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NUTRITION AND HYDRATION STRATEGIES IN ATHLETIC PERFORMANCE

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Abstract
Optimal nutrition and hydration are critical to enhancing athletic performance and ensuring effective recovery. For athletes, proper nutrition provides the necessary fuel for training and competition, while adequate hydration ensures the maintenance of fluid balance, preventing dehydration that can impair performance. This paper explores the vital role of nutrition and hydration strategies tailored for athletes, emphasising how specific dietary plans and fluid intake protocols can maximise performance outcomes. Key nutritional elements, such as carbohydrates, proteins, fats, vitamins, and minerals, are discussed in the context of their functions and timing relative to training and competition. The importance of hydration is also highlighted, detailing how maintaining proper fluid balance can prevent dehydration, reduce the risk of heat-related illnesses, and sustain high-level performance. Additionally, the paper examines how individual athlete needs vary based on factors like sport type, training intensity, and environmental conditions, underscoring the need for personalised nutrition and hydration plans. Through the synthesis of current research and practical applications, this provides a comprehensive understanding of how strategic nutrition and hydration interventions can contribute to optimal athletic performance and overall health. It was recommended that, Athletes should follow a periodized nutrition plan that includes a carb-rich pre-exercise meal, in-exercise fueling with easily digestible carbs, targeted recovery nutrition, and ongoing adjustments based on performance and individual needs.

Keywords: Athletic Performance, Euhydration, Hydration, Nutrition, Optimal, Strategies,

Introduction
Nutrition and hydration play a critical role in optimising athletic performance, influencing both physical capabilities and recovery processes. For athletes, proper nutrition provides the necessary fuel for training and competition, while adequate hydration ensures the maintenance of fluid balance, preventing dehydration that can impair performance. In Nigeria, where the climate is often hot and humid, the importance of these factors is even more pronounced. The physiological demands placed on athletes require well-structured

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nutrition and hydration strategies to sustain peak performance levels and avoid the detrimental effects of dehydration and inadequate nutrient intake.

Athletes in Nigeria, spanning various sports such as football, track and field, and many others, encounter unique challenges that make personalised nutrition and hydration strategies essential for optimal performance (Olaitan and Egbase, 2022). The country's vast geographical landscape, characterised by its diverse climate conditions, imposes significant physiological demands on athletes. In the northern regions of Nigeria, athletes often contend with extremely high temperatures, while those in the southern parts of the country face challenges associated with high humidity levels (Nasara, Muhammad, Haniffah, Bakar, Awhari, Sharrar & Shahid, 2025). These environmental factors create conditions that can significantly impact an athlete's performance, necessitating a tailored approach to both dietary and fluid intake. For athletes competing in such varying climates, a one-size-fits-all approach to nutrition and hydration is inadequate. Instead, there is a need for individualized plans that take into consideration the specific environmental conditions, the nature of the sport, and the individual physiological responses of the athletes. Research has indicated that in hot climates like those found in northern Nigeria, athletes are at a heightened risk of dehydration, which can lead to heat stress, a condition that can severely diminish athletic performance (Nasara et. al, 2025).

Importance of Optimising Athletic Performance

To perform at their best, athletes need to build a strong foundation. This involves regular conditioning and training, following a healthy diet, staying hydrated, and keeping their bodies flexible. On game day or during a big event, it's important to warm up and stay hydrated while eating the right foods to maintain energy levels. After the event, athletes should rest and recover to prevent muscle strain and fatigue (Molony and Fluger, 2024). Achieving peak performance in sports is a complex process influenced by a wide range of factors across multiple scientific disciplines, including genetics, bioenergetics, nutrition, physiology, biomechanics, psychology, tactics, health, and social sciences (Short, 2023). Optimising athletic performance is crucial for achieving success in competitive sports, enhancing the well-being of athletes, and advancing the overall sports industry (Olawale and Alabi, 2018; Akinyele, 2019).

