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Review on the Effects of Sports Supplements and Diet on Athletes

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Abstract: Competitive sports are an integral part of athletics. For athletes to achieve outstanding performance in competitions, in addition to specialized training, sports supplements and diet serve as crucial material foundations. Sports supplements and diet involve the intentional consumption of foods, nutritional components, or non-food compounds beyond habitual dietary intake to achieve specific health or functional benefits. This paper analyzes relevant studies to explore the functions of different types of sports supplements, the impact of dietary structures on athletic performance, body composition, and health, as well as safety and ethical considerations in supplement use. The findings emphasize the importance of rational utilization of sports supplements and dietary planning for athletes, coaches, and professionals, aiming to standardize supplement protocols and dietary strategies, thereby providing a theoretical basis for enhancing athletic performance.

Keywords: Sports Supplements; Diet; Performance Enhancement

1. Introduction

Sports supplements refer to nutritional products used during training or competition, intentionally consumed beyond regular diets to enhance physical capacity, promote recovery, improve athletic performance, or stimulate muscle growth [1]. These supplements are categorized based on their functions (e.g., energy replenishment, metabolic acceleration, fatigue reduction, muscle enhancement) [2], nutrient composition (e.g., carbohydrates, proteins, creatine, fluids) [3], or nutrient types (e.g., carbohydrates, proteins, electrolytes, caffeine, antioxidants) [4]. A scientifically designed diet provides athletes with adequate energy and nutrients to meet training and competitive demands. Recent studies highlight the importance of diversified dietary plans over single-food approaches, emphasizing that specific food combinations yield greater benefits than isolated nutrients [5]. Understanding the effects of sports supplements and diet is critical for optimizing training and elevating competitive performance. This paper systematically examines the impacts of various sports supplements and dietary strategies on athletes.

2. Effects of Sports Supplements on Athletes

2.1 Protein Supplements

Protein is essential for muscle repair and growth. After high-intensity training, muscle fibers sustain microtears, requiring ample protein for repair and synthesis. Protein supplements, typically containing highly purified whey or casein, are rapidly absorbed and provide rich amino acids.

Studies indicate that whey protein effectively aids muscle strength recovery, increases muscle mass, and enhances training intensity. Strength athletes and fitness enthusiasts often consume whey protein post-exercise to stimulate muscle synthesis, inhibit breakdown, and reduce soreness and inflammation [6]. Recommended protein intake ranges from 1.2 to 2.0 g per kilogram of body weight, depending on training intensity and frequency. For example, a 75 kg throwing athlete requires 90–150 g of protein daily. Intake should follow a "small and frequent" principle, prioritizing high-quality complete proteins such as meat, eggs, dairy, and soy products [7]. While beneficial, excessive protein intake may strain kidney function. Athletes should tailor dosages to their weight, training load, and goals, selecting reliable products free of banned substances.

2.2 Creatine

Creatine increases phosphocreatine reserves in muscles. A century ago, feeding experiments demonstrated that creatine supplementation elevates skeletal muscle levels, enhancing performance in strength-based activities but showing limited effects on endurance or maximal oxygen uptake [8].

Research suggests creatine reduces muscle damage, accelerates post-exercise recovery, and lowers risks of musculoskeletal injuries, dehydration, and cramps. It also promotes muscle mass and strength gains [9]. Athletes often supplement creatine before/after exercise to boost performance and recovery. Studies recommend loading phases of 0.3 g/kg/day for 3–5 days or 20 g/day for 5–7 days to rapidly increase intramuscular creatine levels. Alternatively, a 4-week regimen of 3–5 g/day enhances creatine storage, muscle function, and recovery while supporting hypertrophy [10]. Although generally safe at recommended doses, creatine may cause mild side effects like weight gain or gastrointestinal discomfort. Athletes should consult professionals to avoid interactions with medications or other supplements.

2.3 Caffeine

Caffeine is a natural stimulant that activates the central nervous system, improving alertness and focus. During exercise, caffeine also promotes fat breakdown, providing muscles with an additional energy source and conserving glycogen stores.

