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Review Article

Effect of Nutrition on Women Athletic Performance

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Abstract

Today's high performing athletes are more aware of the benefits of carefully structuring their food and fluid intakes to enhance daily training, assist recovery and optimize competition performance. A balanced diet is important for improved sports performance and for health. There are few published studies involving nutritional interventions in athletes, and due to the different methodologies used, the results are inconsistent. The objective of the present study is to focus on the effect of a nutritional intervention in athlete's body composition, eating behavior and nutritional knowledge. The purpose of the food we eat is to provide a variety of nutrients. If these nutrients are not present in our food in sufficient amounts, the result is ill health. Important nutrients include Carbohydrate, Proteins, Lipids, Vitamins, Minerals, and water. Athletes should strive to maintain optimal mineral status through a balanced diet rich in fruits, vegetables, whole grains, lean proteins, and dairy products. In some cases, supplementation may be necessary, especially for athletes at risk of deficiencies or with increased nutrient needs due to intense training and competition. Practical applications and recommendations for sports nutrition encompass a wide range of strategies aimed at optimizing athletic performance, supporting recovery, and promoting overall health and well-being. Recognize that nutrition needs vary among athletes based on factors such as age, gender, body composition, training intensity, and sport-specific demands. Tailor nutrition plans to meet individual goals, preferences, and dietary restrictions, considering personal preferences, cultural considerations, and lifestyle factors. However, individual mineral requirements may vary based on factors such as age, gender, training load, and environmental conditions, so it's essential for athletes to consult with a sports nutritionist or healthcare provider for personalized recommendations. By understanding the potential benefits and risks of nutritional supplements and making informed choices, athletes can optimize their performance while minimizing potential health risks.

Keywords: Macronutrients; Micronutrients; Supplements; Post-Exercise Nutrition; hydration; Fitness

Introduction

Knowledge about the effect of eating habits for elite athlete performance developed cross time, nutrition considering as the body fuel for both sport performance and recovery. The need to be vigilant and conscious of both food intake and quality on an individual basis. Sports nutrition has developed greatly over the years. Today's high performing athletes are more aware of the benefits of carefully structuring their food and fluid intakes to enhance daily training, assist recovery and optimize competition performance.

A balanced diet is important for an improved sports performance and for health. During exercise, athletes may suffer from the depletion of glycogen stores, dehydration and muscle damage. Thus, the ingestion of nutrient rich foods (lean meat/milk, fruits, vegetables and complex carbohydrates) and water may improve thermoregulation, enhance energy stores, maximize muscle protein synthesis and provide the supply of vitamins and minerals [1].

Although the importance of adequate nutrition has been well established [2], many athletes have shown several nutritional inadequacies [3]. Some authors have suggested that the dietary errors found in an athletic population may be due to low levels of nutritional knowledge and a lack of adequate nutritional counselling [4].

One strategy to improve the nutrition knowledge of athletes and coaches could be tailored nutrition programs. In the 1990s, some universities settled upon nutritional educational programs linked to their own sports department [5]. More recently, other nutritional interventions have also been developed [6]. However, these programs did not have their effectiveness evaluated, and they reflect a different reality from which most athletes are exposed, as they have extensive protocols and are dependent on a multi-disciplinary team.

There are few published studies involving nutritional interventions in athletes, and due to the different methodologies used, the

results are inconsistent. Collison [7] did not find changes in the dietary intake of athletes, after participating in two nutritional workshops. In contrast, Carmo, Marins and Peluzio [8] observed a significant reduction in the dietary fat intake and the body fat percentage in Jiu-Jitsu athletes, after nine months of nutritional counselling.

Adolescent athletes are at a high nutritional risk because of the high energy cost of training. In addition, several nutrients are needed for the processes of growth and development. Proteins are needed to maximize muscle protein synthesis, calcium and vitamin D are important in the development and maintenance of skeleton, essential fatty acids may provide energy to support the growth and maturation, iron would prevent adverse athletic performance due to suboptimal iron stores, and so forth [9]. Nonetheless, few studies have studied nutritional interventions in this type of population, and most of them have only focused on improving the athlete's hydration practices [10] or their nutritional knowledge [11]. It is necessary to investigate this type of program in order to develop specific strategies to these individuals.

