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Review

The Interplay of Nutrition, Exercise, and Dietary Intervention for Enhanced Performance of Athletes and General Well-Being of Non-Athletes: A Review

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Abstract

The optimal enhancement of athletic performance, recovery from exhaustion after exercise, and injury prevention are products of appropriate nutrition. Nutritional supplements that contain proteins, carbohydrates, vitamins, and minerals are frequently utilized in various sports to complement the recommended daily amounts. Several of these supplements have been identified to have physiological effects and, thus, are known to help enhance athletic performance and prevent injuries. Our review intends to show the interplay between nutrition, exercise, and dietary intervention on the physical performance of athletic individuals and their importance for the general well-being of non-athletes. Ergogenic aids that help enhance athletic performance are also discussed.

Keywords

Nutrition; exercise; dietary; performance; supplement

1. Introduction

Exercise and nutrition are closely linked and play a crucial role in boosting physical performance and maintaining good health [1]. While exercise is essential for improving cardiovascular function, muscle strength and endurance, nutrition is crucial for providing the necessary energy and nutrients that support the body's general functioning. Although it is commonly assumed that the advantages of good food and regular exercise are separate entities, research suggests that combining both aspects results in better outcomes instead of just emphasizing one over the other [2-4]. A study found that individuals who engaged in regular exercise and had a higher intake of antioxidants had lower levels of inflammation throughout their bodies [5]. Moreover, when Isenmann and his colleagues [6] examined the impact of protein and carbohydrates on the recovery of skeletal muscle in athletes (The 35 athletes who participated ran a 10-kilometer race and then consumed a protein/carbohydrate shake, a meal of white bread and sour milk cheese, or nothing), they found out that consuming carbohydrates and proteins whether in the form of a shake or a meal was

beneficial in reducing inflammation and muscle damage caused by exercise [6]. Furthermore, regular exercise has been associated with improved mental health, including lowered stress, anxiety, and depression [7]. It has also been associated with aiding the management of chronic diseases like diabetes, osteoporosis, hypertension, obesity, cancer etc. [8]. Therefore, engaging in physical activity prevents chronic illnesses and early mortality [9]. Non-transmittable diseases, which correlate with inactivity and unhealthy diets, are prevalent worldwide among the young and old [10]. Research conducted on Palestinian students at An-Najah National University, for instance, found that 26.2% of them were obese. This rate was higher among males (36.4%) than females (19.1%) [11]. 28.6% of those who were obese also had metabolic syndrome [12]. Physical activity and caloric tailoring will be required to change these outcomes. Furthermore, studies conducted by Pedersen and his team [13] found that regular physical activity (burning more than 2000 kcal per week) was associated with an average increase in life expectancy of 1-2 years. Subsequent research has confirmed this, reporting that burning an average of 1000 kcal per week is related to a 20-30% decrease in mortality from all causes [14]. Yet another study found that the risk of death and recurrence of breast cancer was reduced by 26-40% among the most active women compared to the least active ones [11]. Other research shows similar results [15, 16]. Having recognized the benefits, most health and fitness organizations nowadays recommend a minimum of 1000 kcal per week (at least 30 min on at least five days) of exercise [17]. Additionally, dietary interventions, which may include changes in macronutrient intake, timing of meals, and supplementation, also significantly impact performance and well-being. It is important to note that while dietary interventions can improve exercise performance, they cannot replace regular exercise. A well-rounded exercise program that includes cardiovascular, strength, and flexibility training is still essential for maintaining good health and physical performance [1]. Furthermore, individuals who engage in competitive sports or high-intensity athletic activities may require more carbohydrates, proteins, fats, and vitamins than non-athletes who only exercise regularly [18-20]. Our review intends to show the joint roles of nutrition, exercise and dietary intervention on the physical performance of athletic individuals and the wellbeing of people not involved in competitive sports.

2. Methodology

The review, the interplay of nutrition, exercise, and dietary intervention for optimal health of athletes and non-athletes, was written based on information from prominent database sources. Some free text keywords and medical headings were utilized in the search such words as the “benefits of exercise”, “nutrition and health improvement”, “possible dietary interventions for necessary for physical wellbeing”, “the use of ergogenic aids for enhanced performance in sports and others. This search was carried out on Springer Open (https://www.springropen.com), Science direct (https://www.sciencedirect.com), PubMed (https://pubmed.ncbi.nlm.nih.gov/), Research Gate (https://www.researchgate.net) and Goggle Scholar (https://scholar.google.com/) databases.