Optimising performance plays a crucial role in injury prevention. Proper training and conditioning tailored to an athlete's needs can significantly reduce sports-related injuries (Owoeye, Akinbo, Olawale and Tella, 2016). Effective training cycles help athletes peak at the right time, minimise injury risk, and develop necessary traits for their sport. A well-structured recovery plan, combined with detailed macro, meso, and micro cycles, ensures athletes reach their full potential (Zheng, 2024).

The Role of Macronutrients in Athletic Performance

Macronutrients play a critical role in the overall health and performance of athletes, serving as the foundational elements for energy production, muscle building, and recovery. The three primary macronutrients: carbohydrates, proteins, and fats; each contributes uniquely to an athlete's nutritional needs, supporting various aspects of physical performance and well-being. There is no question that macronutrients play a crucial role in sports health. Athletes who do not get enough macronutrients are more likely to suffer from fatigue or

injury, lose muscle mass, and experience a decrease in performance. It is therefore important that young athletes get the right mix of macronutrients (Okon, 2023).

Carbohydrates

Carbohydrates are the body's primary energy source, especially during high-intensity activities, as they provide the necessary fuel for muscles during exercise. A diet rich in carbohydrates ensures that athletes have adequate glycogen stores, which are essential for sustaining endurance and power output during prolonged or intense physical activities (Ismardi, Rahman, Rifki, Welis, Okilanda and Ockta, 2024). Performance during sports which involve several brief sprints may not be improved by carbohydrate loading. Sports which demand that their participants perform a combination of submaximal running and brief periods of sprinting, such as soccer, reduces muscle glycogen concentrations to critically low values. Performance is impaired when this occurs, and so carbohydrate loading would probably be of benefit to participants in multiple-sprint sports.

Fats

Fat is a crucial fuel source for muscles during endurance exercises, though it is not ideal for quick energy bursts. As athletes improve, they become more metabolically efficient, using stored fat at lower intensities to maintain performance. For instance, a 150-pound athlete with 6% body fat has around 1,500-2,000 calories in stored carbohydrates but over 45,000 calories in fat reserves. While carbohydrates are still vital, fat plays a key role in endurance events. The U.S. Anti-Doping Agency (2024) recommends that athletes consume 20 to 35 per cent of their calories from fat.

Substitutions for Reducing Fat Intake

Instead of:	**Try:**
Plain milk	Kefir, ultra-filtered milk
Ice cream	Higher protein ice cream, avocado ice cream, 100% real fruit popsicles
Butter or margarine	Avocado, nut butters, Greek yogurt, olive oil, hummus
Sour cream	Plain Greek yogurt
Bacon	Canadian or turkey bacon
Ground beef	Extra lean ground beef or ground turkey (at least 93% lean)
Fried chicken	Baked chicken
Doughnuts and pastries	Whole-grain breads, homemade breads
Apple pie	Baked or raw apple
Cookies, cakes, or brownies	Peanut butter pretzels, dried fruit, trail mix

Source: (U.S. Anti-Doping Agency, 2024)

Proteins

Proteins are made up of amino acids, and these proteins and amino acids are the main building blocks of the muscles, bones, skin, tissues and organs. When consumed, protein breaks down into individual amino acids during digestion and then uses these amino acids to create new proteins throughout the body. It is essential to consume an adequate amount of protein; otherwise, the body will have to break down muscle to obtain the amino acids that it needs to function (Ryan, 2024). Phillips and Van Loon (2011) stated that, proteins are vital for muscle repair, recovery, and growth, particularly following exercise when muscle fibers undergo stress and damage. Consuming adequate protein helps in the synthesis of new muscle tissues and supports overall muscle maintenance, making it a key macronutrient for athletes focused on strength and recovery.

Micronutrients and their Impact on Athletic Performance

Micronutrients are essential for the body's optimal metabolic functions, including energy production, muscle growth, and recovery, all of which are crucial for sports performance. Their importance in athletic performance should not be overlooked, as athletes may often consume insufficient amounts of these vital nutrients due to poor dietary habits, especially if their intake doesn't align with their physical activity levels. Ensuring adequate micronutrient intake can give athletes a competitive edge, enhancing the effectiveness of their training. Proper levels of micronutrients can boost mental performance, help regulate hormones, and maintain peak cognitive function (Ghazzawi, Hussain, Raziq, Alsendi, Alaamer, Jaradat, Alobaidi, Al Aqili, Trabelsi and Jahrami, 2023).