The field of sports nutrition is the most innovative and dynamic of all sport sciences. It makes perfect sense to be well informed in this very specialized field. The Complete Guide to Food for Sports Performance provides an up to-date, informative insight into various sports for athletes, coaches and administrators alike. In this context, the objective of the present study is focusing on the effect of a nutritional intervention in athlete's body composition, eating behavior and nutritional knowledge. Our secondary aim is to compare the effect of the nutritional intervention between adult and adolescent athletes.

Athletic nutrition

The primary purpose of the food we eat is to provide us with a variety of nutrients. If these nutrients are not present in our food in sufficient amount, the result is ill health. Important nutrients include Carbohydrate, Proteins, Lipids, Vitamins, Minerals, and water. That means there are six major classes of essential nutrients found in foods. Food also contains many other substances, which are non–nutrients e.g., coloring, and flavoring substances in food [12].

This is the science of food values. It is relatively a new science, which evolved from chemistry and physiology. The effect of food in our body is explained in nutrition. In other words, nutrition is defined as the sum of the processes involved when you take in food in the body involving their action, interaction, and balance in relationship to health and diseases, the process by which the organism ingests, digests, absorbs, transport and utilizes nutrients and dispose of their end products [13].

Macronutrients and athletic performance

Carbohydrates

Carbohydrates play a pivotal role in providing energy for exercise, particularly during high-intensity activities. Glycogen, stored primarily in muscles and the liver, serves as a readily available source of glucose for energy production during physical exertion. Optimizing glycogen stores is crucial for enhancing athletic performance, especially in endurance events. Strategies such as carbohydrate loading, involving a combination of high-carbohydrate intake and tapering of exercise, can effectively increase glycogen stores and improve endurance capacity [14].

Individual carbohydrate requirements vary based on factors such as training volume, intensity, and metabolic efficiency. Current recommendations suggest intake levels ranging from 6 to 10 grams per kilogram of body weight per day for endurance athletes, with adjustments made according to individual needs and performance goals [15].

Carbohydrate supplementation during exercise can improve performance by sustaining blood glucose levels and delaying fatigue. Consuming carbohydrates in the form of sports drinks, gels, or chews during prolonged activities helps maintain energy levels and optimize performance [16]. Post-exercise carbohydrate consumption is essential for replenishing glycogen stores and facilitating muscle recovery. Co-ingestion of carbohydrates with protein accelerates glycogen resynthesis and promotes muscle repair and adaptation [17].

Athletes exhibit varying responses to carbohydrate intake due to genetic, metabolic, and training-related factors. Genetic polymorphisms, such as variations in genes related to carbohydrate metabolism, can influence an individual's carbohydrate requirements and performance outcomes [18].

Low carbohydrate and ketogenic diets have gained attention in the sports community, primarily for their potential to enhance fat oxidation and metabolic flexibility. However, the impact of these diets on high-intensity exercise performance remains a topic of debate, with some studies suggesting impairments in glycogen-dependent activities [19].

Future research in sports nutrition is exploring innovative approaches to carbohydrate periodization, personalized nutrition, and alternative carbohydrate sources. Advances in technology, such as metabolomics and nutrigenomics, offer opportunities to tailor carbohydrate intake strategies to individual athletes' metabolic profiles and performance goals [20].

Protein

Protein is essential for athletes as it plays critical roles in muscle repair, growth, and adaptation to exercise. During prolonged or intense physical activity, muscle protein breakdown increases, making adequate protein intake crucial for supporting muscle maintenance and recovery [21].

Athletes' protein requirements depend on factors such as training volume, intensity, and type of sport. Current recommendations

suggest protein intake ranging from 1.2 to 2.2 grams per kilogram of body weight per day for athletes, with higher levels required for strength and power athletes compared to endurance athletes [22]. Distributing protein intake evenly throughout the day, with particular emphasis on post-exercise consumption, is beneficial for maximizing muscle protein synthesis and recovery. Consuming protein-rich meals or snacks within the first few hours following exercise helps stimulate muscle repair and adaptation [23].

The quality and composition of dietary protein influence its effectiveness in promoting muscle protein synthesis. High-quality protein sources, such as whey, casein, and soy protein, contain all essential amino acids in sufficient quantities, making them ideal choices for athletes. Additionally, protein-rich foods rich in leucine, such as dairy and eggs, are particularly effective in stimulating muscle protein synthesis [24]. Protein supplementation, including protein powders, shakes, and bars, is commonly used by athletes to meet their protein requirements and support training adaptations. Whey protein is highly regarded for its rapid digestion and absorption, making it an effective choice for post-exercise recovery [25]. Consuming protein near exercise, either alone or in combination with carbohydrates, promotes muscle glycogen resynthesis and accelerates muscle recovery. The amino acid leucine, found abundantly in protein-rich foods, plays a key role in initiating muscle protein synthesis and enhancing recovery [26].

