high-protein diets, adequate fibre intake throughout the day is particularly important. When fibre intake is too low, gut bacteria shift toward fermenting protein instead, a process that can produce potentially harmful compounds and reduce the number of „good" bacteria in the gut. Given how common digestive issues are in athletes and their increased protein requirements, getting enough fibre is essential. Furthermore, digestive function is shaped by more than just training and diet — the composition of gut bacteria plays a role too. Athletes with poor gut health may experience more severe digestive symptoms during exercise.

Currently, athletes follow the same fibre intake recommendations as the general population, as there are no specific guidelines for athletes. Around 30 g of fibre per day is considered beneficial for healthy adults — though this target may be hard to reach or tolerate for some athletes, particularly when fibre-digesting gut bacteria are lacking. This can occur following:

- antibiotic use;
- common anti-inflammatory medications (e.g., ibuprofen);
- low microbial exposure (e.g., very strict hygiene practices).

3.Proteins

Most athletes can meet their protein needs through a well-planned diet, with protein-rich foods spread across multiple meals during the day. Recommended protein intake is about 0.3 g/kg body weight, 3–5 times per day (around 20–30 g of protein per meal or snack). Special attention should be given to protein intake after exercise, during recovery, to support proper muscle repair and rebuilding.

Protein supplements that have been third-party tested can be a practical option when whole foods are not available or when precise protein intake is needed (e.g. a protein shake before bed). Beyond quantity, protein quality also matters, as it directly affects the body's ability to build muscle protein. In other words, the type of protein consumed also matters, not just the quantity. Quality depends on both the amount and the proportion of essential amino acids a protein contains. Essential amino acids are absorbed more rapidly than non-essential ones.

Table 11. Protein intake based on type of exercise and energy intake

Category	Protein intake
Endurance	1,3 - 1,6 g/kg/day
Strength/power	1.6 - 1.8 g/kg/day
Energy restriction	1.8 - 2.2 g/kg/day

Leucine (an essential amino acid) is particularly important for muscle protein synthesis. An effective leucine dose is around 2–3 g/day. Foods rich in leucine include meat, fish, eggs, and dairy products (Table 12). Milk proteins (whey) are especially effective after strength training due to their high leucine content and fast absorption.

Table 12. Leucine content of certain foods

Food	Leucine content
Milk (360 ml)	2000 mg
Egg whites (3 eggs)	990 mg
Cottage cheese (200 g)	2880 mg
Tuna (120 g)	1740 mg
Chicken breast (120 g)	3690 mg
Beef (120 g)	3005 mg

4.Fats

Most athletes meet or even exceed their recommended fat intake due to their higher overall calorie intake. High-fat diets are not recommended for athletes, mainly because of their potential negative effects on health. On the other hand, athletes who follow very low-fat diets (<15% of total energy intake) may also experience negative health consequences.

Intake recommendations

In general, fat intake recommendations for athletes are like those for the general population, respectively between 20–35% of total daily energy intake, with less than 10% coming from saturated fats. As with carbohydrates, however, fat intake should be individualized based on training load and body composition.

High-fat, low-CHO diets

Some athletes adopt this diet to use more fat as a fuel source and improve performance. It is worth noting, however, that these diets can negatively affect performance at higher exercise intensities.

At the other extreme, low-fat diets (below 20% of daily caloric intake) are not recommended, as they limit the supply of important nutrients such as fat-soluble vitamins and essential fatty acids. Insufficient fat intake also impairs steroid hormone production (e.g. testosterone, the hormone involved in muscle mass growth and recovery after exercise). Furthermore, drastically reducing fat intake offers no additional benefits for weight management.

5.Hydration

Fluid losses of more than 2–4% of body weight can impair both sports performance and cognitive function in endurance and strength athletes. For example, if a 60 kg athlete loses 1.2–2.4 kg during training, their ability to perform at high intensity will decrease due to dehydration.

Greater fluid losses (>2–4% of body weight) further reduce performance and may lead to:

- muscle cramps;
- poor coordination and concentration;
- dizziness;
- headaches.

On the other hand, excessive fluid intake during exercise, which may result in weight gain during the session, can also be harmful. In extreme cases, it can lead to water intoxication and even death.

Intake recommendations

Recommended daily fluid intake is around 35 ml per kg of body weight, plus additional fluids to replace losses during exercise. Both drinks and foods contribute to an athlete's hydration needs, and water is a suitable choice in many situations.

Isotonic sports drinks are particularly useful for athletes who train or compete multiple times a day, or for those with low energy intake or poor pre-exercise nutrition. For trainings lasting longer than one hour, they help maintain hydration and support performance by providing additional CHO. Their sodium content also encourages greater fluid intake. Fluid requirements vary depending on body weight, sweat losses, exercise duration, environmental conditions, and individual tolerance.

Nutritional recommendations before, during, and after exercise

Nutrition before, during, and after exercise should help athletes maintain performance throughout training or competition and recover properly.

Several nutrition-related factors can lead to fatigue and reduced performance, including:

- dehydration;
- electrolyte imbalances (loss of minerals);
- depletion of glycogen stores / low blood sugar levels;
- digestive discomfort.

Fluids and supplements consumed before, during, or between bouts of exercise can help prevent or delay these issues.

Carbohydrate and fluid intake before exercise

Carbohydrates

The pre-exercise meal should be based mainly on carbohydrates (CHO), with a moderate amount of protein and low amounts of fibre and fat. This meal should also be appropriately sized to prevent hunger during exercise, but not so large that it causes digestive discomfort or slows digestion. The amount of food tolerated can vary depending on the type and intensity of exercise (e.g., cyclists generally tolerate larger meals than runners). In general, athletes are advised to consume 1-4 g of CHO per kg of body weight, 1-4 hours before exercise (Table 13).
A meal eaten 3-4 hours before exercise may provide around 400-800 kcal. A light snack taken 30-60 minutes before exercise can provide extra energy before high-intensity efforts (e.g., ~50 g easily digestible CHO and 5-10 g protein, or ~250 kcal).

The choice of CHO before exercise should consider:

- the demands of the activity;
- the athlete's goals, preferences, and tolerance.

Some athletes may react to a pre-exercise snack based on rapidly absorbed CHO (e.g., sweets, sugary drinks, etc.) with a rapid and temporary drop in blood sugar levels (hypoglycaemia) at the beginning of exercise, which may sometimes affect

performance. In such cases, possible strategies for athletes include:
- avoiding snakcs in the 90 minutes before exercise;
- consuming a snack very close to the start of exercise (10-15 minutes before);
- choosing slow-absorbing CHO.

A pre-exercise snack can be helpful when it is difficult to eat during exercise (e.g., swimming).

Table 13. CHO intake before exercise

Timing before exercise	Amount	Type of CHO*
3 - 4 h	3 - 4 g/kg	Whole-grain bread/pasta/rice, sweet potatoes, vegetables, oats, legumes (beans, lentils, chickpeas), fruit
1h - <1 h	1 - 0,5 g/kg	Fresh/dried fruit, rice cakes, fruit juice, white bread, honey, jam etc.

** Fiber content should be adjusted on digestive tolerance*

As exercise approaches, it is recommended to choose smaller, lighter meals (snacks) to allow for proper digestion and nutrient absorption. New foods should always be tested during training (preparation phase) and never introduced before or during competition.

Pre-exercise nutrition and digestive issues

Between 30-50% of endurance athletes and up to 90% of long-distance runners experience digestive issues such as bloating, cramps, nausea, diarrhoea, vomiting, or an urgent need to use the bathroom during or after exercise. These problems are mainly caused by blood flow being redirected away from the gut and toward the working muscles during prolonged exercise. Symptoms can be made worse by dehydration, stress, or a rise in body temperature.

Restricting food before exercise will not solve these issues and may impair performance. Athletes should learn to train their gut, just as they train their muscles, starting from the early stages of training. There is no universal solution: a trial-and-error approach works best, allowing athletes to progressively test different food options during training to find out what works, when, and in what amounts.

Hydration

Recommended fluid intake is around 5–7 ml/kg body weight, 2–4 hours before exercise. For a 60 kg athlete, this equals approximately 300–420 ml. This allows enough time for any excess fluid to be eliminated through urine. Pale yellow urine

(lemonade-coloured) is a good indicator of adequate hydration.

Carbohydrates and fluid intake during exercise

Carbohydrates

The amount of CHO the body can absorb and use during exercise is limited; therefore, intake recommendations are expressed in absolute amounts (g/hour) rather than relative to body weight (g/kg). In general, CHO needs increase as exercise duration increases (Table 14).

For exercise lasting 30 minutes to 1 hour, simply rinsing the mouth with a CHO solution may be sufficient. For stop-and-go sports (e.g., team sports lasting 1.5–2 hours), the target is between 30–60 g CHO/hour, from solid foods (e.g., bars, gels) or CHO-electrolyte drinks (isotonic drinks). During exercise, easily digestible, fast-absorbing CHO are recommended.

For endurance exercise lasting more than 2.5 hours, the recommended CHO intake may reach up to 90 g/hour. The body can only absorb and use a limited amount of energy from a single type of CHO. Therefore, when needs exceed 60 g CHO/hour, it is recommended to combine different types of CHO that are absorbed differently (e.g., glucose + fructose). CHO intake should match the athlete's hydration needs. Food or drinks high in CHO can slow fluid absorption.

Table 14. CHO intake during exercise

Situation	Duration	CHO intake	Type of CHO
Short bouts of exercise	<30/ 45 minutes	-	-
High-intensity training or competition	30 - 75 minutes	Small amounts / mouth rinsing with CHO-containing solutions	Isotonic drinks Gels Low-fat/low-protein/ low-fiber bars
Endurance events or prolonged training	1 - 2 h	30 g/h	
	2 - 3 h	60 g/h	
Ultra-endurance exercise	>2,5 - 3 h	90 g/h	

Hydration

Fluid losses through sweat during exercise are influenced by:

- duration and intensity of exercise;
- fitness level (better-trained athletes tend to sweat more than less trained athletes);
- sex (men generally sweat more than women);
- environmental conditions (temperature, humidity);
- body weight;
- type of clothing/equipment.
- other factors: acclimatization, altitude.

Depending on these factors, sweat losses can range from 0.3 to 2.4 L/hour. Fluid intake during exercise should replace these losses so that the athlete's body weight loss does not exceed 2-4% of initial weight.

Sweat also leads to the loss of minerals, mainly sodium. Sodium replacement may be needed when:

- sweat rate is high (>1.2 L/hour);
- exercise duration is long (>2 hours);
- the athlete loses large amounts of sodium through sweat.

Poor hydration or electrolyte losses can lead to muscle cramps.

For most athletes, fluid intake during exercise ranges in general between 0.4–0.8 L/hour, depending on the type of fluids consumed (e.g., CHO drinks), individual tolerance, and experience. For exercise lasting less than 30–40 minutes, rehydration is generally not necessary. As duration increases, both CHO and sodium intake become increasingly important.

Sweat losses vary greatly between athletes and even from one training session to another in the same athlete, which is why individual assessment is essential. The simplest way to estimate fluid loss is to weigh the athlete before and after exercise. For a more accurate estimation, the amount of fluid consumed during exercise should be considered. In practice, sweat rate can also be calculated to better estimate hydration needs during exercise.

Post-exercise carbohydrates and fluid intake

Carbohydrates

One of the primary goals after exercise is to replenish glycogen stores. Glycogen resynthesis is fastest in the first 4 hours post-exercise, during which an intake of 1–1.2 g CHO/kg/hour is recommended (Table 15). After recovery, normal carbohydrate intake can resume.

This strategy is particularly important after demanding training and when another training or competition follows within 24 hours. Athletes often consume foods containing both CHO and protein after exercise (e.g., chocolate milk, chicken sandwich, yogurt with fruit) — which benefits both glycogen replenishment and muscle recovery. In this case, the recommendation is 0.8 g CHO/kg plus 0.2–0.4 g protein/kg (roughly a 4:1 ratio). Fructose-containing drinks (e.g., fruit juices) should be avoided, as they have a more modest effect on glycogen resynthesis and may cause digestive discomfort.

Table 15. Post-exercise CHO intake

Timing	Amount	Type of CHO
Starting from the first 30 minutes	1-1,2 g/kg/h	Sports drinks (glucose, sugar), chocolate milk, white bread/pasta/rice, rice cakes, biscuits, cereal bars, honey, fruit

Hydration

Post-exercise rehydration should focus on water and sodium intake. Sodium (from food and drinks) helps the body retain ingested fluids.

If weight loss after exercise is less than 5% and no further training or competition is planned within 24 hours, rehydration does not need to be rushed - normal food and fluid intake is sufficient to restore water and electrolyte balance.

However, if dehydration is more significant and another session follows within 12 hours, rehydration needs to be carefully managed. For complete and rapid rehydration, fluid intake should exceed losses — around 1.25–1.5 L per kg of body weight lost.

Chapter 4

NUTRITIONAL PARTICULARITIES ACCORDING TO THE TYPE OF PHYSICAL ACTIVITY

Chapter 4 NUTRITIONAL PARTICULARITIES ACCORDING TO THE TYPE OF PHYSICAL ACTIVITY

4.1. Endurance-based physical activity

Endurance sports are those disciplines in which performance depends on the body's ability to sustain physical effort over prolonged periods of time, at moderate or variable intensities.

Additionally, there are sports which, although not endurance disciplines in themselves, require training that frequently includes endurance work, placing similar demands on the body. Therefore, in both cases, nutritional recommendations are similar.

Endurance athletes often fail to meet their daily requirements for energy, carbohydrates, vitamins, and minerals. This can occur because appetite may be suppressed after intense training, many athletes adopt excessive dietary restrictions to maintain a lighter physique, and meal planning on high-volume training days is often inadequate.

Carbohydrate intake should be adjusted according to the volume and intensity of daily training. In addition, extra carbohydrates should be strategically timed around training sessions to support performance, accelerate recovery, and promote training adaptations.

Estimating daily carbohydrate requirements should consider:

- ✔ the intensity, frequency, and duration of training;
- ✔ body weight and body composition, as well as weight management goals;
- ✔ the athlete's feedback regarding performance and recovery;
- ✔ training level and athletic experience;
- ✔ as well as training conditions, such as heat or altitude.