3. Nutrition

Maintaining a healthy lifestyle is crucial for the overall well-being of an individual [8]. Nutrition is thus the intake of food, particularly vitamins, minerals, and other vital nutrients that can help provide energy, build and repair tissues, and aid in bodily functions [21]. The importance of nutrition (Table 1) in maintaining health has been widely recognized since nutrients in food are vital for the

growth and repair of tissues, the regulation of body processes, and the overall functioning of the body [22]. Proper nutrition ensures the body receives an adequate supply of essential nutrients, including carbohydrates, proteins, lipids, vitamins, and minerals. While adequate nutrition is vital for all stages and conditions of life, it can be considered particularly important for pregnant women since it plays a crucial role in ensuring the proper growth and development of the fetus. Nutrition is also vital for maintaining mental health, as proper nutrition can help to reduce stress and anxiety, improve mood, and boost cognitive function [23]. Moreover, practicing good nutrition can help in maintaining a healthy weight since consuming a diet low in nutrients and high in calories can cause obesity and subsequently predispose one to chronic diseases such as heart disease, diabetes, and cancer. Eating a balanced diet high in fruits, vegetables, whole grains, and lean protein can thus help reduce the risk of these diseases [24]. In addition to maintaining overall health, nutrition is essential for athletes and physically active individuals. Adequate nutrition helps them build and repair muscle tissue and provides them with the energy needed to sustain physical activity [25]. The varied roles nutrition plays are summarized in Table 2.

Table 1 The Effects of Nutrients on General Health.

S/N	Nutrients	Effects on Health	References
1.	Carbohydrate	Provide energy and help regulate blood sugar levels	Asif [26]
2.	Protein	Build and repair tissues, essential for growth and repair	Barchitta and colleagues [27]
3.	Fats	Provide energy, help absorb fat-soluble vitamins, and lower the risk of heart disease when they replace saturated fats in the diet.	Liu and colleagues [28]
4.	Vitamin and minerals	Regulate body processes, help with the formation of bones and teeth, and aid in blood clotting, nerve function, and muscle function.	Tuttolomondo and colleagues [29]

Table 2 The Role of Nutrition in Preventing Chronic Diseases such as Obesity, Diabetes, and Heart Disease.

S/N	Nutrient	Role	References
1.	Fibre	Fiber-rich foods, such as fruits, vegetables, and whole grains, can help prevent obesity by promoting feelings of fullness and reducing overall calorie intake.	Oyindasola [30]
2.	Antioxidant	Antioxidants, such as vitamin C and beta-carotene, can help prevent chronic diseases by neutralizing harmful free radicals in the body.	Pehlivan [31]
3.	Omega-3 fatty acids	Omega-3 fatty acids, found in fatty fish such as salmon and tuna, can help lower the risk of heart disease by reducing inflammation and improving cholesterol levels.	Chaddha and Eagle [32]
4.	Calcium and	Calcium and Vitamin D are essential for maintaining	Chiodini and

	Vitamin D	strong bones and preventing osteoporosis. Adequate intake can also help to lower the risk of colon cancer.	Bolland [33]
5.	Vitamin B12	Vitamin B12 is important for maintaining healthy blood cells and preventing anemia. It also plays a role in maintaining a healthy nervous system.	Mahmood [34]
6.	Magnesium	Magnesium plays a role in maintaining healthy blood sugar levels, which can help to prevent diabetes. It also helps in maintaining a healthy heart and blood pressure.	Barbagallo [35]

3.1 Overview of Different Types of Nutrition and Their Roles in Maintaining Health

The essential nutrition components are carbohydrates, proteins, fats, vitamins, and minerals. Each of these nutrients plays a specific role in maintaining health [36]. Carbohydrates provide energy, proteins build and repair tissues, fats provide energy and help absorb fat-soluble vitamins, vitamins and minerals help regulate body processes, and minerals help form bones and teeth. We discuss the types of nutrition below.