Athletes may exhibit variability in their protein requirements based on factors such as training status, age, body composition, and metabolic rate. Endurance athletes may require lower absolute protein intakes compared to strength and power athletes, but their needs may increase relative to body weight due to higher energy expenditure [27]. Vegetarian and vegan athletes can meet their protein needs through a variety of plant-based protein sources, including legumes, tofu, tempeh, and quinoa. Combining complementary plant proteins throughout the day ensures adequate intake of all essential amino acids and supports muscle repair and growth [28]. Future research in sports nutrition is exploring novel protein sources, such as insect protein and alternative plant-based proteins, for their potential applications in supporting athletic performance. Additionally, personalized nutrition approaches that consider individual protein requirements, metabolic profiles, and training goals hold promise for optimizing protein intake and enhancing athletic performance [29].

Fat

Although carbohydrates are the primary fuel source for high-intensity exercise, fats also play a crucial role, especially during low to moderate-intensity activities and prolonged endurance events. Fats stored in adipose tissue and muscle triglycerides serve as a rich energy source, particularly during activities lasting longer than 90 minutes [30]. The ability to oxidize fats during exercise is an important determinant of endurance performance, as it spares muscle glycogen and delays fatigue. Endurance-trained athletes exhibit greater rates of fat oxidation and metabolic flexibility, allowing them to utilize both fats and carbohydrates efficiently during prolonged efforts [31].

Dietary fat intake can influence athletic performance through its effects on energy availability, substrate utilization, and metabolic adaptations. Low-fat diets may impair endurance performance by limiting fat oxidation rates and glycogen sparing, whereas high-fat, low-carbohydrate diets may enhance fat adaptation but potentially compromise high-intensity exercise performance [32]. Omega-3 and omega-6 fatty acids, essential fats that must be obtained from the diet, play key roles in modulating inflammation, immune function, and recovery in athletes. Incorporating sources of omega-3 fatty acids, such as fatty fish, flaxseeds, and walnuts, into the diet may help mitigate exercise-induced inflammation and support overall health and performance [33].

Fat adaptation strategies, such as high-fat, low-carbohydrate (HFLC) diets and training in a low-glycogen state, have gained attention for their potential to enhance fat oxidation and metabolic efficiency. However, the efficacy of these strategies for improving athletic performance, especially in high-intensity sports, remains a topic of debate and requires careful consideration of individual responses [34]. Athletes exhibit variability in fat utilization rates and metabolic responses to dietary fat intake, influenced by factors such as training status, genetics, and diet composition. Endurance-trained athletes tend to have higher rates of fat oxidation and may benefit from strategies to enhance fat metabolism, whereas individuals with higher carbohydrate requirements may prioritize carbohydrate intake for optimal performance [35].

Fat loading protocols, which involve increasing dietary fat intake in the days leading up to competition, have been proposed as a strategy to enhance endurance performance by promoting fat utilization and glycogen sparing. Ketogenic diets, which are very low in carbohydrates and high in fats, have also been investigated for their potential benefits in endurance sports but may present challenges in maintaining high-intensity performance and muscle glycogen stores [36]. Future research in sports nutrition is exploring novel approaches to fat manipulation, including targeted fat intake timing, specific fatty acid profiles, and personalized dietary strategies. Advances in metabolic profiling, nutrigenomics, and microbiome research offer opportunities to tailor fat intake recommendations to individual athletes' needs and optimize performance [37].