Vitamins

Vitamins are organic essential compounds that cannot be synthesized by the human body. They play a vital role in numerous functions that are relevant to the athlete’s performance. Their functions are evident in co-enzymes, hormones, and autoxidation, as well as their contribution to energy production and serving as essential cofactors in various biochemical pathways that convert food into usable energy. These micronutrients are involved in the breakdown of carbohydrates, fats, and proteins, which are the primary sources of energy for the body (Gibson, Ashwell and Elton, 2021). There are thirteen various kinds of vitamins currently divided into two major groups due to their chemical and biological functions, four of which are fat-soluble vitamins (FSV) including vitamins A, D, E, and K, and the rest are water-soluble vitamins (WSV) including B complex vitamins and vitamin C (Mason, Trewin, Parker, and Wadley, 2020; Ghazzawi et al. 2023).

Fat-Soluble Vitamins

Vitamin A (Liver, **egg yolks**, **carrots**, **sweet potatoes**, **pumpkin**)

Vitamin A plays a significant role in promoting overall well-being and athletic performance by aiding in the formation of healthy tissues, improving oxygen access, and supporting vision, skin health, and immune system functioning. As a potent antioxidant, vitamin A helps neutralize free radicals generated during intense physical activity, potentially preventing conditions like heart failure and muscle damage. Consuming sufficient vitamin A, through sources like beef liver, eggs, and leafy greens, or through multivitamin

supplements, can enhance reaction time, muscle recovery, and protect against injuries by promoting healthy connective tissue formation (Carlsohn, Braun, Großhauser, König, Lampen, Mosler, Nieß, Oberritter, Schäbethal, and Schek, 2020).

Vitamin D (Salmon, sardines, tuna, cod liver oil, egg yolks, beef liver)

Vitamin D plays a crucial role in hormone synthesis, calcium homeostasis, bone health, and the improvement of the immune and musculoskeletal systems. It can be obtained through dietary sources like dairy products, egg yolk, and fatty fish, as well as synthesized in the body through sunlight exposure. Vitamin D supplementation can enhance athletic performance, improving metrics such as speed, muscle power, and strength. For optimal vitamin D levels, athletes are encouraged to combine sun exposure with a diet rich in vitamin D (Most, Dörr, Nef, Hamm, Bauer and Bauer, 2021).

Vitamin E (Almonds. spinach, avocados, mangos, kiwi)

Vitamin E plays a key role in protecting athletes' bodies and can enhance both performance and recovery. Intense exercise and overtraining lead to the production of reactive oxygen species (ROS), which can help muscles adapt to exercise by boosting the body's natural antioxidant defences. However, when ROS build up too much and the body can't clear them effectively, it can cause damage to cells, leading to fatigue, slower recovery, and reduced performance (Kim, Park, Kuo and Park, 2019).

Vitamin K (Turnip greens, broccoli, cabbage, basil, liver)

Vitamin K is a vital nutrient primarily known for its role in blood coagulation, ensuring that the blood clots properly to prevent excessive bleeding. This vitamin is critical for synthesising proteins required for the clotting process, making it essential for overall health and well-being. Beyond its well-established role in coagulation, emerging research highlights the broader benefits of vitamin K, particularly in bone health and cardiovascular function (Guo, Zhou, Gong, Hu and Liu, 2024).

Water-Soluble Vitamins

Vitamins B

Vitamins B are vital in this process. These vitamins work by helping enzymes catalyze the chemical reactions necessary for energy production, thereby enabling athletes to sustain prolonged physical activity and recover effectively (Gibson, Ashwell and Elton, 2021). These vitamins help in managing stress, anxiety, and muscle recovery, while also reducing fatigue, which can negatively impact athletic performance. Additionally, they assist in regulating blood pressure and maintaining a healthy sleep schedule by controlling melatonin levels, which is important for athletes to ensure quality rest (Ghazzawi et al. 2023).