3.1.1 Carbohydrates

It is essential to pay attention to the source of carbohydrates in diet, as some options are healthier than others. The quantity of carbohydrates in the diet is usually not as crucial as the type of carbohydrates in it [37]. Whole grains such as wheat bread, rye, barley and quinoa are healthier than highly processed white bread or French fries [38]. Carbohydrates come in two forms: simple and complex. While simple carbohydrates like sugars provide a quick energy source, they can also cause an insulin spike, which may lead to weight gain and other health complications if consumed in excess. Complex carbohydrates (e.g., starch) such as those found in whole grains, fruits, and vegetables get broken down by the body more slowly, providing a steady energy source throughout the day. Athletes are sometimes found consuming very high amounts of carbohydrates, known as carbohydrate loading. This is one specific dietary intervention that can improve exercise performance. Carbohydrate loading usually involves increasing carbohydrate intake in the days leading up to an endurance event, such as a marathon or long-distance cycling race. The practice helps increase muscle glycogen stores, which can provide energy during prolonged exercise. However, it is essential to note that carbohydrate loading should only be done under the guidance of a healthcare professional or sports nutritionist, as it can also lead to weight gain and gastrointestinal discomfort.

The different forms of carbohydrates that can be found in food include:

- Fibre is usually found in fruits, vegetables, nuts, seeds, beans, and whole grains. The body usually has a hard time digesting these carbohydrates [39].
- Total sugars comprise naturally occurring and added sugars, such as those found in dairy products, baked goods, candies, and desserts. These carbohydrates are readily absorbed and metabolized by the body [40].
- A form of carbohydrate that the body has trouble processing is sugar alcohol. They taste sweet and contain less calories than sugar. They are frequently used in foods like gum, baked goods, and sweets as low-calorie sweeteners [41].

3.1.2 Proteins

Proteins are identified as the building blocks of the body. They are essential for the growth and repair of tissues, the regulation of body processes, and the body's overall functioning. Proteins are made up of amino acids, some of which must be obtained from the diet. Animal products such as meat, eggs, and milk are high-quality sources of protein. However, plant-based sources like legumes, soy, and quinoa can provide enough essential amino acids. The U.S. Food and Drug Administration (FDA) recommends (Table 3) that adults consume 50 grams (g) of protein per day as part of a 2,000-calorie diet. However, the amount of protein a person needs may vary depending on the type of exercise they are involved in or their age or disease state. Proper nutrition and physical activity play a crucial role in disease prevention; however, most adults fail to meet the recommendations for the general public. The following daily quantities (RDA) of protein are suggested by the Dietary Guidelines for Americans 2015-2020 for various age and sex categories.

Table 3 Dietary Guidelines for Americans Daily Protein Intake Recommendation.

Age	Protein RDA
Age 1-3	13 g
Age 4-8	19 g
Age 9-13	34 g
Age 14-18 (Female)	46 g
Age 14-18 (Male)	52 g
Age 19+ (Female)	46 g
Age 19+ (Male)	56 g

3.1.3 Fats

Fats also play an important role in the body. They help absorb fat-soluble vitamins and provide energy. However, consuming too much saturated fat can raise the chances of developing heart disease [42]. Unsaturated fats, such as those found in nuts, seeds, and avocados, and polyunsaturated fats like omega 3 and omega 6 found in fish can lower the risk of heart disease when they replace saturated fats in the diet. Several studies have shown that unsaturated fats are the most beneficial for a human diet because they improve blood cholesterol, stabilize heart rhythm and ease inflammation [43]. Specifically, monounsaturated fats are considered the best type of fat. Saturated fats from animal sources are considered acceptable, while trans fats should be avoided altogether.