Micronutrients and athletic performance

Vitamins

Vitamins play a crucial role in athletic performance, as they are involved in various physiological processes necessary for energy production, muscle function, and recovery. Vitamin D: Known as the "sunshine vitamin," vitamin D is essential for bone health, muscle function, and immune function. Recent studies have highlighted its role in optimizing athletic performance by improving muscle strength and reducing the risk of injury. A study published in the International Journal of Sport Nutrition and Exercise Metabolism

in 2020 found that vitamin D supplementation improved vertical jump height and muscle strength in elite basketball players. Vitamin D is crucial for bone health, muscle function, and immune regulation. It helps maintain calcium homeostasis, which is essential for muscle contraction and bone mineralization. Vitamin E: Another powerful antioxidant, vitamin E protects cell membranes from damage caused by free radicals produced during exercise. Studies have shown that vitamin E supplementation can attenuate exercise-induced oxidative stress and muscle damage. A meta-analysis published in the European Journal of Nutrition in 2019 found that vitamin E supplementation improved endurance performance in athletes. Vitamin A: Vitamin A is essential for vision, immune function, and tissue repair. While research specifically focusing on vitamin A and athletic performance is limited, its role in maintaining overall health and immune function is crucial for athletes, especially during intense training periods. Ensuring adequate vitamin-A intake through a balanced diet or supplementation may support optimal performance and recovery [38,39].

Vitamin C

As an antioxidant, vitamin C helps combat oxidative stress generated during intense exercise. It also plays a role in collagen synthesis, which is important for maintaining the integrity of connective tissues such as tendons and ligaments. A review published in the journal Nutrients in 2021 concluded that vitamin C supplementation may reduce muscle soreness and enhance recovery following exhaustive exercise. Vitamin B complex: B vitamins, including B1, B2, B3, B5, B6, B7, B9, and B12, are involved in energy metabolism and the production of red blood cells. They play a crucial role in converting carbohydrates, fats, and proteins into energy for exercise. Recent research has emphasized the importance of adequate B vitamin intake for optimal athletic performance. For example, a study published in the Journal of the International Society of Sports Nutrition in 2021 found that B vitamin supplementation improved sprint performance in trained cyclists [39].

Minerals

Minerals are essential micronutrients that play critical roles in various physiological processes, including energy production, muscle contraction, oxygen transport, and bone health. Here's a breakdown of key minerals and their importance in athletic performance; Calcium; Calcium is crucial for bone health and muscle function. It plays a vital role in muscle contraction, nerve transmission, and blood clotting. Impact on Athletic Performance: Adequate calcium intake is essential for maintaining bone density and preventing stress fractures, which are common among athletes, especially in high-impact sports like running and gymnastics. Calcium is critical for bone health, muscle function, and nerve transmission. It plays a vital role in muscle contraction and relaxation. A study published in the Journal of the American College of Nutrition in 2020 investigated the effects of calcium supplementation on bone health and muscle function in female collegiate athletes. The researchers found that athletes who received calcium supplementation demonstrated improvements in bone mineral density and muscle strength compared to those who did not receive supplementation [40].

Magnesium is involved in over 300 enzymatic reactions in the body, including energy metabolism, muscle function, and protein synthesis. Impact on Athletic Performance: Magnesium deficiency can impair exercise performance by affecting muscle function and energy metabolism. Supplementing with magnesium may improve muscle strength and endurance. Iron is necessary to produce hemoglobin, a protein in red blood cells that carries oxygen to muscles and tissues. Magnesium is involved in energy metabolism, muscle contraction, and protein synthesis. It also helps regulate blood pressure and maintain heart rhythm. Magnesium supplementation improved muscle strength and power output compared to a placebo, suggesting its potential ergogenic effects [40].

Iron also plays a role in energy metabolism. Impact on Athletic Performance: Iron deficiency can lead to fatigue, reduced endurance, and impaired performance due to decreased oxygen delivery to muscles. Athletes, especially endurance athletes, are at risk of iron deficiency and should monitor their iron levels regularly. Iron is essential to produce hemoglobin, which carries oxygen to muscles and tissues. It also plays a crucial role in energy metabolism and immune function. A systematic review and meta-analysis published in Sports Medicine in 2021 evaluated the effects of iron supplementation on exercise performance and iron status in athletes. The analysis found that iron supplementation improved exercise performance and reduced the risk of iron deficiency in athletes, particularly endurance athletes [41].

Sodium and potassium are electrolytes that help regulate fluid balance, nerve function, and muscle contractions. Impact on Athletic Performance: During prolonged exercise or in hot environments, athletes lose electrolytes through sweat. Replacing sodium and potassium lost through sweat is essential for maintaining hydration, preventing cramps, and sustaining performance. Sodium and potassium are electrolytes that help maintain fluid balance, nerve function, and muscle contractions. They are lost through sweat during exercise and need to be replaced to prevent dehydration and muscle cramps. sodium and potassium supplementation on hydration status and exercise performance in endurance athletes. The researchers found that athletes who received electrolyte supplementation maintained better hydration status and experienced improved exercise performance compared to those who did not receive supplementation [40].

