THE ATHLETE'S GUIDE TO SPORTS SUPPLEMENTS

The most popular supplements:

- ***How they work***
- ***Performance benefits***
- ***Health concerns***

Kimberly Mueller | Josh Hingst

The Athlete's Guide to Sports Supplements

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The Athlete's Guide to Sports Supplements

SUPPLEMENT FINDER

■ Beneficial
□ Possibly beneficial

Supplement	Fuel usage	Aerobic capacity	Anaerobic endurance	Strength, power, and hypertrophy	Strength and power endurance	Psychological	Hydration	Recovery	Joint support	Immunity	Antioxidant	Body composition	Notes
Acetylcysteine		□			□			□					
Arginine			□	□	□								
Astragalus										□			
Avocado soybean unsaponifiables									□				
Beetroot		■	■										
Beta-alanine			■		□								
Beta glucan								■		■			
Boron								■	■				More research needed; appears beneficial only in deficient states
Boswellia serrata								□	□				
Branched-chain amino acids (BCAAs)				■				■					
Caffeine	■			■	■	■		■				□	
Calcium												□	
Capsicum								■	■		■		
Carbohydrate	■			■	■	■		■					
Casein				■				■					
Cat's claw									□				
Chitosan												□	

The supplements listed here include only those that have demonstrated health- and performance-oriented benefits through well-controlled and replicated scientific research. Chapter 3 includes additional supplements that either require further research or don't have demonstrated benefits.

>continued

Supplement Finder >continued

Supplement	Fuel usage	Aerobic capacity	Anaerobic endurance	Strength, power, and hypertrophy	Strength and power endurance	Psychological	Hydration	Recovery	Joint support	Immunity	Antioxidant	Body composition	Notes
Choline		□			□								Only beneficial for longer duration endurance exercise or short-burst, high-intensity efforts lasting longer than 2 hours
Chondroitin									□				
Cinnamon								□			■	□	
Citrulline malate	□				□			□					
Cocoa		□								□	■		
Coconut								□		□		□	
Coenzyme Q10								□			■		
Colostrum				□				□		□			
Cordyceps sinensis		□											
Creatine				■	■			■					
Curcumin								□		□	■		
Devil's claw									□				
Ecdysteroids				■				□					
Egg protein				■				■					
Elderberry										□			
Fenugreek	□							□		□			
Fiber												■	
5-HTP								□					
Folic acid		□											
Garlic								□		■	■		
Ginger								□	□	■	■		
Ginseng		□				□		□					
Glucosamine									□				
Glutamine	□							□		□			
Grape seed								□	□	□			

Supplement	Fuel usage	Aerobic capacity	Anaerobic endurance	Strength, power, and hypertrophy	Strength and power endurance	Psychological	Hydration	Recovery	Joint support	Immunity	Antioxidant	Body composition	Notes
HMB								□					
Hydroxycitric acid												□	
Iron		■						■		■			
Isomaltulose	■							■					
Leucine				■				■					Beneficial only when complete protein intake is inadequate
Magnesium	■	■	■		■				■				Beneficial for deficient populations only
Medium-chain triglycerides (MCTs)												■	
Melatonin								□					Possibly beneficial but only for jet lag
MSM									□				
Omega-3 fatty acids	□	□				□		□	□	□		□	
Phosphate salts	■	■	■		■			■					Beneficial for high-intensity endurance activity (e.g., time trials)
Phosphatidyl-serine		□		□					□				
Piperine												□	
Potassium	■						■		■				Replacement via sport drink beneficial for prolonged activity
Probiotics										■			
Pycnogenol		□						□	□				
Quercetin		□						□		□	■		
Resveratrol	□	□						□		□	■	□	
Rhodiola rosea	□					□		□		□			