Table 16. Daily carbohydrate requirements to support training and recovery

Situation		Carbohydrate intake	Comments on the type and timing of carbohydrate intake
These general recommendations should be individualized based on total energy requirements, body composition, daily training volume, and performance-related feedback.			
Low	Low-intensity or technique-focused activities	3–5 g/kg/day	The timing of carbohydrate intake around training should support the primary objective of each session. Factors such as the athlete's tolerance, individual preferences, ease of consumption, and logistical considerations are essential. Nutrient-dense carbohydrate sources, from both foods and fluids, should be prioritized to meet overall nutritional goals. Rapid consumption of a carbohydrate-containing food or drink immediately after training should be aligned with nutritional objectives, the timing of the next session, and the planned meal.
Moderate	Moderate training program (approx. 1 hour/day)	5–7 g/kg/day	
High	Endurance training program (1–3 hours/day of moderate to high intensity)	6–10 g/kg/day	
Very high	Very high training volume (>4–5 hours/day of moderate to high intensity)	8–12 g/kg/day	
Short term nutrition strategies **These recommendations aim to increase carbohydrate availability to optimize performance in competition or key training sessions. The demands of the event and body composition should be taken into account.**			
General daily fueling	Endurance events <90 minutes	5–10 g/kg/day	Athletes may choose concentrated carbohydrate sources that are low in fiber and residue, and easy to consume, in order to meet energy targets without gastrointestinal discomfort. The timing, amount, and type of carbohydrate-containing foods or drinks should be selected based on the demands of the competition and the athlete's individual experience. Foods high in fat, protein, or fiber may be avoided to reduce the risk of digestive discomfort. Low glycemic index sources may provide sustained energy when carbohydrate intake during exercise is not possible, provided the athlete is already familiar with these foods. Carbohydrate-containing drinks are a practical option, especially for athletes who have difficulty tolerating solid foods due to pre-competition nerves.
Carb loading	Endurance events >90 minutes	36–48 hours with 8–12 g/kg/day	
Pre-exercise fueling	Before exercise (>60 minutes)	1–4 g/kg, consumed 1–4 hours before exercise	

Recovery strategies after exercise should be adapted based on:
- how much glycogen was depleted during the session;
- the time until the next training session;
- the timing of the next meal;
- the athlete's overall nutritional goals.

For lower-intensity sessions, immediate full recovery is not always necessary and, in some situations, may even have beneficial effects on training adaptations.
In the first 1–2 hours after intense exercise, muscles are more receptive to carbohydrate uptake and storage, a period often referred to as the 'window of opportunity.' This is particularly important when recovery time is short and another training session follows soon after. However, over a longer recovery period (24–48 hours), total daily carbohydrate intake has a greater impact on glycogen restoration than the exact timing of intake.

Protein intake for recovery and muscle mass

Proteins play an essential role in post-exercise recovery and in maintaining or increasing lean muscle mass in endurance athletes. Protein requirements are higher than in the general population; however, in most cases, these are met as the athlete increases daily energy intake.

The timing of protein intake is important. Strategically integrating foods or beverages containing protein immediately after training and, in some situations, during prolonged training sessions, can support muscle mass and improve metabolic responses to endurance effort.

Iron – an essential micronutrient in endurance sports

Iron is a particularly important micronutrient for endurance athletes, playing an essential role in oxygen transport and energy production. Adequate iron status is necessary to support performance and exercise capacity.

Endurance athletes are at increased risk of iron deficiency due to insufficient dietary intake or increased losses (through sweating, gastrointestinal microlesions or the destruction of red blood cells during exercise).

Nutritional strategies for competition day

Optimal competition performance is achieved by preventing factors that lead to fatigue, reduced exercise intensity or impaired technical execution. From a nutritional perspective, these include glycogen depletion, low blood glucose levels (hypoglycemia), dehydration, low blood sodium levels (hyponatremia), and gastrointestinal discomfort.

The term "bonking" describes a state of sudden, severe drop in energy — also known as "hitting the wall" — that commonly occurs in endurance events when glycogen stores are insufficient, or carbohydrate intake is inadequate.

Carbohydrate loading in endurance competitions

Carbohydrates are stored in muscle as glycogen, and carbohydrate loading aims

to increase these stores before competition.

Carbohydrate loading is associated with improved performance in endurance events lasting longer than 90 minutes. For shorter competitions, glycogen stores can be optimised through a reduction in training volume and adequate carbohydrate intake (5–10 g per kg body weight) in the last 24–36 hours.

For longer events, such as the marathon or long-distance triathlon, a higher carbohydrate intake is required in the days before the competition (8–12 g per kg body weight).

The pre-competition meal

The meal or snack consumed 1–4 hours before the start serves to top up muscle glycogen stores and to restore liver glycogen after the overnight fast. This represents the final stage of nutritional preparation before competition and can significantly influence perceived energy levels at the start.

The pre-competition meal should be rich in carbohydrates, contain moderate amounts of protein, and be low in fat and fibre. Pairing it with approximately 400–600 ml of fluids helps optimise hydration, especially in events where fluid losses are anticipated. Familiarity with the foods is essential for digestive comfort and for preventing hunger or gastrointestinal discomfort during the race. Liquid alternatives containing carbohydrates and proteins can be useful for athletes who have difficulty tolerating solid foods before the start.

Key considerations for carbohydrate intake during competition

Studies show that faster athletes tend to consume larger amounts of carbohydrates during competition, and in certain events a higher intake is associated with better finishing times.
However, increased carbohydrate consumption may increase the risk of gastrointestinal discomfort, such as nausea or bloating. A common reason is that many athletes do not regularly consume carbohydrates during training, meaning the gut is not “trained” to tolerate and efficiently absorb them under exercise conditions. These observations highlight the importance of the principle "train the way you compete".

Fluid intake in endurance athletes

In many endurance sports, fluid losses through sweating are substantial and can quickly lead to dehydration, especially in hot or humid conditions or when access to fluids is limited.

Hydration strategies for training and competition should be individualized, allowing the athlete to take advantage of drinking opportunities, prevent thirst, and maintain fluid deficits below 2% of body weight.

Excessive fluid intake, especially when sweat losses are low, can have serious effects, leading to hyponatraemia (a dangerous drop in blood sodium). An effective hydration plan should be developed by assessing fluid losses during

training sessions that replicate competition conditions.

Fluids must be familiar, pleasant in taste and temperature, to encourage intake. Water, sports drinks and cola-type drinks are frequently used, and in very long races soups or hot drinks may also be included.

Fluid temperature can be adapted to environmental conditions: cold drinks or ice may help reduce body temperature in the heat, while warm fluids can be beneficial in cold environments.

4.2. Strength- and speed-based physical activity

Strength- and speed-based physical activities rely on the athlete's ability to produce maximal force and explosive power in a very short time.

Athletes in these disciplines consistently include resistance exercises in their training programme, alongside sport-specific training. Depending on the sport, strength training may play a complementary role or may represent the main basis of preparation.

Nutrition plays an essential role in the preparation of strength and power athletes, influencing three key components of training:

- fuelling for sport-specific effort and resistance training;
- recovery after these sessions;
- supporting training adaptations, including increases in muscle mass.

Carbohydrates in strength and speed training

A single resistance training session can reduce muscle glycogen stores by up to 40%, with the level of depletion influenced by the duration, intensity, and total training volume. High-repetition, moderate-load sessions — typical of hypertrophy-focused programs — tend to produce the greatest reductions in muscle glycogen.

Reduced glycogen stores are associated with a decrease in performance and training capacity, especially in situations where the effort involves rapid, repeated contractions. Although this effect is not always immediately noticeable, it may become relevant in sessions or competitions that rely heavily on glycogen utilization.

Given that resistance training is only one component of preparation for sprinters and throwers, and that muscle damage induced by this type of exercise may slow glycogen resynthesis, maintaining a moderate carbohydrate intake is recommended.

Adjusting carbohydrate intake before, during, and after training can be particularly useful to ensure energy availability at key moments. In general, a daily intake of 4–7 g of carbohydrates per kg of body weight is considered appropriate, depending on the training phase and daily training volume.

Proteins in strength and speed training

Current recommendations indicate that athletes performing resistance training should consume more protein than sedentary individuals, namely 1.2–2.0 g protein/kg body weight/day. In practice, most strength athletes easily meet these requirements due to higher overall energy intake and the presence of protein in most daily meals.

Exceeding the upper limit of these recommendations does not bring additional benefits, since excess protein is metabolized and excreted. Moreover, intense periods of resistance training may improve protein retention and reduce the relative protein requirement in well-trained athletes.

Rather than focusing exclusively on total daily amount, it is more effective to pay attention to total energy intake, protein distribution throughout the day, especially around training, and the quality of protein sources. To optimise muscle protein synthesis, 4–5 meals or snacks evenly distributed across the day are recommended, each containing approximately 20-30g of high-quality protein (≈ 0.3 g/kg body weight).

Fats in strength and speed training

Fat intake in the diet of strength and power athletes is generally higher than that recommended for the general population and frequently comes from sources rich in saturated fats. This is often a consequence of high consumption of animal-based foods, associated with the desire to increase protein intake. In this context, a lower carbohydrate intake is often observed.

Replacing part of dietary fat with equivalent amounts of carbohydrates can have a beneficial effect on protein balance, making a reduction in fat intake advantageous—especially for athletes exceeding current recommendations. However, there are situations in which a higher intake of unsaturated fats can be useful, particularly for athletes who have difficulty meeting daily energy requirements.

Nutrition before and during strength training

Pre-training nutrition can influence the exercise capacity of strength and speed athletes, especially in long, high-volume sessions. Carbohydrate intake before—and in some cases during—training may increase total training volume; however, there are currently no precise recommendations tailored exclusively to this type of effort.

Until more specific guidelines are established, general values similar to those used in endurance sports can be applied, but at the lower end (approximately 1 g of carbohydrates/kg body weight before training and 0.5 g/kg during exercise). Adequate hydration before training is essential, as even moderate dehydration can impair performance.

Although combinations of carbohydrates and amino acids have been explored

before or during exercise, current evidence supports protein intake after training as the most effective strategy for stimulating muscle protein synthesis.

Recovery after strength training

Following resistance training, recovery strategies should be applied consistently, as this type of effort is only one component of the overall daily training program. Carbohydrate consumption immediately after training helps replenish muscle glycogen stores; an intake of approximately 1.0–1.2 g/kg body weight is recommended.

Post-exercise protein intake stimulates muscle protein synthesis and reduces protein breakdown, resulting in a positive protein balance. In general, ~20 g of high-quality protein (≈0.25 g/kg) is sufficient to maximize this process, with greater needs after whole-body training or in older or recovering athletes.

Combining carbohydrates and proteins immediately after training provides the best recovery outcomes, supporting both muscle glycogen replenishment and the processes of muscular adaptation and repair.

Competition in strength sports

Competitions in strength sports are typically characterized by single or a small number of explosive efforts, separated by sufficiently long recovery periods. For this reason, muscle energy stores are rarely a limiting factor, even in challenging environmental conditions. Nutritional priorities during competition focus primarily on digestive comfort and preventing unwanted weight gain in the pre-competition period.

In weight-category sports, athletes may resort to rapid weight-loss methods through food and fluid restriction, leading to glycogen depletion and dehydration. Because these practices mainly affect performance in sports with a high metabolic component, events requiring maximal force and power may be less affected.

In bodybuilding, the competitive objective is closely linked to reaching a very low level of body fat. This process begins months before the competition and can, in some cases, lead to losses of muscle mass. In female athletes, severe restrictions are frequently associated with micronutrient deficiencies and menstrual cycle disturbances, caused by low energy availability.

Across all strength sports, the goal of increasing muscle mass must be carefully considered, as it directly influences weight category and the competitive level of opponents.

4.3. Individual sports vs. team sports

Team sports involve complex physical demands that combine variable-intensity efforts, periods of running, sprints, changes of direction and active recovery phases. To apply effective nutritional strategies, it is essential to understand the physiological demands specific to each sport, the duration of play and the intensity of effort.

The effectiveness of nutritional support depends not only on physical demands, but also on the culture of the sport, the athletes' dietary preferences and beliefs, the weekly structure of training, environmental conditions and the logistics available on competition days. These factors directly influence how recommendations can be implemented in practice.

Although team sports involve shared objectives, the athletes remain individuals with different needs. It is therefore important to recognize differences between athletes and provide individualized nutritional recommendations, even within a team setting.

Differences between team sports

Team sports vary in the length of the competitive season, game duration, technical demands, and movement patterns during play. Additionally, some are predominantly played in summer and others in winter, which influences environmental conditions and the corresponding nutritional strategies.

As in individual sports, the nutritional needs of team-sport athletes depend on the physiological demands of the sport, the energy systems used, and the duration, frequency and intensity of effort. In addition, in team sports there are multiple playing positions (e.g., offensive or defensive), and the role held directly influences the athlete's energy and nutritional requirements.

Unlike many individual sports, team sports involve short, frequent, high-intensity efforts alternating with longer periods of light activity or rest. These sports

therefore tax both anaerobic and aerobic systems, and athletes must develop not only speed, agility, strength and power, but also endurance capacity. In addition to the physical component, play integrates technical and tactical elements that vary according to sport and position. Although the general principles of sports nutrition are similar to those in individual sports, team sports involve additional factors that require specific adaptations of nutritional strategies.

Group mentality and nutrition in team sports

Group dynamics can strongly influence athletes' eating behaviors. Both beneficial and suboptimal habits tend to spread quickly within a team environment.
An effective strategy is collaboration with formal or informal team leaders who follow correct nutritional practices. They can become role models and contribute to improving the group's overall nutritional culture.

"One-size-fits-all" approaches in nutritional counselling

"One size fits all" nutritional recommendations, applied identically to all athletes, ignore the individual differences between team members. Each athlete has different physiological characteristics, goals and responses to nutritional interventions. Personalized approaches remain essential, even within a group context.

Group nutritional education and level of knowledge

Group nutritional education sessions are a time- and cost-effective method for improving athletes' knowledge and eating behaviour. They are used to raise the level of understanding of basic nutrition principles and, sometimes, to develop practical skills related to food selection and preparation, with the aim of positively influencing eating habits.

Competition structure and access to food and fluids

Competition structure differs from one sport to another and can make it difficult to optimise food and fluid intake during play. Depending on duration, effort intensity and environmental conditions, athletes may need to take advantage of every available opportunity for hydration and carbohydrate intake.

In addition to moments during play, official breaks play an important role and must not be overlooked. Foods and drinks — such as sports drinks, fruit, gels or sweets — must be presented in an easily accessible way, so that athletes can consume them quickly.

The practical organisation of refuelling points, for example placing food and drink stations at the locker-room entrance, can reduce the risk that athletes miss important opportunities for recovery. However, meeting recommended intakes must be balanced against digestive tolerance, as forcing consumption can have a negative impact on performance.

Team catering – practical principles

Within a team, there are significant differences both in food preferences and in athletes' nutritional priorities.

Posters or informational panels placed in meal-service areas can help reinforce educational messages and guide food choices.
Separating protein, carbohydrate and fat sources allows flexibility in the choice of ingredients and portion sizes.

After competition, some athletes tend to overeat, while others have a reduced appetite. Offering a variety of options tailored to recovery helps manage these situations:

- liquid beverages, such as flavoured milk, are useful for athletes with reduced appetite;
- solid foods — fruit, sandwiches, wraps, bars, protein shakes or hot meals based on pasta and rice — complete the options.

A practical solution is to combine quick snacks in the locker room with a later meal, depending on the competition schedule.