Zinc is involved in immune function, protein synthesis, and wound healing. It also plays a role in cell division and growth. Impact on Athletic Performance: Zinc deficiency can impair immune function, increase susceptibility to infections, and delay recovery from injuries. Athletes with inadequate zinc intake may experience compromised performance and delayed recovery. Zinc is involved in immune function, protein synthesis, and wound healing. It also plays a role in DNA synthesis and cell division. A randomized controlled trial published in the European Journal of Applied Physiology in 2021 examined the effects of zinc supplementation on

immune function and exercise performance in athletes. The study reported that zinc supplementation improved markers of immune function and reduced the incidence of respiratory infections in athletes, suggesting its potential benefits for supporting immune health and performance [41].

Chromium is involved in carbohydrate and lipid metabolism, insulin sensitivity, and energy production. Impact on Athletic Performance: Chromium supplementation has been studied for its potential to improve glucose metabolism and enhance muscle mass gain in athletes, although results are mixed and further research is needed. Selenium is an antioxidant that helps protect cells from oxidative damage. It also plays a role in thyroid function and immune response. Impact on Athletic Performance: Selenium deficiency may impair immune function and increase susceptibility to infections, which can affect training adaptation and performance. Ensuring adequate selenium intake is important for overall health and performance. Chromium is involved in carbohydrate and lipid metabolism, insulin sensitivity, and energy production. It may also play a role in muscle mass gain and fat loss. The effects of chromium supplementation on body composition and athletic performance in athletes. The review found mixed results regarding the effects of chromium supplementation on body composition and exercise performance, highlighting the need for further research in this area [40].

Selenium is an antioxidant that helps protect cells from oxidative damage. It also plays a role in thyroid function and immune response. A study published in the Journal of Trace Elements in Medicine and Biology in 2021 investigated the associations between selenium status, immune function, and exercise performance in athletes. The researchers found that athletes with adequate selenium status had better immune function and exercise performance compared to those with selenium deficiency, highlighting the importance of selenium for supporting immune health and athletic performance [41,42].

Hydration and athletic performance

Hydration is crucial for athletic performance as even mild dehydration can impair physical and cognitive function, leading to decreased endurance, reduced strength, and impaired coordination. Hydration plays a vital role in regulating body temperature, maintaining blood volume and pressure, transporting nutrients, and removing waste products from the body. During exercise, the body loses water and electrolytes through sweat, and inadequate hydration can lead to dehydration, which negatively impacts performance and increases the risk of heat-related illnesses [43].

Decreased Endurance: Dehydration reduces blood volume, which impairs the delivery of oxygen and nutrients to muscles, leading to premature fatigue and decreased endurance. Impaired Thermoregulation: Dehydration compromises the body's ability to dissipate heat, increasing the risk of heat stress and heat-related illnesses such as heat exhaustion and heatstroke. Reduced Cognitive Function: Dehydration can impair cognitive function, including memory, attention, and decision-making, which can affect skill execution and performance [43].

Optimal Hydration Strategies: Pre-Exercise Hydration: Athletes should start exercise dehydrated by consuming fluids in the hours leading up to exercise. During Exercise Hydration: Athletes should drink fluids regularly during exercise to replace fluid losses and maintain hydration status. The American College of Sports Medicine recommends consuming 5-10 ounces (150-300 ml) of fluid every 15-20 minutes during exercise. Post-Exercise Hydration: Adequate fluid intake after exercise is essential for rehydration and recovery. Athletes should aim to replace fluids lost during exercise by consuming 16-24 ounces (450-675 ml) of fluid for every pound (0.5 kg) of body weight lost during exercise [44].

Hydration requirements vary depending on factors such as exercise intensity and duration, environmental conditions, sweat rate, and individual differences in fluid losses and sweat composition. Athletes should monitor their hydration status by assessing urine color, body weight changes, and thirst sensations and adjust fluid intake accordingly. Study evaluated the impact of hydration status on various aspects of athletic performance, including endurance, strength, and cognitive function, by analyzing data from multiple studies. The findings of this meta-analysis provide valuable insights into the importance of hydration for optimizing athletic performance. By prioritizing hydration and implementing effective hydration strategies, athletes can maintain optimal performance, reduce the risk of dehydration-related complications, and support overall health and well-being during exercise and competition [43,44].