Coffee contains various components, including but not limited to caffeine, which have neuromuscular, antioxidant, endocrine, cognitive, and metabolic (e.g., glucose processing and vasodilation) effects that influence exercise performance and recovery [11]. Many studies have found that caffeine significantly enhances endurance sports (e.g., marathons, cycling). In sports requiring high-intensity concentration (e.g., archery, shooting), caffeine also improves performance. According to research, a moderate dose of caffeine (200 mg) taken before exercise is most effective for post-exercise inhibitory benefits [12]. Although caffeine is relatively safe, excessive intake may cause side effects such as rapid heartbeat, insomnia, and anxiety. Individual tolerance to caffeine varies, so athletes should adjust their intake based on personal conditions. Additionally, caffeine may be restricted in some sports competitions, and athletes must comply with relevant regulations.

2.4 Specific Buffers

Among specific buffers, sodium bicarbonate can enhance muscle endurance activities and high-intensity exercises, particularly in efforts lasting 30 seconds to 12 minutes [13]. Applying 10 g of sodium bicarbonate topical emulsion to the outer thigh muscles 30 minutes before training has been shown to improve training load, physical recovery, and performance, positively impacting athletes' training outcomes [14]. Sodium citrate can alleviate lactic acid buildup to some extent, thereby improving endurance and aerobic performance [15]. Nitrate reduces oxygen transport during exercise, enhances exercise endurance, lowers ATP production costs, and improves blood flow and nutrient delivery [16]. Glutamine is a naturally occurring non-essential neutral amino acid. Its benefits for athletes include: providing nutritional support to the immune system and preventing infections; improving intestinal barrier function and reducing the risk of endotoxemia; enhancing intracellular fluid retention (i.e., volumizing effect); accelerating water absorption from the intestines; stimulating muscle glycogen synthesis; promoting muscle protein synthesis and tissue growth; reducing muscle soreness and improving tissue repair; and enhancing buffering capacity and high-intensity exercise performance [17].

3. The Impact of Diet on Athletes

Nutritional intake is a primary factor influencing athletes' overall health, performance, endurance, and general well-being. Numerous studies emphasize the importance of a well-planned diet before, during, and after training to enhance competitive performance. Proper nutritional guidance helps athletes adapt to training intensity, improve performance, and prevent injuries [18]. In recent years, nutritionists have increasingly focused on diversified dietary plans rather than the effects of single foods, proposing that specific food combinations are more effective than individual food supplements.

3.1 Carbohydrates

Carbohydrates are the primary energy source for athletes. During exercise, carbohydrates provide energy to muscles through glycolysis and aerobic oxidation. Different types of carbohydrates (e.g., simple and complex carbohydrates) vary in the speed of energy release. Therefore, before exercise, athletes can consume high-quality carbohydrates such as bananas and corn for quick energy, supplemented with high-fiber foods like celery and nuts containing healthy fats and proteins for sustained energy [19]. The golden recovery

window after exercise is within 30–45 minutes of completing the activity. During this period, the diet should focus on replenishing energy. For athletes engaged in highly demanding sports (e.g., soccer, basketball), appropriate carbohydrate intake can quickly restore glycogen levels, while high-quality protein intake supports the repair and rebuilding of damaged muscles.

The proportion of carbohydrates in an athlete's diet should be adjusted based on the type of sport, training intensity, and individual needs. Generally, endurance athletes require 60%–70% of their calories from carbohydrates, while strength athletes may reduce carbohydrate intake slightly and increase protein consumption.

3.2 Fats

Fats are a high-energy-density nutrient and an essential energy reserve for the body. During low-intensity, prolonged exercise, fats serve as the primary energy source. Additionally, fats play a crucial role in maintaining normal physiological functions, protecting organs, and regulating hormone levels.

Moderate fat intake is necessary for athletes' health and performance. For athletes who spend extended periods in cold environments (e.g., cross-country skiers), sufficient fat reserves help with warmth and energy supply. Essential fatty acids also aid in reducing inflammation and accelerating recovery [20].

However, a high-fat diet may lead to weight gain and elevated blood lipids, negatively impacting athletes' body composition and health. Therefore, fat intake should be carefully controlled. For athletes:

① Pre-competition: In the days leading up to a competition, athletes can gradually increase fat intake to ensure sufficient energy reserves. It is recommended to increase fat intake by 0.5–1.0 g/kg/day in the days before the event.