3.1.4 Water

Water is one of nature’s most essential and prevalent substances, and its physical and chemical properties are well understood. Water is an excellent solvent and carrier for many electrovalent substances, including NaCl. Because it enables appropriate alignment of the dissolved ions, water acts as a catalyst for various chemical reactions. Athletes lose a significant volume of water after only a few hours during competitions [44]. Sweating and higher respiration are factors in the significant water losses that occur during training. It would be illogical to hinder sweat production

by ingesting less liquid, which can impair athletic performance. As a result, athletes must have a healthy fluids balance. Depending on the proportion of loss, several illnesses are brought on by the loss of water in the body. According to research, about 1% of athletes have experienced the starting point for thermoregulation disorders, usually characterized by the beginning of thirst and a 10% reduction in athletic performance [45]. The threshold for intense thirst, discomfort, and appetite loss has occurred in at least 2% of athletes. In at least 3%, utter dryness of the mouth, increased haemoconcentration, and decreased urine have been seen, at which stage athletic skills decline by up to 20% (especially cardiocirculatory endurance). In 4% of persons who have experienced thermoregulation disorder, there is up to a 30% reduction in athletic ability, and the attention of a professional medical staff is usually required to manage the situation. Difficulty focusing, severe headache and trouble falling asleep are the other symptoms of thermoregulation experienced by about 5% of people. About 6% of people have a complete and severe disorder of thermoregulation that can result in clinical heat stroke (edema, tetany, syncope, and hyperventilation). Another 7% of people experience collapse due to heat stroke and potential hyperthermia [46].

3.1.5 Vitamins and Minerals

A study showed that vitamins and minerals regulate body processes [47]. They help form bones and teeth and blood clotting nerve and muscle function. Good sources of vitamins and minerals include fruits and vegetables, whole grains, and lean meats. Taking vitamins and minerals in the right proportion is essential because an over or under-dose may be harmful or futile (Table 4).

Table 4 Recommendation of Intake of Minerals and Effects of Overdose.

Minerals	Recommended	Over-dosage	References
Calcium	1000 mg	For people with sensitive stomachs, doses greater than 1500 mg can create issues.	Nikkhah and colleagues [48]
Chromium	120 µg	Doses of more than 200 g may result in difficulty concentrating and dizziness.	Grubina and Klocke [49]
Copper	2 mg	10 milligrams of copper can have extremely harmful effects.	Taylor and colleagues [21]
Iron	15 mg	More than 20 mg of a dose may result in upset stomach, constipation, and dark stools.	Liu [50]
Magnesium	350 mg	Diarrhea and digestive problems will occur at concentrations higher than 400 mg.	Semrad [51]
Manganese	5 mg	Additional magnesium will hinder the absorption of the iron.	Piskin and colleagues [52]
Molybdenum	75 µg	Moreover, 200 g of a substance can cause copper deficiency and kidney problems.	Burkhead and Collins [53]
Nickel	<1 mg	Nickel-containing foods can cause skin rashes in those with allergies.	Sharma [54]
Phosphorus	1000 mg	The FDA states that dosages above 250 mg can be problematic for sensitive individuals.	Karalis and colleagues [55]
Potassium	3500 mg	High doses may cause cardiac arrhythmia	Maruyama

		disturbance, gastrointestinal upset, or other problems.	and colleagues [56]
Selenium	35 µg	More than 200 g of a dose may be hazardous.	Willson [57]
Zinc	15 mg	Copper deficiency and anaemia can arise from doses greater than 25 mg.	Wazir and Ghobrial [58]

3.2 Exercise

Exercise is any physical activity that improves or maintains physical fitness and overall health. There are different types of exercises, each with its unique health benefits [59] for example, one of the most significant benefits of regular exercise [60] is the maintenance of cardiovascular health as it has been demonstrated to improve overall cardiovascular function, lower blood pressure, and reduce the risk of heart disease. Aerobic exercises like running, cycling, and swimming are particularly effective for improving cardiovascular health. Additionally, weight management is another benefit of regular exercise, as calories get burned through exercise, aiding in weight loss [61]. Weight-bearing exercises like walking, running, and weightlifting also help strengthen bones and reduce the risk of osteoporosis. Improved mobility and flexibility are also benefits of regular exercise. Yoga or tai chi, which combines flexibility and balance exercises, can assist in increasing the range of motion and lowering the risk of injury [62]. Moreover, a powerful form of exercise known as high-intensity interval training (HIIT) alternates short bursts of intensive activity with rest intervals. HIIT has been demonstrated to be especially helpful for reducing body weight and enhancing cardiovascular health [63]. In addition to the physical benefits, exercise has also been shown to be beneficial for mental health [64]. Stress management, mood improvement, increased cognitive function, and better sleep. It is significant to mention that combining different types of exercises can better impact overall health and wellness. For example, a combination of aerobic, strength and flexibility exercises are recommended for optimal health outcomes [65]. Nevertheless, exercise should always be tailored to the individual's fitness level, age, and health condition. Consultation with a healthcare professional is also recommended before starting a new exercise regimen.