4.4. Dietary supplements

Dietary supplements are a sensitive topic, one that requires caution and professional oversight. Without guidance from a sports physician or dietitian, uncontrolled use can lead to metabolic imbalances, side effects, or impaired body function. Also, many products on the market are poorly regulated, raising the risk of contamination with substances banned under anti-doping rules.

Overusing supplements or replacing whole foods with them entirely is another risk, as it can deprive the body of the complex nutrients that only a varied, balanced diet can provide. In this context, the coach plays an important preventive role, working alongside nutrition and sports medicine specialists to monitor supplement use and educate athletes about the associated risks and limitations. The guiding principle should be that supplements are complementary, not a substitute, for food and should only be used when physiological needs cannot be met through diet alone.

Any decision to use dietary supplements should be made carefully and in close collaboration with a sports physician and a dietitian. Supplements should never be taken arbitrarily but only based on a professional recommendation that defines the duration, appropriate dose, and expected effects. Only this kind of controlled approach can minimize the risks of improper use and ensure supplements are integrated appropriately into the athlete's training program.

A further concern is the risk of contamination with banned substances. To reduce this risk, athletes can opt for products tested by an independent third-party, although it is important to emphasize that such testing reduces, but does not eliminate, the risk of contamination. Absolute safety cannot be guaranteed.

Monitoring supplement use involves a series of steps designed to ensure safety and effectiveness within the athlete's training program:

- compliance with anti-doping rules;
- individualized prescription based on individual energy and metabolic needs;
- testing to identify individual nutrient deficiencies;
- appropriate dosing and timing (periodization);
- regular review of the supplementation plan based on results and the athlete's physiological adaptations.

Important

A well-structured diet is a key factor in achieving high-level sports performance. Nutrition should not be seen as optional, but as an essential part of modern training strategy, helping transform an athlete's biological potential into top-level performance.

Dietary supplements with demonstrated efficacy in sport

While many supplements are available on the market, only a handful have sufficient evidence for both effectiveness and safety. In 2018, an International Olympic Committee expert group identified five supplements with proven direct benefits for performance in specific sports.

1.Creatine

Is a substance found naturally in food, particularly meat and fish, and is also produced by the body. Most creatine (Cr) is stored in the muscles as phosphocreatine, where it helps rapidly regenerate energy (ATP), making it especially valuable for short, high-intensity efforts.

A loading phase of 5 g Cr taken 4 times/day for 4–5 days (Cr loading) can significantly increase muscle Cr stores. This is followed by a maintenance phase of 3–5 g Cr /day. The loading phase can also be skipped by taking 3–5 g Cr /day for 3–4 weeks, which produces similar results over time.

Athletes with lower dietary Cr intake (e.g., vegetarians and vegans) may see greater increases in both muscle stores and performance with supplementation. When combined with strength training, Cr supplementation can improve strength, power, and muscle mass. It also enhances performance during short (<30

seconds), repeated high-intensity efforts, typical of team sports. Evidence for benefits in endurance sports is less clear.

2.Caffeine

Is naturally found in drinks such as coffee, tea, and cocoa, and is also added to a variety of energy drinks, foods, and pre-workout supplements. Its performance-enhancing effects are mainly due to its action on the central nervous system, helping to reduce the feeling of fatigue and perceived effort during exercise.

Caffeine can improve performance in strength, power, endurance, and sprint events. Individual responses vary considerably, influenced by genetic factors, the form of administration (e.g., chewing gum, gels, capsules), and the type of effort involved. The recommended dose ranges from 2–6 mg/kg body weight, though athletes should test their individual tolerance under training conditions. Very high doses (9 mg/kg) can cause adverse effects such as anxiety, irritability, and insomnia.

Caffeine is generally taken around 60 minutes before exercise, though optimal timing depends on the form used: caffeinated chewing gum, for example, can take effect much faster than tablets. Coffee and tablets produce similar performance effects when the dose is equivalent.
At high doses (>350 mg), caffeine has a diuretic effect. However, at the doses typically used for performance enhancement, this effect is modest, particularly in athletes who consume caffeine regularly.

3.Nitrates

Nitrates can enhance sports performance by increasing nitric oxide production, a compound that plays an important role in muscle function and blood flow regulation during exercise. Nitrates are produced naturally by the body but can also be obtained through diet, from vegetables, fruit, processed meat (nitrate salts), or water. Given the potential health risks associated with nitrate salts, athletes are encouraged to meet their nitrate needs through plant-based foods, such as beetroot juice.

The effects of nitrate supplementation appear to be less pronounced in athletes with a high aerobic capacity (VO_2max >65 ml/kg/min), though they should not be overlooked particularly during competition, where even modest improvements can make a difference. As with Cr, the benefits of nitrate supplementation may also be influenced by diet: athletes who already consume large amounts of dietary nitrates may see smaller gains from supplementation.

Nitrate supplementation can improve muscle strength, repeated sprint performance, and high-intensity intermittent efforts, making it potentially useful in team sports as well. The effective dose is approximately 350–500 mg (6–8 mmol of nitrates), taken 2–3 hours before exercise — an amount equivalent to around 70 ml of concentrated beetroot juice. Supplementing for 3 or more days prior to competition may provide additional benefits, particularly in well-trained athletes.

4.Beta-alanine

Is an amino acid produced in the liver and obtained through diet (primarily from meat). In the body, it serves as the main precursor to carnosine — a compound found in muscle that helps buffer acidity during intense anaerobic exercise, potentially delaying the onset of muscle fatigue.

The effects of beta-alanine supplementation are most pronounced during short-duration efforts (1–4 minutes), such as sprint events. The effective dose is 4–6 g beta-alanine/day, divided into doses of 2 g or less, taken for at least 2–4 weeks. The only reported side effect is a tingling sensation (paresthesia), which can be reduced by spreading the dose throughout the day or by using slow-release formulations.

5.Sodium bicarbonate

Is effective in supporting sports performance and is found in both nutritional supplements and various medications. It works by increasing the body's capacity to neutralize acidity produced during intense exercise, which can delay the onset of fatigue.

Sodium bicarbonate can improve performance in high-intensity efforts lasting between 30 seconds and 12 minutes, and has shown benefits in sports such as cycling, running, swimming, rowing, and combat sports (judo, karate, taekwondo, wrestling).

The minimum effective sodium bicarbonate dose is 0.2 g /kg body weight, with an optimal dose of 0.3 g/kg, taken 60–180 minutes before training or competition. Alternatively, sodium bicarbonate can be taken for 3–7 days before competition at doses of 0.4–0.5 g/kg, divided into multiple smaller doses throughout the day. This strategy may reduce the risk of side effects on competition day.

The most common side effects are bloating, nausea, vomiting, and abdominal pain. These can be minimized by taking smaller doses of sodium bicarbonate about 3 hours before exercise, having it with a carbohydrate-rich meal, or using enteric-coated capsules that dissolve in the intestine rather than the stomach.

4.5. Warning signs for coaches

Proper nutrition and hydration are essential for maintaining good health, energy levels, and athletic performance. When the body does not receive enough nutrients

or water, it shows several warning signs that something is not right. Early recognition of these signs can prevent injuries, fatigue, and long-term health problems.

Warning signs of poor nutrition:

Deficient nutrition occurs when the body does not obtain the correct balance of carbohydrates, proteins, fats, vitamins, and minerals. Common warning signs include:

- Fatigue and low energy: Athletes may appear slower, less motivated, or unable to complete their usual training loads;
- Frequent illnesses: Repeated colds or infections indicate a weakened immune system;
- Slow recovery: Muscle soreness lasts longer than usual, and progress is limited;
- Dry skin, hair loss, or brittle nails: Visible signs of vitamin and mineral deficiencies;
- Poor concentration or irritability: Low glucose or insufficient B vitamins affect brain function and mood;
- Unexpected weight loss or gain: Indicates an imbalance between caloric intake and energy expenditure.

What the coaches can observe:

- Reduced endurance or loss of strength across multiple training sessions;
- Lack of motivation or irritability during training;
- Slower reaction time and poor concentration during exercises;
- Longer recovery after physical activity or frequent complaints of muscle soreness.

Warning signs of dehydration:

Water is essential for every cell and function in the body. Even mild dehydration can impair coordination, reaction speed, and mental clarity. Common signs include:

- Thirst and dry mouth: The first and most obvious sign;
- Dark yellow urine: Indicates low fluid intake;
- Headaches and dizziness: Often appear during or after intense sessions;
- Dry skin and chapped lips: A visible sign of dehydration;
- Fatigue and muscle cramps: The body loses electrolytes through sweat;
- Reduced concentration and balance: Dehydration affects neuromuscular control.

What coaches may observe during training:

- The athlete appears pale or unusually flushed without significant effort;
- Sweating less than usual or a complete stop in sweating;
- Frequent muscle stretching or twitching due to cramps;
- Confusion, delayed reactions, or difficulty following instructions;
- Unusual fatigue or a sudden drop in performance.

Conclusion

Coaches play a key role in recognizing the early warning signs of poor nutrition and hydration. Regular monitoring, open communication with athletes, and encouraging balanced meals and fluid intake before, during, and after training can prevent serious problems and maintain optimal performance.

Chapter 5

WEIGHT AND BODY COMPOSITION MANAGEMENT

Chapter 5 WEIGHT AND BODY COMPOSITION MANAGEMENT

5.1. Introduction

Body weight and body composition influence sports performance, though not equally across all disciplines. In some sports, body weight and the muscle-to-fat ratio are critical, particularly in weight-category sports such as judo, boxing, and weightlifting. Body characteristics can also provide a competitive advantage in sports performed against gravity, such as gymnastics, while in long-distance running, lower body weight is often associated with better performance. In other sports, such as baseball, body weight and composition play a less important role.

Different sports and training methods lead to different changes in body composition, which is why there is no ideal body composition that applies to all athletes. While a higher muscle mass combined with a lower body fat percentage can offer a performance advantage in many sports, the goal is not to minimize fat or maximize muscle at all costs, but to find the right balance between the two, tailored to the demands of the sport and the individual athlete.

5.2. Body weight

Optimal body weight cannot be defined by standard tables as it varies across sports and individuals. An optimal body weight is one that:

- supports health, reduces injury risk, and allows the athlete to perform at their best;
- considers genetic background and body shape;
- considers age and stage of physical development;
- can be maintained long term without severe or prolonged dietary restriction;
- is accepted by the athlete.

Optimal body weight should support both health and performance and be sustainable without excessive effort. Repeated dieting or frequent weight fluctuations may suggest that the athlete is trying to reach or maintain an unrealistic weight.

Body weight and body mass index

Body weight can be assessed in relation to height using a measure known as the body mass index (BMI) which is calculated using the following formula:

BMI= weight (kg)/height (m)²

In the general population, BMI is used to define a "healthy" weight range (18.5–24.9 kg/m²) and to estimate the risk of chronic disease (the interpretation of BMI values is presented below). However, BMI is not a useful tool for athletes, as it assumes that any increase in body weight reflects an increase in body fat. Athletes typically have greater muscle mass and a lower body fat percentage than non-athletes. For example, a male athlete who is 190 cm tall and weighs 109 kg has a BMI above 30 kg/m² which falls within the obesity category. However, this athlete does not have obesity (excess body fat), but rather a well-developed muscle mass. In other words, his body weight is primarily driven by high muscle mass rather than excess fat. This highlights the key limitation of BMI: it does not distinguish between muscle mass and fat mass.
In many cases, knowing the amount and proportion of different body tissues (i.e. body composition analysis) is far more important than total body weight alone. That said, BMI can still be useful when working with athletes, particularly for assessing the risk of malnutrition, menstrual irregularities, or disordered eating, where values are typically low (<18.5 kg/m²).

Table 17. BMI weight categories

Category	BMI (kg/m²)
Underweight	< 18,5
Normal weight	18,5–24,9
Overweight	25,0–29,9
Obesity class I	30,0–34,9
Obesity class II	35,0–39,9
Obesity class III	≥ 40,0

5.3. Body composition

Body composition refers to the components that make up the human body: total body water, fat-free mass (muscle, bone, organs, blood, and skin), and fat mass.

Total body water is essential for all bodily functions. The amount of body water varies with age, sex, and body fat percentage. Assessing body water provides useful information about hydration status - whether the athlete is dehydrated or over-hydrated. Total body water percentage decreases with age. In adults, it accounts for approximately 60% of body weight.

Fat-free mass includes all tissues that contain no fat: skeletal muscle, bone, internal organs, skin, and so on. Approximately 50% of fat-free mass is made up of skeletal muscle.

Bone mass peaks at around age 25, after which it declines at a steady rate of approximately 1% per year. In women, a more significant reduction occurs following menopause.

Fat mass consists of both **storage** fat and **essential** fat.

Storage fat includes subcutaneous fat and visceral fat:

- subcutaneous fat is stored beneath the skin and makes up the largest proportion of body fat;
- visceral fat is stored deep in the abdominal area, surrounding internal organs; excess amounts are linked with increased cardiovascular disease risk.

Essential fat is the minimum amount of fat required to support normal physiological functions and is not a performance target. It is found in the brain, nerves, bone marrow, and organs. Essential fat accounts for approximately 3% of body weight in men and 12% in women - around 9% of this essential fat supports hormonal and reproductive functions. Due to these physiological differences, women have a higher body fat percentage than men competing in the same sport, such as bodybuilding.

Body fat percentage

The most common body composition difference between athletes and non-athletes is fat mass – athletes typically carry less. Fat mass can be expressed in absolute terms (kg of fat) or relative terms (body fat percentage). Reference ranges for body fat percentage in male and female athletes are shown below. As age increases, body fat percentage tends to rise, while muscle mass gradually declines.

Table 18. Body fat percentage by sex and age group

A. Male athletes

% body fat	20–29 y	30–39 y	40–49 y	50–59 y	60–69 y
Essential	3% (all age groups)				
Very low	≤ 6.6%	≤ 10.3%	≤ 12.9%	≤ 14.8%	≤ 16.2%
Adequate	7.9–10.5%	12.4–14.9%	15.0–17.5%	17.0–19.4%	18.0–20.2%
Good	11.5–14.8%	15.9–18.4%	18.5–20.8%	20.2–22.3%	21.0–23.0%
Fair	15.8–18.6%	19.2–21.6%	21.4–23.5%	23.0–24.9%	23.6–25.6%
High	19.7–23.3%	22.4–25.1%	24.2–26.6%	25.6–28.1%	26.4–28.8%
Very high	≥ 24.9%	≥ 26.4%	≥ 27.8%	≥ 29.2%	≥ 29.8%

B. Female athletes

% body fat	20–29 y	30–39 y	40–49 y	50–59 y	60–69 y
Essential	12–15% (all age groups)				
Very low	≤ 14.0%	≤ 13.9%	≤ 15.2%	≤ 16.9%	≤ 17.7%
Adequate	15.1–16.8%	15.5–17.5%	16.8–19.5%	19.1–22.3%	20.2–23.3%
Good	17.6–19.8%	18.3–21.0%	20.6–23.7%	23.6–26.7%	24.6–27.5%
Fair	20.6–23.4%	22.0–24.8%	24.6–27.5%	27.6–30.1%	28.3–30.8%
High	24.2–28.2%	25.8–29.6%	28.4–31.9%	30.8–33.9%	31.5–34.0%
Very high	≥ 30.5%	≥ 31.5%	≥ 33.4%	≥ 35.0%	≥ 35.6%

Methods for assessing body composition

Although assessing and optimizing body composition is considered essential in high-performance sport, no single universally accepted method exists. Available techniques each have their own benefits and limitations, ranging from simple anthropometric measurements to more complex and costly methods such as dual-energy X-ray absorptiometry (DXA). Simpler methods are more accessible but may be less precise, while advanced methods require specialized equipment. The choice of method should consider factors such as measurement accuracy, cost, practicality, comfort, the level of effort required from the athlete, and the expertise needed to interpret the results. In practice, the most convenient method is often chosen without fully considering its precision or limitations.