② During competition: During the event, athletes should supplement fats based on exercise intensity and duration. Foods rich in unsaturated fats, such as nuts and avocados, are ideal. It is recommended to consume 10–20 g of fat every 2–3 hours [21].

③ Post-competition: Timely fat replenishment after the event aids in rapid recovery. Foods rich in monounsaturated fats, such as avocados, can promote body repair. It is recommended to consume 10–20 g of fat within 2 hours after the event and every 2–3 hours thereafter [22].

3.3 Vitamins and Minerals

Vitamins primarily act as regulators of metabolic functions. Depending on the nature of the sport, athletes may use high doses of specific vitamins to enhance particular metabolic processes [23]. For example: Vitamin A maintains night vision. Thiamine, riboflavin, niacin, and pantothenic acid are involved in muscle cell energy metabolism. Niacin may also block the release of free fatty acids. Folate and vitamin B12 are closely related to red blood cell development. Vitamins C and E are antioxidants, offering potential protection against muscle damage [24]. Vitamin D influences bone density and quality, thereby affecting muscle strength [25].

Athletes can obtain vitamins and minerals through a diversified diet. Fresh fruits, vegetables, whole grains, lean meats, and fish are excellent sources. However, during high-intensity training, some athletes may require additional supplementation due to increased bodily demands. Supplementation should follow the principle of moderation to avoid potential adverse effects from excessive intake.

3.4 Common Trace Elements and Probiotics

Calcium

Adequate calcium intake helps prevent exercise-induced fatigue. The daily calcium requirement for normal individuals is 0.6–1.0 g, with dietary supply typically providing 0.5–1.0 g [26]. Athletes often use bone broth as a source of calcium, with spine and pelvic bones being the best choices. The bones should be cleaned of nerve tissue, blood vessels, fat, and connective tissue, and the broth should avoid leafy greens high in oxalic acid to ensure optimal calcium absorption [27].

Iron

The total iron content in the human body is 54–90 mmol (approximately 3000–4000 mg). Adult males require 1 mg of iron daily, with dietary intake typically providing 10–15 mg [28]. Iron deficiency can impair athletic performance. While dietary absorption of iron is around 10%, vitamin C enhances iron absorption. Many endurance athletes use iron supplements during heavy training periods, which has been shown to improve performance.

Zinc

Zinc is closely related to muscle mass growth, and zinc deficiency can reduce the body's

antioxidant capacity. The Recommended Dietary Allowance (RDA) for zinc is 15 mg for males and 12 mg for females [28].

Probiotics

Probiotics play a significant role in maintaining athletes' immune systems and enhancing performance. Athletes can maintain health, boost physical fitness, improve nutrient bioavailability, and enhance aerobic capacity through a balanced diet and probiotic supplementation, ultimately achieving better athletic performance [29].

4. Practical Examples of Dietary Pairing

4.1 Dietary Pairing for Marathon Runners

4.1.1 Pre-Race Die

Marathon runners typically adopt a high-carbohydrate diet in the days leading up to the race. For example, they may consume large amounts of complex carbohydrates such as whole wheat bread, rice, and potatoes. These foods slowly release energy, helping to increase muscle glycogen reserves. To ensure normal metabolism and nutritional balance, they also consume moderate amounts of protein, such as lean meats, fish, and legumes, along with fresh vegetables and fruits rich in vitamins and minerals. On the day before the race, athletes may engage in "carbohydrate loading," consuming more carbohydrates, such as high-carbohydrate sports drinks or energy bars.

4.1.2 Dietary Strategies During Competition

During a marathon race, athletes need to replenish energy and fluids in a timely manner. They may consume sports drinks containing an appropriate amount of carbohydrates (typically at a concentration of 6% - 8%) and small amounts of electrolytes (such as sodium and potassium) at regular intervals. This helps replenish fluids and electrolytes lost through sweating while providing sustained energy to muscles, maintaining blood sugar levels, and preventing premature fatigue.