Each B vitamin has specific roles:

i. **Thiamine (B1)** is necessary for carbohydrate metabolism, neurotransmitter synthesis, and energy production. It is found in foods like whole grains and nuts. Deficiency can lead to decreased energy production and impaired exercise capacity.
ii. **Riboflavin (B2)** supports energy production and is found in foods like almonds, beef liver, and eggs. It is essential for optimal exercise performance.
iii. **Niacin (B3)** is involved in energy metabolism and can lower cholesterol levels. It is found in foods like meat, whole grains, and dairy products. However, excessive niacin during exercise can reduce performance.
iv. **Pantothenic Acid (B5)** plays a role in aerobic energy systems and is widely available in the diet. It contributes to energy production, though supplementation has not shown a significant impact on performance.
v. **Pyridoxine (B6)** is involved in muscle growth, strength, and neurotransmitter synthesis. It can reduce anxiety and improve motor skills when combined with other B vitamins.
vi. **Cyanocobalamin (B12)** is important for DNA synthesis, brain function, and serotonin production. It may enhance cognitive function and reduce anxiety, which can benefit athletes in sports requiring focus.
vii. **Folic Acid (B9)** aids in DNA and red blood cell synthesis, enhancing oxygen supply to muscles during exercise. However, supplementation has not shown a performance benefit in athletes with adequate folate levels.

Vitamin C

Vitamin C, also known as ascorbic acid, is a vital nutrient found in various foods such as oranges, strawberries, broccoli, and sweet potatoes (Hunt and Maggini, 2015). Vitamin C is integral to wound healing and collagen production, both of which are crucial for maintaining the strength and integrity of joints and muscles, which is vital for athletic success. Vitamin C acts as a cofactor in the production of collagen by stabilising its structure and enhancing collagen gene expression in fibroblasts, thereby contributing to tissue repair and recovery (Al-Nasiry, Geusens, Hanssens, Luyten and Pijnenborg, 2007).

Minerals: Supporting Muscle Function and Recovery

In athletic performance, minerals play physiological roles in muscle contraction, normal heart rhythm, oxygen transport, antioxidant activity, bone health, and immune function (Balchem Corp, 2021). They are crucial for energy production during exercise, muscle contraction, and nerve impulses. They act as catalysts for metabolism, aiding in the digestion of proteins, fats, and carbohydrates, and help absorb nutrients while protecting the body from disease. Minerals also play a vital role in hormone balance and serve as natural buffers for the body's acid-base balance. They are essential for bone health and provide protection against muscle and joint pain, making them integral to athletic performance and recovery (Acko, 2024). Key minerals for athletic performance and recovery includes:

Calcium

Calcium (Ca) is vital for athletes as it helps maintain muscle contractions, which are crucial for optimal performance. It also supports normal heart rhythm and healthy bones. Calcium can lead to muscle spasms and fatigue after exercise, impairing performance. Athletes need

adequate dietary calcium, which can be obtained from dairy products like milk, yoghurt, and cheese, fortified soy milk, calcium-set tofu, and dark green vegetables.

Magnesium

Magnesium (Mg) is essential for muscle contractions, nerve function, and regulating the body's acid-base balance. It plays a role in energy metabolism and aids in the metabolism of carbohydrates and proteins, crucial for optimal pre-exercise performance. Magnesium also helps prevent exercise-induced muscle cramps and reduces muscle fatigue after exercise. Foods rich in magnesium include dark green vegetables, nuts and nut butters, legumes, tofu, seeds, and whole grains.

Zinc

Zinc (Zn) is vital for regulating carbohydrate and protein metabolism and is involved in the synthesis of hormones like testosterone. It is important for muscle repair and tissue growth, protecting against exercise-induced muscle soreness, reducing fatigue, and enhancing immune system function. Foods high in zinc includes shellfish, dairy products, nuts, seeds, and whole grains. To ensure adequate intake of these essential minerals, athletes should consume a balanced diet rich in fruits, vegetables, dairy, and whole grains.