>continued

Supplement Finder >continued

Supplement	Fuel usage	Aerobic capacity	Anaerobic endurance	Strength, power, and hypertrophy	Strength and power endurance	Psychological	Hydration	Recovery	Joint support	Immunity	Antioxidant	Body composition	Notes
S-adenosyl methionine (SAMe)								□	□				
Salt							■						
Sea buckthorn		□						□					
Selenium					□			□		□			
Sodium bicarbonate and sodium citrate	■		■		■								Beneficial primarily for female athletes engaged in short, high-intensity activities
Soy protein				■				■			■		
Superoxide dismutase								□			■		
Synephrine												□	
Tart cherry								■			■		
Thiamine	□				□	□							
Tyrosine		□			□								Only beneficial in warm environments
Undenatured type II collagen									□				
Vitamin C					□			□	□	□	■		Possibly beneficial for ultra-athletes
Vitamin D				■				■				■	
Vitamin E								□			■		Possibly beneficial for ultra-athletes
Whey protein				■				■					
Willow bark									□				
Withania somnifera								□		□			
Zinc		■						■		■			Beneficial for deficient athletes; possibly beneficial in nondeficient population

PREFACE

> Doctors and scientists said that breaking the four-minute mile was impossible, that one would die in the attempt. Thus, when I got up from the track after collapsing at the finish line, I figured I was dead.
>
> Roger Bannister (after becoming the first person to break the 4-minute mile in 1952)

Each year, there are a handful of athletes who defy odds and break performance barriers once believed to be impossible. In 2010 professional baseball player Ichiro Suzuki became the first major league baseball player to string together 10 consecutive seasons of 200+ hits. In the same year, Tony Gonzalez of the Atlanta Falcons became the first tight end in National Football League history to record 1,000 career receptions and 12,000 career receiving yards. In 2011 Patrick Makau of Kenya set the world record for the marathon by running a blazing 2:03:38 in Berlin, leaving many to wonder if a sub-2-hour marathon is indeed realistic. In 2012 several athletes performed at record-breaking levels during the Summer Olympics in London.

The science of training athletes has come a long way in the last 100 years. Top-level sport scientists are developing new methods of training, strategies for nutrition and supplement use, recovery protocols, and psychological tools to assist athletes in optimizing their abilities. This is in large part why performance milestones continue to be broken. This book is designed to shed light on the truths behind the most popular performance-focused nutritional supplements.

Chapter 1 focuses on what you, the athlete, coach, or health professional should know about supplements. We address the history of the sports supplement industry and provide you with insight into the manufacturing practices and regulation of sports supplements. We give you the tools to assess, evaluate, and purchase supplements to fit your needs and the needs of your athletes. Common questions are addressed, especially concerning the efficacy of supplement use in sports.

Chapter 2 explores the performance keys that are often targeted by supplement industry marketing, including claims that these key performance indicators can be enhanced through supplementation with various ingredients. This chapter will give you a better understanding of how supplements might be beneficial, and which areas of performance they will affect. In general, the cardiovascular, muscle, and psychological systems may all be influenced through specific nutritional supplements. To specifically address how a particular supplement may be ergogenic (i.e., enhance physical performance), each system is examined closely. For example, the

section on the cardiovascular system addresses aerobic capacity, anaerobic endurance, and fuel usage. The section on muscle performance looks at muscle size and composition, neurological function, strength and power production, and resistance to fatigue. The section on psychological aspects notes several nutrients that may affect cognitive performance. There are also several outside variables that have a profound impact on performance in sport, including hydration status, overall recovery of body systems, and an athlete's body composition. Most athletes will tailor their training to focus on one or several of these performance factors. For example, a football player who is unable to hold his position will work on building muscle size and composition during the off-season while a marathon runner will increase weekly distance run as a means of boosting aerobic capacity. In addition to training, athletes will often seek nutritional guidance from a sports dietitian to learn about whole foods and ergogenic supplements that may help give them a legal performance edge on their competition.

Chapter 3 provides an alphabetical guide to the most popular performance-focused supplements marketed today. For each supplement, you'll find a description of the ingredient along with common supplement names and food sources, a discussion of the latest scientific research practical applications for dosing, recommended performance daily intake (if applicable), deficiency and toxicity symptoms (if applicable), and drug or supplement interactions (if applicable). Some supplement descriptions include information about additional performance benefits as a separate section; these other uses are not detailed in the research discussion. As you flip through the supplement guide, you'll see that each performance variable is assigned a symbol that will serve as a quick reference tool. If a supplement has been proven to be beneficial for a particular performance variable, the supplement entry will be marked with the corresponding black symbol; if the research shows that a supplement is possibly beneficial, the entry will be marked with a gray version of the corresponding symbol. You can use the supplement finder (located at the beginning of the book) to quickly identify supplements that have demonstrated benefits based on these performance variables.