Bioelectrical impedance analysis (BIA)

BIA is a non-invasive, easy-to-use, and accessible method for indirectly estimating fat-free mass and fat mass. It works by passing a low-intensity electrical current through body tissues (e.g., fat, muscle), which creates a resistance proportional to their water content. Muscle contains a large amount of water and allows current to pass through more easily. The greater an individual's muscle mass, the lower the resistance.

Results are particularly sensitive to hydration status, which is one of the method's main limitations. Since body water directly affects electrical conductivity, dehydration leads to an overestimation of body fat. Despite these drawbacks, BIA is a practical and widely used tool for tracking changes in body composition over time in athletes.

5.4. Body types (somatotypes)

Body shape (somatotype) is also useful when considering body weight and composition. Three main body types are generally recognized:

- ectomorphs - naturally lean with a lighter build and lower muscle mass; tend to find it hard to gain weight;
- mesomorphs - build muscle relatively easily and are less prone to accumulating body fat;
- endomorphs - larger, broader build with a greater tendency to store body fat, particularly around abdomen and internal organs.

Understanding somatotypes sheds light on the role genetics play in body composition. This is particularly relevant for coaches working with athletes who pursue unrealistic goals or struggle with how they perceive their own physique.

Athletes often have a mesomorphic body type, characterized by a strong, muscular build. In female athletes, an endomorphic profile is more common, meaning a relatively higher body fat level. Both genetics and environment shape body composition: genetics largely determine build (lean or athletic), while lifestyle has a stronger influence on body fat levels.

Mesomorphic builds tend to be advantageous in strength and power sports, while ectomorphic builds can be beneficial in endurance sports.

5.5. Body weight and body composition goals in athletes

Setting body weight and body composition goals should be done realistically, considering genetic predisposition (e.g., naturally leaner or more robust build), age, sport and playing position, performance level, health status, and starting body composition. Focusing exclusively on achieving a supposedly "optimal" body composition combined with societal pressure around the "ideal" physique, or expectations from coaches, teammates, and parents can lead athletes to set unrealistic goals. The consequences can include malnutrition, hormonal imbalances, and psychological issues, and in young athletes, impaired growth and development.

5.6. Optimizing body composition

Building muscle mass

Skeletal muscle increases in size and strength when exposed to progressively greater training loads and when nutrition and hormonal status support this process. Muscle responds to progressive overload (strength training) by increasing in volume - a process known as muscle hypertrophy.

The amount of muscle mass gained through strength training is difficult to predict and is influenced by several factors:

- genetics - play a major role in how much muscle mass and strength an individual can develop (accounting for 50-80% of muscle mass and up to 85% of muscle strength);
- body type - ectomorphic individuals will develop less muscle mass than mesomorphic ones;
- hormonal status - the main hormones driving muscle growth are growth hormone and testosterone; testosterone levels vary considerably not only between men and women, but also among men;
- nutrition.

Nutrition

While many nutrients are involved in muscle growth, increased energy intake and optimal protein intake are the key factors. As a general recommendation, daily energy intake should increase by 400-500 kcal for men and 300-400 kcal for women - though individual variation means caloric targets must be personalized for each athlete. Protein intake can be increased to around 2 g/kg body weight/day. Weight gain through muscle accumulation should be gradual and controlled to avoid excess fat gain. The expected rate of muscle gain is estimated at 0.25-0.5 kg/week for male athletes and 0.1-0.35 kg/week for female athletes.

Recommendations for muscle building:

- prioritize high-quality, leucine-rich protein sources, which are the most effective for muscle growth: meat, cheese, milk, yogurt, fish, eggs, beans, chickpeas, lentils, peas, peanut butter, unsweetened cocoa, pine nuts, cashews, walnuts, pistachios, millet, and others;
- whole food protein sources are preferable to isolated proteins - e.g., whole milk

over skimmed milk, whole eggs over egg whites;
- spread protein intake throughout the day across multiple meals and snacks (3-5 hours apart);
- one protein serving = 0.3 g protein/kg body weight per meal (roughly 20-30 g protein);
- a serving of 30-40 g of casein is recommended as a pre-sleep snack;
- the caloric surplus can be achieved through energy-dense foods such as avocado, nuts, and nut butters, as well as by increasing intake of nutritious foods like legumes (beans, lentils, chickpeas), lean meat, and dairy.

Reducing body fat

Reducing body fat in athletes follows the same basic approach as in the general population:
- increase energy expenditure through physical activity;
- reduce energy intake;
- combine both strategies.

Many diets exist, but they all work the same way, by reducing energy intake to achieve fat loss over time. Unlike in people with obesity, where the degree and duration of restriction matter most, in athletes it is important to consider not only total kcal intake, but also the types and proportions of carbohydrates, proteins, and fats consumed. Therefore, any reduction in food intake should be accompanied by a higher protein intake to help preserve muscle mass.

The energy deficit can also be widened by increasing physical activity, for example through strength training, which, alongside higher protein intake, helps limit muscle loss.

That said, doing both at once (eating less and training more) can compromise training quality and performance. Cutting carbohydrates and protein too aggressively can deplete glycogen stores and erode muscle mass, while excessive training can lower energy levels and increase the risk of injury and dehydration.

Nutrition

To reduce body fat, daily calorie intake should be lower than usual, though excessive restriction risks insufficient carbohydrate intake. A daily deficit of 300–500 kcal is generally recommended. For example, an athlete could reduce food intake by 400 kcal/day while increasing energy expenditure through exercise by 100 kcal. For smaller athletes, the deficit should be proportionally lower. A safe and effective rate of weight loss is about 0.5–1 kg per week.

Recommendations for fat loss:

- on consecutive days with moderate-intensity training, carbohydrate intake should be at least 5 g/kg body weight/day;
- protein intake can be increased up to 2.2 g/kg body weight/day, particularly at breakfast and after training;
- fat intake should account for around 20–25% of total daily energy intake;
- a pattern of around 6 meals or snacks per day is recommended, focusing on foods that are lower in fat and higher in protein and fibre (e.g. whole grains, fruits, and vegetables), which help increase satiety;
- avoid high-calorie drinks such as specialty coffees (with cream or syrups), soft drinks, energy drinks, and alcohol.

Can muscle gain and fat loss happen at the same time?

Some athletes want to improve body composition without significantly changing body weight (e.g. replacing 2 kg of fat with a similar amount of muscle). However, muscle gain and fat loss are opposing processes that require different conditions: muscle growth needs a caloric surplus, while fat loss requires a caloric deficit. Because it is difficult to establish an energy intake that effectively supports both muscle gain and fat loss at the same time, it is generally recommended to focus on one goal at a time.

Chapter 6

SPECIFIC CONSIDERATIONS IN SPORTS NUTRITION

Chapter 6 SPECIFIC CONSIDERATIONS IN SPORTS NUTRITION

6.1. Food allergies and intolerances

Food allergies

Food allergies are an issue that must be treated with utmost seriousness in sports. Unlike intolerances, a food allergy is an immune system reaction to a food and can occur rapidly, sometimes with severe, potentially life-threatening manifestations.

If a food allergy is suspected, the following are recommended:

- Confirmation of the diagnosis by an allergist;
- Strict avoidance of the allergen:
  - Meals, snacks, and foods provided during training camps and travel must be carefully checked;
- Informing the team:
  - The allergy must be known to the relevant staff: physician, dietitian, physical trainer, physiotherapist and other coaches;
  - Communication reduces the risk of accidental exposure;
- Provision of nutritional alternatives:
  - Eliminating important foods can lead to deficiencies if no adequate substitutes are provided;
- Prevention of cross-contamination, in which the allergen accidentally ends up in dishes where it should not be:
  - Attention should be given to shared meals, buffets, utensils, and common preparation surfaces;
  - Supplements and foods provided during travel or in restaurants may contain the allergen as an ingredient;
- Athlete education:
  - Reading labels and asking questions about ingredients can prevent accidental consumption of the allergen;
  - Planning meals and safe snacks in advance, especially during travel, help prevent unpleasant situations.

Table 19. Major food allergens and recommended alternatives for athletes

Food allergen	Examples of food sources	Recommended alternatives
Milk and dairy products	Milk, yogurt, cheese, butter, whey, casein	Fortified plant-based drinks and yogurts (soy, oat, rice, almond – if tolerated); alternative calcium sources: fish with soft bones, leafy green vegetables, sesame seeds; for protein: eggs, meat, fish, tofu (if tolerated)
Egg	Raw or cooked egg, mayonnaise, baked goods	Meat, fish, dairy (if tolerated); plant-based alternatives: tofu, legumes; in cooking: fruit purée, soaked flax or chia seeds (if tolerated)
Wheat (gluten)	Wheat, spelt, barley, rye	Rice, corn, potatoes; quinoa, buckwheat, millet; gluten-free pasta and bread; certified gluten-free oats (if tolerated)
Peanuts	Peanuts, peanut butter, peanut oil	Seeds (sunflower, pumpkin, sesame – if tolerated); seed butters; avocado, olive oil for fat intake
Tree nuts	Almonds, walnuts, cashews, pistachios, pesto sauce etc.	Seeds (if tolerated); vegetable oils; fatty fish for healthy fats
Fish	White fish, oily fish	Lean meat, eggs; plant sources of omega-3 (flax, chia – if tolerated); omega-3 supplements only if recommended by a specialist
Crustaceans and mollusks	Shrimp, crab, lobster, mussels	Meat, fish (if no fish allergy); eggs, legumes
Soy	Soy milk, tofu, tempeh, soy lecithin	Other fortified plant-based drinks; meat, fish, eggs; non-soy legumes (lentils, chickpeas)
Sesame	Sesame seeds, tahini, hummus	Other seeds or vegetable oils; avocado, olive oil

Food intolerances

Food intolerances are different from food allergy and do not involve the immune system. They occur when the athlete's body cannot efficiently digest or metabolise a food or one of its components. Common examples in sport include lactose intolerance, FODMAP sensitivity and histamine-related reactions.

Food intolerances do not mean that a food is "bad" or permanently excluded. Most often, it reflects a temporary functional imbalance in the digestive system. Periods of high training volume, frequent competitions, stress, travel, or insufficient sleep can increase gastrointestinal sensitivity and alter food tolerance. Identifying the underlying cause with the help of qualified professionals is essential for effective management.

Unlike food allergies, complete elimination is not always necessary, and tolerance can often be improved over time. Many athletes tolerate small amounts or specific forms of a food (for example, fermented dairy products in the case of lactose intolerance). Unnecessary or poorly planned elimination can lead to reduced energy intake and nutritional deficiencies that negatively affect performance.

Intense physical exercise redirects blood flow from the digestive system to working muscles, while psychological stress further increases gastrointestinal sensitivity. As a result, foods that are well tolerated during rest periods may cause discomfort during demanding phases of training or competition. Monitoring when symptoms occur — during intense training days, competitions, travel, or stressful periods — can provide valuable insights.

Athletes with intolerances may benefit from:
- ☑ adjusting meal timing relative to training;
- ☑ temporarily reducing hard-to-digest foods before effort;
- ☑ using easier-to-digest carbohydrate sources on intense days;
- ☑ gradual reintroduction of foods, tested in training, never in competition.

The reasons for gut discomfort are various, and gut discomfort should not be immediately attributed to food intolerances.

Gastrointestinal symptoms in athletes can be caused by a combination of physiological, nutritional and training-related factors. The most common causes are:

- Exercise-related factors:
  - Redistribution of blood flow to the muscles during intense effort, with reduced perfusion of the digestive tract;
  - High intensity and duration of effort, especially in endurance sports;
  - Mechanical vibrations (e.g., running) that can irritate the gastrointestinal tract;
- Nutritional factors:
  - Low energy availability, with the body prioritising functions essential for survival and immediate performance at the expense of the digestive system;
  - Consumption of hard-to-digest foods before or during effort (rich in fats, fibre or proteins);
  - Inadequate or excessive carbohydrate intake, particularly high intakes of

fructose or carbohydrate doses that exceed the gut's absorptive capacity;
- Products or supplements not previously tested in training;
- Dehydration or, conversely, excessive fluid intake;
- Hypertonic or highly concentrated drinks;

▪ Hydration and electrolyte factors:
- Electrolyte imbalances (particularly sodium);
- High temperatures, which exacerbate digestive stress;

▪ Individual and medical factors:
- Food intolerances (lactose, FODMAP, gluten — in sensitive individuals);
- Altered bowel transit;
- Pre-existing gastrointestinal conditions;
- Medication (anti-inflammatories, antibiotics, laxatives, diuretics, etc.);

▪ Psychological and behavioural factors:
- Competition-related stress and anxiety;
- Inappropriate meal scheduling;
- "Forcing" feeding to reach theoretical targets, without considering individual tolerance.

Lactose intolerance is a non-immunological reaction that occurs when the body does not produce enough lactase, the enzyme required for lactose digestion, leading to symptoms such as bloating, gas, abdominal cramps and diarrhoea after consuming milk or dairy products; their severity depends on the amount ingested, the gut flora and individual tolerance.

Table 20. Lactose content of dairy products

High lactose content	Low lactose content	Lactose-free products
Cow's milk (whole, semi-skimmed, skimmed)	Greek yogurt	Lactose-free milk
Goat's / sheep's milk	Natural fermented yogurt (small–moderate amounts)	Lactose-free yogurt
Milk powder	Kefir (small amounts)	Lactose-free cheeses
Condensed milk	Aged/hard cheeses (cheddar, parmesan, grana padano, emmental, gouda)	
Regular yogurt (in large amounts)	Sour cream (fermented)	
Sweet cream	Mold-ripened cheeses (brie, camembert – small amounts)	
Liquid whipping cream		
Fresh cheeses (cottage cheese, ricotta, whey cheese)		
Cream cheese		
Milk-based ice cream		

Histamine intolerance is a functional, non-immunological reaction that occurs when the body cannot efficiently break down histamine derived from food or formed in the body. It manifests through a variety of symptoms, which may include gastrointestinal discomfort (bloating, cramps, diarrhoea), headaches, nasal congestion, skin rashes, itching, palpitations or fatigue, symptoms that often appear shortly after consuming certain foods. The causes are multiple and include:

- reduced activity of the histamine-degrading enzyme, diamine oxidase (DAO);
- frequent consumption of foods rich in histamine or which inhibit its degradation;
- chronic stress, intense physical effort, intestinal inflammation, imbalances in gut flora.