Manganese

Manganese (Mn) is a mineral gaining recognition for its potential benefits to athletes. It is essential for various bodily functions, including energy production, bone formation, and enzyme activity. Manganese helps break down carbohydrates, proteins, and fats, aiding in efficient energy utilisation, which can improve endurance during prolonged workouts. It also supports the production of neurotransmitters that enhance mental focus and coordination. Manganese plays a crucial role in bone health, helping to develop strong bones, which is vital for injury prevention and recovery in athletes.

Selenium (Se)

Selenium (Se) is a beneficial mineral for athletes, known for its antioxidant properties that protect against cell damage, enhance endurance, and improve overall performance. It also supports mental focus and reduces inflammation, aiding in quicker recovery and lowering injury risks. Selenium boosts the production of glutathione peroxidase, an enzyme that combats oxidative stress, which is crucial during intense exercise.

Iron

Iron is of critical importance for athletic or sports performance. It is a component of haemoglobin, myoglobin, cytochromes, and other enzymes in the muscle cells. All of these substances are involved in the transport and metabolism of oxygen for energy required for aerobic performance during endurance exercises. Iron-rich foods include red meat, spinach, lentils, and fortified cereals. (Balchem Corp, 2021).

Potassium

When it comes to athletes' health and performance, one mineral that is essential to success is potassium (K). It has a crucial role in muscle contractions and helps the body regulate fluid balance, blood pressure, and the heart rate. It is also involved in nerve functions and proper electrolyte balance, which may be beneficial to athletes who may be sweating during a long practice or game. Proper potassium levels can help prevent injuries and help athletes maintain their energy levels (Hinsinger, 2020).

Hydration Needs for Athletes

It is important to recognise that fluid needs vary among individuals based on factors such as body size, sweat rate, exercise intensity, and environmental conditions. Hydration is crucial for all athletes as it helps delay fatigue and supports optimal performance. It's especially important for those involved in activities lasting longer than an hour. Athletes participating in extreme heat or cold conditions may require increased hydration to meet their body's needs. (Ashton, Jill, Klufa, Kroll & Wollenberg, 2021). Getting enough to drink before, during and after a sport or activity is essential. For every hour of activity, people can lose up to 2 quarts of fluid, and salt along with it. Endurance activities, such as distance running and intense hiking and bicycling, can drain up to 3 quarts per hour. Hydration during a game, tournament or workout, not just before and after, can fall below the radar of an athlete and their trainer, but performance depends on it (Rayven, 2024).

Effects of Dehydration on Performance

Fatigue toward the end of a prolonged sporting event may result as much from dehydration as from fuel substrate depletion. Dehydration negatively affects various physiological functions, which are crucial for athletic performance. When the body loses more fluids than it takes in, blood volume decreases, leading to reduced cardiac output and impaired circulation. This results in a lower supply of oxygen and nutrients to the muscles, causing fatigue to set in more quickly. Additionally, dehydration can impair cognitive function, affecting an athlete's decision-making and reaction times during competition (Jeukendrup and Gleeson, 2024).

Exercise performance is impaired when an individual is dehydrated by as little as 2% of body weight. Losses over 5% of body weight can decrease the capacity for work by about 30% (Nwankwo, 2018). This underscores the importance of fluid balance in maintaining peak performance levels. Also, Casa, Armstrong, Hillman, Montain, Reiff, Rich, Roberts, and Stone (2010), highlighted that as little as 2% dehydration can result in a noticeable decrease in physical performance, particularly in endurance-based activities. Dehydration also impacts cognitive function, leading to impaired decision-making, reduced concentration, and slower reaction times, all of which are detrimental in sports that require quick thinking and precision.

Dehydration decreases a person's VO2max and impairs work capacity in fatiguing exercise of an incremental nature. Dehydration causes a fall in plasma volume both at rest and during exercise, and a decreased blood volume increases blood thickness (viscosity), lowers central venous pressure, and reduces venous return of blood to the heart. During maximal exercise, these changes can decrease the filling of the heart during diastole (the phase of the cardiac cycle when the heart is relaxed and is filling with blood before the next

contraction), hence, reducing stroke volume and cardiac output. Also, during exercise in the heat, the opening up of the skin blood vessels reduces the proportion of the cardiac output available to the working muscles (Jeukendrup & Gleeson, 2024).