Nutritional supplements and performance enhancement

Nutritional supplements are widely used by athletes to enhance performance, support recovery, and maintain overall health. Types of Nutritional Supplements: Macronutrients: Protein, carbohydrates, and fats are essential macronutrients that provide energy and support muscle growth and repair. Micronutrients: Vitamins and minerals play crucial roles in energy metabolism, immune function, and tissue repair. Performance Enhancers: Creatine, caffeine, beta-alanine, and nitric oxide precursors are among the most popular performance-enhancing supplements [45].

Impact on Performance Enhancement: Creatine: Creatine supplementation has been shown to increase muscle creatine stores, enhance ATP production, and improve high-intensity exercise performance, especially during repeated bouts of short-duration, high-intensity activity. Caffeine: Caffeine supplementation can enhance endurance performance by increasing alertness, reducing perceived exertion, and stimulating fatty acid oxidation, which spares glycogen stores and delays fatigue. Beta-Alanine: Beta-alanine supplementation increases muscle carnosine levels, which helps buffer acidosis during high-intensity exercise, delaying fatigue and improving exercise capacity. Nitric Oxide Precursors:

Supplements like arginine and citrulline are precursors to nitric oxide, a vasodilator that enhances blood flow and nutrient delivery to muscles, potentially improving exercise performance, especially during endurance activities [46].

Nutritional supplements have shown promising results in improving athletic performance, their efficacy can vary depending on factors such as dosage, timing, individual response, and training status. Athletes should be cautious when using supplements, as some may pose risks to health or result in adverse effects. It's essential to choose supplements that are supported by scientific evidence and to consult with a qualified healthcare provider or sports nutritionist before use [47]. The supplement industry is not tightly regulated, and products may vary in quality, purity, and effectiveness. Athletes should choose supplements that have been independently tested for quality and safety by third-party organizations such as NSF International or Informed-Sport. Athletes should also be aware of the risks of inadvertent doping, as some supplements may contain banned substances not listed on the label. Using certified supplements can help mitigate this risk. reviews provide comprehensive summaries of recent research on nutritional supplements and their effects on athletic performance [48].

Timing and composition of pre- and post-exercise nutrition

Optimizing pre- and post-exercise nutrition is crucial for maximizing athletic performance, supporting recovery, and promoting adaptations to training. Pre-exercise nutrition should be consumed 1-4 hours before exercise to ensure adequate digestion and absorption of nutrients. A smaller snack can be consumed 30-60 minutes before exercise to provide immediate energy. Carbohydrates: Consuming carbohydrates before exercise replenishes glycogen stores and provides readily available energy for muscles. Aim for a moderate to high carbohydrate intake, with a focus on complex carbohydrates to sustain energy levels. Protein: Including a small amount of protein in pre-exercise meals or snacks can help support muscle protein synthesis and reduce muscle protein breakdown during exercise. opt for easily digestible protein sources such as lean meats, dairy products, or plant-based proteins. Fluids: Adequate hydration is essential before exercise to maintain fluid balance and prevent dehydration. Aim to drink water or a sports drink containing electrolytes to ensure proper hydration status. Fats: While fats are not typically a primary focus of pre-exercise nutrition due to their slower digestion, including small amounts of healthy fats can help provide sustained energy and promote satiety [49].

Consuming post-exercise nutrition within 30-60 minutes after exercise is crucial for maximizing recovery and promoting muscle glycogen resynthesis. This window of opportunity allows for optimal nutrient uptake and utilization by muscles. Carbohydrates: Rapidly replenishing glycogen stores after exercise is essential for recovery and subsequent performance. Aim for a carbohydrate intake of 0.5-0.7 grams per kilogram of body weight within the first 30 minutes post-exercise and continue to consume carbohydrates with meals in the following hours. Protein: Consuming protein post-exercise stimulates muscle protein synthesis and promotes muscle repair and growth. Aim for a protein intake of 0.2-0.4 grams per kilogram of body weight within 30 minutes post-exercise, with higher doses (0.4-0.5 grams/kg) recommended for endurance or resistance-trained athletes. Fluids: Rehydrating after exercise is essential for replacing fluid losses and restoring hydration status. Aim to drink water or a sports drink containing electrolytes to replace fluids lost through sweat. Electrolytes: Consuming electrolytes such as sodium and potassium post-exercise helps restore electrolyte balance and support hydration. Electrolyte-containing beverages or foods can help replenish electrolyte losses [50].