3.2.1 The Effects of Exercise on Different Systems of the Body

Regular exercise is essential for maintaining physical fitness and overall health. Exercise has a wide range of physical and mental health benefits (Table 5), including improving cardiovascular and muscular health, reducing the risk of developing chronic disease, and improving cognitive function. Below are the benefits of exercise on different organs of the body.

Table 5 Effect of Exercise on Health Performance.

Type of Exercise	Effect on Health	References
Balance Exercises	Maintains balance and stability, and can lower the risk of falls	Thomas and colleagues [66]
Flexibility Exercises	Increases the range of motion in joints and muscles and can reduce the risk of injury and improve posture	Iwata and colleagues [67]

Strength Training	Builds and tones muscles and improves bone density	Hong and Kim [68]
Aerobic Exercises	Maintains balance and stability, and can lower the risk of falls	Bednarczuk and Rutkowska [69]

On Mental Health. A large body of research supports physical activity as a non-invasive treatment for cognitive and mental health problems [70]. In 1979, research conducted by Greist and colleagues found that running had similar effects in reducing the symptoms of depression as psychotherapy. However, the exact mechanisms through which exercise prevents or mitigates depression are not yet fully understood [71]. Exercise contributes to different aspects of mental health. For example, stress management is a significant benefit of regular exercise, decreasing stress hormone levels and improving mood [72]. Physical exercise has also been shown to increase the release of endorphins [73], which are neurochemicals responsible for the feeling of happiness and well-being. Better sleep is yet another benefit of regular exercise, as it improves sleep quality and reduces insomnia symptoms [74]. Furthermore, also, exercise increases cognitive function by improving memory and concentration [75].

Benefits of Exercise for Non-Athletes. For non-athletes, setting goals is an essential preliminary step in incorporating exercise into daily life. Setting specific, measurable, and realistic goals can help to keep one motivated and on track. Creating a plan is also vital as it will assist in determining what type of exercise one should do, how often they should do it, and how long they should do it. Moreover, different types of exercises have other benefits; it is, therefore, important to find the type of exercise that one enjoys and will help one achieve their goals. Whether running, weightlifting, yoga, or some other activity, one should find an activity that one enjoy and can stick to. Those intending to begin an exercise regime must also prepare for eventualities because there may be obstacles to overcome since life is unpredictable. In such a case, they can adopt flexibility and find ways to work around any challenges. For example, if one can't make it to the gym, one should try walking during the lunch break or working out at home [76]. Sadly, despite the many health advantages of exercise, most people lead relatively sedentary lifestyles and don't exercise enough to benefit from its advantages.

3.3 Dietary Intervention

Dietary intervention is any change or treatment made to a person's diet with a specific intention, usually to enhance that person's general health. According to the Academy of Nutrition and Dietetics, dietary intervention aims to resolve or improve nutrition diagnosis by offering guidance, education, or the food component of a particular diet or meal plan tailored to the patient or client's needs. Sometimes, dietary interventions are incorporated to enhance an athlete’s stamina (the capacity of the muscle cells to function continuously while sustaining the strains of exercise) during training. Usually, trainings that require endurance have three periods: the pre-, during-, and post-workout phases. The dietary needs that drive these phases change depending on the intensity, kind of exercise, body composition of the individual, training period, weather conditions, etc. Typically, glycogen synthesis and reserve glycogen breakdown are needed during pre-workout. The workout phase requires athletes to quickly absorb exogenous glucose to be transported into muscle cells by insulin to replace lost electrolytes and encourage fluid retention. On the other hand, the post-

workout phase involves cell growth, repair of injured muscle tissue and joints, and decrease of inflammatory and oxidative stress [77]. It is, therefore, advised to consume dietary foods that can support these metabolic needs.