In many cases, histamine intolerance reflects a temporary imbalance in the body rather than a permanent intolerance, and proper management involves identifying triggers and making individualised nutritional adjustments.

Table 21. Examples of foods high in histamine, foods low in histamine, and foods that may affect histamine-related reactions

High histamine content	Low / no histamine content	Histamine-interacting foods
Aged cheeses (parmesan, cheddar, gouda, brie)	Fresh meat (chicken, turkey, beef - cooked and consumed promptly)	Citrus fruits (oranges, lemons)
Processed meats (salami, ham, sausages)	Fresh eggs	Strawberries
Canned or smoked fish (tuna, mackerel, herring)	Very fresh fish	Very ripe bananas
Seafood (shrimp, mussels)	Rice	Chocolate
Fermented foods (sauerkraut, pickles, soy sauce, miso, kombucha)	Potatoes	Nuts
Alcohol (red wine, beer)	Plain pasta	Egg whites (in some individuals)
Vinegar and vinegar-containing foods	Quinoa, oats	Alcohol
Tomatoes and tomato products	Carrots, zucchini, cucumber	Black tea, green tea
Eggplant	Broccoli, lettuce	Energy drinks
Spinach	Apples, pears, blueberries, grapes, melon	Medications/supplements that inhibit DAO*
Very ripe avocado	Olive oil, coconut oil, butter (small amounts)	

FODMAPs describe a group of fermentable carbohydrates (oligosaccharides, disaccharides, monosaccharides and polyols) that are poorly digested or absorbed in the small intestine. When they reach the colon, these carbohydrates are rapidly fermented by bacteria and can draw water into the intestine, leading to symptoms such as bloating, gas, abdominal cramps, diarrhoea or constipation.

FODMAP sensitivity is not a disease or a permanent intolerance, but a functional reaction, frequently exacerbated by stress, intense physical effort, fatigue, intestinal inflammation or low energy availability.

In the sports context, symptoms may occur especially on heavy training or competition days. Management generally involves temporary reduction of FODMAP-rich foods, followed by controlled reintroduction to identify individual tolerance thresholds, rather than permanent elimination of entire food groups.

Table 22. Foods high and low in FODMAPs

High FODMAP content	Low / no FODMAP content
Wheat, rye (regular bread, pasta)	Rice, corn, potatoes
Onion, garlic, leeks	Carrots, zucchini, eggplant
Legumes (lentils, chickpeas, beans)	Lettuce, cucumber, spinach
Dairy with lactose (milk, regular yogurt)	Lactose-free dairy products
Apples, pears	Unripe bananas
Watermelon, mango	Blueberries, strawberries
Dried fruits	Oranges, kiwi
Honey	Sugar, maple syrup
Polyol sweeteners (sorbitol, xylitol)	Glucose, dextrose
Mushrooms	Eggs
Cauliflower	Meat, fish, poultry
Processed foods with “high-fructose corn syrup”	Olive oil, butter

6.2. Athletes with special functional needs (disabilities)

Paralympic athletes compete with physical, visual or intellectual disabilities, each category involving specific challenges and requirements. To ensure competitive fairness, a classification system is used to group athletes based to functional level, so that they compete against opponents with similar abilities.

Table 23. Types of disabilities in sport and their characteristics

Impairment	Explanation
Impaired muscle strength	Reduced ability to generate force in a muscle or muscle group in a limb or in the lower half of the body, for example in spinal cord injury (SCI).
Impaired passive range of motion	The range of motion in one or more joints is permanently reduced. Joint hypermobility, instability, and acute conditions (e.g., arthritis) are not considered eligible impairments.
Limb deficiency	Total or partial absence of bones or joints, present from birth or acquired due to trauma or disease.
Leg length difference	Bone shortening in one leg, either congenital or acquired following trauma.
Short stature	Reduced standing height due to abnormal bone size in the upper limbs, lower limbs, or trunk, for example achondroplasia.
Hypertonia	Abnormally increased muscle tension and reduced ability of the muscle to stretch, resulting from injury, disease, or condition (e.g., cerebral palsy).
Ataxia	Lack of coordination of muscle movements caused by a neurological condition (e.g., cerebral palsy).
Athetosis	Involuntary, uncontrolled movements and difficulty maintaining a symmetrical posture (e.g., cerebral palsy).
Visual impairment	Impaired vision due to a physical or neurological condition.
Intellectual impairment	Limitations in intellectual functioning and adaptive behavior (conceptual, social, and practical skills), with onset before the age of 18.

Table 24. Paralympic sports

Summer Paralympic sports	Winter Paralympic sports
Archery	Paralympic alpine skiing
Paralympic athletics	Paralympic biathlon
Badminton	Paralympic cross-country skiing
Boccia	Para ice hockey
Canoe	Paralympic snowboarding
Cycling	Wheelchair curling
Equestrian	
5-a-side football (visually impaired)	
Goalball	
Judo	
Paralympic powerlifting	
Rowing	
Paralympic shooting	
Sitting volleyball	
Paralympic swimming	
Table tennis	
Taekwondo	
Triathlon	
Wheelchair basketball	
Wheelchair fencing	
Wheelchair rugby	
Wheelchair tennis	

In these athletes, there is often a complex interaction between medical needs, daily living requirements, and sport-specific demands. For this reason, training and nutrition strategies must be carefully adapted and individualized, considering functional characteristics, personal context, and each athlete's performance goals.

Table 25. Common nutritional challenges in athletes with disabilities and recommendations

Challenge	Solution
Energy requirements are difficult to estimate, as they vary widely depending on the type of impairment, muscle mass, and activity level.	Regular monitoring of body weight and body composition, with gradual adjustment of energy intake.
Daily "energy budget" may be reduced, especially in athletes with spinal cord injuries or those using a wheelchair.	Choosing nutrient-dense foods to ensure adequate intake of vitamins and minerals even with lower caloric intake.
Risk of low energy availability, which can affect bone health, immunity, and recovery.	Ensuring adequate energy intake relative to training load and monitoring for signs of persistent fatigue or performance decline.
Glycogen stores may be lower in athletes who rely predominantly on the upper body.	Careful planning of carbohydrate intake before and during exercise, with strategies tested in training.
Athletes with reduced functional muscle mass may require lower total protein intake, and in some cases renal function may impose additional restrictions.	Individual adjustment of protein intake based on active muscle mass and associated medical conditions.
Thermoregulation may be impaired, especially in athletes with spinal cord injuries, increasing the risk of overheating.	Adequate hydration, regular breaks, and cooling strategies (cold drinks, cooling vests, crushed ice, water sprays), as well as heat acclimatization.
Hydration strategies may be influenced by catheter use or logistical constraints, leading some athletes to voluntarily reduce fluid intake.	Planning hydration strategies and testing individualized approaches that balance hydration and comfort.
Increased risk of urinary tract infections in athletes using catheterization.	Maintaining strict hygiene, regular bladder emptying, and adequate fluid intake.
Gastrointestinal issues or discomfort in exercise positions may limit food intake before training or competition.	Adjusting meal timing and testing well-tolerated foods.
Medical conditions and medications may affect nutrition and hydration.	Collaborating with a physician and dietitian before making changes to diet or supplementation.
Adherence to the nutrition plan may be challenging during travel or training camps.	Planning meals, snacks, and hydration in advance, and adapting food organization (e.g., placing foods at accessible heights).

6.3. Nutrition of junior athletes. Advice for parents

The family, the first coach in the young athlete's nutrition

Junior athletes are in a stage where physical, cognitive, and emotional development intertwines with the increasing demands of performance sport. During this formative period, the bodies of children and adolescents undergo rapid transformations, and their energy and nutrient needs differ from those of adults.

At the same time, the diet of young athletes depends almost entirely on the family, which decides what is bought, what is cooked, and what is served at meals. An unbalanced diet — whether through deficiencies or excesses — can affect not only performance, but also growth, mood, and the ability to concentrate. Therefore, the family's role goes beyond simply deciding "what the athlete eats"; it extends to how the entire household supports a healthy and relaxed food culture.

The family should not aim for perfection in organizing meals, but should provide consistency, balance, and a positive example, turning healthy nutrition into a natural routine, not a rigid obligation.

Children and adolescents develop their first eating habits within the family environment. The way parents choose, prepare, and consume food becomes a natural reference point for young athletes. Regularly eating fruits, vegetables, and drinking water in front of them has a greater impact than theoretical advice.

Involving juniors in planning groceries, preparing meals, or choosing snacks helps them become aware and autonomous.

Creating an environment that supports healthy eating starts with simple habits: keeping the fridge and kitchen stocked with basic foods and pre prepared snacks, limiting exposure to ultra processed products, establishing a clear meal routine, and aligning the eating schedule with training and competition times.

Parents are active partners in the child's performance: by supporting proper nutrition, they contribute to optimal energy, quick recovery, injury prevention, and the development of a healthy relationship with food.

At the same time, the emotional support provided by the family is just as important as the food itself. Negative comments about weight, comparisons between children, or excessive pressure can lead to anxiety, frustration, and even eating disorders. It is preferable for parents to encourage children to listen to their internal hunger and satiety cues — "eat when you're hungry and stop when you're full" — rather than imposing strict quantities or rigid rules. Parents thus become the first 'nutritional coaches'.

Consistent collaboration between parents, coaches, and dietitians helps deliver a coherent message to the child. Open communication about food preferences, needs, and any eating related difficulties prevents conflicting guidance and provides real support for the young athlete. All adults involved should reinforce the same idea: food is both fuel and enjoyment; balance is built through consistency and trust, not through restrictions.

Checklist for Parents: GENERAL TIPS

1.Be a positive role model
Eat balanced meals based on the Healthy Plate model, including fruits and vegetables, whole grains and starchy vegetables, protein-rich foods, and healthy fats; children imitate behaviors, not just listen to advice.

2.Organize the home food environment
Keep healthy foods (washed fruit, nuts, plain yogurt) visible and limit constant access to ultra-processed products.

3.Establish regular meal routines
Encourage family meals at predictable times, in a relaxed atmosphere.

4.Avoid pressure and comparisons
Do not criticize the child's portions or weight; encourage them to listen to their hunger and fullness cues.

5.Involve them actively
Let them take part in grocery shopping, preparing simple snacks, or choosing a meal from the menu.

6.Connect nutrition with sport
Plan snacks, meals and hydration according to training and competition schedules to ensure optimal energy and effective recovery.

The junior athlete's diet: balance between needs, budget, and sustainability

The nutritional needs of children and adolescent athletes differ depending on age, sex, growth stage, and activity level. They require more energy relative to weight than adults, because growth processes consume a significant portion of the body's resources.

Carbohydrates are the main source of energy, proteins support muscle development and recovery, and high-quality fats contribute to hormonal and brain health. At the same time, micronutrients such as iron, calcium, and vitamin D are essential for bones, blood, and immunity.

Children and adolescents store less glycogen than adults, which means they fatigue more quickly if they do not consume enough carbohydrates. It is important for their meals to include carbohydrates from grains, fruits, starchy vegetables, milk, or yogurt, spread evenly throughout the day, and to receive additional carbohydrates after exercise to support recovery.

They also require more protein to sustain growth and development. Protein should be included in every meal, especially after training sessions, to support muscle repair and replenish energy stores. Protein supplements are not necessary as long as they get enough protein from regular foods.

Young athletes dehydrate more quickly than adults because they have a higher body surface area to mass ratio, their bodies heat up faster, and they sweat less efficiently. Studies show that many young athletes are often dehydrated, which can negatively affect both performance and health. This makes it essential for

them to drink water or electrolyte containing beverages during and after training.

There is no need for "special" or expensive products; most nutritional needs can be met with simple, local, and seasonal foods.

A balanced, varied, and economically accessible diet supports growth and performance without placing financial pressure on the family.

Simple sources of energy and nutrients — whole grains, legumes, fruits, vegetables, dairy products, eggs, lean meat, fish, and seeds — are sufficient to meet daily requirements. Local, seasonal, or frozen products offer an optimal balance between quality, cost, and availability. Home cooked meals, with portions adapted to the child's age and activity level, remain the safest and most effective option.

An important aspect for families with young athletes is organizing meals in a way that avoids waste. Food waste affects not only the household budget but also the young athlete's health and the environment.

Well organized nutrition supports athletic performance, nutritional balance, and a responsible lifestyle.

Planning meals according to training and competition days helps prevent both nutritional deficits and excesses.

Checklist for Parents: HEALTHY, AFFORDABLE, AND WASTE-FREE MEALS

1.Plan meals in advance, based on your budget and the training schedule – this helps avoid impulsive purchases and ensures the right nutritional intake.

2.Choose local and seasonal foods– they are more affordable and often more nutritious.

3.Include frozen or canned products (e.g., peas, beans, tuna, corn) – they keep longer, are just as nutritious, and are often more budget friendly.

4.Cook healthy and simple meals – opt for boiling, steaming, or baking to preserve vitamins and minerals.

5.Prepare snacks at home: simple sandwiches, yogurt with fruit, oat based bars — cheaper and healthier than packaged options.

6.Portion appropriately – adjust quantities according to the child's age, appetite, and activity level, using the "healthy plate" model as a guide.

7.Reuse leftovers creatively – turn them into soups, stews, or omelets so nothing goes to waste.

8.Encourage your child to serve only what they know they will eat – this reduces waste and builds responsibility.

Nutritional checklist for the junior athlete: TO DO / TO AVOID[4]

Situation	☑YES – TO DO	☒ NO –TO AVOID
Daily meals	▪ Eat a healthy breakfast to support muscle recovery the after overnight fasting period. ▪ Follow the healthy plate model at every meal (½ vegetables/fruits, ¼ protein, ¼ whole grains) ▪ Eat 3 main meals + 2–3 healthy snacks that include: - Complex carbohydrates every day (whole grain bread, brown rice, potatoes, pasta) - Daily protein intake (~1.2–1.6 g/kg/day) from milk, yogurt, lean meat, eggs, and legumes - Fat intake: no more than 30% of total daily energy., - Adequate calcium (~1300 mg/day) and vitamin D (≥600 IU/day)	▪ Skipped or unbalanced meals. ▪ Too many ultra-processed products (fast food, concentrated sweets, chips). ▪ Protein supplements without the specialist's recommendation.
Daily hydration	▪ Monitor urine color (pale yellow = well hydrated). ▪ Drink water throughout the day and during training: - 400–600 mL of water 2–3 hours before exercise - During exercise: 150–300 mL every 15–20 minutes or ~13 mL/kg/hour. - After exercise: continue drinking until urine returns to a pale yellow color.	▪ Wait for intense thirst as a signal. ▪ Sugary carbonated drinks or energy drinks (unsuitable for children/adolescents).
Before effort	▪ Eat 2–3 hours before exercise: rich in carbohydrates, moderate in protein, low in fat and fiber ▪ If a full meal isn't possible, choose a light snack 1–2 hours before training (bread with cream cheese and an apple, a banana, yogurt, cereal bar).	▪ Fatty, fried, or spiced foods. ▪ Overeat immediately before training.
During the effort	▪ For exercise lasting 60–150 minutes (intense or in hot conditions) include: 30–60 g of carbohydrates per hour, taken in small amounts, plus hydration. ▪ Use simple carbohydrate snacks: fresh or dried fruit (banana, orange, dried apricots, raisins); sports drinks with carbohydrates and electrolytes. ▪ For exercise under 60 minutes: drinking water is sufficient.	▪ Ignore hydration. ▪ Energy drinks or concentrates unsuitable for the age.
After effort (recovery)	▪ If another training session follows in less than 24 hours use: carbohydrates + protein within the first 30 minutes (e.g., chocolate milk, yogurt and fruit smoothie) ▪ If the next session is more than 24 hours away include: a balanced meal is sufficient, without the need to rush. ▪ Eat 1–1.2 g of carbohydrates/kg for each hour of training in the first hours after exercise.	▪ Excessive postponement of meals after training. ▪ Snacks only with plain sugar (e.g., candies).