Our final chapter explores the unique nutritional challenges athletic populations have to overcome in order to perform at peak and details the supplements that may help them excel. This chapter also includes nutritional recommendations for the following categories of athletes:

- Master's-level athletes
- Child and adolescent athletes
- Female athletes
- Injured athletes
- Athletes with diabetes
- Athletes with food allergies or intolerance
- Vegetarian athletes
- Athletes competing in heat or cold
- Athletes competing at altitude

Finally, a complete list of references and resources can be found at www.humankinetics.com/products/all-products/Athletes-Guide-to-Sports-Supplements-The.

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When esteemed publisher Human Kinetics first approached me about taking on this project a few years ago, my athlete mentality of "go after it" immediately came to the fore, and I enthusiastically took on the monumental challenge, one that had been a prominent part of my career bucket list since becoming a registered dietitian over 10 years ago. I will forever be grateful for this wonderful opportunity to help dispel the myths and discuss the truths that exist in the nutrition field and dietary supplement industry and ultimately create an important reference tool for all involved in the training and development of athletes.

Much like in a sport where a team of people, including coaches, teammates, parents, trainers, doctors, dietitians, and others all aid in the success of an athlete, the completion of this project could have not been accomplished without the invaluable support of several key players over the years. My undergraduate and graduate studies and athletic career at both Illinois State University and Florida State University certainly laid the groundwork for my career passion as a sports dietitian. In particular, research collaboration with professors Dr. Robert Cullen and Dr. Dale Brown as well as work on the nutrition and dietary supplement front with former team physician Dr. Bryan Barootes of Illinois State University really opened my eyes to the nutritional issues in sports and fostered my determination to help fellow athletes successfully and safely achieve peak performance. I am thankful for these career-paving experiences and the breakthrough research revelations and work fellow sport science colleagues continue to do. Their efforts no doubt have contributed to some of the mind-blowing performances that have made history in recent years. Most importantly, though, I'd like to extend a huge amount of gratitude to my brilliant colleague and coauthor, Josh Hingst, for the thousands of hours he has put into our project and to the team of editors and staff at Human Kinetics who have helped make this dream a reality for the two of us.

Finally, I'd like to thank my parents, Charles and Nancy Mueller, family, and friends for the unparalleled amount of support, love, and encouragement to *carpe diem* that they have provided as I have chased after my professional and athletic dreams.

—Kimberly Mueller

Helen Keller said, "Alone we can do so little; together we can do so much." I am grateful for the opportunity to have had an important role in the completion of this book and believe it will be a powerful reference for many. There are many people to thank and acknowledge for their work and insight. First, I thank the scientific community of professors and researchers who diligently work to discover the benefits of the many supplements addressed in this book. It is their dedication to ethical, unbiased science that enables us to find true understanding. Particularly, I'd like to thank the many professors of Florida State University and the University of Nebraska who invested their time and effort in me as a graduate and doctoral student, especially Dr. Wanda Koszewski from the University of Nebraska. Thank you to Dr. Jeff Stout, University of Central Florida, for his insightful review of the book, as well as to Dave Ellis and Lori Bestervelt. I'd like to thank Human Kinetics for the opportunity to coauthor this book and for the diligent work of their editors and staff. Thank you to my parents, Glenda and David Hingst, for their encouragement and support in all my professional endeavors. Finally, I acknowledge God, His son and my savior Jesus Christ, who shows His love for us in that while we are still sinners, Christ died for us.