Personalised Nutrition and Hydration Strategies

As athletes strive to push the boundaries of their physical capabilities, personalised nutrition and hydration strategies have emerged as critical components in optimising performance, recovery, and overall well-being. Unlike generic dietary guidelines, personalised approaches take into account the unique physiological needs, metabolic profiles, and specific goals of individual athletes. This tailored approach is increasingly recognised as essential, given the diverse demands of different sports, training intensities, and environmental conditions.

Personalised nutrition is crucial for addressing the unique energy, macronutrient, and micronutrient needs of athletes, which vary based on factors like age, sex, body composition, and metabolism. For example, endurance athletes may need more carbohydrates for energy, while strength athletes benefit from higher protein intake for muscle repair (Stellingwerff, Morton and Burke, 2019). Personalised hydration is equally important, helping to prevent dehydration and electrolyte imbalances by considering factors like sweat rate, environmental conditions, and individual fluid responses, ensuring athletes maintain peak performance (Cheuvront and Kenefick, 2014).

Tailoring diet and fluid intake based on the specific demands of a sport not only enhances performance but also reduces the risk of injury and promotes overall athlete well-being. As sports science continues to evolve, the importance of individualised nutrition and hydration strategies will likely become even more pronounced, helping athletes achieve their full potential.

Pre-Competition Nutrition and Hydration

Proper fuel and hydration before an athletic event are essential for maximising performance and endurance. The main goal of pre-event nutrition is to optimise glycogen stores, maintain stable blood glucose levels, and ensure adequate hydration. Carbohydrates are the most important nutrient for pre-event fueling, as they provide readily available energy for high-intensity exercise. A balanced meal with carbohydrates, moderate protein, and minimal fat should be consumed 3-4 hours before the event to allow for digestion and absorption (Burke, 2015). For events lasting over 90 minutes, a small carbohydrate snack or sports drink 30-60 minutes before can help sustain energy levels (Thomas, Erdman and Burke, 2016).

Proper hydration is crucial for pre-event preparation, as even mild dehydration can impair performance. The American College of Sports Medicine (ACSM) in 2007 recommends that, athletes start hydrating at least 4 hours before activity, aiming for about 5-7 mL per kilogram of body weight. If dehydration is detected, an additional 3-5 mL per kilogram is advised two hours before the event, potentially using sodium-containing drinks to enhance fluid retention. The International Society of Sports Nutrition (ISSN) in 2018,

suggests drinking 500 mL of water or a sports drink the night before, another 500 mL upon waking, and 400-600 ml 30 minutes before exercise (Sawka et al., 2007; Kerksick, Wilborn, Roberts, Smith-Ryan, Kleiner, Jäger and Kreider, 2018).

Intra-Competition Nutrition and Hydration

Intra-competition nutrition and hydration are critical elements for optimising athletic performance and maintaining health during sports events. Proper management of these factors helps athletes sustain energy levels, delay fatigue, and enhance overall performance. During competition, athletes should:

Carbohydrate Intake: Consuming easily digestible carbohydrates during competition helps maintain blood glucose levels and provides quick energy. This can include sports drinks, energy gels, or bars. For endurance events, athletes often consume 30-60 grams of carbohydrates per hour (Jeukendrup and Killer, 2010).

Hydration: Maintaining fluid balance is crucial. Athletes should drink fluids regularly to replace losses from sweat and prevent dehydration. Water is sufficient for short events, but for longer or more intense competitions, drinks with electrolytes (sodium, potassium) are recommended to replace lost electrolytes and maintain hydration status (Casa et al., 2000). For prolonged events, include carbohydrates in the beverage at a concentration of 6–8% to help sustain energy levels Drink 4-8 ounces of cold fluid during event at 15–20-minute intervals.

Electrolyte Replacement: Sodium and other electrolytes help retain fluid and prevent cramping. Sports drinks often contain these electrolytes, and their inclusion in the diet during competition can help maintain performance and prevent hyponatremia (Maughan and Shirreffs, 2004).