3.3.1 Dietary Supplements

The Dietary Supplement Health and Education Act of 1994 defines a "dietary supplement" as one that contains at least one or more dietary elements, such as vitamins, minerals, amino acids, herbs, or other botanicals and helps enhance one's diet [78]. Dietary supplements are primarily consumed to prevent diseases, meet nutritional needs, strengthen health, makeup patients' dietary needs regarding food intake restrictions, boost energy, etc. Their ability to supply the daily recommended amount of nutrients makes dietary supplements a crucial source of critical nutrients. However, excessive consumption of fat-soluble vitamins may lead to large nutrient stores within the body. This, in addition to interactions they may have with meals and other pharmaceuticals, is the negative effect of excessively consuming supplements [79]. Nutritional supplements comprising proteins, carbohydrates, vitamins, and minerals are frequently utilized in various sports to complement the daily recommended amounts. Additionally, several supplements like coenzyme Q10 (CoQ10), dried garlic, and hawthorn have been identified to have physiological effects, and some of them are regarded as helpful for enhancing exercise performance or for injury prevention

3.3.2 Ergogenic Aids

Any chemical or substance that can be used to improve athletic performance is referred to as an "ergogenic aid." Ergogenic aids are commonly categorized as dietary, pharmacologic, physiologic, or psychological (nootropic) substances. They can range from legal and safe methods like carbohydrate loading to illegal and risky ones like the usage of growth hormone and anabolic-androgenic steroids (AAS). Due to the widespread usage of ergogenic aids in sports, many athletes seek information on the safest supplements to increase their strength, endurance, and lean body mass. Some dietary supplements' ergogenic effects can have noteworthy short- and long-term benefits for bodybuilders, fitness fanatics, or competitive athletes. However, it's crucial to distinguish between authorized and illicit ergogenic aids, particularly for athletes who compete in organizations that carry out drug testing on athletes. The use of AAS, peptides (such as growth hormone), and other pharmacological doping drugs is strictly prohibited by the rules of almost every significant sporting commission. Moreover, even harmless substances like water can become harmful when taken excessively, whereas poisonous substances like cyanide and carbon monoxide can become safe at relatively low doses. One must, therefore, carefully determine the dose of ergogenic aids to take. Hydration is vital to physical and mental performance, so water is considered an ergogenic aid. In addition to plain old water, a variety of easily accessible sports nutrition supplements provide ergogenic benefits and are supported by scientific investigations to e safe for both healthy athletes and non-athletes (Table 6). The table below shows some legal and effective ergogenic Aids.

Table 6 Effects of Caffeine Supplementation.

Confusion	Too much caffeine can overstimulate the brain, leading to confusion Kolahdouzan and Hamadeh [80].
Pregnancy Issues	Obstetrical Problems Caffeine abuse during pregnancy has been linked to miscarriage and newborn developmental problems. It's advised that pregnant women limit their daily caffeine intake to 200 mg, or roughly one 12-ounce cup of coffee Wierzejska and colleagues [81].
Fertility issues	The inability of some women to become pregnant may be caused by excessive coffee use. Limiting your daily intake to 300 mg is advised if you're attempting to get pregnant Lyngsø and colleagues [82].
Increased Urination	Caffeine may cause you to urinate more frequently. Long-term consumption of large amounts of caffeine raises the risk of bladder instability and makes people who already have bladder issues more vulnerable Bradley and colleagues Wassef and colleagues [83].
Rapid heartbeat	Fast heartbeat: A quick heartbeat can be brought on by caffeine. If you already have a cardiac condition, this could be a problem. Every time you consume coffee, you can experience arrhythmias Wassef and colleagues [84].
Heartburn	Heartburn can be brought on by the acidity of several caffeinated beverages, including soda and coffee Wierzejska and colleagues [81].
Jitters	Caffeine may make you feel jittery if you're not used to it. Caffeine may exacerbate any anxiety or sleep disorders you might have, Zou and colleagues [85].

Caffeine as an Ergogenic Aid. Although it has no nutritional benefit and is not necessary for any fundamental bodily functions, caffeine is one of the world's most widely used pharmacologically active drugs [86]. Due to its widespread inclusion in various foods, beverages, and dietary supplements, caffeine use is widespread and is influenced by some socio-cultural factors [87]. As a result, up to 80% of people worldwide consume caffeine daily.