—Josh Hingst

CONTENTS

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Understanding Supplements

> The strongest thing I put into my body is steak and eggs. I just eat. I'm not a supplement guy. Steroids are not even a thought.
>
> Jim Thome, professional baseball player

Jim Thome, a designated hitter and first baseman for the Minnesota Twins, hits a homerun with his quote. Balanced whole food nutrition is indeed the most important factor in fueling athletic performance. However, when every second faster, every ounce stronger counts, an athlete will often do everything possible to gain that competitive edge, from using specialized gear to the latest in sport nutrition. Combine this innate drive to succeed in sport with an interest in filling nutritional gaps and maintaining overall health and wellness, and you have serious fuel for the dietary supplement industry, making it one of the fastest-growing markets worldwide with an estimated $25 billion in yearly sales in the United States alone.

A dietary supplement, officially defined in the Dietary Supplement Health and Education Act of 1994, is a pill, capsule, tablet, powder, or liquid intended to supplement the whole food diet by providing any combination of the following nutritional ingredients: vitamins; minerals; herbs or other botanicals (excluding tobacco); amino acids; a dietary substance used to increase total dietary intake (such as carbohydrate and protein); and a concentrate, metabolite, constituent, or extract. Many of the sport nutritional supplements currently used by athletes are advertised as increasing testosterone levels in the body, similar to anabolic steroids (AAS), thereby enhancing the athlete's ability to build lean body mass. Other nutritional supplements

are marketed as improving energy levels during workouts or competition or speeding recovery postworkout. There are supplements whose labels claim they facilitate body fat and weight loss, which is especially alluring to athletes competing in sports such as dance and gymnastics, where physique is spotlighted. Unlike steroids, however, which are only available in the United States with a doctor's prescription thanks to the list of known side effects, nutritional supplements can be purchased over the counter with relatively scant regulation on claims being made and safety for the consumer. Even so, data have indicated that some 70%-90% of collegiate and Olympic-level athletes supplement with at least one ingredient, hoping that the potential benefits of taking these substances outweigh any associated risks (Froiland et al., 2004; Burns et al., 2004).

With the growing popularity and use of nutritional supplements has come an alarming increase in the number of athletes, both amateur and professional, testing positive for banned substances, further raising concern from ethical and safety standpoints. In the late 1990s and early 2000s, Victor Conte and Bay Area Laboratory Co-Operative (BALCO) worked with chemists to develop tetrahydrogestrinone (the Clear), a formerly undetectable performance-enhancing steroid that was distributed to several high-profile sport stars in the form of so-called nutritional supplements. Agents of the Internal Revenue Service, Food and Drug Administration (FDA), San Mateo Narcotics Task Force, and United States Anti-Doping Association (USADA) eventually brought BALCO to justice, but the outcome left several athletes with tarnished images.

Perhaps in his quotation, Thome intended to share some of his frustration about the revelations from BALCO and later the 2007 Mitchell Report, which accused 89 fellow Major League Baseball players of using anabolic steroids, human growth hormone (HGH), or other performance-enhancing substances to drive their professional careers to another level, often a record-breaking level. From October 2000 until November 2001, the International Olympic Committee investigated 634 nonhormonal nutritional supplements such as vitamins, minerals, proteins, and creatine obtained from 215 suppliers; the investigation found 15% to be contaminated with banned substances, mainly steroidal substances or prohormones, that were not listed on the product labels and that would have caused an athlete using the supplement to test positive during a doping test (Geyer et al., 2004). The news hasn't improved much in recent years. An investigation of over 60 dietary supplements, for example, discovered 12.5% contained banned substances not declared on the labels, specifically anabolic steroids and ephedrine (Martello, Felli, & Chiarotti, 2007). Additionally, a popular nutritional supplement for weight loss was found to contain the beta2-agonist clenbuterol, which is banned by both the World Anti-Doping Agency (WADA) and the NCAA (Geyer et al., 2008). These cases demonstrate how easily an athlete may become the victim of inadvertent doping, not to mention experiencing a heightened health risk.

Perhaps the most captivating 2012 news was the charging of seven-time Tour de France champion, Lance Armstrong, by USADA for having used illicit performance-enhancing drugs during his professional career. This charge not only lead to all his titles since 1998 being stripped from him but also to a lifetime ban from competition in all sports that follow the WADA code. A ban from sport, a passion for most athletes, is a legitimate risk for any athlete choosing to use a banned drug or unregulated substance during a competitive season. This emphasizes the importance of being an educated consumer when making the decision to use nutritional supplements in coordination with balanced whole food nutrition to enhance health and performance.