[4]Include recommendations according to Sports Nutrition for Youth: A Handbook for Coaches (Alberta Health Services) and Nutrition for Children and Adolescents Who Practice Sport. A Narrative Review (Nutrients, MDPI, 2024)

6.4. Collective meal provision for athletes

Canteens dedicated to athletes, and more broadly the collective meal provision systems used by teams and training centers, represent a central component of the performance sports ecosystem. They are not merely administrative spaces for serving meals, but integrated support mechanisms that directly influence athletes' work capacity, recovery, long term health, and nutrition education.

Ideally, such units combine rigorous nutritional planning, food safety, efficient procurement, and modern sanitary standards with an environment that promotes healthy eating behaviors.

In practice, the level of development and professionalization varies considerably. Large training centers, sports campuses, or facilities with dedicated infrastructure often benefit from well equipped kitchens, qualified staff, and menus tailored to athletic objectives. In contrast, smaller sports clubs and temporary locations sometimes operate with limited resources, non specialized personnel, or outsourced catering services, which may affect the quality of nutrition and the ability to personalize meals according to physical effort. The lack of unified standards, inconsistent application of food safety regulations, and budget constraints remain common challenges.

However, even in the absence of a fully equipped canteen, it is possible to provide adequate nutrition for athletes through planning, careful selection of suppliers, simple and nutritious menus, the use of local products, and collaboration, even part-time, with nutrition specialists.

In this context, it is essential that athletes' nutrition — regardless of resource level — follows clear principles. The main objective is to ensure varied, balanced meals that are appropriate to the level of effort, based on fresh and quality ingredients.

Basic dietary principles

Athletes' diets should include complex carbohydrates, lean protein at every meal, generous portions of fruits and vegetables, healthy sources of fats, and constant hydration, with permanent access to water.
Fried foods, sugar rich items, and highly processed products should be avoided, while deli meats, fast food products, and carbonated or energy drinks should be limited.

Caloric intake and meal structure should be adjusted according to training volume: on high intensity days, a higher carbohydrate intake is recommended to support energy needs and replenish glycogen stores, while on rest days the quality of the diet is maintained, with portion sizes adapted to the lower energy requirements.

Essential components for daily meal planning

Applying the „Food First" principle means using whole, natural foods as the primary source of nutrients, reducing reliance on supplements and ultra processed products. Each component contributes to athletes' performance, recovery, and long term health.

✔ Fresh, minimally processed foods
Follow the Food First principle: use ingredients that are as natural and whole as possible to ensure high nutritional value and avoid additives, refined sugars, and ultra processed foods.

✔ Carbohydrates (e.g. whole grain pasta, brown rice, potatoes, quinoa)
Plan menus so that athletes receive long lasting energy and can replenish the glycogen stores needed for training.

✔ Protein at every meal (lean meat, fish, eggs, dairy, legumes)
Include varied protein sources to support muscle repair, muscle growth, and metabolic functions.

✔ At least 5 servings of fruits and vegetables per day, in varied forms
Ensure diversity and adequate quantity to provide essential vitamins, minerals, fiber, and antioxidants, supporting overall health and recovery.

✔ Healthy fats (e.g., nuts, seeds, olive oil, avocado)
Integrate unsaturated fats into menus to support cardiovascular health, absorption of fat soluble vitamins, and additional energy intake.

✔ Constant hydration, permanent access to water
Ensure easy access to water and, when appropriate, electrolyte beverages to maintain fluid balance, prevent dehydration, and support performance.

The structure of the daily menu

A balanced daily eating pattern may include a substantial breakfast, lunch, dinner, and two to three snacks. This should be adapted to the training schedule.

Main meals should generally include carbohydrate-rich foods, quality protein sources, small amounts of healthy fats, and daily sources of calcium. After training, a snack or meal rich in carbohydrates and containing protein supports the replenishment of energy stores and muscle recovery.

The annexes at the end of the guide include practical examples of meals used in different nutritional contexts for athletes: lunch menus served in a collective setting at the "U" Cluj canteen, options adapted to the Mediterranean diet tested through individual ordering in a restaurant, as well as examples of pre exercise meals and snacks for junior athletes, which can also be applied in home settings.

Planning and procurement

- ✔ Rigorous planning and a well organized procurement system ensure high quality products delivered on time and at optimal cost, while allowing real time monitoring of consumption, gradual adjustment of portion sizes, and reduction of food waste.
- ✔ Menus should be designed weekly or monthly, in collaboration with coaches/technical staff and nutrition specialists, so that they are adapted to the requirements of each sport and the individual needs of athletes. In the absence of a dietitian, canteen staff may rely on validated nutritional guidelines and meal plans, official resources, and good practices from similar centers to ensure balanced and high quality meals.
- ✔ Set the menu and estimate, as accurately as possible, the actual number of people who will eat each day before purchasing ingredients.
- ✔ Procurement should be based on fresh, seasonal ingredients and, whenever possible, local suppliers: check which vegetables, fruits, and grains are available locally during each period of the year and include them in the menus; establish relationships with farms, cooperatives, or local markets to obtain high quality ingredients with clear traceability and minimal transport time; alternate suppliers to ensure menu variety and avoid dependence on a single source.
- ✔ Use the FIFO (First In, First Out) principle for stock monitoring and management: this allows quick identification of available ingredients, those that must be used immediately (the first items entering the stock), and those that need to be reordered.

Food safety

Compliance with national and European food safety legislation ensures that food is handled, stored, prepared, and served in ways that protect consumers (athletes) and preserve the nutritional quality of meals. Canteen staff must receive periodic training, and procedures should follow HACCP[5] requirements.

Implementing international standards such as ISO 22000:2018[6], ISO 9001:2015[7], and ISO 14001:2015[8] would further strengthen consumer confidence by demonstrating that the collective catering unit adheres to internationally recognized, verifiable, and transparent procedures.

Proper storage, temperature control, and maintenance of the cold chain are mandatory. A well-organized workflow — from receiving and storing food to preparing, serving, and sanitizing — supports efficient operations and reduces the risk of contamination. Personal hygiene, surface hygiene, and keeping retained food samples for safety checks are equally important.

[5]Hazard Analysis and Critical Control Points - a risk analysis and critical control point system used to ensure food safety throughout the entire production and distribution chain

[6]International standard for food safety management systems, based on HACCP principles

[7]International standard for quality management systems

[8]International standard for environmental management systems

In addition, appropriate, good quality tableware and a pleasant dining environment turn the meal into a positive experience and reinforce respect for the act of eating.

Communication with athletes and the educational role

Enhancing athletes' knowledge and awareness regarding their eating habits is essential for both performance and health. In this context, the sports canteen plays an important social role, becoming not only a place where meals are served but also an environment for nutrition education. Through displayed menus and ongoing communication, athletes can know in advance what options are available and better organize their meals, while their feedback helps adapt dishes to real preferences without compromising nutritional value. Dining areas also become spaces for promoting healthy eating behaviors, through visual materials and strategies that encourage balanced choices.

To support this approach, the following measures can be implemented:

- The menu is displayed and communicated in advance—through notice boards, websites, or digital applications—so that athletes know their options and can plan their meals;
- Regular feedback from athletes and coaches is used to adjust dishes, taking into account their real preferences without compromising nutritional quality;
- In the dining hall or serving areas, images and messages promoting healthy eating behaviors are displayed, and beneficial foods are highlighted through posters, and continuous nutrition education for athletes.

Special situations: transport, training camps, and temporary locations

In camps, training camps, or locations with limited resources—where spaces and equipment are temporary and variable—greater attention must be given to food storage and transport, hygiene, maintenance of the cold chain, and menu planning.

Specific challenges such as food variety, allergy management, and more difficult resource control require essential measures, including rigorous menu and procurement planning, appropriate equipment for food preservation, additional staff training, careful monitoring of temperatures and transport conditions, and daily evaluation of consumption to allow rapid adjustment of portion sizes to fit resources.

During travel, food must be packed in insulated containers or coolers that maintain the cold chain throughout the journey, while beverages and perishable items should be distributed in stages to prevent spoilage. Logistical planning may include intermediate supply points, and for hydration, constant access to drinking water and electrolyte beverages is recommended, stored in containers that are easy to transport and distribute.

Additionally, preparing individual kits of healthy, energy dense, easy to consume snacks can ensure the necessary nutrient intake even when serving a traditional meal is difficult.

These measures help maintain food safety and athlete hydration even in temporary or resource limited conditions, reducing the risks of contamination and exhaustion.

Therefore, regardless of the level of infrastructure, an organized approach, careful planning, and adherence to nutritional and safety principles ensure that feeding athletes remains a pillar of performance and recovery.

6.5. Approaching nutrition within the multidisciplinary team – the psychologist's perspective

1.Nutrition in performance sport: ensuring the balance between physiological demands and psychosocial influences

In performance sport, the way adult athletes relate to nutrition is closely linked to the sport-specific energy demands of the discipline they practice, to past eating experiences, to body image, and to influences from the sporting environment and social media. The specialized literature shows that performance athletes frequently experience disordered eating behaviors, at a higher rate than the general population, and the constant pressure related to maintaining optimal body weight and an athletic, well-defined physique represents a risk factor present throughout the entire duration of the sporting career.

In this context, athletes' relationship with food often becomes instrumental ("I eat only for performance"), and when it is guided predominantly by restriction and rigid perfectionism, the risk of low energy availability and of the development of relative energy deficiency in sport (RED-S: Relative Energy Deficiency in Sport) increases. Energy deficiency has a negative impact both physically, through an increased risk of injury, reduced performance, and hormonal and bone-related problems, and psychologically, through the emergence of anxiety, irritability, and social withdrawal.

By contrast, a healthy relationship between athletes and nutrition involves perceiving food as support for physical effort, recovery, and as a source of satisfaction naturally integrated into the daily routine. The specialized literature supports that such a balanced and flexible approach to food is associated with better long-term adherence to functional nutrition principles, more stable athletic performance, and a higher quality of life.

Coaches constantly transmit messages about the body and nutrition within the sporting environment, and the way they communicate plays an important role either in supporting a healthy relationship with food or, conversely, in increasing the risk of unhealthy behaviours. Recent studies show that athletes who feel accepted by coaches and teammates regarding their body have greater confidence and a better relationship with their own body. On the other hand, when coaches' discourse places excessive emphasis on diet and weight, the risk of food- and eating-related problems increases.

Practical recommendations for coaches

Communication about nutrition and eating behaviour

- Use language centred on functionality and on supporting performance, not on appearance and body aesthetics. For example, instead of "you need to be thinner so that you can run faster," it is useful to formulate the message as follows: "let's see, together with the dietitian, what level of energy intake helps you maintain your movement intensity throughout the entire match".
- Avoid labelling foods as "good/bad"; use functional categories: "more suitable for competition/recovery" versus "to be consumed occasionally, in social contexts";
- Convey messages that encourage athletes' autonomy and collaboration. Frame discussions about food as a process of ongoing learning and adaptation, using questions such as: "what helps you feel in peak form during training?" Avoid rigid nutritional instructions related to the strict observance of rules.
- Do not comment publicly on athletes' weight or physical appearance. Any discussion related to an athlete's body composition or physical appearance should take place only individually and, ideally, in the presence of a specialist (dietitian, sports physician) who can provide specific recommendations.

Establishing explicit team norms

- Introduce a clear "zero body-shaming" rule. Jokes or ironic remarks referring to the body, weight, or body shape should not be accepted within the team environment.
- Convey a functional perspective on body diversity, emphasizing that different roles and positions within the team require different physical qualities and body structures.

Building a flexible relationship between athletes and food

- Encourage athletes to include their favorite foods in their eating routine, so they avoid situations where very strict restrictions later lead to a loss of control over their eating.
- Discuss naturally the difficulties and barriers frequently encountered in following the nutritional plan. Refer to obstacles such as a busy schedule, travel, and competitive stress, without interpreting them as "lack of willpower" or "lack of professionalism." Instead, try to provide practical support adapted to each situation.

Team micro-interventions

- Organize, at least once per season, a 30–45-minute discussion, preferably with the contribution of a sports psychologist and a dietitian, on the topic "How do we want to relate to food and to the body in our club?" In these sessions, athletes can be actively involved in formulating written rules, which are displayed in the locker room and reviewed periodically, or in proposing solutions to some specific difficulties.

- Invite athletes to formulate 1–2 personal principles related to nutrition and health, for example, "I want to treat my body as a teammate, not as an opponent." You can use these principles, referring to them before critical periods such as training camps, play-offs, international competitions, etc.

2. Supporting athletes in adhering to the nutritional plan

Scientific context

Beyond accurate information about food, the quality of the nutrition-related decisions made by performance athletes is closely linked to psychological factors such as self-regulatory capacity, time management, awareness of the importance of routines, and personal beliefs about performance. Most of the time, from this perspective, athletes' problems do not arise from lack of knowledge, but from difficulties in maintaining behaviours when fatigue, pressure, or emotional strain occur, alongside the need to manage numerous professional and personal responsibilities. The specialized literature warns that athletes' adherence to nutritional plans depends on the clarity of the demands involved, in a situation in which the athlete understands what, how much, when, and why to make certain food choices, on the athlete's self-efficacy, understood as the belief that they can implement the changes, and on a motivational climate that supports athletes' autonomy, in which they do not feel rigidly controlled.

The coach has a key role in supporting adherence to the nutritional plan: they can provide athletes with constructive feedback and can create a structured context in which nutritional rules relate to specific moments or routines. In this context, the better the coach's understanding of nutrition, the clearer and more useful the messages directed to athletes are in supporting eating habits.