Additional Considerations: Individual Needs: Adjust pre- and post-exercise nutrition based on individual factors such as exercise intensity, duration, and goals, as well as personal preferences and tolerance. Sports Supplements: Some athletes may benefit from incorporating sports supplements such as protein powders, carbohydrate gels, or branched-chain amino acids (BCAAs) into their pre- and post-exercise nutrition regimen. However, these supplements should complement a balanced diet and not replace whole foods. Meal Timing: In addition to immediate post-exercise nutrition, regular meals and snacks throughout the day should also be optimized to provide adequate nutrients to support training adaptations and recovery. By paying attention to the timing and composition of pre- and post-exercise nutrition, athletes can optimize their performance, support recovery, and enhance their overall health and well-being [49,50].

Special considerations for specific sports or populations

Different sports and populations have unique nutritional needs and considerations based on factors such as energy expenditure, metabolic demands, body composition goals, and training schedules. Endurance athletes require sufficient carbohydrates to fuel prolonged exercise, adequate protein to support muscle repair and recovery, and electrolytes to replace those lost through sweat. Hydration: Endurance athletes should prioritize hydration before, during, and after exercise to maintain fluid balance and prevent dehydration, especially during long-duration events. Fueling Strategies: Endurance athletes may benefit from carbohydrate loading before extended competitions or high-intensity training sessions to maximize glycogen stores and enhance performance [51].

Strength and Power Sports: Protein Intake: Strength and power athletes require higher protein intake to support muscle protein synthesis, repair, and hypertrophy. Consuming protein-rich foods or supplements before and after resistance training can optimize muscle recovery and adaptation. Creatine Supplementation: Creatine supplementation may benefit strength and power athletes by increasing phosphocreatine stores, enhancing ATP resynthesis, and improving high-intensity exercise performance. Hydration: Maintaining adequate hydration is essential for strength and power athletes to support muscle function, maintain performance, and prevent fatigue during intense training sessions [52].

Team sport athletes should consume sufficient carbohydrates to

fuel high-intensity, intermittent activity during training and competition. Timing carbohydrate intake around workouts and games can optimize glycogen stores and performance. Hydration: Hydration is critical for team sport athletes to maintain performance, cognitive function, and thermoregulation, especially during matches played in hot or humid conditions. Recovery Nutrition: Consuming a combination of carbohydrates and protein post-exercise can promote glycogen replenishment, muscle repair, and recovery in team sport athletes who engage in frequent training sessions and competitions [53].

Youth athletes should focus on nutrient-dense foods to meet their increased energy and nutrient needs for growth, development, and athletic performance. Hydration: Ensuring proper hydration is essential for youth athletes to support thermoregulation, cognitive function, and overall health during exercise. Education and Monitoring: Providing education on balanced nutrition, hydration, and healthy eating habits, along with monitoring growth, maturation, and training loads, is crucial for supporting the health and performance of youth athletes [52,53].

Master athletes may benefit from strategic nutrient timing to optimize recovery and adaptation, especially as aging can impact muscle mass, strength, and recovery. Protein Intake: Increasing protein intake, particularly high-quality proteins rich in essential amino acids, can help preserve muscle mass, support recovery, and maintain physical function in master athletes. Micronutrient Needs: Master athletes may have increased nutrient needs for vitamins and minerals involved in bone health, immune function, and oxidative stress management. Adequate intake of calcium, vitamin D, and antioxidants can support overall health and performance [51].

Practical Applications and Recommendations

Practical applications and recommendations for sports nutrition encompass a wide range of strategies aimed at optimizing athletic performance, supporting recovery, and promoting overall health and well-being. Recognize that nutrition needs vary among athletes based on factors such as age, gender, body composition, training intensity, and sport-specific demands. Tailor nutrition plans to meet individual goals, preferences, and dietary restrictions, considering personal preferences, cultural considerations, and lifestyle factors [54].

Emphasize a balanced intake of carbohydrates, proteins, and fats to support energy production, muscle repair, and overall health. Carbohydrates should make up most of athlete's diet to fuel high-intensity exercise and replenish glycogen stores. Include high-quality protein sources in each meal to support muscle protein synthesis, repair, and recovery. Incorporate healthy fats from sources such as nuts, seeds, avocados, and fatty fish to provide essential fatty acids and support overall health [55].