The purpose of this chapter is to provide an in-depth look at the evolution and use of dietary supplements in sports; discuss the legalities and regulations that affect the supplement industry; and explain the keys to being an informed consumer, including how to decipher supplement labels, safety considerations, important supplement resources, and various supplement bans.

Nutrition, Dietary Supplements, and Performance: A Historical Perspective

It is well known that certain nutrients, specifically carbohydrates, fats, proteins, vitamins, minerals, and water, are essential for health and sport performance. As sport scientist Ronald Maughan puts it, "Without proper nutrition, the full potential of the athlete will not be realized, because performance will not be at its peak, training levels may not be sustained, recovery from injury will be slower, and the athlete may be more susceptible to injury and infection." The idea that various ingredients in food could enhance physical stature, health, and athletic performance is not a modern phenomenon; rather, it dates to over 4,000 years ago. The ancient Greeks were at the forefront of sport nutrition as they sought various ingredients they could use to optimize athletic prowess during competition. Warriors of the time were reported to use such foods as deer liver and lion heart, hoping that consumption would produce bravery, speed, or strength. Although in its infancy, the concept of ergogenic or work-enhancing nutrients and the sport nutrition market it produced was beginning to bloom. In modern times, the topic of sport nutrition has continued to evolve, with health scientists working overtime to isolate and define ingredients that could enhance various metabolic reactions important to health and athletic performance. Current research continues to build on these nutritional discoveries and further refine the correct dosing, form, and timing of administration of each nutrient to help athletes maximize their health and performance potential.

Vitamin and Mineral Supplementation

At the forefront of the discovery of vitamins and minerals was the ancient Greek physician Hippocrates, who once stated, "Let food be thy medicine and medicine be thy food." These famous words served as a launching point for a series of research studies evaluating the impact of food ingredients on the prevention of debilitating diseases such as scurvy, which is estimated to have afflicted and killed millions of prisoners, slaves, soldiers, orphans, and sailors over several hundred years before Doctor James Lind discovered in the mid-1700s that a diet rich in citrus juices, later known to be rich in vitamin C, helped combat the disease. Nearly two hundred years later, in 1912, the term vitamin was officially coined by Polish biochemist Casmir Funk while he was busy making the discovery that thiamine helped correct symptoms of beriberi, including muscle weakness and heart failure, in deficient pigeons.

Over the following 30 years, a total of 13 vitamins, 9 water-soluble and 4 fat-soluble, were isolated and named along with their associated deficiency conditions. Collectively, along with 7 major minerals and 10 trace minerals, vitamins are known as micronutrients, or substances considered essential for health and protection against deficiency symptoms. See table 1.1 for descriptions and examples of these micronutrients. Beyond playing an important role in energy production, hemoglobin synthesis, maintenance of bone health, adequate immune function, and protection of the body against oxidative damage, micronutrients assist with synthesis and repair of muscle tissue during recovery from exercise and injury.

The importance of micronutrients in protection against deficiency symptoms and debilitating disease lead the United States Food and Nutrition Board to establish the Recommended Dietary Allowances (RDA) in 1941. The purpose of the RDAs is to define the daily dietary intake level of nutrients, including vitamins and minerals, considered sufficient to meet the requirements of nearly all (97%–98%) healthy individuals in each life stage and gender group. There is still debate, however, as to whether the RDAs are sufficient to support the increased metabolic demands of an athlete. Intense exercise, in particular, can accelerate the turnover and loss of micronutrients from the body, thus supporting the concept of increased micronutrient requirements to support building, repair, and maintenance of lean body mass in athletes.

As early as the late 1930s, vitamin and mineral supplements were being used in athletics. Front-of-the-pack Tour de France cyclists reporting that they rode better after taking vitamin and mineral supplements. In fact, the multivitamin and multimineral supplement, introduced in the 1940s, has remained one of the most commonly used supplements by athletes. While a multivitamin can certainly serve as nutritional insurance for an athlete in combination with a balanced whole food diet, research has failed to support the correlation between supplementation and enhanced performance.