Practical recommendations for coaches

Clarifying roles

- Communicate explicitly to athletes that the coach does not replace the dietitian but supports implementation of the plan through the formation of functional routines, the feedback provided, and continuous support. Ask the dietitian for a concise formulation in the form of 2–3 key principles that you can communicate and reinforce in training and in competitive situations.
- Avoid modifying specialists' nutritional recommendations on your own initiative and without consultation within the multidisciplinary team, for example, to achieve drastic weight loss in the case of an athlete. Research evidence shows that these practices increase the risk of the development of RED-S and of the onset of eating disorders.

Support in the practical planning of adherence to the nutritional plan

- Suggest that athletes monitor their eating behaviours using a concrete tool such as a food diary, an easy-to-complete checklist, a digital application for monitoring dietary intake and/or energy intake, in which the athlete records key behaviours such as the number of main meals, water intake, etc. for 2–3 weeks. This exercise is useful for increasing awareness of eating routines or of the personal barriers encountered by the athlete.

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Establishing appropriate behavioural goals

- Formulate for each athlete specific, realistic goals anchored in context. For example, the recommendation: "Have at least 3 main meals + 1 snack after evening training over the next 2 weeks" is sufficiently concrete and clear and may play an instrumental role in guiding the athlete.
- Link nutritional goals to observable performance: "We apply this meal plan and hydration strategy and observe how they influence your energy and responses toward the end of the match."
- Monitor and periodically review the athlete's progress: what worked, what was difficult, what we adjust together. Avoid negative feedback and direct reproaches and formulate constructive messages about what needs to be done next, involving the athlete in the decision-making process.

Communication about adherence to the nutritional plan

- Adopt a collaborative communication style: ask the athlete what works, what does not, and what they would like to adjust. Validate their effort, not only the outcome, using statements such as: "You tried to follow the meal plan, even though some days were more difficult. Let's see what worked well and where you should persist."
- Avoid humiliating the athlete ("it is obvious that you have been eating junk again"), threats ("if you do not eat properly, you will not play"), or comparisons between athletes ("look, X can do it, why can't you?"). These approaches can reduce motivation and make the athlete less willing to communicate the difficulties or symptoms they are experiencing.

Integrating healthy eating behaviours into the team routine

- Establish "anchor moments" for healthy eating, for example, 20–30 minutes immediately after evening training, when the team has access to appropriate recovery options: fruit, yogurt, sandwiches with protein, recovery drinks. These moments, shared by the whole team, tend to increase athletes' adherence to nutritional recommendations, through their establishment as routines and through the validation provided by the group.
- During travel, participate actively in meal planning, proposing fixed times, specific foods, etc. Discuss with athletes acceptable alternatives when logistics do not allow ideal eating, for example, what to choose in emergency situations from a menu poor in options.

3. Prevention and identification of eating disorders

Scientific context

Recent studies show that approximately one in five athletes presents disordered eating behaviors, with a risk of progressing toward eating disorders. The risk is higher in sports that place emphasis on weight, aesthetic appearance, or in which performance depends directly on weight. Eating disorders and relative energy

deficiency in sport are associated with decreased performance, poorer recovery, more frequent injuries, hormonal disturbances, and impaired bone health. These consequences are often overlooked in performance sport. Adult athletes may hide symptoms for a longer period, which makes the coach's role in early observation more important.

Risk factors for the occurrence of eating disorders include a personal or family history of eating problems, a tendency toward rigid perfectionism, pressure to modify weight coming from coaches or family, as well as career transition periods, such as breaks from competition, injuries, or retirement from sport. A high level of anxiety and dissatisfaction with one's own body may amplify these risks. In sports with strict weight requirements, prolonged caloric restriction is frequently associated with social isolation, emotional difficulties, reduced concentration, and an increasingly tense relationship with food, effects that may continue even after the end of the sporting career.

Warning signs in adult athletes

Changes in weight and in physical or sporting performance: rapid or frequent weight loss, fluctuations from one season to another without medical justification, chronic fatigue, reduced strength and endurance, increased recovery time between training sessions, repeated stress injuries.

Maladaptive eating behaviours and attitudes: systematic skipping of meals, lack of concern for nutrition, avoidance of team meals or social situations involving food; rigid, compulsive rituals such as obsessive calorie counting, long lists of "forbidden foods," excessively intensified training after food intake in order to lose the calories consumed, excessive use of laxatives, diuretics, or saunas for rapid weight loss.

Emotional and cognitive signs: intense preoccupation with weight, very frequent weighing, elevated anxiety at the idea of eating "in front of others," increased irritability, social withdrawal, reduced concentration, a combination of extreme perfectionism and severe self-criticism.

Recommendations for addressing suspicions of eating disorders

Conversational approach

- Approach the athlete in a private context, with a clear message of concern and without judgment: "I have noticed X (for example: that you have been skipping breakfast for several weeks, that you have lost a lot of weight in a short time, that you seem constantly tired) and I am concerned about your health. I would like us to discuss this and see how we can help you."
- Avoid direct confrontations ("What are you doing? Don't you realize the consequences?"), accusations ("Why are you doing this? You are not taking care of yourself!"), and blame ("Only you can correct this aspect"). Acknowledge that this is a sensitive topic and propose a specialized assessment as a natural measure of care in the context of sport performance.

Interdisciplinary approach

- Collaborate with the team physician, psychologist, and dietitian for an integrated plan and strictly follow the recommendations regarding training adaptation. Remind

athletes that these services are available and guide them to use them as well.

- If serious medical warning signs appear, such as fainting, rapid weight loss, bulimic-type eating behaviors, etc., accept a temporary pause from competition until health is stabilized, clearly explaining that the measure has a protective role, not a punitive one.
- Ensure confidentiality regarding information about the athlete's health status. Do not discuss the athlete's situation with the rest of the team without the athlete's explicit consent.

4. Education for healthy nutrition and the development of healthy habits

Scientific context

- Adult athletes have eating habits that are already largely established. These can, however, be improved through practical education, direct experience, and a more appropriate adaptation of these habits to the demands of the sport. Nutritional knowledge, together with abilities such as meal organization, emotion regulation, and decision-making in unforeseen situations, supports high-quality nutrition and reduces the risk of unhealthy eating behaviours.
- Educational interventions are effective for athletes when they are interactive, centred on autonomy, and focused on practical application, not only on the transmission of information. Structured approaches that combine goal setting, step-by-step support, and motivational dialogue support real changes in eating behaviours and can be adapted both for young athletes and for adults. In this process, it is important that nutrition education also include the development of critical thinking toward messages from the online environment and consider the real barriers in athletes' lives, such as time, access to food, or organizational skills.

Practical recommendations for education for healthy nutrition and the development of healthy habits

Ongoing educational interventions, integrated into the team routine

- Plan 3–4 educational micro-modules per season (20–30 minutes each) on relevant topics. The topics should be formulated in an applied way and focused on issues specific to performance sport. Topics may include Nutrition for intense training, Recovery and sleep strategies, Nutrition during travel and tournaments, Optimal hydration, Nutrition during periods of injury and return to/after exertion, Dietary supplements: what is useful and what can be avoided, how we critically evaluate information on social media about nutrition, etc.
- Link each module to a practical task applied immediately (for example, athletes develop their own meal plan for a typical competition week, identifying concrete solutions for their personal barriers).
- Repeat key concepts in different contexts to consolidate learning: before tournaments, in training camps, at the beginning of the competitive season.

Practical and experiential approach in education for healthy eating

- Occasionally organize short sessions for analysing the menus available in training camps or competitive situations, discussing together food options that better support sporting goals, with emphasis on usefulness and informed choices, without judgment or moralizing messages.
- Encourage the exchange of strategies among athletes, strengthening the sense of community and mutual support.
- If possible, involve a dietitian in practical workshops for preparing quick and balanced meals, adapted to athletes' reality depending on the available budget, limited time, available equipment, etc.

Development of psychological competencies

- Collaborate with the team psychologist in order to introduce short exercises for identifying the emotions–food link, the stress–food link, relaxation activities, sleep routines, pleasant non-food-related activities, exercises for recognizing signals of hunger, satiety, and fatigue, strategies for managing anxiety related to weight and performance, discussions regarding how body image is constructed and evolves, the risks of dysfunctional perfectionism, etc.
- Discuss strategies for decision-making in unforeseen situations (what do I choose from a menu when I do not have the ideal option? how do I negotiate a social event when I am in a period of intense preparation?).

Access to information and media literacy

- Organize open discussions about nutrition and body related information found on social media: how images are edited, how extreme diets and products unsupported by scientific evidence are promoted, and what impact they have on self-evaluation and behaviour.
- Explicitly recommend credible and verified sources such as the official guidelines of professional organizations in sports nutrition and encourage athletes to verify information with the club's dietitian before trying new diets or supplements.
- Draw attention to the signs of media manipulation in online content: unrealistic promises, extreme recommendations, miracle products, apparently harmless pharmacological treatments, etc.

Strengthening the identity of the "healthy athlete"

- Discuss with athletes the long-term perspective on their own sporting career: career longevity, an active and healthy life after retirement from competition, prevention of musculoskeletal, metabolic, and cardiovascular complications, while associating goals and recommendations with healthy eating behaviour and functional nutritional routines.
- Emphasize that an authentic professional builds sustainable habits and avoids quick solutions with high long-term costs.
- Promote models of athletes who have had long and healthy careers, emphasizing the role of nutrition in their success.

Chapter 7

DIGITAL TECHNOLOGY IN SPORTS NUTRITION

Chapter 7 DIGITAL TECHNOLOGY IN SPORTS NUTRITION

7.1. Introduction

From video analysis of movements and heart-rate monitoring to digital planning of training and nutrition, technology has become an essential partner and an undeniable support in building athletic performance.

Today's performance athletes are part of a digitalized generation, used to learning, communicating, and processing information through technology. Smartphones, apps, and online platforms are not just tools, but part of their natural environment. In this context, technology becomes an essential ally in nutritional communication and in managing the relationship between coach and athlete.

Communication no longer depends exclusively on face-to-face meetings. Rapid feedback, sent through messages, apps, or collaborative platforms, can make the difference between an effective adjustment of the plan and a misunderstanding that affects performance.

For coaches, integrating technology into their work with athletes is important for several reasons:

- Athletes respond better to digital communication because it is part of their natural learning and interaction environment. Instructions transmitted through apps, videos, or graphics are easier to understand and apply, while rapid feedback motivates them and allows them to correct mistakes immediately.
- Nutritional and training information can be digitally structured so athletes can clearly follow it and reduce the risk of confusion.
- Progress monitoring becomes objective through apps or devices that allow the coach to observe deviations and adjust the plan in real time.
- Digital channels maintain continuity between physical training sessions, offering athletes instructions, reminders, and feedback even when they are not in the gym. This keeps them engaged, connected to their goals, and responsible for their own preparation process.

However, technology must be used with balance. Coaches should see it as a supportive tool, not a method of excessive control. The main risks include:

- Information overload, which can lead to overwhelm or confusion if messages are unclear or come from multiple sources.
- The risk of" micromanagement", when every step of the athlete is digitally monitored, potentially reducing autonomy and confidence.

Technological progress allows wearable devices—smartwatches, heart-rate monitors, glucose or sweat sensors—to provide increasingly detailed data about the athlete's metabolism and condition during training. Although these technologies are not yet perfect, they represent an important step toward a deeper understanding of physiological responses to effort and nutrition.

Moreover, AI-based systems can already integrate information about training and nutrition, generating automated suggestions to adjust the dietary plan.

Soon, the concept of "Smart Coaching" will increasingly describe a coach capable of using these tools to guide, analyse, and personalize interventions without losing the human dimension of the coach–athlete relationship.

Technology does not replace the human relationship between coach, athlete, and dietitian — on the contrary, it enhances it; it provides faster communication, a better understanding of eating behaviour, and a solid foundation for informed decisions.

In a world where information moves faster than ever, technology becomes a reliable ally for teams that know how to use it intelligently.

Monitoring athlete nutrition through digital apps

Technology enables close coordination between training plans and nutritional plans. Through apps, athletes can send daily feedback, and coaches can receive weekly reports on energy intake and performance parameters. Meal photos ("food logs"), automated alerts regarding deviations from the plan, and quick adjustments of nutritional recommendations allow rapid and precise interventions.

The coach can use this tech-generated information to observe trends (e.g., performance decline, signs of fatigue, non-compliance with the nutritional plan) and identify when the intervention of a dietitian or sports physician is needed. With dedicated apps, athletes can view simple charts showing the evolution of energy intake, hydration levels, or adherence scores, while automated notifications for meals, hydration, or supplements maintain a steady routine and foster healthy habits.

However, it's important to remember that the data entered may be inaccurate, and interpretation must be done carefully. Accuracy depends on athlete engagement and specialist guidance.Almost any dedicated app can be used to monitor athlete nutrition, but the best choice depends on the goals, the type of information you want to collect, and the functionalities provided (calorie tracking, food logs, hydration, automatic feedback, etc.).

The most important part is convincing athletes to be honest and responsible with their data input and explaining the importance of nutrition and hydration for their well-being and performance.

Calorie counting can be useful but understanding the right types of macro- and micronutrients for the specific training day, session, or period is far more valuable.

7.2. The U-NutriCoach App

The U-NutriCoach app was developed through a partnership between three professional sports clubs from Romania ("U" Cluj), Bulgaria (Deya Sport Volleyball Club), Greece (OFI Sports Club), and an IT services provider (GNS SRL).

It is designed for both coaches who can coordinate, monitor, and adapt training and nutrition plans for each athlete (whether working with a team or individually) and performance athletes, who receive personalized nutritional recommendations, can track their progress, and collaborate transparently with their coach.

Through the app, the coach can configure training plans, view performance parameters, and track how well athletes follow the automatically generated nutritional recommendations.

Additionally, the app guides the training process, helping athletes understand the relationship between what they eat, how they train, and how they perform – an approach that promotes an educational model where decisions are based on learning, not imposition.

Account creation and profile setup

To interact and benefit from the features and support offered by U-NutriCoach, both coaches and athletes create their own accounts in the app.
Through the created account, the coach has access to all collaborating athletes, configuring their training plans, while the athlete personalizes their profile based on individual data and objectives.

The initial setup includes the following elements specific to the athlete:

- ☑ personal and anthropometric data: age, sex, height, weight, body fat percentage, muscle mass;
- ☑ activity information: practiced sport, weekly and daily training schedule, physical activity level;
- ☑ performance objectives: general or specific — weight loss, muscle gain, improved aerobic capacity, strength, speed, or post-injury recovery.

This information forms the basis on which the app later generates individualized nutritional recommendations, and its collection provides a framework for awareness of personal characteristics and needs.

Personalized nutritional recommendation generation

Based on the entered data, U-NutriCoach automatically calculates each athlete's energy and nutritional needs, offering specific values for:

- ☑ total energy requirement (kcal/day);
- ☑ recommended proportions of carbohydrates, proteins, fats, and fiber;
- ☑ optimal intake of vitamins and minerals (including sodium, magnesium, calcium, iron, etc.);
- ☑ water and hydration needs;
- ☑ meal schedule correlated with training and competition;
- ☑ food suggestions for each nutrient category.