Additionally, caffeine use has become widespread in the context of sports, especially after the World Anti-Doping Agency removed caffeine from its list of prohibited substances [6]. According to available research, caffeine supplementation is frequently seen among athletes before or during competitions [88]. All sports disciplines usually include some form of caffeine administration. Because many athletes utilize caffeinated pills and sports beverages, the amount of caffeine they ingest may be higher than that the general public consumes. Many research studies demonstrate caffeine's ergogenic effects in various metrics related to exercise performance. Acute caffeine intake has been linked to improvements in sprint and agility performance, maximal strength and endurance muscular performance, and aerobic endurance and anaerobic performances. While getting equivalent ergogenic benefits with low-dose caffeine intake is possible, athletes may at least need to consume it at moderate-to-high levels while competing [89]. It is important to note, however, that ingesting caffeine, especially in excessive amounts (9.0 mg/kg) can have several negative effects, such as headache, nausea, vomiting, tachycardia, sleeplessness, nervousness, and tremor. This is especially true for individuals who are not accustomed to consuming caffeine. So,

there will be discomforts instead of boosted effectiveness, which could hurt their performance, especially in sports where competitors are required to contend multiple times in a single day or with little time for recuperating. In extreme situations, a caffeine overdose can even result in severe intoxication, posing a health danger to the athlete. It is, therefore, crucial to analyse the prevalence of negative effects associated with different caffeine dosages in the context of sports to design caffeine supplementation regimes that improve athletic performance while also considering their safety and well-being. However, low-dose caffeine consumption has been linked to little or no adverse effects, showing that the frequency and severity of negative impacts are dose-dependent [90].

Caffeine Intake for Normiees. The American Food and Drug Administration (FDA) estimates that about 80% of American adults consume caffeine daily in some manner. Caffeine is a stimulant of the central nervous system that has a variety of physiological effects, but it primarily causes alertness when entering the brain. Given that it increases alertness and decreases drowsiness, it is frequently found in medications that treat or manage sleepiness, headaches, and migraines. Excess caffeine does not get stored in the body; it is broken down in the liver and expelled through urine. This explains why one may experience increased urination upon consuming coffee. Cardiac output might also momentarily rise in people after coffee consumption. Elevated adrenaline levels are believed to be responsible for this effect. Excessive consumption of this stimulant may also obstruct calcium absorption and metabolism. This may cause thinning of the bones (osteoporosis). Furthermore, the placenta is exposed to caffeine traveling through the bloodstream; hence, its stimulant properties may increase fetal heart rate and metabolism, thereby hindering their growth and development. The excessive use of coffee by a pregnant woman is additionally able to increase the risk of a miscarriage. Pregnant women can, however, drink a little caffeine without any problems. The following foods and beverages frequently contain caffeine. They are not to be taken regularly: Black and green tea, coffee, espresso, chocolate, energy drinks, and a few over-the-counter drugs like Excedrin. Table 7 below shows some adverse effects of caffeine supplementation.

Table 7 Some Legal and Effective Ergogenic Aids.

Beta-alanine	As one of the most widely used compounds in pre-workout supplements, beta-alanine is a non-essential amino acid. Higher strength gains, enhanced physical performance, and increased endurance are some outcomes of beta-alanine administration Maté-Muñoz and colleagues [91].
Whey protein	Whey protein, whether it is protein isolate or protein concentrate, is a pure protein because it has all nine essential amino acids. Leucine, an amino acid that has been proven to efficiently increase muscle protein synthesis and support the development of greater lean muscle mass, is a component of both whey protein isolate and concentrate Park and colleagues [92].
L-Citrulline (malate)	Increasing the synthesis of nitric oxide in endothelial cells, which causes vasodilation developing insulin sensitivity and promoting glucose metabolism Increasing the production of beta-endorphins Meza and colleagues [93].

Carbohydrates powder	When it comes to promoting muscle protein synthesis and restoring glycogen, CARB POWDER is the ideal complement to protein powder Margolis and Allen [94].