Prioritize hydration before, during, and after exercise to maintain fluid balance, support thermoregulation, and optimize performance. Monitor hydration status through urine color, body weight changes, and thirst sensations, and adjust fluid intake accordingly. Consume fluids with electrolytes, especially during prolonged or intense exercise, to replace electrolyte losses through sweat and maintain hydration status. Fuel workouts and optimize recovery by consuming meals and snacks that contain a balance of carbohydrates, proteins, and fats [56].

Timing of meals and snacks around workouts should consider individual preferences, gastrointestinal tolerance, and exercise timing. Aim to consume a carbohydrate-rich meal or snack 1-4 hours before exercise to maximize glycogen stores and provide sustained energy. Consume a post-exercise meal or snack containing carbohydrates and protein within 30-60 minutes after exercise to replenish glycogen stores, support muscle repair, and promote recovery. Capitalize on the "anabolic window" by consuming a combination of carbohydrates and protein within the first 30-60 minutes post-exercise to maximize muscle glycogen resynthesis and protein synthesis. Choose easily digestible carbohydrate and protein sources, such as a protein shake with fruit or a turkey sandwich on whole-grain bread, for post-exercise nutrition [56].

Experiment with different pre- and post-exercise meals and snacks to identify what works best for individual performance and recovery. Use sports supplements judiciously to complement a balanced diet and fill nutrient gaps, rather than relying solely on supplements for nutritional needs. Consult with a sports dietitian or healthcare professional before starting any supplementation regimen, as some supplements may interact with medications or have potential side effects. Choose reputable brands that undergo third-party testing for quality, purity, and safety, such as NSF Certified for Sport or Informed-Sport. Regularly assess nutritional intake, hydration status, performance, and recovery to identify areas for improvement and make necessary adjustments to nutrition plans. Keep a food and fluid diary, track training load and performance metrics, and listen to the body's hunger, thirst, and satiety cues to optimize nutrition strategies over time. By implementing these practical applications and recommendations, athletes can develop personalized nutrition plans that support their training goals, optimize performance, and enhance overall health and well-being. Raising functional issues and providing practical advice, this review imparts sensible, no-nonsense guidance to help athletes gain that extra edge for peak performance. I encourage every athlete, regardless of their level, to have a copy on their bookshelves [57,58].

Conclusion

In conclusion, minerals play essential roles in athletic performance by supporting energy metabolism, muscle function, bone health, and immune function. Athletes should strive to maintain optimal mineral status through a balanced diet rich in fruits, vegetables, whole grains, lean proteins, and dairy products. In some

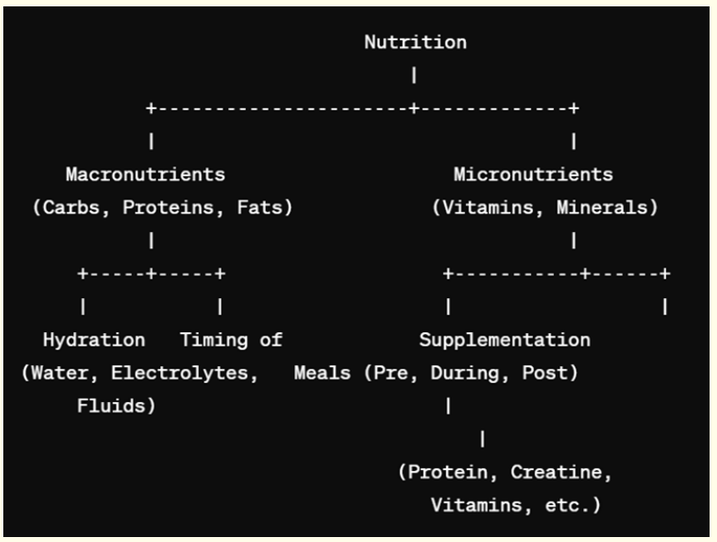

Figure 1: Nutrition: Impact on Athletic Performance.

cases, supplementation may be necessary, especially for athletes at risk of deficiencies or with increased nutrient needs due to intense training and competition. However, individual mineral requirements may vary based on factors such as age, gender, training load, and environmental conditions, so it's essential for athletes to consult with a sports nutritionist or healthcare provider for personalized recommendations. By understanding the potential benefits and risks of nutritional supplements and making informed choices, athletes can optimize their performance while minimizing potential health risks.

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