Timing: It's important to plan nutrition and hydration around the competition schedule. Consuming a small snack or meal 1-2 hours before the event can provide sustained energy. During the competition, athletes should take in small amounts of carbohydrates and fluids at regular intervals rather than consuming large amounts at once.

Hydration Guidelines During Activity

According to the U.S. Anti-Doping Agency (2023), the following guidelines for maintaining body fluid balance, improving performance in the heat, and preventing heat-related illness appear to be prudent based on current scientific knowledge.

1. For intense training and long workouts, a fluid replacement drink containing carbohydrates may provide an important source of energy. A 6-8 per cent carbohydrate beverage is typically most effective in maintaining fluid balance while supplying the muscles with fuel.
2. The fluid consumed during activity should contain a small amount of sodium and electrolytes. The sodium may be beneficial for quicker absorption and replacement of sweat loss.
3. The beverage should be palatable and taste good.

4. The athlete should drink 7-12 ounces of cold fluid about 15-30 minutes before workouts. If the workout is prolonged, add carbohydrates to the beverage at a 6-8 per cent concentration.
5. Drink 4-8 ounces of cold fluid during exercise at 15–20-minute intervals.
6. Start drinking early in the workout because thirst does not develop until 2 per cent of body weight has been lost, by which time performance may have begun to decline.
7. Avoid carbonated drinks, which can cause gastrointestinal (GI) distress and may decrease the volume of fluid consumed.
8. Avoid beverages containing caffeine, alcohol, and those promoted as energy drinks.
9. Athletes should take sports drinks. Sports drinks containing electrolytes can also be beneficial, particularly during prolonged exercise, as they help replace sodium and other electrolytes lost through sweat.

Post-Competition Recovery Nutrition

Post-competition recovery nutrition is vital for optimising recovery and preparing athletes for future performance. After training or competition, there is fatigue accumulation and a reduction in sports performance. In the hours and days following training, the body recovers and performance is expected to return to normal or improve. To improve comprehension regarding the nutritional strategies that impact post-exercise recovery, a mnemonic entitled the 4R's (Rehydrate, Refuel, Repair, and Rest) is presented (Bonilla, Pérez-Idárraga, Odriozola-Martínez and Kreider, 2020).

1. **Rehydrate**

One of the primary goals during recovery is to replenish any fluid and electrolyte losses. Most physically active individuals experience significant sweating, which varies based on exercise intensity, duration, and environmental factors like altitude, heat, and humidity. Rehydration is especially crucial in team sports, endurance, or ultra-endurance events where it is often difficult to fully replace fluids and electrolytes, such as sodium and potassium, lost during exercise, particularly in hot and humid conditions.

Rehydration can take anywhere from four to 24 hours. If there is sufficient recovery time, consuming sodium-rich foods such as crackers, peanuts, bread, milk, cheese, ham, kabanos, and soups may be adequate to restore euhydration. However, if the recovery period is less than 12 hours, more aggressive rehydration strategies, including the use of hydrating beverages like those containing glycerol, may be necessary before the next training session or competition (Kavouras, Armstrong, Maresh, Casa, Herrera-Soto, Scheett and Kraemer., 2006).

2. **Refuel**

After exercise, effective recovery strategies are crucial, particularly when training multiple times a day or competing on consecutive days. Key factors include training status, schedule, glycogen depletion, and exercise type. Consuming 1.0-1.5 grams of carbohydrates per

kilogram of body weight within 30 minutes to 2 hours post-exercise is recommended for muscle glycogen replenishment (Ivy, 2001). High-glycemic carbohydrates, like fruit juices or sports drinks, are especially effective for rapid recovery. The amount needed depends on factors such as time until the next session, nutritional periodisation, muscle repair needs, and overall dietary requirements (Jeukendrup, 2017).

3. **Repair**

Protein is essential for muscle repair after intense exercise. During digestion, proteins break down into amino acids, which are crucial for repairing and strengthening muscles, tendons, bones, and other tissues. Protein synthesis, the process of binding amino acids to these tissues, is key to recovery. Consuming 20-25 grams of high-quality protein post-exercise is recommended to stimulate muscle repair and support recovery, especially when combined with carbohydrates (Jentjens and Jeukendrup, 2003). Elite athletes often track weight loss during training, using it to determine fluid intake, with 1.5 liters of water recommended for each kilogram lost.