3.3.3 Creatine

Creatine is one of the energy sources that the body uses to contract muscles organically. It takes its name from the Greek word for meat. A meat diet provides roughly half of the body's supply of creatine, while the other half is produced in the liver and kidneys and then transported to the skeletal muscles for use. Creatine ensures that working muscles have a consistent energy source by maintaining production in active muscles. Little amounts are present in the heart, brain, and other tissues. Creatine is also found in milk, red meat, and seafood. In a typical omnivorous/carnivorous diet, one to two grams of creatine are consumed daily. In a stable state, creatine coexists alongside creatinine, which is usually assessed in lab tests to measure the kidney's function since the body excretes it in the urine. The body must release stored creatine daily to maintain normal levels; the quantity depends on the individual's muscle mass. Although the human body produces creatine on its own, one will still need to keep its levels, which can be done by eating the right foods daily. Athletes of all levels benefit from creatine supplements regarding training regimens and post-workout recovery. Creatine increases energy and strength and gives a "quick boost" to improve performance but has little effect on aerobic endurance. Most male athletes who use creatine supplements participate in power sports like football, track events, wrestling, hockey, and bodybuilding. The supplement has earned the endorsement of the National Collegiate Athletic Association, the International Olympic Committee, and professional sports associations (NCAA). Both men and women have benefited, even though most studies have been done only on men. More so, studies suggest that women taking creatine supplements may not gain as much strength or muscle mass as men do [95]. According to research, taking supplements containing creatine may boost the capacity for activity, enhance creatine to recover from a demanding workout, minimize the severity of an injury, help athletes endure demanding training loads and increase the lean muscle one has (Table 8).

Table 8 The Effect and Results of Creatine.

Strength, muscle size and performance	By using oral creatine, an athlete may be able to put up more effort during sprints or repetitions, leading to greater gains in strength, muscle mass, and performance. Creatine is commonly used by athletes who take part in high-intensity intermittent sports that require speedy recoveries during practice and competition Jiménez and colleagues [88].
Injury protection	If you take oral creatine supplements, you can experience fewer injuries to your muscles, bones, ligaments, tendons, and nerves Ewing and colleagues [96].
Rare creatine-metabolizing syndromes	Oral creatine supplementation may help symptoms in kids with specific creatine deficient disorders Rodak and colleagues [90].

Cognition and brain health	Supplementing with creatine may enhance cognitive performance, particularly in elderly persons Dyson and colleagues [97].
Sarcopenia and bone health	Age-related reductions in skeletal muscle and bone mineral density may be slowed by using creatine supplements Bakar and colleagues [98].
Skin aging	Preliminary research suggests that men may experience less skin sagging and wrinkles after applying a lotion containing creatine and other compounds to their faces every day for six weeks. According to a different study, a moisturizer containing folic acid and creatine can reduce UV damage and wrinkles Mahmood [34].

4. Conclusions

Keeping an energy requirement, a nutrient-dense diet, training, correctly regulating nutrition consumption and obtaining sufficient recovery are the foundations of increasing athletic performance. In some cases, using a small number of nutritional supplements (for example, sports drinks, carbohydrates, protein supplements, caffeine, b-alanine, etc.) may boost energy or aid in recovery. Sporting nutritionists must keep themselves informed on the connection between diet and physical activity in order to precisely and honestly advise their students and clients about the effects of food and nutritional substances on workouts and performance, as well as to help the public make educated decisions about the best forms of exercise, diet, and specific dietary supplements to make. Furthermore, sports and nutrition specialists should actively participate in exercise nutrition research and write objective scholarly reviews for journals and lay publications to help disseminate current research findings to the public. Businesses that offer nutritional supplements should develop products based on science, fund research on such products, and properly make known the results of studies so that users may make well-informed choices.

Author Contributions

OE, GE, EY, PS, AJ, KZ, AM, WN, SN, UU, JA, IA, HU, HE, EO, PA, JO, LE, PO, UI, FI, AE were responsible for the conception and design of the study; OE, GE, AJ performed data collection. OE, GE, AJ performed data analysis and drafted the article. GE, EY supervised the study, contributed to data analysis, interpretation, and critical revisions. All authors approved the final manuscript.

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Competing Interests

The authors declare no conflict of interest.

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