4.1.3 Post-Competition Dietary Strategies

After the race, athletes' bodies are in a state of fatigue and recovery. At this stage, they need to consume sufficient protein to repair damaged muscle tissues, such as drinking a whey protein-rich shake or eating a piece of grilled chicken breast. Additionally, to replenish glycogen stores depleted during the race, they should continue to consume an appropriate amount of carbohydrates, such as a bowl of brown rice or a few sweet potatoes. Fresh fruits and vegetables can also provide essential vitamins and minerals, aiding in overall recovery.

5. Dietary Strategies for Strength Athletes

5.1 Daily Diet

Strength athletes require more protein to support muscle growth and repair. Their daily diet includes a significant amount of high-protein foods such as beef, chicken, eggs, and milk, which provide essential amino acids necessary for muscle protein synthesis. To ensure sufficient energy for training, they also consume complex carbohydrates like whole wheat bread and oatmeal, as well as healthy fats such as unsaturated fats from olive oil. In selecting vegetables and fruits, they prioritize those rich in vitamin C (e.g., oranges, broccoli) and vitamin D (e.g., mushrooms, salmon), as vitamin C aids collagen synthesis, benefiting joint and muscle health, while vitamin D supports calcium absorption, crucial for bone health.

5.2 Dietary Supplementation During Training

During strength training, athletes may consume easily digestible carbohydrates, such as bananas, before training to provide quick energy and ensure training intensity. To enhance muscle pump and promote muscle growth, they may immediately supplement with protein sources like whey protein after training, paired with complex carbohydrates such as a slice of whole wheat bread to stimulate insulin secretion and improve protein absorption.

6. Comprehensive Considerations for Sports Supplements and Diets

6.1 Individual Differences

Athletes differ in age, gender, genetics, and training levels, leading to varying needs and responses to sports supplements and diets. For example, younger athletes may have lower tolerance to certain supplements, while female athletes have unique nutritional needs during specific physiological periods.

6.2 Sport-Specific Requirements

Different sports place varying demands on athletes' physical abilities, necessitating tailored approaches to sports supplements and diets. For instance, sprinters focus on supplements like creatine to enhance power output, while

endurance athletes prioritize supplements or high-carbohydrate diets that improve stamina.

6.3 Safety and Ethical Concerns

6.3.1 Safety

When using sports supplements, athletes must ensure the safety of the products. Some illegal or substandard sports supplements may contain prohibited substances such as steroids. These substances not only harm athletes' health but also result in severe doping penalties. Therefore, athletes should choose sports supplements that have passed formal inspections and meet relevant standards.

6.3.2 Ethical Issues

The use of certain sports supplements can also raise ethical concerns. Fair competition is a fundamental principle in sports, and athletes and practitioners must adhere to ethical standards while pursuing performance. For young athletes, whose bodies are still developing, premature or inappropriate use of supplements can negatively impact growth. Additionally, young athletes may lack the maturity to understand and judge the proper use of supplements, making them susceptible to misuse. Coaches, parents, and educational institutions should play a regulatory and guiding role, educating young athletes on the responsible use of supplements and avoiding products that may pose potential health risks.

7. Outlook and Conclusion

7.1 Outlook

With advancements in science and technology, future strategies may involve wearable devices and artificial intelligence to monitor athletes' physiological states (e.g., heart rate, blood oxygen, muscle fatigue) in real time, dynamically adjusting supplement use and dietary plans to ensure optimal nutrition support aligned with training demands. Additionally, the development of more functional foods tailored for athletes, such as energy bars enriched with specific nutrients, performance-enhancing beverages, and recovery drinks, could provide targeted benefits in improving performance, accelerating recovery, or boosting immunity.

7.2 Conclusion

Sports supplements and dietary supplements have a positive impact on athletes' competitive performance and are also an important means of post-competition rehabilitation for athletes. Currently, a large number of sports supplements and dietary supplements are available on the market. However, people do not have a sufficient understanding of various supplements. Therefore, the standardized use of various supplements and the systematic popularization of relevant knowledge have a positive impact on the promotion of sports nutrition supplements. It is believed that the influence of sports supplements and diets on athletes will show a more scientific, personalized, and sustainable development trend in the future, providing a better quality of life for both athletes and the general public.

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