Through this information, the athlete receives a clear picture of the appropriate nutrition for their effort, and the coach can quickly see whether intake matches the training plan requirements.

Monitoring nutrition and adherence to the nutritional plan

Daily recording of meals and consumed foods helps athletes develop self-discipline and become more aware of their nutrition. Athletes can record daily:

- ☑ type of meal (breakfast, snack, lunch, dinner, etc.);
- ☑ consumed foods;
- ☑ estimated quantity.

The U-NutriCoach app automatically evaluates how well the athlete follows the nutritional recommendations and whether energy, macronutrient, micronutrient, or water intake is adequate. Notifications and reports sent to the athlete and coach provide clear information about the impact of nutrition on performance, such as:

- ☑ too little energy intake leading to fatigue, exhaustion, or insufficient recovery;
- ☑ carbohydrate deficits leading to impaired intense physical capacity;
- ☑ insufficient hydration increasing dehydration risks and negative effects on performance.

These alerts help prevent performance drops and enable rapid adjustment of the dietary plan.

Monitoring progress and athletic parameters

U-NutriCoach enables tracking the athlete's evolution over time by entering and graphically displaying key indicators such as:

- ☑ body weight, body fat percentage, muscle mass, water percentage;
- ☑ heart rate, strength, speed, jump height (for sports like volleyball);
- ☑ sleep quality;
- ☑ results from effort tests;
- ☑ other configurable parameters depending on the sport or team goals.

The graphical monitoring section (weight, body composition, heart rate, strength, speed, sleep, etc.) offers an educational visual dimension: athletes can see the direct connection between nutrition, training, and performance evolution. Coaches can use these charts not only for analysis but also for instructional conversations: what changes occurred, what influenced them, and what adjustments are needed.

The charts generated by the app provide a clear overview of progress, helping the coach adjust training volume and intensity and identify when nutrition or recovery requires intervention.

The app gives coaches direct access to relevant chapters of the "Practical Guide on Sport-Specific Nutrition", so they can quickly consult the theoretical principles underlying the generated recommendations.

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ANNEXES

ANNEXES

Annex 1. Examples of lunch menus in sports canteens

Sports Club: "U" Cluj (Cluj, România)

Daily nutritional targets

Average nutritional values for athlets

GIRLS / BOYS, 1-2 TRAININGS/ DAY, VARIOUS SPORTS	
Kilocalories	~2 700 – 3 800 kcal
Carbohydrates	~430 – 640 g (~5 – 8 g/kg)
Protein	~110 – 180 g (~1,4 – 1,8 g/kg)
Fat	~80 – 110 g (~1 – 1,2 g/kg)

Recommended structure of the pre-training meal

30-35 % of total
~1000-1300 kcal | 150–200 g CHO | 40–60 g protein | 25-40 g fat

MEAL IDEAS

Note: All quantities refere to cooked products

OPTION 1	Quantity
Country-style vegetable soup with beef bone	400 ml
Bread	60 g
Oven-baked pork chop	50 – 100 g
Pasta with tomato sauce	200 – 300 g
Green salad	100 g
Fruit: apple	150 g
Semolina pudding with milk/fruit syrup	125 – 250 g

OPTION 2	Quantity
Meatball soup	400 ml
Bread	60 g
Oven-baked carp	100 – 200 g
Boiled potatoes	200 - 400 g
Cooked vegetables	100 g
Apple juice	300 – 350 ml

OPTION 3	Quantity
Bean soup with smoked meat	400 ml
Bread	60 g
Grilled turkey	50 - 100 g
Couscous	100 – 200 g
Baby carrots	100 g
Cabbage salad	100 g
Pasta pudding	100 – 200 g

OPTION 4	Quantity
Chicken noodle soup	400 ml
Chicken livers	50 - 100 g
Rice	200 – 300 g
Beetroot salad	100 g
Cocoa cake	100 - 150 g

OPTION 5	Quantity
Lentil cream soup	400 ml
Croutons	30 g
Chicken drumsticks	50 - 100 g
Rice pilaf	100 – 200 g
Mexican-style vegetables	100 – 200 g
Cabbage and carrot salad	100 g
Plain cake	100 - 150 g
Fruit: mandarins	100g

Annex 2. Examples of meals for athletes based on the mediterranean diet

Sports Club: OFI (Heraklion, Greece)

Daily nutritional targets

Average nutritional values for boys and girls.

1 TRAINING / DAY	
Kilocalories	~2.700 – 3 300 kcal
Carbohydrates	~420 – 490 g (~6 – 6,5 g/kg)
Protein	~115 – 130 g (~1,6 – 1,7 g/kg)
Fat	~85 – 90 g (~1,1 – 1,2 g/kg)

2 TRAININGS / DAY	
Kilocalories	~3.100 – 3.700 kcal
Carbohydrates	~500 – 600 g (~7 – 8 g/kg)
Protein	~115 – 130 g (~1,6 – 1,7 g/kg)
Fat	~90 – 100 g (~1,2 – 1,3 g/kg)

Pre-training meal

Boys (average weight 80 kg; average height 195 cm)	Girls (average weight ~70 kg; average height 180 cm)
~800–950 kcal 110–130 g CHO | 40–45 g protein | 25–30 g fat	~700–800 kcal 85–105 g CHO | 35-40 g protein | 20–25 g fat

Post-training meal

Boys (average weight 80 kg; average height 195 cm)	Girls (average weight ~70 kg; average height 180 cm)
~900–1.050 kcal 140–160 g CHO | 35–40 g protein |20-25 g fat	~750–950 kcal 105–140 g CHO | 30-35 g protein | 18–20 g fat

OPTION 1	Quantity
Pre-training meal (3-4 hours before training)	
Baked chicken	120 g (cooked)
Rice	250 g (cooked)
Wholegrain bread	1,5 slices (60 g)
Salad	200 g
Extravirgin olive oil	15 g
Fresh fruits	150 g
Post-training meal (2 hours after training)	
Turkey burger	150 g (cooked)
Oven-baked potatoes	300 g
Salad	100g
Extravirgin olive oil	15 g
Fresh fruits	300 g

OPTION 2	Quantity
Pre-training meal (3-4 hours before training)	
Wholegrain pasta	250 g (cooked)
Lean minced beef	80 g (cooked)
Tomato juice	200 ml
Wholegrain bread	1 slice (40 g)
Ricotta cheese	50 g
Salad	200 g
Extravirgin olive oil	10 g
Fresh fruits	150 g
Post-training meal (2 hours after training)	
Grilled beef steak	120 g (cooked)
White rice	250 g (cooked)
Salad	200 g
Extravirgin olive oil	15 g
Fresh orange juice	350 ml

OPTION 3	Quantity
Pre-training meal (3-4 hours before training)	
Lentils	120 g (cooked)
White fish	100 g (cooked)
Oven-baked potatoes	300 g
Wholegrain bread	40 g (1 slice)
Extravirgin olive oil	15 g
Fresh fruits	250 g
Post-training meal (2 hours after training)	
Chicken breast	100 g (cooked)
Roasted vegetables	200 g
White pasta	200 g (cooked)
White bread	40 g (1 slice)
Feta cheese	30 g
Extravirgin olive oil	10 g
Apple juice	350 ml

Annex 3. Examples of pre-exercise meals for junior athletes

Sports Club: Volleyball club DEYA Sport (Burgas, Bulgaria)

Daily nutritional targets

Average nutritional values for boys.

1 TRAINING / DAY	
Kilocalories	~4000 kcal
Carbohydrates	~620–650 g (~6,5-6,8 g/kg)
Protein	~170 g (~1,8 g/kg)
Fat	~110 g (~1,1 g/kg)

2 TRAININGS / DAY	
Kilocalories	~4.500 kcal
Carbohydrates	~700–800 g (~7,3-8,4 g/kg)
Protein	~170 g (~1,8 g/kg)
Fat	~110 g (~1,1 g/kg)

Recommended structure of the pre-training meal

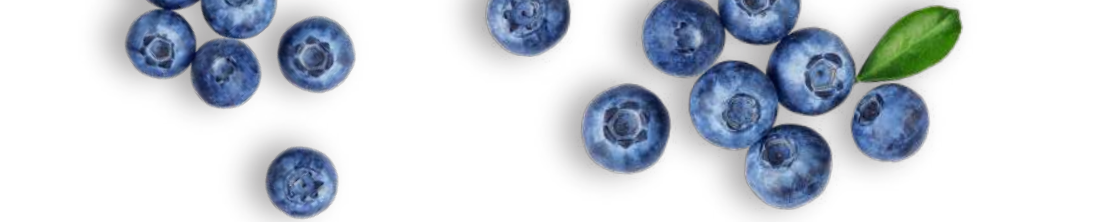
Boys (weight 90-100 kg; height 195-205 cm)
~1050-1300 kcal | 145–200 g CHO | 40–60 g protein | 15-25 g fat

MEAL IDEAS

Note: The indicated quantities are for 1 training session per day, boys.
Note: All quantities refere to cooked products.

OPTION 1	Quantity
Chicken soup	400 ml
Oven baked lean pork	100 g (cooked)
Peas in tomato sauce	300 g
Wholegrain bread	120 g (3 slices)
Fresh fruits	300 g

OPTION 2	Quantity
Spinach soup	350 ml
Croutons	60 g
Rice	250 g (cooked)
Chicken breast	100 g (cooked)
Roasted vegetables	200 g
Apple juice	350 ml



OPTION 3	Quantity
Tarator (yogurt and cucumber soup)	350 ml
Croutons	30 g
Potato and meat moussaka	400 g
Wholegrain bread	80 g (2 slices)
Fruit salad	300 g

OPTION 4	Quantity
Creamy lentil soup	350 g
Croutons	60 g
Pork chop	100 g (cooked)
Roasted potatoes	300 g
Green salad	200 g
Extravirgin olive oil	5 g
Oranges	300 g

OPTION 5	Quantity
Creamy vegetable soup	350 g
Croutons	60 g
Grilled turkey breast	100 g (cooked)
Bean stew	300 g
Rice pudding	250 g

OPTION 6 - Match day	Quantity
Tomato, cucumber and cheese salad with croutons	200 g
Grilled chicken breast	100 g (cooked)
Rice	250 g (cooked)
Roasted vegetables	100 g
Fruit yogurt	250 g

Annex 4. Digital tools and practical resources for coaches

Example of useful links and interactive resources

The resources listed below are provided solely for informational and educational purposes as examples of digital tools that may support nutrition monitoring, physical activity tracking, and health management. Their inclusion does not constitute endorsement, recommendation, sponsorship, or promotion by the authors, partner organisations, or the Erasmus+ Programme. The list is non-exhaustive and users are encouraged to independently assess the suitability, availability, privacy policies, costs, and functionalities of any digital tool before use.

Nutrition education

▪ AIS Sports Nutrition – https://www.ais.gov.au/nutrition
Practical, coach-friendly guides on sports nutrition and supplements.

▪ IOC Consensus Statements – https://www.olympics.com/ioc
Evidence-based recommendations in sports nutrition.

Hydration monitoring tools

▪ Urine colour chart (easy visual tool) – https://performancepartner.gatorade.com /content/resources/pdfs/hydration-color-scale.pdf
- A simple tool to assess hydration status based on urine colour.
- Pale yellow = well hydrated; dark colour = dehydration.

Supplements

▪ AIS Supplement Framework – https://www.ausport.gov.au/ais/nutrition/supplements#the-ais-sports-supplement-framework
Evidence-based classification of supplements.

Anti-doping and supplement safety

▪ World Anti-Doping Agency (WADA) – https://www.wada-ama.org
Official list of prohibited substances.

Food journals and nutritional tracking

▪ Cronometer — https://cronometer.com
Canadian nutrition tracking application focused on data accuracy, allowing detailed monitoring of macro and micronutrient intake. It enables meal logging and synchronization with various physical activity devices.

▪ Foodvisor — https://foodvisor.io
French nutrition app with food recognition through photography and personalized AI recommendations, useful for athletes for quickly assessing meals and optimizing nutritional intake.

▪ Lifesum — https://lifesum.com
An application originating from Europe (Sweden) appreciated for personalized that supports nutritional plans, meal recommendations, and integration with health data. Lifesum allows setting nutritional goals based on the type of sport and adjusting them based on progress.

▪ MyFitnessPal — https://www.myfitnesspal.com
An American Nutrition tracking application, widely used internationally, with a large food database and barcode scanning, allowing users to log meals, monitor calorie

and macronutrient intake, and synchronize data with other fitness platforms (egg. Garmin, Fitbit, Apple Health, Google Fit)

▪ MacroFactor / Macro Tracker – https://macrofactorapp.com/
An American Nutrition and macro tracking application that provides food logging, adaptive calorie targets, and data-driven progress analysis. It supports long-term nutritional planning without rigid rules and includes educational resources and regular feature updates.

▪ Yazio — https://www.yazio.com
An European (Germany) nutrition tracking application offering a food diary, personalized nutritional goals, and integration with health and activity platforms.

Integrated coaching and planning platforms

▪ HubFit — https://hubfit.com
Solution that allows coaches to create personalized nutrition and training plans, send notifications, and view athletes' progress from a single dashboard — ideal for teams and high-performance athletes.

▪ Trainerize — https://www.trainerize.com
Platform used by professional coaches to combine training and nutrition plans into a single ecosystem.

▪ TrainingPeaks — https://www.trainingpeaks.com
A platform used by athletes and coaches for planning, monitoring, and analyzing training sessions, with options for integrating physiological and performance data.

Physical monitoring connected with nutritional data

▪ Apple Health – https://apps.apple.com/us/app/apple-health/id1242545199
Centralize nutritional data, hydration, and other health information by syncing data from various tracking apps.

▪ Garmin ConnectTM
– https://apps.apple.com/ro/app/garmin-connect/id583446403
–https://play.google.com/store/apps/details?id=com.garmin.android.apps.connectmobile&pcampaignid=web_share
Synchronizes the data collected by Garmin watches and bracelets (heart rate, steps, physical activity), useful for correlating with the nutritional plan.

▪ Google Fit — https://www.google.com/fit
Health and activity tracking platform that can centralize data regarding steps, activity, sleep, and calorie intake from other nutritional applications, providing a complete picture of the user's condition

▪ Strava — https://www.strava.com
A platform used to track sports activities such as running and cycling, providing performance analysis features and synchronization with wearable devices.

Other complementary digital resources

▪ HeiaHeia — https://www.heiaheia.com/
Finnish platform for wellbeing and social activity that allows logging activity and progress, encouraging the formation of healthy habits (including nutrition through integration with other tools).

▪ WaterMinder — https://waterminder.com
An application for monitoring daily fluid intake, allowing users to set hydration goals and track progress in relation to physical activity

This guide includes photographs taken within the **“U” Cluj Canteen**, as well as images kindly provided by our partners — **Euphoria Biergarten**, **Ferma Steluța**, and **Panemar.** We extend our sincere appreciation to these partners for their valuable visual contributions.