4. **Rest**

Sleep is undeniably a crucial physiological function and plays a pivotal role in post-exercise recovery. It is one of the most important factors influencing an athlete's ability to recover and perform optimally. Adequate sleep not only aids in the physical repair of muscles but also contributes to mental recovery, which is essential for overall well-being and peak performance (Fullagar, Skorski, Duffield, Hammes, Coutts, & Meyer, 2015) Sleep supports the body's ability to repair tissues, regulate hormones, and maintain energy balance, all of which are critical factors in preventing injuries and ensuring sustained athletic performance (Mah, Kezirian & Dement, 2011).

Rehydration Strategies after Exercise

Rehydration is a critical component of post-exercise recovery, particularly for athletes who lose significant amounts of fluid and electrolytes through sweat. Effective rehydration strategies help restore fluid balance, replenish lost electrolytes, and support overall recovery, ensuring athletes are ready for subsequent training sessions or competitions.

Timing and Quantity of Fluid Intake: Rehydration should begin as soon as possible after exercise. It is generally recommended that athletes consume 1.5 litres of fluid for every kilogram of body weight lost during exercise. This accounts for ongoing fluid losses through urine and helps to restore hydration status more effectively.

Electrolyte Replacement: Rehydration is not just about replacing lost fluids; it's also crucial to replace electrolytes, particularly sodium and potassium, which are lost in sweat. Consuming beverages that contain electrolytes or eating sodium-rich foods like salted nuts, crackers, or sports drinks can help maintain the body's electrolyte balance, preventing issues such as cramping and hyponatremia.

Beverage Choice: While water is effective for general rehydration, in cases of intense or prolonged exercise, sports drinks or other beverages containing electrolytes are often more

beneficial. These drinks not only replenish fluids but also provide essential electrolytes and carbohydrates that can enhance glycogen replenishment and overall recovery.

Glycerol Supplementation: For situations where rapid rehydration is necessary, such as when there's limited time between training sessions or competitions, glycerol supplementation may be used. Glycerol can enhance fluid retention and improve the rate of rehydration. However, it should be used under professional supervision to avoid potential side effects, such as gastrointestinal discomfort.

Monitoring Hydration Status: Athletes should monitor their hydration status by checking the colour of their urine, with lighter colours indicating better hydration. Weighing themselves before and after exercise can also provide a practical measure of fluid loss, helping to guide rehydration strategies.

Environmental Considerations: Rehydration strategies should be adjusted based on environmental conditions. In hot and humid environments, where sweat rates are higher, more aggressive rehydration efforts may be necessary. Conversely, in cooler conditions, fluid requirements may be lower, but hydration should still be prioritised.

Conclusion

In conclusion, tailored nutrition and hydration are essential for athletes to optimize performance, recovery, and health. Pre-exercise, athletes should focus on carbohydrates, moderate protein, and sufficient hydration. During exercise, especially endurance events, maintaining energy and hydration with easily digestible carbs and fluids, including electrolytes, is crucial. Post-exercise, replenishing glycogen, repairing muscles with carbs and protein, and rehydrating with electrolyte-rich fluids are key to effective recovery.

Recommendations

Based on the review, the following recommendations were made:

1. Athletes should prioritise consuming a balanced meal 3-4 hours before exercise, focusing on carbohydrates to maximise glycogen stores, moderate protein to support muscle maintenance, and low-fat content for easier digestion.
2. During exercise, particularly in endurance and ultra-endurance events, it's essential to maintain energy levels by consuming easily digestible carbohydrates such as sports drinks, gels, or energy bars.
3. Recovery nutrition should focus on replenishing glycogen stores, repairing muscle tissue, and rehydrating the body.
4. Coaches and athletes should implement nutritional periodisation, aligning dietary intake with different training phases.

5. There should be a regular monitoring and adjustments in the nutrition and hydration strategies for athletes based on their performance outcomes, recovery markers, and individual feedback.

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